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Social Eating Role in Ultra-Processed Food Consumption Among Urban Young Adults: The 2018 Indonesian Food Barometer

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Abstract

This study investigated the differences in ultra-processed food (UPF), fruit, vegetable, and total fat consumption in different aspects of social eating among urban young adults. This cross-sectional study used the 2018 Indonesian Food Barometer dataset with 180 participants aged 18–25 years living in urban areas from 6 provinces in Indonesia. The data on social eating (cooking habits, eating out, and eating alone), UPF, fruits, and vegetables were obtained from an extended 24-hour food recall interview. The Mann-Whitney U test (CI 95%) was employed for data analysis. This study found that groups with less frequent cooking habits tended to have more total energy intake, fat intake, and total energy from UPF (p-value <0.05). The more frequent eating out habit was related to the lower vegetable intake (p-value <0.05). This study provided relevant evidence to better understand the social and behavioral aspects of eating and its implications for public health nutrition. Extensive studies are needed to analyze the nutritional profile of frequently consumed UPF in Indonesia to provide insight into the condition of the food environment, thus relevant as a basis for policy limiting sugar, fat, and salt intake.

Keywords: social eating, urban, ultra-processed food, young adult

Introduction

Prior literature suggests that urbanization is linked to the increasing burden of noncommunicable diseases (NCDs). The urbanization and metabolic syndrome trend has been a particular concern in low- and middle-income countries.[1] A 2023 longitudinal study in Indonesia showed a trend toward an unhealthy diet aligned with the rate of urbanization. Growing urbanization correlates with a rise in food intake associated with NCDs and healthy diets; however, the significant non-linear finding is that only people living in the most urbanized areas consumed certain meals connected to an increased risk of NCDs.[2] Another finding showed that rural residents who move to an urban location may have worse metabolic health alterations due to urban lifestyle adoption. An increase in poor diet quality is the cause of the rising body mass index of rural people living in urbanized nations.[3]

Urbanization is also associated with higher consumption of ultra-processed food (UPF), the formulation of which, according to the NOVA classification system (food grouping based on the extent and purpose of industrial food processing) is mostly derived from a series of industrial processes, including adding food additives.[4,5] This was prompted by the fact that urban regions are often the first to undergo swift modernization in food systems, characterized by the greater availability of UPF.[4,6] Consumption of UPF is inversely related to fruit and vegetable consumption, whereas a positive association was found between UPF consumption and foods high in fat and sugar.[7] Evidence suggests another interesting perspective on the health benefits of fruit and vegetable consumption in preventing NCDs amidst the modernization of food systems. It might help mitigate the impact of UPF on metabolic syndrome.[8] However, there is a consistent link between the rise in UPF consumption and a decline in overall diet quality.[9] Therefore, it is important to view UPF as not only an individual component of an unhealthy diet but also a factor that shapes the overall quality of the diet.

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Social eating, defined as food consumption in the presence of family, peers, or during communal events, has been shown to influence dietary choices through peer influences and food-sharing habits. Social eating also defines norms for certain food choices.[10] Social life is closely linked to the quality of diet, food choice, and eating patterns. Eating is not only a means of sustenance but also a universal human experience. Meals are frequently shared with family, friends, or coworkers in many cultures worldwide, transforming them into occasions for celebration, connection, and bonding. In addition to making food more enjoyable, these social interactions affect what, when, and how much we eat. Hence, social factors, such as eating companions, interaction during eating, cooking habits, and eating out, significantly impact eating behavior and overall diet quality, highlighting the importance of considering the social context when promoting healthy eating habit.[11]

There is substantial evidence that people genuinely enjoy eating with others and find social eating both inherently pleasure and uplifting. However, some individuals prefer to eat alone because it is more relaxing, less stressful, and offers greater control over their eating.[11,12] People who often eat foods prepared outside of home have higher daily intakes of energy, total fats, and sodium. Additionally, studies have consistently shown that eating out is detrimental to the diet quality of men and young adults.[13] With data from the 2018 Indonesian Food Barometer (IFB), this study analyzed the differences in UPF, fruit, vegetable, and total fat consumption in different aspects of social eating among urban young adults. This study will provide evidence on how the social eating context, particularly how the food was prepared (cooked or purchased outside home), where the food was consumed (eaten at home or eating in and eaten away from home or eating out), and who the participants were eating with (alone or with companion) could shape the frequency of UPF, fruit, and vegetable consumption.

Method

This cross-sectional study used a dataset from the latest data from the IFB collected in 2018. The Food Barometer is a survey that aims to analyze the transformation of food habits and patterns. The IFB is a part of the Asian Food Barometer that aims to provide evidence on the relationship of social, cultural, and nutritional determinants of nutritional transition for making contextually relevant recommendations on the nutritional status of the population in Indonesia.[14]

This study systematically sampled provinces, urban areas, villages, hamlets, and individuals. First, the sampling focused on the most populous provinces, mostly located on Java Island. For this study, one urban district was chosen within each province, which was also likely to be the provincial capital city. The selected urban cities were Jakarta, Bandung, Surabaya, Denpasar, Padang, and Makassar. A cluster was referred to as a village, consisting of approximately 400–550 households. The survey team visited selected households and listed household members aged 18–45 years. An eligible respondent from a household was then selected at random. Subject selection was applied using multistage random sampling using the proportionate-to-population-size cluster method. A total of 180 participants aged 18–25 years living in urban areas chosen by the IFB from the most populous provinces were included in this study.

Sex, age, occupation, education, and wealth index were observed in this study. Sex differed as male and female, age was presented as mean±SD, occupation was classified based on type of employment, and wealth status was classified based on the ownership of household assets. The type of employment consisted of professional (people with specialized education or training, often in fields like law, medicine, engineering, and finance), white-collar (office-based or administrative jobs, often involving clerical work rather than physical labor), blue-collar (manual labor or skilled trades, often involved physical work), and student/unemployed (either currently enrolled in education or is seeking employment). The wealth index differed by tertile based on the ownership of household assets, such as a water source, the place for defecation, fuel for cooking, floor material, roof material, wall material, and other electronic and vehicle assets.

Social eating aspects were observed in the IFB as part of the socialization process of eating. This study observed three aspects: cooking practice, eating out, and eating alone. The pattern of eating out was calculated using the percentage frequency count based on the 24-hour dietary recalls, where the location for food preparation and food consumption was probed. The calculation steps were as follows: First, for each eating occasion, how the food was prepared (cooked or purchased outside home), where the food was consumed (eaten at home or eating in and eaten away from home or eating out), and who they were eating with (alone or with companion) were identified. Second, the frequency count for each respondent was summed up from the total number of eating occasions and presented as a percentage. The percentage for each aspect (cooking habit, eating out, and eating alone) was then categorized into

"frequent" (>66.7%) and "less frequent" (≤66.7%).[15]

Total fat, UPF, fruit, and vegetable intakes per day were obtained from the interview using an extended 24-hour food recall. The UPF is defined as the formulation of ingredients, mostly of exclusive industrial use, typically created by a series of industrial techniques and processes.[5] In this study, the consumption of UPF was determined according to the NOVA classification system. Food classified as UPF in this study were ready-to-consume products (carbonated soft drinks, sweet or savory packaged snacks, chocolate and candies (confectionery), ice cream, mass-produced packaged bread and buns, margarines and other spread, cookies and biscuits, pastries, cakes, and cake mixes, cereals, energy bars, energy drinks, milk drink, fruit yogurts, fruit drinks, cocoa drinks, instant sauces); pre-prepared ready-to-heat products (nuggets, sausages, burgers, noodles, desserts); and infant formulas.[16]

Food intake data were presented as total energy from UPF/day (kcal), total fruit consumption/day (g), total vegetable consumption/day (g), and total fat consumption/day (g). The frequency distribution of macronutrient, fruit, and vegetable intake was compared to the Recommended Daily Allowance (RDA) for the Indonesian population and was presented in categories: <80% RDA, 80%–100% RDA, and >100% RDA. The frequency distribution of UPF was presented based on food items according to the NOVA classification system: bread, cereals, processed meat, dairy products, drinks, sauce and seasoning, snacks, fast food, and confectionery.

The characteristics of the participants in this study were presented using frequencies with percentage (n, %) for categorical variables and mean with standard deviation (mean±SD) for continuous variables. The median and interquartile range (IQR) were presented for not normally distributed data. The independent t-test and Mann–Whitney U test were used to determine the association between continuous variables (CI 95%). The Kolmogorov–Smirnov test was used to determine the normality of the dataset. The normal assumption was set when it met the p-value of <0.05. Statistical analysis was conducted using IBM SPSS Statistics Version 29 (license number c10d5d881901674c0f46).

Results

The participants' sociodemographic characteristics are presented in Table 1. There were more male (60.6%) than female (39.4%) participants. The mean age was 21.4±2.01 years. The participants mostly worked as white-collar workers (38.9%), followed by students/unemployed (16.7%). Most participants completed the secondary level of education (82.2%), followed by the tertiary level (14.5%). Most subjects were in the highest tertile of the wealth index (38.9%).

The median intakes of energy, protein, fat, and carbohydrates were 1669.2 (742.5) kcal, 56.2 (31.3) g, 62.0 (45.3) g, and 202.3 (115.3) g, respectively. The energy intake from the UPF was 342.5 (535.4) kcal, which contributed to 22.8% of the total energy intake. It was found that subjects had poorer consumption of fruit (median, 0 (0) g) and vegetables (median, 30 (100) g). Table 1 also lists the distribution of social eating aspects. Most subjects (76.1%) were less frequent to cook, less frequent to eat out (90%), but mostly frequent to eat alone (53%).

Figure 1 presents the distribution of subjects meeting the recommendations according to the Indonesian Dietary Guideline.[17] The results showed that although most participants did not meet the dietary recommendation for total energy intake, fat and protein consumption tended to be excessive. This condition indicated that the diet mainly consisted of fat and protein. The consumption of fruit and vegetables was mostly insufficient. As previously mentioned in Table 1, UPF contributed 22.8% of the total energy intake. Figure 2 shows that the most frequently consumed UPFs in this study were bread (20.3%), followed by cereals (16.2%) and processed meat (15.3%).

Table 1. Participants' Sociodemographic, Food Intake, and Social Eating Characteristics

Characteristics	Category	Frequency (n)	Percentage (%)
Sex	Male	109	60.6
	Female	71	39.4
Age (years)	-		21.41±2.01*
Occupation	Professional	4	2.2
	White-collar	70	38.9
	Blue-collar	29	16.1
	Student/unemployed	30	16.7
	Housewife	47	26.1
Education	Primary (Elementary)	6	3.3
	Secondary (Junior High, Senior High)	148	82.2
	Tertiary (Diploma/bachelor's degree)	26	14.5
Wealth index	Tertile 1	47	26.1
	Tertile 2	63	35
	Tertile 3	70	38.9
Macronutrient intake	Energy (kcal)		1669.2 (742.5)⊥
	Protein (g)		56.2 (31.3)⊥
	Fat (g)		62.0 (45.3)⊥
	Carbohydrate (g)		202.3 (115.3)⊥
Energy from the UPF (kcal)	-		342.5 (535.4)⊥
Contribution of energy intake from UPFs (%)	-		22.8 (31.62)⊥
Fruit intake (g)	-		0 (0)⊥
Vegetable intake (g)	-		30 (100)⊥
Cooking habit	Frequent	43	23.9
	Less frequent	137	76.1
Eating out	Frequent	18	10
	Less frequent	162	90
Eating alone	Frequent	95	53
	Less frequent	85	47

*Mean±SD – SD = standard deviation

⊥Median (IQR) – IQR = interquartile range

UPF = ultra-processed food

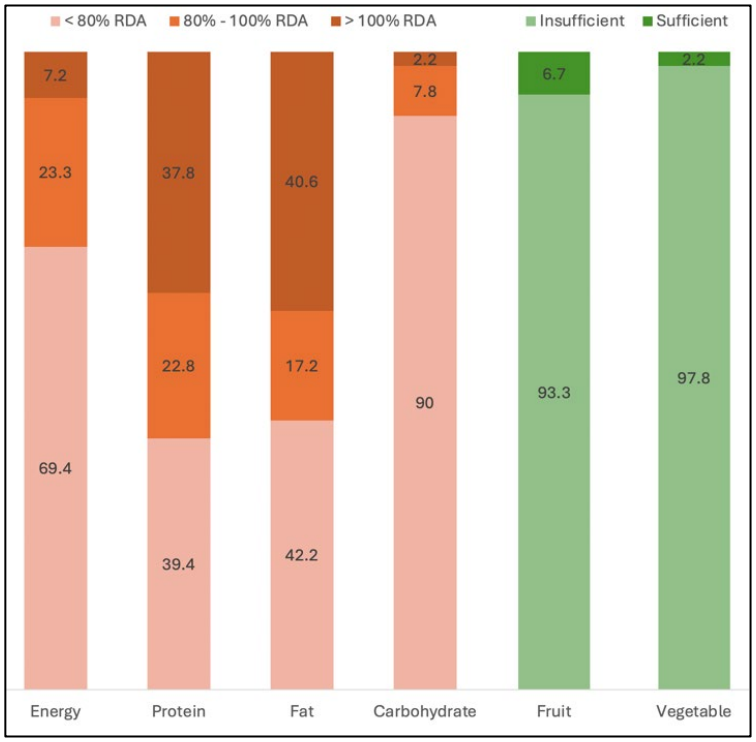

Figure 1. Frequency Distribution of Macronutrient, Fruit, and Vegetable Intake Compared to Recommendations[17]

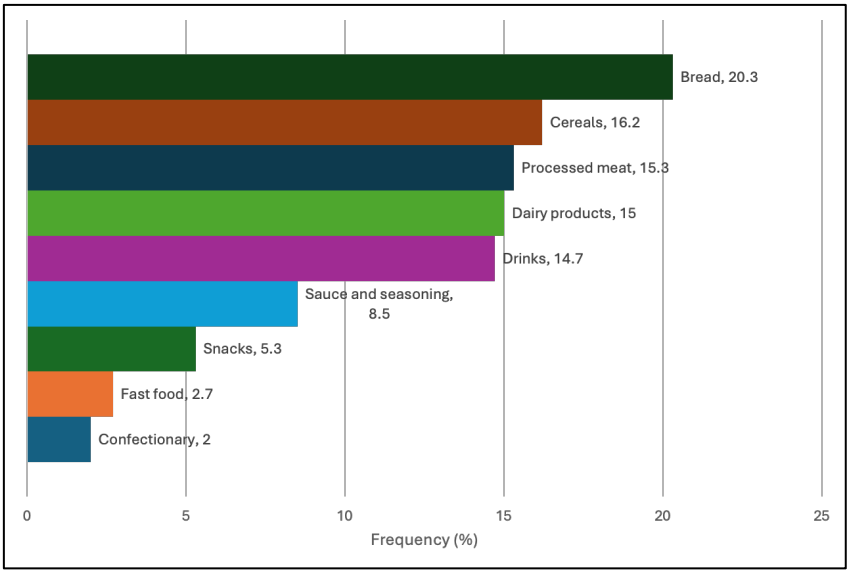

Figure 2. The Most Frequently Consumed Ultra-Processed Foods

Table 2 shows that fruit intake was not significantly different across social eating aspects. There was a slightly different trend of fruit consumption in the eating out aspect, as seen in the IQR value, suggesting that those who ate out more frequently tended to have more fruit consumption. The fruit consumption trend was similar to that of vegetable consumption. Vegetable consumption seems to be associated with eating out and eating alone. More vegetable consumption was found among those who frequently ate out and those who ate alone.

The total energy intake was different among different cooking habits. Those who were less frequent when cooking tended to have more energy intake than those who cooked more frequently. This finding was consistent with the total fat intake, which showed a similar trend. Moreover, this result was supported by the trend of UPF consumption, demonstrating that those who were less frequent to cook tended to have almost three times higher median UPF consumption. The total energy intake also tended to be higher among those who were less frequently able to eat alone. This finding was aligned with total fat and vegetable intake, which showed increased trends among those eating alone less frequently.

Table 2. Median Intake of Total Fat, Vegetables, Fruits, and Energy from Ultra-Processed Food Based on the Respective Social Eating Aspects

	Cooking habit			Eating out			Eating alone		
	Frequent	Less frequent	p-value	Frequent	Less frequent	p-value	Frequent	Less frequent	p-value
Total energy intake (kcal)	1,464.5 (918.2)	1,712.1 (768.8)	0.039	1,636 (402)	1,669.2 (837.6)	0.657	1,542 (811.8)	1,753.5 (783.8)	0.105
Total fat intake (g)	47 (39.4)	67.7 (49.9)	0.001	65.9 (23.9)	61.9 (48.3)	0.280	55.9 (44.7)	69.4 (48.3)	0.011
Fruit intake (g)	0 (0)	0 (0)	0.453	0 (103)	0 (0)	0.149	0 (0)	0 (0)	0.310
Vegetable intake (g)	30 (110)	30 (100)	0.575	1,27.5 (150)	30 (83)	0.033	20 (80)	45 (115)	0.011
Energy from the UPF (kcal)	140.1 (421.5)	411.2 (548)	0.002	422.8 (512.7)	336.35 (547.3)	0.973	287.4 (514.9)	402.9 (563.7)	0.671

Notes: data are presented as median (IQR). The difference between the two groups was analyzed using the Mann–Whitney U test (CI: 95%)

Discussion

The IFB data collected in 2018 across six different provinces in Indonesia were used for analysis in this study. Food consumption data were collected from the population aged 18–25 years living in an urban area. To the best of the authors' knowledge, this study is the first to observe the social eating aspect affecting UPF consumption among urban young adults according to IFB data. A previous study using the same secondary data was conducted to identify the quality of breakfast in terms of macronutrient and micronutrient content[18] and the sociodemographic effect on social eating among adults.[15]

This study found that the total energy intake of the participants mostly did not meet the national recommendations based on specific age and sex. However, the consumption of fat and protein was more likely to be excessive for each macronutrient. These results implied that it is important to look beyond nutrient quantity. Apart from macronutrient

intake, fruit and vegetable intake tended to be insufficient compared with the national recommendation, 250 grams of vegetables and 150 grams of fruit. Therefore, this study emphasized the importance of consuming a balanced diet among the urban young adult population. This study supported a previous study's findings about food insecurity among young adults that raised an issue on diet quality, particularly the low intake of dietary fiber sources, and high intake of sugar and fat.[19]

According to the type of UPF, the most frequently consumed UPF in urban young adult was bread, followed by cereals, and processed meat. This result captures the type of available UPF in the surrounding food environment which affected the food choice, though, it needs further studies to investigate the motivation in choosing those UPFs. Previous evidence explained the role of food environment, which affect the desirability, convenience and affordability, and availability in choosing certain food.[20] The profile of UPF products consumed is also depends on the region and culture. A study conducted in Europe demonstrated that the products contributing most to UPF were processed meat, cakes, pies, and pastries.[21] In India, categories of UPF preferred were bread, chips, and sugary drinks.[22]

This study also found that UPF contributed to a remarkable amount of total energy intake during the day. Previous studies highlighted a similar amount of the contribution of UPF consumption to total energy intake in adults, such as one-third of total calories in Brazil,[23] 29.8% in Mexico,[24] 23.8% in Portugal,[4] and 46% in Canada.[25] Numerous findings support the theory that UPF can be used to define overall diet quality.[5,9] This study revealed that the most consumed UPF products in Indonesia were bread, cereals, dairy products, and processed meat. These food sources contributed to a significant amount of fat. UPF consumption is linked to obesity. The possible mechanism is that UPF consumption tends to shape a diet low in fiber and high in sugar and fat.[26]

This study highlighted that different social eating aspects, including cooking habits, eating out, and eating alone, can potentially influence the consumption patterns of urban young adults aged 18–25 years. Less frequent cooking habits were associated with higher total energy intake, total fat intake, and the contribution of UPF energy intake. These results were in line with the previous report in 2020, which demonstrated that frequent cooking is associated with a higher healthy eating index.[27] Cooking at home more often is linked to higher scores of total fruit consumption,[28] which was not confirmed in this study.

In addition, the previous study[28] findings supported the positive correlation between cooking and diet quality, which is related to higher socioeconomic status. Adjusted socioeconomic status and sex in the study population are needed to confirm the theory. Beyond cooking practices, several works have gone deep into the concept of food agency, which is made of cooking self-efficacy, food, and cooking-related attitudes and structural barriers. Food agency was found to be associated with frequent cooking, less frequent use of packaged foods, and healthier dietary intake.[28] Regarding sex, the association between cooking skill and unhealthy diet was found to be more pronounced in males in the older population.[29]

This study found that eating out was not significantly associated with energy, fat, and UPF consumption. However, it was associated with a higher intake of vegetables. A previous study demonstrated a similar result, showing that eating out was weakly associated with total energy intake.[30] However, this study tended to yield different findings compared with the trend of previous studies explaining that eating out is associated with lower vegetable intake.[30,31] A previous study explained that the higher consumption of vegetables when eating out is related to the possibility that there are more vegetable options in the food environment outside of home, such as convenience vegetable products in the market that giving more option for vegetarian.[32] It can also be explained that it is related to peer influence.[33]

This study revealed that eating alone was associated with fat and vegetable intake. These findings suggested that eating together might decrease fat intake, whereas eating alone might increase vegetable intake. A previous study demonstrated that sex and age play an important role in defining the association between eating alone and diet quality.[34] Commensality, or eating together, is a fundamental human social activity that spans all cultures and eras. Rapid social change has altered the environments in which people eat together, leading to a decline in commensality, which is now a growing concern in modern societies.[34] Eating alone is also related to reduced appetite, leading to a lower energy intake.[35] Eating alone is also related to age; younger generations frequently eat alone. A study found that the group that ate a healthy meal was found to have less frequency of eating alone.[36]

This study is the first to explore the role of social eating on UPF consumption among Indonesian urban young adults. The IFB report focused on exploring the nutrition transition, particularly in a social context. The present secondary data analysis focuses on a specific population: young adults (18–25 years) living in an urban setting. Given the evidence previously mentioned that urbanization leads to a shift in food consumption patterns that increases fat, sugary

beverages, UPF, and sedentaryism, this study is important to enrich the knowledge on the role of social eating among urban young adults. However, this study did not provide information about the overall dietary quality and analysis of the quantity of sugar, fat, and salt from the UPF consumed by urban young adults. Future studies are needed to analyze the nutritional profile of frequently consumed UPF in Indonesia to provide insight into the condition of the food environment, thus relevant as a basis for policy limiting sugar, fat, and salt intake.

Conclusion

The UPF consumption is observed more frequently in individuals who are less likely to cook. Moreover, less frequent cooking habits are also found in those with higher energy and fat intake. Vegetable consumption is associated with eating out. Total fat and vegetable consumption is associated with the habit of eating alone. However, the causal relationship cannot be determined from the study design. This study provides further evidence to the field by exploring the role of social eating and the growing trend of unhealthy diets among young adults. Further study is needed to confirm the role of age and sex in shaping the influence of social eating aspects on dietary habits. Extensive studies with a longitudinal design are needed to confirm the possible strategies to prevent UPF consumption in the context of social eating.

Abbreviations

NCDs: noncommunicable diseases; UPF: ultra-processed Food; IFB: Indonesian Food Barometer; RDA: recommended daily allowance; SD: standard deviation; CI: confidence interval; IQR: interquartile range.

Ethics Approval and Consent to Participate

The IFB obtained ethical clearance from the Human Ethical Committee of the Faculty of Medicine, Universitas Indonesia (reference number 927/UN2.F1/ETIK/2017). Ethical approval to research this secondary data was based on an ethical approval letter from the Ethical Committee for Health Research, Universitas Islam Negeri Syarif Hidayatullah Jakarta (Un.01/F.10/KP.01.1/KE.SP/04.08.060/2024).

Competing Interest

The authors declare no conflict of interest.

Availability of Data and Materials

All data and related materials from this study are available from the first author.

Authors' Contribution

Conceptualization: IA and RNA; methodology: IA and HK; data collection: HK and JF; data analysis: JF, NAP, SNL, and GAA; writing, review, and editing: IA, HK, and JF.

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Understanding Occupational Health and Safety Regulations and the Influence on Students' Behavior in Practical Workshops

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Abstract

Understanding occupational health and safety (OHS) is essential for engineering students, especially in high-risk environments such as mechanical workshops, where unsafe practices can lead to accidents and injuries. Although Regulation Number 5 of 2018 from the Indonesian Ministry of Manpower mandates OHS implementation in all workplaces, students' knowledge and behavior still fall short of the expected safety standards. This study aimed to measure students' understanding of OHS, their basic knowledge of OHS law, and their behavior during workshop practicum activities. A cross-sectional research design was used, involving 203 students in State Polytechnic in Badung District, Indonesia. Data were collected through direct observation, surveys, and interviews. OHS understanding and legal knowledge were assessed using a test questionnaire, while OHS behavior was evaluated using a Likert-scale-based questionnaire. Data were analyzed using structural equation modeling at a 95% confidence level. The results indicated that combined OHS understanding and legal knowledge influence OHS behavior by 25.1%, with legal knowledge alone contributing only 1.8%, suggesting that knowledge of the law cannot shape behavior independently. Other contributing factors, such as engaging teaching methods and continuous monitoring, are needed.

Keywords: basic knowledge, behavior, comprehension level, occupational health and safety, occupational health and safety law

Introduction

Occupational health and safety (OHS) regulations serve as the legal foundation for workplace safety in Indonesia, as outlined in the Indonesian Minister of Manpower Regulation No. 5 of 2018.[1] This regulation mandates that both state-owned and private companies implement OHS standards to ensure workers' protection. As future professionals, students are expected to understand these regulations before entering the workforce. OHS encompasses both occupational safety and health, forming a critical aspect of labor protection and human rights.

In industrial settings, an OHS culture—characterized by strict adherence to safety protocols and continuous implementation of OHS standards—is essential for minimizing workplace risks. Additionally, advancements in technology can enhance safety measures when integrated effectively into OHS practices. OHS is a basic right of every worker whose scope has expanded to include it.[2,3] OHS is also a policy used by companies and governments to reduce the risk of work-related accidents and thereby avoid hazards in the workplace.[4,5] However, one of the greatest challenges faced by industries is a lack of adequately prepared individuals who possess not only OHS knowledge but also the behavioral discipline to apply it effectively.

In other words, OHS policies are designed to reduce workplace accidents, ensuring that workers internalize and practice safety measures remains a significant concern. Since prospective workers are still in college, it is crucial to instill OHS behavior early on through practical experiences such as workshop training, internships, and practicums. Despite these opportunities, many students struggle to develop proper OHS habits, highlighting the gap between theoretical knowledge and practical application. Addressing this issue requires an in-depth investigation into students' understanding of OHS, legal knowledge, and behavior in workshop environments to identify key factors influencing safety compliance and professional preparedness.

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Failure to follow OHS procedures can result in practicum-related work accidents. These work accidents occur primarily due to a lack of understanding of OHS procedures, a lack of discipline in carrying out work procedures, and other factors.[6–8] A lack of safe and healthy behavior at work can be a major factor in work accidents.[9,10] At school or college, work accidents can occur during practicums or when students do internships in workshops.[11,12] Until now, there have rarely been any measurements of OHS behaviors among mechanical engineering students practicing in laboratories or workshops. For this reason, it is necessary to make various real efforts to improve the quality of human resources, especially among students.

The real effort is through education. Education that strives to encourage the OHS culture is applied education delivered in polytechnics. According to Higher Education Law No. 12 of 2012,[13] a polytechnic is a tertiary institution that provides vocational education in various fields of science and/or technology, and if it meets the requirements, the polytechnic can also provide professional education. This law indicates that its position as a tertiary institution is part of the national education system, which aims to prepare students to become members of society who have competent, responsible professional abilities. The hope is that graduates will be able to apply and develop a professional culture at work, and polytechnic education focuses on preparing students to apply specific skills.

Students must understand how OHS operates and appreciate how standard OHS regulations can become a habit or work culture. It is necessary to have a good understanding of OHS and the laws or regulations of OHS itself to make OHS a work culture.[14,15] It is necessary to explore the level of students' understanding of OHS, especially when they do a practicum in the laboratory, as an illustration of their future employment prospects when they graduate. Previous studies revealed that educational programs still pay less attention to OHS both in the classroom and in the laboratory or workshop.[16,17] Knowledge management regarding OHS in organizations, schools, and universities still lacks.[18,19] Studies on OHS in the laboratory have not emphasized prevention factors but rather, the impact of a lack of understanding of OHS.[20,21] Therefore, it is deemed necessary to conduct research to measure the level of understanding of OHS and OHS behaviors in students who will later become practitioners in global companies or industries.

Several previous studies have examined OHS knowledge in educational settings, and most have focused on either the general impact of accidents, rather than their root causes in behavior and understanding, or OHS management in organizations, rather than the development of OHS behavior during training at the student level.[22–25] Moreover, studies covering this scope often lack quantitative or behavioral measurement of OHS practices among students during practical activities in laboratories or workshops.

This study filled the research gap by specifically assessing students' understanding of OHS laws and standards, evaluating safety behaviors during practicum and internship sessions, and exploring the relationship between knowledge, behavior, and institutional support for building an OHS culture. By focusing on student-level behavior in applied learning environments, this study provided empirical evidence and practical insights largely overlooked in the existing literature. This study can be an input for policymakers in the field of education to improve students' OHS behavior during practicums or internships, also for educational curriculum makers and lecturers to revise the practicum module to further improve the basic understanding of OHS law and provide a significant contribution to building safe and healthy behaviors during practice or when working in the industry in the future. Building this OHS behavior will also have an impact on the global industry, as it can reduce the number of work accidents and increase productivity.

Method

This cross-sectional study was conducted from August to December 2023. A cross-sectional design was chosen because it can measure research variables while students are completing a practicum without losing samples, as in a longitudinal design. The population in this study consisted of sixth- and eighth-semester students in the Department of Mechanical Engineering of State Polytechnic in Badung District, Bali Province, Indonesia. The population size was 203 students. The sample calculation used a saturated sampling technique,[26] so all populations were used as samples in this study. The samples came from 10 classes—8 classes in semester 6, totaling 172 students, and 2 classes in semester 8, totaling 31 students. This saturated sampling was chosen because the existing population was not too large, everyone could be reached, bias could be avoided, and the validity of the research results could be improved.

The inclusion criteria were (a) mechanical engineering students, (b) in semester 6 or 8, and (c) willing to be research participants until completion. Meanwhile, for the exclusion criteria, subjects who were (a) dropped out of college when the research was conducted and (b) suffered from illnesses that interfered with the research based on reports from the subjects or accompanying laboratory staff. For the dropout criteria were subjects withdrew from the sample for various

reasons, so missing data were not taken into account in the analysis.

Research instruments for measuring the level of understanding of OHS and basic knowledge of OHS law were used in tests. OHS behavior in the workshops was measured using Likert-type questionnaires on a scale of 1–5. The framework of the questionnaire and basic knowledge test of OHS was modified from the previous studies' test and questionnaire.[27,28] The percentage values of this Likert scale were as follows very poor 0–20%, poor 21–40%, good enough 41–60%, good 61–80%, and very good 81–100%. Based on the total score of the questionnaire measurement results, the measurement of the level of OHS behavior was based on a normal curve reference, which was divided into five intervals. Each interval was given an attribute as very poor (Mi - 3.0 SDi ≤ X ≤ Mi - 1.5 SDi), poor (Mi - 1.5 SDi ≤ X ≤ Mi - 0.5 SDi), good enough (Mi - 0.5 SDi ≤ X ≤ Mi + 0.5 SDi), good (Mi + 0.5 SDi ≤ X ≤ Mi + 1.5 SDi), and excellent (Mi + 1.5 SDi ≤ X ≤ Mi + 3.0 SDi), whereas Mi means ideal mean, X means score value, and SDi means ideal standard deviation. The valid criteria for each question were ≥0.5.

The level of understanding of OHS was defined as the level of understanding of the concept, principles, and implementation of OHS in the work environment. The level of understanding of OHS was measured using a questionnaire test with indicators of basic understanding of OHS, knowledge of risks and hazards, compliance with OHS regulations, implementation of OHS, and OHS culture. The OHS behavior in the workshop was defined as the behavior of students in implementing OHS in the workshop, such as using personal protective equipment, following safe work procedures, maintaining cleanliness and tidiness, operating tools properly, being aware of potential hazards, and obeying signs and warnings. The level of understanding of OHS and OHS behavior in the workshop was measured using a Google Form questionnaire. Meanwhile, interviews were conducted to determine whether students had adequate knowledge, carried out the OHS steps correctly, and had completed all parts of the questionnaire correctly. The interview was conducted based on interview guidelines that had been prepared previously based on the research objectives. Meanwhile, observations were conducted to assess the actual behavior of students when they were carrying out practical activities and whether they were following OHS procedures or not. These observations were conducted using a checklist with yes or no answers.

Data analysis used quantitative descriptive and structural equation modeling (SEM) analysis with a significance level of 95% or alpha 5%. Quantitative descriptive analysis was used to evaluate sample characteristics, and SEM was used to find relationships between variables. SEM analysis was used because it can measure all variables simultaneously and can take into account the effects of latent variables on the indicator variables.[29] Another advantage of SEM is that it provides measurement and structural models in one analysis. However, multiple regression is not designed to handle latent variables directly.[30]

Results

This study involved 203 students from the Department of Mechanical Engineering of State Polytechnic in Badung District, Bali Province, consisting of 6th and 8th semester students. Most respondents were from the 6th semester, totaling 172 students (84.7%), while 8th semester students numbered 31 (15.3%). Most students (132 students, 65.0%) were aged 20 years, and the rest. 33 students (16.3%), 29 students (14.3%), and 9 students (4.4%) were aged 19 years, 21 years, and 22 years, respectively. This distribution indicated that most students are in the active practicum phase and within a productive age range, which was highly relevant to this study.

There was a dominant number of male students, 198 individuals (97.5%), while female students totaled only 5 (2.5%). This imbalance reflects a common trend in mechanical engineering programs, which tend to attract more male students. Regarding compliance with the use of personal protective equipment (PPE), 135 students (66.5%) reported routinely using PPE during practicum activities, while the remaining 68 students (33.5%) were inconsistent or rarely used it. This figure indicated that there was still a gap between knowledge and actual OHS practices.

The results of the SEM analysis for instrument reliability using Cronbach's alpha were an OHS understanding level of 0.972, a basic understanding of OHS law of 0.966, and an OHS behavior of 0.966, while calculated construct validity using average variance extracted (AVE) results were an OHS understanding level of 0.655, a basic understanding of OHS law of 0.792, and OHS behavior of 0.655. The Cronbach's alpha value in all variables was above 0.7. The value of the OHS understanding level variable was 0.966, the OHS behavior variable was 0.966, and the basic understanding of OHS law was 0.972. These results showed that this study's instrument could be used because it produced valid and reliable results. The AVE value was also met in all three variables because it was above 0.5.

Occupational Health and Safety Understanding Level

The OHS understanding level was measured using questionnaires. Of the 20 questions, 19 were valid and and 1 question (question number 19) was invalid (dropped), so the questionnaire on OHS understanding questions totaled 19. The results of measuring OHS understanding in respondents were the frequency of correct answers, 2,512 (62.5%), and the frequency of wrong answers, 1,345 (37.5%). Therefore, the correct answer from the total score of respondents was found to be 62.5%. The percentage value of students' level of understanding OHS was be in the good category, but there is still room for improvement.

Table 1. Validity of Occupational Health and Safety Comprehension Level Question Items

Question Items	Topic	Validity Value (Outer Loading)	Valid/Invalid	Information
TPK3-1	OHS abbreviation	0.61	Valid	applied
TPK3-2	Definition of OHS	0.51	Valid	applied
TPK3-3	Occupational Health	0.61	Valid	applied
TPK3-4	The purpose of OHS	0.61	Valid	applied
TPK3-5	Work Safety	0.60	Valid	applied
TPK3-6	Occupational Safety Objectives	0.58	Valid	applied
TPK3-7	Factors Affecting OHS	0.63	Valid	applied
TPK3-8	OHS Management	0.53	Valid	applied
TPK3-9	Personal Protective Equipment	0.56	Valid	applied
TPK3-10	Work Accident	0.56	Valid	applied
TPK3-11	Company Productivity	0.55	Valid	applied
TPK3-12	Elements of Production	0.55	Valid	applied
TPK3-13	Occupational Disease	0.63	Valid	applied
TPK3-14	OHS Management System	0.46	Valid	applied
TPK3-15	The Purpose of OHS Management	0.63	Valid	applied
TPK3-16	Measuring instrument	0.56	Valid	applied
TPK3-17	Flammable Substances	0.55	Valid	applied
TPK3-18	Unsafe Behavior	0.51	Valid	applied
TPK3-19	Work Environment	0.45	Invalid	drop
TPK3-20	OHS Training	0.52	Valid	applied

Notes: TPK3 = number of occupational health and safety understanding questions, OHS = occupational health and safety, valid criteria: outer loading ≥0.5

Basic Understanding of Occupational Health and Safety Law

The basic understanding of OHS law was measured using questionnaires. Of the 10 questions, one (question number 10) was invalid, so the questionnaire on understanding OHS law amounted to 9 items. The results of measuring the understanding of OHS law in respondents were the frequency of correct answers, 1,026 (56.2%), and the frequency of wrong answers, 801 (43.8%). Those who answered correctly from the total score of respondents amounted to 56.2%. The percentage value of the level of understanding of the law on OHS was in the sufficient category, but there is still room for improvement.

Table 2. Validity of Question Items on the Basic Understanding of Occupational Health and Safety Law

Question Items	Topic	Validity Value (Outer Loading)	Valid/Invalid	Information
PDH-1	Constitution	0.66	Valid	applied
PDH-2	OHS Regulations	0.66	Valid	applied
PDH-3	Occupational Health Law	0.63	Valid	applied
PDH-4	Labor Laws	0.64	Valid	applied
PDH-5	Labor Protection Act	0.66	Valid	applied
PDH-6	OHS implementation	0.65	Valid	applied
PDH-7	Purpose of the OHS Act	0.65	Valid	applied
PDH-8	OHS legal basis	0.62	Valid	applied
PDH-9	PPE Regulations	0.64	Valid	applied
PDH-10	Sanction	0.27	Invalid	drop

Note: PDH = number of question items on basic understanding of Occupational Health and Safety Law, OHS = occupational health and safety, valid criteria: outer loading ≥0.5

Occupational Health and Safety Behavior Level

The level of OHS behavior was measured using a questionnaire in the form of a five-item Likert scale. Of the 16 questions, 3 (question number 2, 10, and 12) were invalid, so the questionnaire about OHS behavior in students amounted to 13 items. This measurement of the OHS behavior level was based on the reference of the normal curve divided into five intervals. The ideal mean was 1/2 (ideal maximum score+minimum score) = 609, and the SDi was 1/6 (ideal maximum score–minimum score) = 135.33. Predicate classification on OHS behavior is presented in Table 4.

Table 3. Validity of Occupational Health and Safety Behavior Question Items

Question Items	Topic	Validity Value (Outer Loading)	Valid/Invalid	Information
PRK-1	Pay attention to OHS	0.62	Valid	applied
PRK-2	OHS knowledge	0.34	Invalid	drop
PRK-3	Maintain health	0.62	Valid	applied
PRK-4	Practical Procedures	0.55	Valid	applied
PRK-5	Using PPE	0.54	Valid	applied
PRK-6	Work accident	0.59	Valid	applied
PRK-7	Sick condition	0.65	Valid	applied
PRK-8	Attention to work accidents	0.59	Valid	applied
PRK-9	Work posture	0.59	Valid	applied
PRK-10	Maintaining equipment	0.49	Invalid	drop
PRK-11	Tidy up equipment	0.53	Valid	applied
PRK-12	Cleanliness	0.42	Invalid	drop
PRK-13	Clothes	0.64	Valid	applied
PRK-14	Emergency measures	0.61	Valid	applied
PRK-15	work break	0.66	Valid	applied
PRK-16	Healthy food	0.59	Valid	applied

Notes: PRK = number of occupational health and safety behavior questions, OHS = occupational health and safety, PPE = personal protective equipment, valid criteria: outer loading ≥0.5

Table 4. Predicate Classification on Occupational Health and Safety Behavior

Score Range	Classification/Predicate
$10.556 < X \leq 13.195$	Excellent
$8.797 < X \leq 10.556$	Good
$7.037 < X \leq 8.797$	Good enough
$5.278 < X \leq 7.037$	Poor
$2.639 \leq X < 5.278$	Very poor

The total score on respondents' OHS behavior was 7.487. By referring to Table 4, the score at the OHS behavior level is, therefore, categorized as good enough, but this category of behavior still urgently needs to be improved. The classification of predicates, as in Table 4, is based on the acquisition of the scores from the questionnaire completed by the students. There were 5 Likert scale levels on the questionnaire. Level 1 was very poor, 2 was poor, 3 was quite good, 4 was good, and 5 was very good.

Based on the number of questionnaire items multiplied by the Likert scale, the lowest total score was 2.639, which was very low, and the highest total was 13.195, which was very good. With a total score of 7,487 from the students' questionnaire responses, this study fell within the good enough range, between 7.037 and 8.797. These results were quite good for students, but there is still room for improvement in how students behave when forming OHS habits during lectures and practice.

Classroom instruction, laboratory, or workshop practicum activities must be used to build this improvement in OHS behavior. Classroom instruction includes instructors teaching students and administering tests based on OHS questions. This takes the form of tasks in the lab or workshop, such as reading safety instructions, learning how to use tools, putting on personal protective equipment, and keeping equipment neat and clean. In addition, lecturers and other staff need to supervise students to ensure that they can act correctly according to OHS principles.

The image of the relationship model between variables at the level of understanding of OHS, basic knowledge of OHS law, and OHS behavior in students was analyzed using SEM and Smart PLS 4 software (free version). Before analyzing the relationship between the variables, reliability and construct validity tests were conducted. The reliability analysis results using Cronbach's alpha were OHS understanding level = 0.972, basic understanding of OHS law = 0.983, and OHS behavior = 0.972. The result of the AVE construct validity tests was 0.668 for OHS understanding level, 0.877 for basic understanding of OHS law, and 0.754 for OHS behavior.

Cronbach's alpha value was above 0.7, and the AVE value was above 0.5, which indicated that all the constructs had good validity and reliability. Evaluation of the structural model was carried out using the R-squared test. The results of the R-squared test were OHS behavior of 0.251 and OHS understanding level of 0.018. These results indicated that the relationship model was moderate/sufficient and weak. The results of analyzing the relationship between variables using Smart PLS 4 obtained the results shown in Figure 2.

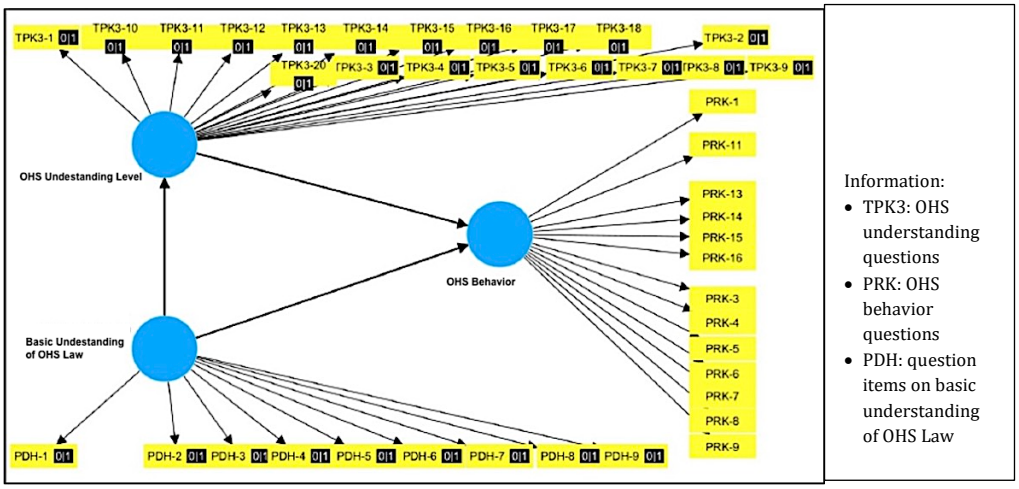

Figure 1. Model of Relationships Between Variables Using SEM Analysis with Smart PLS 4

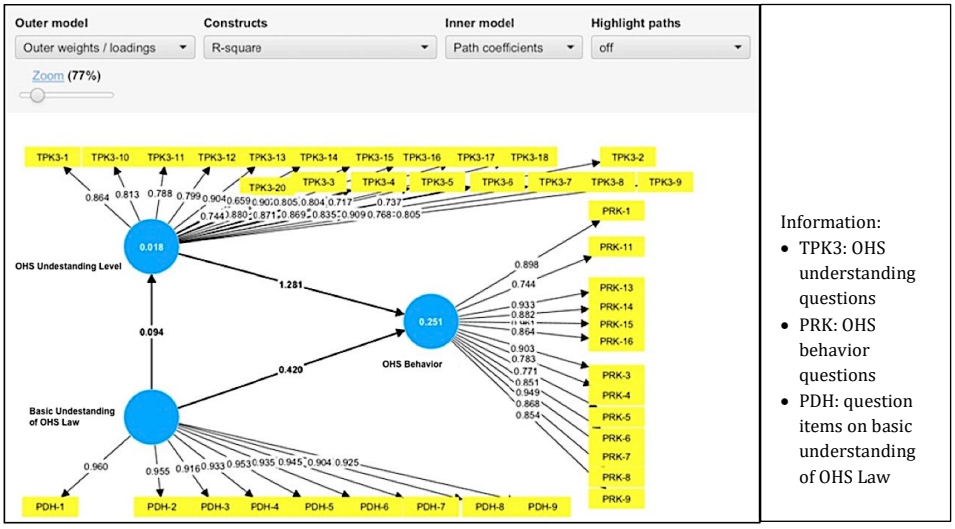

Figure 2. Results of the SEM Analysis Using Smart PLS 4

Based on the results of the SEM analysis, the OHS understanding level and basic understanding of OHS law were found to have influenced the OHS behavior of students by 25.1%, while basic understanding of OHS law was only able to contribute to the OHS understanding level by 1.8%. An advanced analysis of respondents was conducted to test the knowledge and behavior differences between sixth- and eighth-semester students. The analysis was calculated using an independent t-test.

The results revealed that no significant difference between the sixth- and eighth-semester students in OHS understanding level (p-value = 0.122; 95% CI: -2.596–21.735) and OHS behavior (p-value = 0.619; 95% CI: -3.144–1.879) was found. These results showed no activities that could increase the OHS understanding and behavior level of students, either in learning activities or practical activities in the seventh semester. For this reason, higher education observers must attend to improving and monitoring the understanding and behavior of the OHS of students in the final semester. This can be done through OHS workshop activities or OHS seminars with pretests and posttests, and needs to be done in preparation for students to enter the industrial world when they graduate.

Discussion

After testing the validity and reliability of the three measurement instruments in this study, the results were declared valid and reliable. These three instruments were a questionnaire on the OHS knowledge level, a basic understanding of OHS law, and the OHS behavior. Therefore, this research instrument can be declared suitable for measuring the research variables. Research instruments must be valid and reliable so that they can be used to measure or predict the measurements of research variables.[31,32]

The OHS understanding level of this study's respondents was 62.5%, which was in the good category but still needs to be improved. The basic understanding of OHS law was 56.2%, which was in the sufficient category, but needs to be improved. Meanwhile, the OHS behavior was quite good, but it still needs to be improved. The OHS understanding level and the basic understanding of OHS law affected the OHS behavior of students by 25.1%. These results are certainly not so good for students in the final semester, when students are already prepared to work in the industry. For this reason, effort is needed to improve OHS behavior by increasing knowledge of OHS and OHS law in courses in the first semester. Students, particularly those at vocational colleges, require OHS training. If knowledge about OHS is increased and students exhibit good OHS behavior, the number of work accidents in laboratories and workshops should decrease. These students are ready to enter the workforce, and of course, the number of work accidents in the industry will also decrease. These findings indicated that improving students' understanding of and behavior in OHS is very important. This improvement can be stronger if OHS materials are included in the design of the education curriculum because the results will be evaluated continuously.[33,34] Activities can take the form of training, tutorials in class, or posters that are easy to understand and placed strategically and accessibly.

The level of understanding of OHS is very important in the world of work, so that workers at work can act safely and avoid unsafe behavior.[35,36] Unsafe behavior will increase the likelihood of work accidents.[28,37,38] A basic understanding of OHS law will be needed to increase motivation not to violate existing provisions. People tend to be careless and make mistakes, so if they are not given basic rules for practicing OHS, there will often be violations that result in work accidents.[1,39]

Based on the findings of the structural equation modeling (SEM) study, it was found that the level of OHS comprehension and the basic grasp of OHS law had a 25.1% influence on the OHS behavior of students. In the meantime, the fundamental comprehension of occupational health and safety law was only able to contribute to a level of OHS comprehension that was 1.8%. These results showed that legal knowledge alone is not enough to build OHS behavior; therefore, other underlying factors are needed. In the context of education and teaching, these other factors can be more appropriate teaching methods, behavioral examples from lecturers and peers, more binding regulations, and continuous monitoring and evaluation. The results of this study are in line with previous studies stating that there is a relationship between understanding OHS and OHS behavior at work.[23,40]

The practical implications of this article can be seen in the context of meeting the educational needs for continuous learning and knowledge enhancement/lifelong learning in the field of OHS. Improving the understanding and behavior of OHS on campus requires cooperation by all parties, including students, lecturers, and other staff. With a combination of education, policy, active participation, and technology, an OHS culture on campus can be built well. Steps that can be implemented include education and training in the form of OHS workshops and seminars, integration into the curriculum by including OHS material in certain courses in the early semesters, provision of OHS information and tools, and strengthening OHS policies and procedures in campus regulations.

Increasing the understanding and behavior of OHS in students will produce graduates who will work more professionally in the future because they will be able to apply safe, comfortable, healthy, and productive work principles. Good OHS insight will also help reduce accidents on campus and in the industry where they will work later. Besides that, educational programs for OHS have been developed in several institutions, but only a few have shown high levels of success.[24,34]

This study has some limitations. It was conducted in one polytechnic, which will limit the generalizability of the conclusions; therefore, it needs to be tested in other polytechnics. In addition, there is potential bias in the questionnaire and interview data if the subject is not completely honest in providing answers to questions in the questionnaire or interview. The results of this study also obtained a small relationship value (R-squared) for both OHS behavior and knowledge; therefore, future studies are needed to conduct interventions on OHS behavior and knowledge in students so that a greater relationship value can be obtained later.

Conclusion

The students' understanding of OHS and OHS law is good in general, but can be improved since the knowledge will affect the behavior. This study highlights the need to improve the understanding and behavior of OHS in the campus environment by combining education, policies, active participation, technology, and OHS culture. This improvement can be made by delivering education and training in the form of OHS workshops and seminars, integrating OHS into the curriculum by including OHS material in certain courses in the early semester, providing OHS information and tools, providing examples of OHS steps—both theoretical and practical, in related courses—and strengthening OHS policies and procedures in campus regulations.

Abbreviations

OHS: Occupational Health and Safety; SEM = Structural Equation Modeling; AVE = Average Variance Extracted.

Ethics Approval and Consent to Participate

Ethical approval was achieved from the Ethical Committee on Social Studies and Humanities- National Research and Innovation Agency with the certification of ethical review clearance number 398/KE.01/SK/05/2023.

Competing Interest

The authors declare no competing interests in this study.

Availability of Data and Materials

The primary author can provide all data and materials from this study.

Authors' Contribution

MY designed and was responsible for the conduct of the study. IKGJS made the analysis and provided suggestions. NWMSD, NWS, and IMS wrote, proofread, and reviewed the manuscript. All authors read and approved the final manuscript.

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Job Satisfaction Among Health Workers at Primary Health Care in Palembang City, Indonesia

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Abstract

Health workers at primary health care are the frontline providers of community health services. This study aimed to investigate the level of job satisfaction of health workers at primary health care in Palembang City, South Sumatra Province, Indonesia, and its influencing factors. Using a questionnaire developed by the authors' team, the study involved 257 samples. A total of 66.15% of respondents indicated high satisfaction, 21.79% reported moderate satisfaction, and 12.06% expressed dissatisfaction. A statistically significant correlation was found between knowledge, skills, income, promotion opportunities, work supervision, and relationships with colleagues and job satisfaction (p-value <0.001). The correlations were strong, with Spearman's rho of 0.822, 0.869, 0.912, 0.895, and 0.821, respectively. Statistical analysis of the Wilcoxon rank-sum and Kruskal-Wallis tests showed no significant differences in median satisfaction scores between sociodemographic groups (p-value 0.072 to 0.552>0.05). These findings showed that job satisfaction depends on multiple factors. Both intrinsic and extrinsic factors play a key role in shaping job satisfaction. Health workforce management should prioritize organizational factors to sustain job satisfaction over sociodemographic factors. Key strategies include regular training, fair salaries, clear promotion paths, strong supervision, and fostering teamwork through leadership training and staff meetings.

Keywords: health workers, job satisfaction, primary health care

Introduction

Health workers' job satisfaction is linked to the quality of health services and organisational success. Job satisfaction boosts health workers' motivation, productivity, and teamwork, enhancing patient care, reducing errors, and ensuring service continuity. A satisfied workforce contributes to better health outcomes and increased patient trust. Therefore, health workers need strong management support and job satisfaction to deliver quality healthcare and ensure patient satisfaction.[1] Consequently, job satisfaction is a critical factor in ensuring the sustainability of healthcare services.[2] Understanding the determinants of job satisfaction is essential for healthcare administrators and policymakers.

Job satisfaction can be affected by factors such as working conditions, leadership style, financial compensation, relationships with colleagues, and work benefits, with working conditions having the most significant impact on job satisfaction (odds ratio: 8.16; 95% confidence interval: 2.39–27.91).[3] Therefore, addressing working conditions is crucial to enhancing job satisfaction, which in turn can positively impact healthcare service delivery and patient outcomes. A previous study indicates that these factors are closely linked to motivation, particularly regarding the quality and style of supervision, which has the greatest influence on hospital organizational performance (Spearman's rank correlation coefficient = 0.490; p-value <0.001).[4] Organizational managers should foster a culture of unity, support, and mutual concern among staff members. Such an environment encourages individuals to strive diligently to achieve common goals, fostering both organizational growth and development.[5] By promoting this culture, hospital administrators can mitigate dissatisfaction and enhance employee retention, ultimately improving overall healthcare quality.

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A study in Athens, Greece, found that many health workers were dissatisfied with their jobs during the COVID-19 pandemic, reflecting the emotional and physical demands of the profession.[6] As supported by other studies, health workers' job satisfaction is influenced by six factors: financial, professional, working conditions, living conditions, cultural, and personal factors.[1,2,7] In contrast, research in Ethiopia revealed low levels of job satisfaction among health workers in both private and public hospitals, with significantly lower satisfaction in public hospitals (29.0%).[8]

Employee performance, absenteeism, and turnover are linked to job satisfaction. Employees with high job satisfaction tend to work harder than those with low job satisfaction. Job satisfaction reflects how employees perceive their jobs based on positive or negative emotional feelings. Measuring job satisfaction depends on key factors like interactions with employers and coworkers, adherence to company policies, the fulfillment of life standards, and the quality of the working environment.[9-12]

Numerous studies indicate that job satisfaction among health workers in developing nations is significantly lower.[13-15] In the healthcare sector, which is characterized by its demanding nature, frequent interactions occur between patients, functioning as customers, and health workers.[16] To enhance the job satisfaction of health workers, health service managers should adapt their leadership style and offer supportive supervision in the hospital.[17]

In Indonesia, primary health cares (PHCs) are available in various subdistricts, including in Palembang City, staffed by doctors, dentists, nurses, midwives, pharmacists, and other health workers. As the capital city of South Sumatra Province, Palembang City has a diverse population. This may lead to a higher workload compared to other cities in the province. Increased workload could have an impact on job satisfaction among health workers. Job satisfaction at PHC is crucial, as health workers serve as frontline providers of community health care. Maintaining their motivation and satisfaction is essential for ensuring high-quality and effective healthcare delivery. This study aimed to analyze the level of health workers' job satisfaction at PHCs in Palembang City and identify the factors that influence the job satisfaction of health workers. This study helps policymakers and administrators develop strategies to improve job satisfaction, strengthen workforce stability, and enhance patient care.

Method

This cross-sectional descriptive analytical study was conducted between October 3 and November 30, 2022, and targeted all health workers at 42 PHCs in Palembang City, South Sumatra Province, Indonesia. A non-probability convenience sampling method was applied, allowing voluntary participation to ensure a sufficient number of respondents within the timeframe. Based on a previous study, simple regression analysis requires at least 50 samples, with 100 being standard for most studies.[18] Although the minimum sample size was set at 100, participation was open to all interested health workers. The inclusion criteria for participants included being actively working in all PHCs of Palembang City during the study period. Exclusion criteria included health workers on leave or those unwilling to provide informed consent. The invitation contained a brief study description and a link to the online questionnaire.

The data collection comprised three sections: informed consent, sociodemographic characteristics, and questions related to job satisfaction factors. The job satisfaction-related questions were developed based on existing literature on job satisfaction and adapted to the study setting. Expert consultation was conducted with professionals in human resources management to ensure the relevance and clarity of the items. This study examined eight key variables. Among them, seven were sociodemographic variables, including age (21-30, 31-40, 41-50, or 51-60 years), sex (male or female), marital status (single or married), educational status (senior high school or master's and doctoral degrees), area of residence (Palembang City or surrounded districts), job position (holding or not holding a managerial position), and work experience (≤10 years or >10 years). Job satisfaction was assessed using five factors: knowledge, skills, and competency required for the job, income, promotion opportunity, work supervision, and relationship with coworkers. Consistent with a similar study, a 7-point Likert scale, ranging from 1 (very strongly dissatisfied) to 7 (very strongly satisfied), measured job satisfaction.[19]

A previous study demonstrated that the reliability test for the self-medication behaviour questionnaire yielded satisfactory results with a sample of 30 respondents.[20] Therefore, self-administered questions concerning job satisfaction factors were tested for validity and reliability by distributing the questionnaires to 30 health workers. An online survey using Google Forms was conducted among health workers at PHC in Ogan Ilir District, South Sumatra Province, who were not included in the study sample. A significance level of 0.05 was used for analysis. The validity test was conducted on 30 people and showed valid results with a calculated r-value of 0.3620. Each questionnaire item (item 1 = 0.640, item 2 =

0.823, item 3 = 0.715, item 4 = 0.604, and item 5 = 0.800) surpassed the cut-off point, indicating the validity of all five questionnaire items. Cronbach's alpha coefficient was used to test the internal consistency, with values of 0.60 or above considered acceptable. The computed Cronbach's alpha score of 0.763 indicated that the questionnaire was reliable. The validated and reliable questionnaire was then distributed through an online survey using Google Forms.

Descriptive statistics were applied to analyze sociodemographic variables and mean values for each job satisfaction factor. The job satisfaction level was measured by calculating the average score for each factor. Overall job satisfaction was categorized as dissatisfied (scores 5–19), moderately satisfied (scores 20–26), and satisfied (scores 27–35). This grouping was based on the nonnormal distribution of the data. The cutoff for the satisfied category was set above the median (median = 26). The lower limit of the moderately satisfied category was determined by assuming that respondents selected a neutral response (4) for all five questionnaire items, resulting in a score of 20. Scores <20 were classified as dissatisfied.

The data were statistically analyzed. Categorical variables were presented as frequencies and percentages, whereas continuous variables, such as job satisfaction factor scores, were presented as means and standard deviations. The relationship between job satisfaction factors and overall job satisfaction was examined using Spearman's rank correlation coefficient analysis. Differences in job satisfaction across sociodemographic characteristics were assessed using the Kruskal–Wallis and Mann–Whitney tests. The level of statistical significance was set at a p-value of <0.05. All respondents received standardized instructions before completing the questionnaire to ensure consistency and minimize potential bias. The survey was conducted anonymously to ensure honest and unbiased responses.

Results

Table 1. Characteristics of Respondents (n=257)

Variable	Frequency (n)	Percentage (%)
Overall Score of Job Satisfaction		
Dissatisfied	31	12.06
Moderate satisfied	56	21.79
Satisfied	170	66.15
Age		
21-30 years	76	29.57
31-40 years	111	43.19
41-50 years	61	23.74
51-60 years	9	3.50
Sex		
Male	32	12.45
Female	225	87.55
Marital Status		
Single	42	16.34
Married	215	83.66
Educational Status		
Senior high school	2	0.78
Diplomas (D1/D2/D3)	139	54.09
D4/Bachelor	95	36.96
Master/Doctorate	21	8.17
Area of Residence		
Palembang City	105	40.86
Surrounded districts	152	59.14
Job Position		
Not holding a managerial position	229	89.11
Holding a managerial position	28	10.89
Work Experience		
≤10 years of working	168	65.37
>10 years of working	89	34.63

A total of 257 health workers employed at 25 public health centers voluntarily participated in this study. Table 1 shows the participants' sociodemographic characteristics, including age, sex, marital status, educational status, area of residence, job position, and work experience, and level of job satisfaction, were identified among 257 respondents. The majority (66.15%) of respondents were satisfied with their current job, 21.79% were moderately satisfied, and 12.06% were dissatisfied. Of the 257 respondents, 111 (43.19%) were in the 31–40-year age group, 76 (29.57%) were in the 21–30-year age group, 61 (23.74%) were in the 41–50-year age group, and 9 (3.5%) were in the 51–60-year age group. Most

respondents were female (87.55%), married (83.66%), had a diploma (54.09%), lived in districts surrounding Palembang City (59%), did not hold a managerial position (89.11%), and had ≤10 years of work experience at PHCs (65.37%).

Table 2 shows the mean scores and standard deviations for job satisfaction-related factors. In the "satisfied" group, the mean values for the five elements, knowledge, skills, and competency required for the job, income, promotion opportunity, work supervision, and relationships with coworkers, were 5.43, 5.12, 5.17, 5.25, and 5.45, respectively, with mean values above 5 indicating that most respondents experience high job satisfaction in these aspects and standard deviation values of 1.45, 1.54, 1.53, 1.49, and 1.42 indicating moderate variability, with a reasonable spread of responses around the mean and a relatively normal data distribution.

Table 2. Mean Value of Job Satisfaction Factors Among Health Workers (n=257)

Job Satisfaction Factors	Mean	Standard Deviation	Category
Knowledge, skills, and competency required for the job	5.43	1.45	Satisfied
Income	5.12	1.54	Satisfied
Promotion opportunity	5.17	1.53	Satisfied
Work supervision	5.25	1.49	Satisfied
Relationship with coworkers	5.45	1.42	Satisfied

Table 3. Factors Affecting Job Satisfaction Among Health Workers (n=257)

Job Satisfaction Factor	Frequency (n)	Percentage (%)	Spearman rho (r)	p-value	95% CI
Knowledge, skills, and competency required for the job					
Very strongly dissatisfied	10	3.89			
Strongly dissatisfied	9	3.50			
Dissatisfied	6	2.33			
Neutral	27	10.51	0.822	<0.001**	0.760-0.884
Satisfied	28	10.89			
Strongly satisfied	137	53.31			
Very strongly satisfied	40	15.56			
Income					
Very strongly dissatisfied	12	4.67			
Strongly dissatisfied	11	4.28			
Dissatisfied	15	5.84			
Neutral	30	12.45	0.869	<0.001**	0.818-0.920
Satisfied	42	16.34			
Strongly satisfied	117	45.53			
Very strongly satisfied	28	10.89			
Promotion opportunity					
Very strongly dissatisfied	11	4.28			
Strongly dissatisfied	11	4.28			
Dissatisfied	11	4.28			
Neutral	39	15.18	0.912	<0.001**	0.873-0.950
Satisfied	35	13.62			
Strongly satisfied	118	45.91			
Very strongly satisfied	32	12.45			
Work supervision					
Very strongly dissatisfied	9	3.50			
Strongly dissatisfied	13	5.06			
Dissatisfied	11	4.28			
Neutral	30	11.67	0.895	<0.001**	0.858-0.932
Satisfied	32	12.45			
Strongly satisfied	133	51.75			
Very strongly satisfied	29	11.28			
Relationships with coworkers					
Very strongly dissatisfied	9	3.50			
Strongly dissatisfied	8	3.11			
Dissatisfied	7	2.72			
Neutral	28	10.89	0.821	<0.001**	0.760-0.882
Satisfied	27	10.51			
Strongly satisfied	137	53.31			
Very strongly satisfied	41	15.95			

Notes: **Significant at p-value <0.01.

Table 3 shows factors influencing job satisfaction among health workers. Most study participants (53.31%) expressed a high level of satisfaction with their knowledge, skills, and competency required for the job, 45.53% showed a high level of satisfaction with their income, 45.91% expressed significant satisfaction with the promotional opportunities available, 51.75% reported high satisfaction with the work supervision, and 53.31% were very satisfied with their working relationships with colleagues. All factors (knowledge, skills, and competency required for the job, income, promotion opportunity, work supervision, and relationships with coworkers) were statistically significantly correlated with overall job satisfaction (p-value = <0.001), with Spearman's rho values of 0.822, 0.869, 0.912, 0.895, and 0.821, respectively, indicating a strong positive correlation. These findings indicated that these factors play a significant role in improving the job satisfaction of health workers at PHCs in Palembang City.

The results of the two-sample Wilcoxon rank-sum (Mann-Whitney) tests for sex, marital status, area of residence, job position, and work duration in Table 4 revealed that there are no statistically significant differences in mean satisfaction scores between the two groups based on these sociodemographic factors, with p-values of 0.306, 0.072, 0.165, 0.251, and 0.552, respectively. Similarly, the Kruskal-Wallis population rank equality test yielded p-values of 0.296 and 0.457, indicating no substantial variation in mean satisfaction scores across the age groups and educational status variables, respectively.

Table 4. Job Satisfaction Difference Among Groups of Sociodemographic Variables

Variable	p-value	95% CI
Age		
21–30 years		
31–40 years	0.296	-5.759-12.906
41–50 years		
51–60 years		
Sex		
Male	0.306	-1.422-3.470
Female		
Marital status		
Single	0.072	-0.129-3.723
Married		
Educational status		
Senior high school		
Diplomas (D1/D2/D3)	0.457	-4.335-9.365
D4/Bachelor		
Master's/Doctorate		
Area of residence		
Surrounded districts	0.165	-3.301-0.527
Palembang City		
Job position		
Not holding a managerial position	0.251	-1.026-3.323
Holding a managerial position		
Work experience		
≤10 years of working	0.552	-1.384-2.572
>10 years of working		

Notes: Mann-Whitney test and Kruskal-Wallis tests *significant at p-value <0.05

Discussion

This study analyzed the job satisfaction levels of health workers in PHCs in Palembang City. A total of 66.15% of health workers at PHCs in Palembang City expressed satisfaction with their current position. The results showed a considerable difference with the group of health workers who felt dissatisfied at 12.06%. This result aligned with positive findings reported in several studies.[21-23] However, other studies have shown lower job satisfaction among workers in similar roles.[2,13] This discrepancy may be due to local contextual factors such as organizational culture, leadership styles, and regional economic conditions, which were not explored in the cited studies. Sociodemographic factors, including age, sex, marital status, educational status, area of residence, job position, and work experience, may influence health workers' job satisfaction. Previous studies have examined the correlation between sociodemographic variables and job satisfaction.[16,24,25]

This study revealed that five job satisfaction factors—knowledge, skills, and competency (53.31%), income (45.53%), promotion opportunities (45.91%), work supervision (51.75%), and relationships with coworkers (53.31%)—were significantly correlated with overall job satisfaction. These findings indicated that job satisfaction depends on multiple factors. Both intrinsic factors like skills and relationships, and extrinsic factors like income, promotions, and supervision play a key role in shaping job satisfaction. Health workers at PHCs in Palembang City exhibited strong capabilities and

sufficient opportunities for skill development. Moreover, they enjoyed satisfactory income levels and promising prospects for job advancement. This condition indicated that their financial compensation is adequate in the local context, reflected by the 2022 Palembang City minimum wage of USD200 (approximately 1 USD = IDR16,430), and may contribute positively to their overall job satisfaction. Surprisingly, this study challenges common assumptions by showing that health workers at PHCs in Palembang City hold positive perceptions of their supervisors and generally maintain positive relationships with their coworkers. Health workers' positive perceptions of supervisors may stem from effective supervision, strong competencies, supportive coworkers, and fair income and promotion opportunities, fostering an unexpectedly positive work environment despite common challenges in PHCs.

Previous studies have revealed that higher levels of personal knowledge and skills are associated with increased job satisfaction.[21,26] Diverse skills among health workers allow them to handle a wider range of tasks, serve patients, and reduce the boredom of repetitive work. Job satisfaction increases when an individual's competencies align closely with job demands.[26] This suggests that individuals with higher competence levels are more likely to excel in their tasks. Furthermore, high levels of competence increase adaptability to the work environment and job demands.[27] Highly competent employees generally experience increased self-confidence, which leads to reduced job stress and ultimately fosters greater job satisfaction.[10,26]

Several studies have shown a positive correlation between income and job satisfaction, identifying income as a key determinant.[28,29] Financial rewards, including income and other monetary incentives, are primary motivators for individuals in their works[2] and drive for individuals in their work. Since individuals primarily work to meet their essential needs. Higher incomes not only help alleviate financial needs for health workers but also enable them to meet their daily needs and foster emotional satisfaction. Satisfied and happy workers will naturally be more satisfied with their jobs. A previous study emphasized how salary factors among young Chinese workers can influence their job satisfaction.[30] Health workers should receive salaries that reflect their responsibilities and performance. Overtime and additional responsibilities should be compensated separately from regular pay to ensure a fair and transparent system. Career advancement also plays a crucial role in job satisfaction. Job promotions often come with salary increases and greater job complexity. In this study, job promotion emerged as a factor influencing job satisfaction. Structural Equation Modeling (SEM) analysis using Analysis of Moment Structures (AMOS) from a previous study found that career development exerts a positive and significant impact on work engagement among employees in the Bukittinggi City Govenment.[31]

Consistent with previous study's findings, this study affirmed that the employer or leader in the workplace significantly influences the job satisfaction of health workers.[32,33] Most respondents expressed moderate to high job satisfaction, meaning that leadership or employers generally have a positive impact on health workers in the PHCs of Palembang City. Empowering managers with the right skills improves personnel management, creating a productive, harmonious workplace. Effective leadership drives job satisfaction by supporting communication, employee growth, and engagement.[32] Positive leadership from supervisors in the workplace encourages health workers, contributing to an increase in their job satisfaction. Involving staff in the decision-making process will encourage them to voice their opinions and share ideas. On the other hand, this helps leaders gain diverse perspectives to overcome workplace challenges.[3,8] Staff involvement in the organization is beneficial.[33] Good relationships with coworkers can influence job satisfaction. Effective communication and coworker support have been shown to increase job satisfaction.[13,34] Being part of a work team will increase regular interactions with coworkers.[35] Commitment to working as a team results in benefits for delivering health services in PHC settings.

Health care teams commonly face challenges in accountability, conflict management, decision-making, reflecting on progress, and coaching, which are consistent across clinical and administrative teams.[36] Effective leadership within the healthcare sector can have a beneficial influence on the teamwork of health workers.[37] The positive sense of being part of a team and cultivating positive relationships fosters higher job satisfaction. In addition, by fostering interprofessional collaboration, healthcare teams can address challenges more effectively, thus enhancing the overall work experience and job satisfaction.

This study's results contributed to Herzberg's Two-Factor Theory by highlighting the need to create work environments that value and support employees, enabling them to apply their skills to enhance healthcare delivery.[38] Furthermore, these findings suggested that effective leadership and positive interpersonal relationships play an integral role in job satisfaction, extending the theory's applicability in healthcare settings. For policymakers and healthcare administrators, the results suggested practical recommendations for improving health workers' job satisfaction. It is important to foster leadership that emphasizes communication, professional development, and recognition of employees'

contributions. These efforts can increase retention rates, improve service delivery, and achieve better overall health outcomes.

This study had several limitations. The questionnaire did not include questions about respondents' employment status (civil servant vs. non-civil servant). Additionally, this study was limited to Palembang City, which may not be representative of health workers across Indonesia. The reliance on self-reported data and the participant selection process might have also influenced the results. Future research should aim to include more diverse health care settings and employ different methods to gain a more comprehensive understanding of job satisfaction.

Conclusion

This study's findings highlight that most health workers at PHCs in Palembang City reported high job satisfaction, with both intrinsic and extrinsic factors contributing positively. Statistical tests confirm a correlation between job satisfaction and five factors, including knowledge, skills, and competency, income, job promotion, work supervision, and coworkers. However, none of the sociodemographic variables (age, sex, marital status, educational status, area of residence, job position, and work experience) has a statistically significant relationship with job satisfaction among the health workers. Job satisfaction is likely influenced more by workplace factors than by sociodemographic factors. Health workforce management should prioritize organizational factors to sustain job satisfaction over sociodemographic factors. Key strategies include regular training, fair salaries, clear promotion paths, strong supervision, and fostering teamwork through leadership training and staff meetings.

Abbreviations

PHC: primary health care.

Ethics Approval and Consent to Participate

Approval for ethical considerations was obtained from the Ethics Committee of the Faculty of Public Health, Universitas Sriwijaya, with the number 274/UN9.FKM/TU.KKE/2022. To maintain privacy, the personal information of participants was omitted. Moreover, detailed and transparent informed consent was acquired from every participant, specifying their voluntary involvement, the choice to answer all queries, and the freedom to conclude the interview at any point before completing all questions.

Competing Interest

The authors declare that they have no competing interests associated with the publication of this article.

Availability of Data and Materials

Data used in this study is available from the corresponding author upon reasonable request.

Authors' Contribution

AA was responsible for conceptualization, methodology, formal analysis, and final draft writing. MNS performed the investigation and wrote the original draft. PF and HI interpreted the data and contributed to writing the final draft. TT critically reviewed the manuscript. All authors read and approved the final manuscript.

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Assessing the Impact of the First Feeding Practice on Wasting Risk Among Indonesian Children Under the Age of Five

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Assessing the Impact of the First Feeding Practice on Wasting Risk Among Indonesian Children Under the Age of Five

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Abstract

The problem of undernutrition among children under the age of five (the under-five) continues to be alarmingly high in Indonesia, including in West Sumatra Province. Various factors contribute to this issue, with studies suggesting a relationship between intergenerational causes and undernutrition. This study analyzed the main risk factors of wasting among children in Padang City. Data were collected from 174 under-five and divided into unmatched cases that were selected randomly and control groups. The mothers were interviewed using a questionnaire regarding their children's feeding habits, and weight and height data were collected from primary health care. Multiple logistic regression analysis was used to calculate the odds ratio for undernutrition. The findings revealed that 37.6% of the under-five were breastfed, whereas over half received inadequate complementary feeding. Poor breastfeeding practices (p-value = <0.001; OR = 8.389; 95% CI 2.611–14.432) and inadequate complementary feeding (p-value = <0.001; OR = 13.534; 95% CI 6.025–30.400) were identified as major contributors to the increased risk of undernutrition in the under-five. The high prevalence of suboptimal under-five feeding practices in the study area highlights the necessity of enhancing maternal nutrition education to ensure optimal growth and nutrition.

Keywords: breastfeeding, complementary feeding, under-five, undernutrition

Introduction

Undernutrition in children under the age of five (the under-five) remains a significant public health issue in many developing countries, including Indonesia.[1] The 2022 Indonesian Nutritional Status Survey highlighted alarmingly high rates of underweight, wasting, and stunting among the under-five, with prevalence rates of 17.1%, 7.7%, and 21.6%, respectively.[2] However, the 2023 Indonesian Nutritional Status Survey indicated a positive trend, with reductions in underweight and stunting rates to 15.9% and 21.5%, respectively, although the prevalence of undernutrition persisted unchanged.[3] A previous study has consistently shown that childhood malnutrition is largely attributable to inadequate nutrition during critical rapid growth and development periods.[4] World Health Organization (WHO) recommends exclusive breastfeeding for the first 6 months of a newborn's life, and thereafter, introducing complementary foods while continuing breastfeeding until 2 years to ensure that their nutritional needs are adequately fulfilled.[5]

Undernutrition is a broad term that refers to the states of being underweight, wasting, stunting, and having micronutrient deficiencies. Wasting is defined as acute undernutrition and is a strong predictor of morbidity and mortality during childhood and later in adulthood.[6,7] The 2021 WHO reports estimated that undernutrition contributed to 45% of child mortality worldwide.[8] Considering the consequences of wasting, immediate treatment is required to ensure the survival of the children.[9,10]

Studies have shown that various factors affect the nutritional status of the under-five.[11–13] Wasting is directly caused by inadequate nutrient intake and recurrent infections, leading to weight loss.[14] Studies in Indonesia and Ethiopia have highlighted that poor breastfeeding practices can increase the likelihood of stunting, wasting, and being underweight.[15,16] In Indonesia, there is a considerable risk of suboptimal feeding practices, particularly when it comes to the timing, frequency, and diversity of complementary foods.[17] When these foods are not properly introduced, malnutrition risk can significantly increase.[18,19]

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However, some studies have reported inconsistent findings on the risk factors of undernutrition. Sociocultural factors are associated with undernutrition, particularly underweight and stunting.[20] Other studies found that maternal characteristics, such as education level and working status, and characteristics of children, such as small posture and health facility where children were born, were risk factors of the under-five with stunting, wasting, and being underweight.[21,22] Household factors, mainly income and expenditures per month for childcare, were also associated with underweight under-five.[23] Moreover, limited studies have focused on the role of inappropriate feeding practices in wasting among the under-five in Indonesia. Thus, the study was conducted to provide evidence from a context in which undernutrition is prevalent, aiming to gain insight into feeding patterns as a dominant risk factor for wasting among the under-five

Method

The authors conducted an unmatched case–control study among the under-five in Padang City, Indonesia, from June to September 2022. An unmatched case control in the study indicated that the controls were not selected based on matching with individual cases with specific characteristics. A number of 174 under-five were counted using the Lemeshow formula for case-control design. The cluster sampling was performed at the three primary health care (PHC) (Seberang Padang 9.45%, Andalas 7.68%, and Pauh 1.67%) with higher and lower wasting rates in Padang City.

Subsequently, the sample was grouped into cases and control groups at a ratio of 1:1. Cases were defined as under-five with weight for height Z-Score (WHZ) <−2 standard deviation (SD) according to the WHO anthropometric and growth standards (WHZ <−2 SD), which were selected by simple random sampling. The controls were the under-five with normal nutritional status (−2 SD > WHZ > +1 SD), selected purposively from similar subdistricts where cases were recruited.[24] The under-five who were sick or whose mothers could not communicate well were excluded.

Anthropometric information, including weight and height, was obtained secondary from PHC in the subdistricts. These data were collected through a permission letter to the Padang City Health Office. Anthropometric data were analyzed and classified according to the WHO anthropometric and growth standards into low weight-for-age (underweight) and low height-for-age (stunted) groups based on a Z-score cut-off of <−2 SD.[25] Sociodemographic information such as the mother's and father's educational level, family-related data such as working status, and feeding practices were collected from the mothers or caregivers using a validated questionnaire (using questionnaires from the previous study).[26] Complementary feeding practices were assessed using semiquantitative food frequency questionnaires (SQ-FFQ).

Appropriate and adequate complementary feeding, including the timely introduction of complementary foods, proper frequency and portion sizes, a wide variety of foods, and suitable texture and taste. Appropriate breastfeeding practices were defined as breastfeeding only for the first six months after giving birth, except for medications or vitamin and mineral supplements, which were continued by breastfeeding until 2 years. Optimal complementary feeding was described as providing adequate and safe nutritious foods alongside breastfeeding from six months onward, with gradual increases in quantity, frequency, and texture, according to the child's needs and abilities. Indicators such as timely initiation, frequency adequacy, nutrient adequacy, food diversity, and appropriate texture were used to evaluate complementary feeding practices.

The under-five were considered to have a timely introduction to complementary feeding or a timely initiation if they received complementary foods at six months. The authors considered children to have an adequate frequency of complementary feeding if they received foods at least three times per day and nutrient adequacy if the amount met 80% of their daily nutrition requirement. Children who consumed a minimum of four food groups in the past 24 hours were considered to have a diverse diet. The flavor of complementary feeding was considered appropriate when children were given sweet and salty foods according to their age (more than 12 months). Finally, the texture was considered appropriate when children were given soft, semi-solid, or solid foods based on their age.

A Chi-square test was performed to examine the association between a single predictor and outcome variable with a level of significance p-value of <0.05 and a 95% confidence interval (CI). A multiple logistic regression using the enter method was employed to develop a predictive model and identify the most significant risk factors for wasting, with significance determined by a p-value of <0.05 and an odds ratio (OR) >1. The IBM SPSS Statistics for Windows (free version) software was used for statistical analyses.

Results

This study involved 174 under-five from three subdistricts with a high prevalence of wasting in Padang City. The under-five in the case group were mostly male (57.5%) and aged more than 24 months (51.7%). This study found more underweight under-five in the case group compared with the control group (63.2% vs. 39.1%); however, the control group had more stunted children than the case group (40.2% vs. 23.0%) (Table 1).

Table 1. Demographic and Nutritional Status of the Participants (n = 174)

Characteristics of the Children	Nutrition Status	
	Cases n (%)	Controls n (%)
Sex		
Male	50 (57.5)	41 (47.1)
Female	37 (42.5)	46 (52.9)
Age		
≤24 months	42 (48.3)	45 (51.7)
>24–36 months	19 (21.8)	12 (13.8)
>36–60 months	26 (29.9)	30 (34.5)
Weight by age		
Underweight	55 (63.2)	34 (39.1)
Normal	32 (36.8)	53 (60.9)
HAZ		
Stunted	20 (23.0)	35 (40.2)
Normal	67 (77.0)	52 (59.8)

Notes: WHZ = weight by age, Underweight = WHZ <-2 SD, HAZ = height for age Z-score, Stunted = HAZ <-2 SD

Table 2 shows that breastfeeding practices do not appropriately follow the WHO recommendations (57.5%). Likewise, complementary feeding practices are below the recommendation in terms of portion size and food variations (>50%). The SQ-FFQ also revealed the main sources of children's food intake. Potato and rice consumption were the main sources of carbohydrates, whereas eggs and chicken were the main sources of protein (> 80% of daily intake for both food groups). On the other hand, spinach and carrots were the most preferred vegetables consumed, and oranges and bananas were the fruits with the highest consumption among the under-five (>90% of daily intake for both food groups).

Table 2. Association Between Feeding Practices and Nutritional Status (Wasting) Among the Under-Five

Variable	Wasting Status		p-value
	Yes n (%)	No n (%)	
Breastfeeding practices			
Inappropriate	50 (57.5)	14 (16.1)	<0.001
Appropriate	37 (42.5)	73 (83.9)	
Timely initiation of complementary feeding			
Inappropriate	35 (40.2)	8 (9.2)	<0.001
Appropriate	52 (59.8)	79 (90.8)	
Frequency of the complementary feeding			
Inadequate	38 (43.7)	7 (8.0)	<0.001
Adequate	49 (56.3)	80 (92.0)	
Portion of complementary feeding			
Inadequate	69 (79.3)	33 (37.9)	<0.001
Adequate	18 (20.7)	54 (62.1)	
Variation in the complementary feeding			
Not diverse	70 (80.5)	20 (23.0)	<0.001
Diverse	17 (19.5)	67 (77.0)	
Flavors of complementary feeding			
Inappropriate	8 (9.2)	3 (3.4)	0.211
Appropriate	79 (90.8)	84 (96.6)	
Texture of the complementary feeding			
Inappropriate	13 (14.9)	15 (17.2)	0.837
Appropriate	74 (85.1)	72 (82.8)	

From the bivariate analysis, this study found that poor breastfeeding practice, an unageable timely introduction to complementary feeding, inadequate frequency and portion, inappropriate taste for age, and poor food diversity were risk factors for wasting among the under-five. However, inappropriate texture was not significantly associated with wasting (p-value >0.05).

Table 3. Risk Factors for Wasting Among the Under-Five

Variable	OR	95% CI		p-value
		Lower	Upper	
1st Model–Full Model				
Breastfeeding practices	2.955	0.919	9.503	0.069
Timely initiation of complementary feeding	1.112	0.273	4.520	0.883
Frequency of the complementary feeding	2.187	0.569	8.413	0.255
Portion of complementary feeding	1.039	0.184	3.700	0.802
Variation in the complementary feeding	14.713	3.577	60.508	<0.001
Flavors of complementary feeding	3.564	0.589	21.555	0.166
Texture of the complementary feeding	0.894	0.272	2.940	0.854
2nd Model–Adjusted Model				
Breastfeeding practices	8.389	2.611	14.432	<0.001
Variation in the complementary feeding	13.534	6.025	30.400	<0.001

Notes: OR = odds ratio; CI = confidence interval

Further analysis with a multiple logistic regression to examine the main risk factor of wasting among the under-five showed inappropriate breastfeeding practice (p-value <0.001; OR = 6.139; 95% CI 2.611–14.432) and food diversity of the complementary feeding (p-value <0.001; OR = 13.534; 95% CI 6.025–30.400) as significant factors for wasting. From the final model of multivariate analysis, the under-five with inappropriate breastfeeding practices had an OR of 8.389 (95% CI: 2.611–14.432) being wasting compared to those with appropriate breastfeeding practices. In addition, inappropriate variation in complementary feeding had an OR of 13.534 (95% CI: 6.025–30.400) being wasting compared with children with appropriate variation in complementary feeding.

Discussion

This study found that the percentage of wasting was higher among males (57.5%) than females under-five (42.5%), consistent with a previous study in Indonesia and in the Congo.[21,27] Poor breastfeeding and complementary feeding practices were identified as significant risk factors for wasting in the under-five, respectively, OR = 8.389 (95% CI 2.611–14.432) and OR = 13.534 (95% CI 6.025–30.400). These include the untimely initiation of complementary feeding as well as inappropriate frequency, portion, variation, and taste of complementary foods. Poor breastfeeding practices and a lack of dietary diversity in complementary foods were identified as the most significant risk factors.

This study's findings were consistent with those of several studies on Asia and Africa. A study in Ethiopia indicated that appropriate breastfeeding is a protective factor against wasting (adjusted odds ratio (AOR) = 0.38; [95 % CI: 0.14–0.99]).[28] A study from Uttar Pradesh, India, found that children who were not exclusively breastfed, bottle-fed within one hour of birth, and not given colostrum were at a higher risk of being underweight and wasting.[29] A study conducted in South Kivu Province, Democratic Republic of Congo, found that inadequate complementary feeding was strongly associated with undernutrition among children aged 2 years (AOR 6.88; 95% CI 1.24-18.37).[30] A study in South Sulawesi Province, Indonesia, found that exclusive breastfeeding, prolonged breastfeeding, and duration of complementary feeding were correlated with constant body weight among children 12–24 months.[31] Similarly, a study in Norhtern Tanzania reported that children with less diverse complementary foods had a higher risk of stunting (absolute risk reduction (ARR) 1.3; 95% CI 1.01–1.6), and the introduction of prelacteal food was linked to an increased risk of wasting (ARR 2.9; 95% CI 1.3–6.3).[32] In northwest Ethiopia, being underweight was associated with shorter breastfeeding durations (<2 years) (AOR 2.60; 95% CI: 1.35–5.00) and a lack of food diversity in complementary feeding (AOR 6.30; 95% CI: 1.70–23.00).[33]

However, this study's findings contradict those of a cross-sectional study in Yogyakarta, Indonesia, which reported no association between feeding practices and the nutritional status of children aged 7 to 59 months.[33] These contradictory findings could be related to differences in the study design. However, another case–control study in Pasar Prabumulih PHC, Indonesia, indicated that the dietary pattern was significantly associated with stunting among children (OR = 2.667; 95% CI: 1.099–6.468).[34]

Failure to adhere to the WHO guidelines on infant and young child feeding practices can lead to malnutrition in the under-five.[32] Evidence from multiple studies suggests that practices such as providing colostrum, initiating breastfeeding, Exclusive breastfeeding until 6 months, continuing breastfeeding until the recommended 2 years, and timely introduction

of appropriate and adequate complementary foods are associated with a reduced risk of recurrent diarrhea and other infectious diseases, both of which are significant contributors to malnutrition.[35,36] Postponing breastfeeding initiation can result in infants missing out on colostrum, essential for strengthening immunity against infections. In addition, Inadequate nutrition combined with infections inhibits optimal growth in children.[37]

Appropriate and adequate complementary feeding was defined as the timely introduction of complementary foods, proper frequency and portion sizes, a wide variety of foods, and suitable texture and taste. Adequate nutrition in the first 1,000 days of a child's life, from conception until post-delivery, is extremely important for healthy growth and development.[38] This study found that feeding practices in the first year of children's age, especially fully breastfeeding during the first six months and continuing with nutritious complementary feeding, were relatively low among mothers in Padang City, Indonesia. The complementary feeding often lacked variety and was inappropriate in terms of texture, taste, and portion sizes for the child's age. Therefore, strategies must be developed to raise awareness and improve knowledge among mothers and caregivers regarding optimal feeding practices to combat malnutrition. A previous study has shown that maternal knowledge is linked to early complementary feeding in Indonesia.[39] A good partnership between the Ministry of Education and the Ministry of Health is essential to create a comprehensive educational approach targeting adolescent girls and women of reproductive age, aiming to prevent these issues before they even arise. However, the interpretation of the findings should consider the limitations of the study. As the SQ-FFQ was used to assess the adequacy of complementary feeding, recall bias may have occurred during data collection, potentially leading to over- or underestimation of reported food consumption.[40]

Conclusion

This study highlights that inadequate breastfeeding and poor complementary feeding practices, particularly those lacking diversity and proper timing, are risk factors for wasting among the under-five. There is a need for strategies to prevent malnutrition among children by providing education about breastfeeding and complementary feeding targeted at mothers and caretakers. Strategies must highlight the benefits of providing diverse foods to children as well.

Abbreviations

The under-five: children under the age of five; WHO: World Health Organization; PHC: primary health care; WHZ: weight for height Z-Score; SD: standard deviation; SQ-FFQ: Semiquantitative Food Frequency Questionnaires; CI: confidence interval; OR: odds ratio; AOR: adjusted odds ratio; ARR: absolute risk reduction

Ethics Approval and Consent to Participate

This study was granted ethical clearance from the Research Ethics Commission of the Faculty of Public Health, University of Andalas, under approval number of 6/UN16.12/KEP-FKM/2022. Prior to data collection, permission was obtained from the Padang City Health Office. The study's purpose and data collection procedures were thoroughly explained to all participants. Written and signed informed consent was obtained from the mothers, who provided consent on behalf of their children to participate in the study.

Competing Interest

The authors declared no conflicts of interest to disclose.

Availability of Data and Materials

This article contains all the data that were generated or analyzed during the study.

Authors' Contribution

A was responsible for data collection, data entry, and performing data analysis. A, ADA, and MTPLK collaborated in manuscript preparation, content refinement, and administrative tasks. The results were discussed by all the authors, who also contributed to preparing the final version of the manuscript.

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Factors Associated with Caregivers' Concern in Maintaining the Oral Function of Elderly Living in Long-Term Care Facilities

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Abstract

This study investigated the attentiveness of elderly caregivers in long-term care facilities in maintaining oral function. A cross-sectional approach was used to achieve the study's purpose. The sample size formula accounted for 213 caregivers randomly selected from 18 long-term care facilities in 4 provinces. A self-reported questionnaire of sociodemographic characteristics and an adapted Leopold's oral care checklist was distributed. The average age of study participants was 35.24 (±11.2 SD; aged 18–70 years), dominated by females (62.9%), and only 39% had experienced long-term care training. Multiple linear regression analysis indicated that younger caregivers likely pay more attention in the swallowing periods (β = -.182), females pay more attention in meal preparation (β = .146), and environmental observation (β = -. 238). Caregivers working in public long-term care facilities and having longer working experience paid more attention in environmental observation (β = .172) and (β = -.161), while training experience showed a significant association with feeding and swallowing periods (β = .291) and (β = .211). This study highlights the importance of training programs for care capacity, particularly oral care.

Keywords: aspiration pneumonia, caregiver, elderly, oral care

Introduction

Most countries have experienced aging population,[1] including Indonesia. Statistics Indonesia reported that the proportion of the older population in 2023 had reached 11.75%.[2] Aging population has substantial implications for various aspects of life, as well as for health policy and healthcare service needs.[3] The elderly naturally experience degeneration and functional decline throughout their entire organ system,[4-5] resulting in the emergence of chronic diseases and problems in the oral cavity. Chronic diseases share common risk factors with most oral diseases; for example, the aging process is associated with diminished function of salivary glands, which results in mouth dryness and dental caries caused by reduced salivary flow.[4]

Aging is also strongly associated with decayed, missing, or filled teeth (DMF-T). According to the 2023 Indonesian Health Survey, the prevalence of DMF-T in the elderly aged 65 or above is 13%.[6] Dental and oral health problems are among the top ten health issues suffered by the elderly, along with hypertension, stroke, diabetes, pneumonia, joint diseases, and upper respiratory tract infections.[6] Furthermore, poor oral health is significantly associated with the risk of aspiration pneumonia,[7] coronary heart disease, metabolic syndrome, and reduced quality of life for the elderly.[8]

Aging causes a decline in the function of the digestive system,[9] including oral and swallowing function. This situation causes frequent visits to health care providers. Simultaneously, changes in the oral cavity in older adults may limit their ability to eat and enjoy a normal diet, impacting their nutritional intake and contributing to malnutrition.[10] These aging-related conditions negatively affect older adults' quality of life, dignity, and general health.[11] Degeneration of the oral cavity and masticatory function causes decreased swallowing ability.

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This condition makes the elderly susceptible to aspiration of foreign material (such as food debris, saliva, and fluid) that descends into the bronchial tree and the lung alveoli. With age and functional decline, coughing reflexes, ciliary transport, and intact immune systems that act as defense mechanisms become impaired. This condition renders fragile elders more vulnerable to developing aspiration pneumonia.[12] Addressing both oral health and swallowing function can significantly reduce the risk of aspiration pneumonia, especially in vulnerable populations.

The elderly living with various physical deterioration often need long-term care and require various levels of assistance in performing their activities of daily living, including self-care.[13] Appropriate support for oral care and swallowing function necessitated by aging-related decline is also essential to maintain and improve not only oral health but also the overall health and well-being of older adults.[14-15] As various diseases and disorders cause functional disabilities in older adults, they require caregivers to support their daily activities. Caregivers are particularly essential in assisting older persons suffering from physical and/or mental limitations.[16] Residents of long-term care institutions are at a greater risk for oral health problems due to their declining physical condition.[17-18] Moreover, long-term care institutions often have difficulty providing good oral health care to their residents due to the lack of human resources.[19]

While long-term care services in Indonesia emphasize family-based care in the community, there are various reasons why many older adults reside in long-term care facilities.[20] In 2019, 445 long-term care facilities were managed by the government and private companies in Indonesia. Government-managed long-term care services mainly provide social protection for older persons, assisting them in restoring and developing social functions managed by the Indonesian Ministry of Social Affairs' insurance system.[21] Privately owned long-term care facilities are retirement homes or care institutions prioritizing housing and services tailored to each individual's needs. These can include living facilities, meals, recreational activities, and some form of health or hospital care.[22]

Implementing a comprehensive oral care program in a stroke unit reduced aspiration pneumonia rates from 4% to 1.4%.[23] Another study concluded that improving oral hygiene could prevent 1 in 10 deaths from pneumonia in elderly nursing home residents.[24] To the authors' knowledge, there have not been many studies on oral care that involve the importance of maintaining swallowing function in the elderly, who are a vulnerable group to experience aspiration pneumonia. This study used oral care and swallowing function instruments, adapted from Leopold's five-stage ingestion checklist, aimed at identifying the extent of elderly caregivers' attention in performing oral care and maintaining swallowing function, and identifying the associated factors. This study's findings could become evidence to strengthen the capability of elderly caregivers in long-term care facilities in Indonesia as frontliners for aspiration pneumonia prevention in long-term care facilities. Maintaining the swallowing function is critical for preventing life-threatening complications, supporting healthy aging, and reducing healthcare burdens globally.[25] The growing emphasis on innovative assessment methods and targeted interventions reflects both the urgency and evolving strategies in addressing dysphagia as well as reducing the risk of aspiration pneumonia.

Method

A cross-sectional observational study was used to clarify the attentiveness of caregivers in providing meal assistance to the elderly in long-term care facilities and determine the potential associated factors. Long-term care facilities refer to the institutions that provide long-term care for the elderly, both medical and personal support services, to individuals who are unable to live independently due to chronic illnesses, disabilities, or age-related conditions.[13] In Indonesia, there are several types of long-term care facilities, including nursing homes, respite care, assisted living, and Griya Lansia, as well as centers for seniors or any type of elderly home.

The procedure for implementing research permits begins with coordination with the Indonesian Ministry of Social Affairs, as the guardian of elderly homes in Indonesia. A total of 30 letters of request for research permits were sent to the list of accessible long-term care facilities from November 2018 to March 2019. There were 18 responses from 4 provinces that were finally followed up with research procedures comprising 11 privately owned institutions managed by profit and non-profit foundations. The four provinces, including Special Region of Yogyakarta, Banten, Special Capital Region of Jakarta, and West Java, employed 400 caregivers. A Lameshow sample size calculator accounted for 197 study participants with 10 inflation, 216 participants with 3 incomplete responses, and 213 study participants (Table 1). A random proportional selection method was used to enroll caregivers working in long-term care facilities. Furthermore, a research explanation was delivered, followed by obtaining signed informed consent.

Table 1. The Distribution of Long-Term Care Facilities

Province	Long-Term Care Facilities	Ownership	Number of Caregivers	Percentage (%)
Special Region of Yogyakarta	Long-Term Care Facility A	Government	18	8.37
	Long-Term Care Facility B	Government	13	6.05
	Long-Term Care Facility C	Government	8	3.72
West Java	Long-Term Care Facility D	Private	10	4.65
	Long-Term Care Facility E	Government	13	6.05
	Long-Term Care Facility F	Private	4	1.80
	Long-Term Care Facility G	Private	4	1.80
	Long-Term Care Facility H	Private	18	8.37
	Long-Term Care Facility I	Government	17	7.91
	Long-Term Care Facility J	Private	20	9.30
Special Capital Region of Jakarta	Long-Term Care Facility K	Government	17	7.91
	Long-Term Care Facility L	Government	20	9.30
	Long-Term Care Facility M	Private	20	9.30
	Long-Term Care Facility N	Private	5	2.33
	Long-Term Care Facility O	Private	4	1.80
Tangerang Banten	Long-Term Care Facility P	Private	6	2.79
	Long-Term Care Facility Q	Private	6	2.79
	Long-Term Care Facility R	Private	10	4.65
Total			**213**	100.00

Data were collected using a background questionnaire regarding participants' sociodemographic details (age (<35 and ≥35), sex, educational background (elementary school, junior school, high school, and higher education), years of working experience, training received in the last five years after assigned at the nursing home staff, and the type of care facility that consist of private care facility (managed by private sector) and public care facility (managed by the government). To assess the outcome variable, a 42-item validated checklist was adapted from previous studies.[26-27] The original instrument is relevant to Japanese and Indonesian culture. It incorporates Leopold's five-stage process of ingestion, which emphasizes the sequential and coordinated nature of ingestion, from anticipation to digestion, which involves both motor and sensory systems in the ingestion process.[28]

The adapted version of the checklist comprises two domains. The first is environmental observation, which is observations of the care-setting environment relative to older residents' dietary needs; the domain includes nine items. The second is function and eating capabilities observations, which is divided into five periods: a) before-meal period (the patient's overall condition before meals; five items), b) meal preparation period (three items), c) feeding period (eight items), d) swallowing period (13 items), and e) after-meal period (four items).[22] Multidisciplinary experts (gerontologists, dentists, occupational therapists, nurses, and Japanese experts) were involved during the oral care checklist adaptation to confirm that the content and construct validity in Japanese and Indonesian cultures, including eating habits, were clarified. Cronbach's alpha, indicating Internal consistency reliability for each checklist category, ranged from 0.541 to 0.896.

This study used IBM SPSS Statistics for Windows (version 25.0 IBM Corp., Chicago, IL, USA) for data analysis, descriptive statistics to identify participants' sociodemographic characteristics, and Pearson's correlation coefficient to test the bivariate association between the variables and oral care in each domain. The enter method of multiple linear regression was conducted to explore the association of sociodemographic characteristics with each oral care implementation domain score. Statistical analysis was performed using a 95% degree of confidence, and oral care implementation scores were tabulated by summing the total scores of all items in each domain and period of the respective factors; higher scores indicated better implementation.

Results

Table 2 shows that the average age of the study participants was 35.24 years (±11.2 SD). Most participants were female (62.9%), graduated from high school (46.0%), had no long-term care training (60.6%), and had more than five years of working experience (62.4%). Private and public care institutions were equally represented, and oral care practice implementation was poor.

Table 2. Sociodemographic Characteristics and Oral Care Implementation of the Participants (N = 213)

Category	Frequency	Percentage (%)
Ages (mean: 35.24±11.2 SD (18–70))		
<35.24 years old	97	45.4
≥ 35.25 years old	116	54.5
Sex		
Male	79	37.1
Female	134	62.9
Educational Background		
Elementary school	13	6.1
Junior school	29	13.6
High school	98	46.0
Higher education	73	34.3
Working Experience (mean: 7.74±6.8 SD (1–37))		
>5 years	133	62.4
<5 years	80	37.6
Training Experience		
Yes	84	39.4
No	129	60.6
Type of Care Facility		
Public	106	49.8
Private	107	50.2
Oral Care Implementation by Each Domain		
Environmental observation	119	56.0
Function and eating capabilities observation		
Before-meal period	108	50.8
Meal preparation period	127	49.6
Feeding period	116	54.7
The swallowing period	119	54.6
After-meal period	88	41.4

Table 3. Bivariate Association Between Sociodemographic Characteristics and Oral Care Implementation

Sociodemographic Characteristics	Environmental Observation	Before-Meal Period	Meal Preparation Period	Feeding Period	Swallowing Period	After-Meal Period
Age	-0.009	-0.050	-0.094	-0.233*	-0.204*	-0.198*
Sex	-0.229*	0.034	0.160*	0.159*	0.162*	0.104
Educational background	-0.041	-0.051	-0.049	0.024	-0.027	0.155*
Type of care facility	0.111	0.058	0.079	-0.119	-0.104	0.074
Working experience	-0.130	-0.080	-0.103	-0.208*	-0.167*	-0.109
Training experience	0.042	0.141*	0.052	0.301*	0.231*	0.025

Notes: *correlation is significant at the 0.05 level (2-tailed) at 95% CI

Table 3 shows the bivariate correlation of sociodemographic characteristics and oral care implementation by domain. Age, sex, and working experience were most frequently and significantly correlated with various domains, although educational background was significantly correlated with one domain each. On the other hand, training experience showed a significant correlation to at least three periods in the function and eating capabilities observation domain. Table 4 presents details of the multiple linear regression analysis to determine the predictive model for caregivers' attentiveness in implementing oral care services in each domain. In the environmental observation domain, the care-setting environment was influenced by females, government-type long-term care facilities, and working experience. In the functions and eating capabilities observation domain, it was found that at least three periods in which sociodemographic factors could predict. The meal preparation period was associated with males, the feeding period was influenced by training experience, and the swallowing period was influenced by both young age and training experience.

Table 4. The Prediction Model for Oral Care Implementation by Domain

Predictor Variables	Environmental Observation (R^2 = 10.2; F = 3.906; p-value = 0.01)		Before-meal Period (R^2 = 0.05; F = 1.722; p-value = 0.12)		Meal Preparation Period (R^2 = 0.06; F = 2.157; p-value = 0.04)		Feeding Period (R^2= 0.17; F = 7.224; p-value = 0.01)		Swallowing Period (R^2 = 0.13; F = 4.940; p-value = 0.01)		After-Meal Period (R^2= 0.05; F = 1.179; p-value = 0.11)	
	β	p-value	β	p-value	β	p-value	β	p-value	β	p-value	β	p-value
Age	0.006	0.949	-0.037	0.693	-0.067	0.468	-0.161	0.065	-0.182	0.042	-0.142	0.127
Sex Female = 0 Male = 1	-0.238	0.001	0.019	0.784	0.146	0.037	0.109	0.097	0.118	0.081	0.066	0.348
Type of care facility Public = 1 Private = 0	0.172	0.020	0.142	0.061	0.132	0.080	-0.038	0.587	-0.030	0.677	0.034	0.654
Working experience	-0.161	0.047	-0.079	0.340	-0.082	0.323	-0.132	0.087	-0.089	0.264	-0.007	0.929
Educational background	-0.088	0.261	-0.099	0.219	-0.138	0.087	-0.025	0.743	-0.093	0.226	0.073	0.365
Training experience Yes = 1, No = 0	0.103	0.147	0.178	0.015	0.075	0.301	0.291	<0.001	0.211	0.003	0.002	0.979

Notes: β = standardized coefficient; R^2 = coefficient of determination.

Discussion

This study identified the association of sociodemographic factors with caregivers' attentiveness and implementation of oral care services in long-term care facilities in various domains. While its limitations derive from its descriptive nature, the results are significant given that similar studies have not been conducted in Indonesia. This study found that age was associated with the implementation of oral care only in the domain of the swallowing period, which is crucial due to the possibility of choking or potentially fatal aspiration.[29] This study's finding showed that younger caregivers (aged <35.24 years) tend to pay more attention to the elderly during the swallowing period than older caregivers (aged ≥35.24 years), suggesting more eager engagement, while older caregivers need encouragement to remain vigilant during the swallowing period.

Sex was significantly associated with environmental observation and meal preparation domains, which were related to care environment safety for the elderly's dietary needs, preparation of the eating environment, the presence of food variations, availability of tools for emergencies, and an adequate ratio of caregivers to residents.[27] Female caregivers tended to be more careful observers, paying more attention to the surrounding environmental conditions and the general condition of the elderly before feeding them. Meanwhile, males tend to be attentive to meal preparation. Previous studies also revealed modest distinctions between males and females, with females displaying higher levels of environmental concern and behavioral adjustments,[30] females are more likely to have a stronger connection to their environment.[31] This study also indicated female caregivers had a distinctive relationship with their care-setting environment. Interestingly, females are the predominant providers of care for chronic medical conditions.[32]

A significant association between males and meal preparation was also identified. This domain consists of observations about the ability to sit in a stable position and observing the older person's consciousness and tranquillity.[18] In this study, male caregivers tended to pay more attention to the meal preparation period, a crucial period that showed the severity of the older adult's condition. Improper observation during this period can have serious health implications. This finding supports a previous study showing that male caregivers respond more strongly to the severity of the caregiving situation.[33] Sex differences may also result from females and male dealing differently with the caregiving process; even if the older adults' conditions are similar, males generally focused on problem-solving strategies and anticipatory efforts,[33] this statement is supporting this study's findings that male caregiver are paying more attention during the meal preparation to avoid potential risks during the meal preparation period.

This study identified caregivers working in government-managed long-term care facilities as likely to have better implementation in the observation domain of the care-setting environment. Government-managed long-term care facilities often have a larger staff with various duties and responsibilities. As the government guarantees management costs of running the institution,[21] the government-managed long-term care facilities can have a better ratio of employees

to residents than private institutions. This gives staff more time to observe the eating environment compared to the private care facilities. The different types of long-term care facilities are also related to caregivers' quality, especially in terms of the opportunity to receive education and training to improve their ability to perform care.[34]

Working experience is inversely associated with the observation domain of the care-setting environment; caregivers with less work experience (those with shorter years of service) tend to make better eating environment observations, such as maintaining a calm environment. Caregivers with shorter work experience (<5 years) may be relatively more enthusiastic about their work environment and pay more attention.[35] Conversely, senior workers (>5 years working experience) tend to be more indifferent due to routine and monotonous nursing activities, which hinders their willingness to learn new ideas, such as oral care issues.

Training experience was associated with observation during the feeding and swallowing periods. Although less than half (39%) of the participants had experience in long-term care-related training within the last five years, their learning process significantly influenced oral care implementation, especially in observing swallowing and feeding periods. However, the training programs offered to caregivers vary and are not specific to oral care. As mentioned, the elderly are prone to problems with swallowing or aspiration; training is therefore essential, particularly during the feeding and swallowing periods. A previous study identified that a lack of education and oral care knowledge in caregivers raises the risk of poor oral care among older adult patients residing in long-term care facilities.[36] Training and education for caregivers in long-term care facilities in Indonesia remain limited,[27] as indicated in prior interviews that the authors conducted with managers of six long-term care facilities (four private and two public) in West Java and the Special Capital Region of Jakarta Provinces. All six managers revealed that the facilities had no routine schedule for caregiver training, including for oral care. Hence, the authors developed an oral care checklist to promote its implementation because such institutions may not prioritize or implement oral care due to a lack of awareness.

No significant association was found between any indicators before and after meals in this study, possibly because Indonesian customs do not include environmental observation before eating or activities after eating, regardless of the caregivers' sociodemographic characteristics as seen in the long-term care guideline of the Indonesian Ministry of Health[37] that include the oral care procedures. Those caring activities are still limited; hence, oral hygiene, such as teeth brushing, is yet to be included as part of oral care. However, studies stated that maintaining good oral hygiene, including brushing teeth, decreases the risk of pneumonia,[38,39] making it beneficial to Indonesian older adults, among whom the prevalence of pneumonia was reportedly 5.4% in 2018.[40] Therefore, the Indonesian Government should encourage caregivers to improve oral care by stressing its importance, particularly after meals, and add it to the guidelines for long-term care services.[37] Specific training concerning oral care and maintaining swallowing function must be provided to promote the health and quality of life of older adults in long-term care.

The oral care checklist used in this study was found effective for guiding caregivers and improving oral health for older adults, even with its minimum requirements for preventing aspiration pneumonia. It is particularly useful for caregivers in Indonesia, as many are not aware of the importance of oral care, particularly in the before-meal and after-meal periods.[20] The checklist also helps caregivers with long working hours and excessive work demands, due to the high ratio of residents per caregiver,[36] efficiently implement essential oral care practices. The ultimate goal of this study was to provide appropriate oral care in accordance with the individual needs of the elderly, regardless of caregivers' characteristics. Therefore, further studies are needed to develop training and determine what kind of programs should be provided for caregivers with varying characteristics.

This study had some limitations, particularly in participants' recruitment, which was incidentally based on their availability to be interviewed. These data might not accurately represent the target population, or reliance on self-reported data, which can be prone to bias. However, these study findings were expected to lead to further research, such as determining whether this oral care checklist applies to family caregivers in home settings. Overall, this study's results showed a robust implicit association between sociodemographic characteristics and the implementation of oral care, which can be implemented to improve the quality of care in the elderly in long-term care facilities to prevent aspiration pneumonia.

Conclusion

This study identified associations between the sociodemographic characteristics of caregivers and the implementation of oral care in various domains. The oral care checklist used in this study can enhance caregivers' knowledge and skills in Indonesia, particularly when maintenance for patients in the after-meal period is emphasized.

Abbreviations

DMF-T: decayed, missing, or filled teeth.

Ethics Approval and Consent to Participate

The ethical approval for the study was obtained from the Universitas Respati Indonesia Institutional Ethics Review Board, and the study was carried out following its guidelines and regulations. This study was approved with approval number: 153/KE/UNR/IX/2018. Written informed consent was collected prior to data collection.

Competing Interest

The authors declare that they have no competing interests.

Availability of Data and Materials

The datasets generated and analyzed in this study are not publicly available because ethical guidelines prohibit researchers from providing research data to third-party individuals.

Authors' Contribution

Study concept and design: SN, YH, TBWR, MH; Acquisition of data: TBWR, SN, YH; Analysis and interpretation of data: SN, YH; Drafting of the manuscript: SN, YH; Critical revision of the manuscript for important intellectual content: TBWR, MH, YH. All authors have read and approved this final manuscript.

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Risk Factors Associated with Long COVID Among Hospitalized Adults in Several Hospitals in Palembang City, Indonesia

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Risk Factors Associated with Long COVID Among Hospitalized Adults in Several Hospitals in Palembang City, Indonesia

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Abstract

Long COVID is characterized by one or more symptoms experienced by individuals prior to a COVID-19 infection that last for ≥2 months, and its risk factors remain unclear. This study aimed to identify risk factors associated with long COVID among patients admitted between June 1, 2020, and October 31, 2023, at three referral COVID-19 hospitals in Palembang City, Indonesia. This cohort study included adults who were admitted for ≥5 days. The participant's medical records were reviewed for admission and discharge dates, sociodemographic and clinical characteristics, and vaccination and therapy status. A standardized and validated instrument was used to assess fatigue during admission, and a structured questionnaire was used to evaluate long COVID. Cox regression was employed to determine factors associated with long COVID. Among 256 patients, long COVID was identified in 39.1%. Fatigue during admission, chronic kidney disease, thrombocytosis, and positive RT-PCR test at hospital discharge increased the risk of long COVID, whereas being fully vaccinated decreased its risk. This study identifies five risk factors for long COVID and determines that fatigue during admission is the strongest.

Keywords: coronavirus disease 2019, hospitalized patients, long COVID, risk factors

Introduction

Since the first coronavirus disease 2019 (COVID-19) case in Indonesia was reported on March 2, 2020, several policies have been implemented by the government to limit the transmission of the disease. Although daily reports of COVID-19 showed a decrease in new cases since the first quarter of 2023 compared to prior data (October to December 2022), studies showed that patients still experienced one or more symptoms after the acute phase and prolonged to 12 weeks or more, known as long COVID.[1] Studies revealed that patients with long COVID suffer from various systemic symptoms such as persistent fatigue, cough, dyspnea, eyesight problems, hair loss, and depression.[2,3] Although regulations or guidelines are available for managing COVID-19 patients, a comprehensive guideline for treating long COVID patients in Indonesia is lacking.[4]

Several studies have been conducted to understand long COVID and its distribution. In 2024, the global prevalence of long COVID-19 was 23%, with sleep disorder as the most common symptom.[2] A large survey from China reported that 35% of COVID-19 patients experienced long COVID with memory decline as the most frequently observed symptom.[3] A study in Indonesia reported that the prevalence of long COVID in 2022 was 43%, with fatigue as the most frequent symptom (29.4%).[5] Studies performed in several countries to understand the risk factors of long COVID revealed that older adults, females, depression or anxiety history, comorbidities, autoimmune history and the increment anti-nuclear antibody, and high ferritin or vitamin D levels increased the risk of long COVID.[2,3]

Palembang City has one vertical hospital (managed by the Indonesian Ministry of Health), which is the biggest COVID-19 referral hospital in the southern area of Sumatra. This hospital serves five provinces on Sumatra Island.[6] Data from the vertical hospital in Palembang City has not yet been fully explored compared to data from referral hospitals in Java Island.[7]

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This study aimed to understand the comprehensive important risk factors of long COVID by including the factors of sociodemographic characteristics, symptoms during hospitalization, clinical manifestations, vaccination, and therapy status among hospitalized adults in Palembang City. Currently, 1,465 COVID-19 active cases remain reported,[8] thus, the long COVID risk factors determined in this study may provide valuable insights to improve the management and prevention of long COVID in Indonesia.

Method

This cohort study was conducted in one vertical hospital (Hospital A), one Type B hospital (Hospital B), and one Type C hospital (Hospital C) in Palembang City and examined individuals with an inpatient history of COVID-19 by doing interviews from March 1 to December 21, 2024. Hospital A was the main study site, and two other neighboring hospitals (Hospital B and C) were included to obtain more samples as minimally required. Research permission from the three hospitals was acquired through an agreement to follow regulations from the hospitals. After obtaining ethical clearance and permission, all data were collected and anonymously kept in a personal computer with a secured identifier number accessible to only the authors.

In this study, fatigue was a symptom experienced by participants at onset and during hospitalization. The Fatigue Assessment Scale (FAS), developed and standardized by Michielsen and used by other studies to assess fatigue in COVID-19, was utilized as a data collection tool to assess fatigue during hospitalization and as a long COVID symptom.[9] The FAS was translated into the Indonesian language and validated (Cronbach's Alpha = 0.812).[10] To assess fatigue during admission, 256 participants were interviewed by phone. The FAS questionnaire consisting of 10 statements was read to the participants, and responses using Likert scales of 1 ("never") to 5 ("always") were obtained. The COVID-19 pandemic has an unforgettable history; therefore, participants may have had good memories related to the admission period. Time probing was performed to minimize recall bias and help recall the memory of fatigue during admission.

The long COVID status of 256 participants was assessed through phone interviews according to World Health Organization guidelines.[1] The participants were asked about the indication of their hospitalization, experienced symptoms during hospitalization, and prolonged symptoms after hospital discharge and its duration. Long COVID was determined based on when the symptom started (onset) and the duration of the symptom experienced. Participants were considered to be experiencing long COVID if their symptoms were due to COVID-19 and lasted for ≥2 months or the symptoms newly developed within 3 months after initial COVID-19 onset and lasted for ≥2 months.

The symptoms of long COVID were obtained as self-reported by the participants. The study variables included sociodemographic characteristics: age (18–49, 50–59, and ≥60 years), sex (female or male), education (below junior high school or above junior high school), occupation (employed or unemployed), and ethnicity (Melayu Palembang, non-Melayu Palembang, mixed (Melayu Palembang and non-Melayu Palembang); body mass index (BMI) (underweight: BMI <18.5; normal: BMI of 18, 5–25; and overweight: BMI >25); symptoms at hospitalization, such as fatigue (yes if FAS score was ≥22), dyspnea, nausea, fever (temperature >36.5°C), and cough; hematology abnormality, including thrombocytopenia (thrombocyte $<189\times10^3/\mu L$), thrombocytosis (thrombocyte $>436\times10^3/\mu L$), and erythrocytopenia (erythrocyte $<4.0\times10^6/\mu L$); RT-PCR result at discharge; type of comorbidities, such as hypertension, diabetes mellitus (DM), cancer, chronic kidney disease (CKD), lupus, asthma, anemia, cardiovascular disease (CVD), and chronic co-infection; number of comorbidities and severity; and vaccination and therapy (i.e., antivirus, oxygen therapy, and anti-inflammatory drugs).

The participants were considered partially vaccinated if they had received one dose of the COVID-19 vaccine at least 14 days before admission and fully vaccinated if they had received at least two doses of the COVID-19 vaccine at least 14 days before admission. Moreover, the participants were considered antiviral RdRp-inhibitor-treated if they received at least one loading dose at 1,600 mg/12 hours for the first day and followed with 2×600 mg of favipiravir for the next 4 days or one loading dose at 200 mg for the first day and followed with 100 mg remdesivir for the next 4 days and NA-inhibitor-treated if they received 800 mg/12 hours of molnupiravir for 5 days. Unless stated otherwise, all the variables were categorized as written in the medical record.

Participant recruitment was based on patients' admission between June 1, 2020, and October 31, 2023. Convenience sampling was employed based on the recentness of admission. The sample size was estimated using the Kelsey formula for the different proportion hypothesis test, with a minimum of 246 samples required to obtain 0.8 statistical power. During data collection, 256 patients were examined (Figure 1).

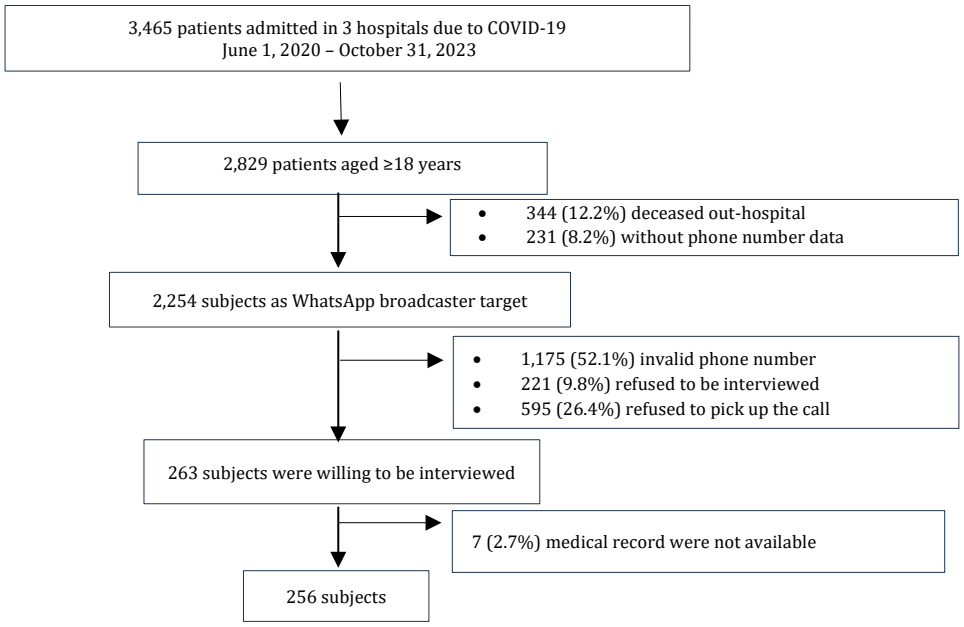

Figure 1. Sample Recruitment Flow Chart

Univariate analysis was conducted to calculate the proportion (%) of long COVID and all independent variables. Moreover, bivariate analysis was performed to measure the association between independent variables and long COVID using the Chi-square test. Further analysis using multivariate Cox regression was performed in two steps: selecting candidate risk factor variables based on p-value <0.25 and determining the final significant risk factors of long COVID based on p-value <0.05.

Strength of association was measured using risk ratio (RR), together with the 95% confidence interval (CI) and corresponding p-value. RR was interpreted as a multiplication of long COVID risk incidents among exposed people compared to the risk among nonexposed individuals. All statistical analyses were performed using a computer with a statistical analysis package licensed to the Faculty of Public Health, Universitas Indonesia (no. 501809408022).

Results

Approximately 39.1% of the participants experienced long COVID, with fatigue as the most common symptom (48 out 100). Over half of the participants were female (57.4%), aged 18–49 years (62.1%), and did not finish junior high school (57%), and 26.1% worked in the private sector. Additionally, most participants had mixed ethnicity (37.9%) (Table 1). Over half of the participants had normal BMI (55.1%). Furthermore, 70.1% experienced fatigue, 55.1% had cough, and 50% suffered from dyspnea. Concerning hematology, erythrocytopenia was common among the participants (55%). Viral genetic material was still detected in 87 participants (33.9%) upon discharge (Table 2).

Table 1. Sociodemographic Characteristics of Participants

Variable	Frequency (N = 256)	Percentage (%)
Long COVID	100	39.1
Fatigue	48	18.7
Dyspnea	30	11.7
Weakness	11	4.3
Allergic	5	2.0
Easily get ill	2	0.8
Others (cough, anorexia, chest pain)	4	1.6
Age, year	43.5 ±15.3	
Age		
18–49	159	62.1
50–59	58	22.7
≥60	39	15.2
Sex		
Female	147	57.4
Male	109	42.6
Education		
<Junior high school	146	57.0
≥Junior high school	110	43.0
Occupation		
Private sector	67	26.1
Housewives	60	23.3
Civil servant	37	14.4
Self-employed	20	7.8
Freelance	7	2.7
Others (farmers, fishermen)	12	12.7
Unemployed	53	20.6
Ethnicity		
Melayu Palembang	93	36.3
Non-Melayu Palembang	66	25.8
Mixed (Melayu Palembang and Non-Melayu Palembang)	97	37.9

Table 2. Body Mass Index, Symptoms, and Hematology of Participants During Admission with COVID-19

Variable	Frequency (N=256)	Percentage (%)
Body Mass Index		
Underweight	16	6.2
Overweight	55	21.5
Normal	141	55.1
Fatigue during admission		
Yes	181	70.1
No	75	29.3
Dyspnea **)		
Yes	128	50.0
No	128	50.0
Nausea **)		
Yes	37	14.5
No	219	85.5
Fever >36.5°C		
Yes	103	40.2
No	153	59.8
Cough **)		
Yes	141	55.1
No	115	44.9
Weakness **)		
Yes	63	24.6
No	193	75.4
Thrombocytopenia*)		
Yes	60	24.0
No	190	76.0
Thrombocytosis*)		
Yes	25	10.0
No	225	90.0
Erythrocytopenia*)		
Yes	104	55.0
No	85	46.0
RT-PCR result at discharge **)		
Positive	87	34.0
Negative	169	66.0

*) Missing data were found in several variables, i.e., BMI (44 cases), thrombocytopenia (6 cases), thrombocytosis (6 cases), and erythrocytopenia (67 cases).
**) Symptom history was taken from patients' reports as written in the medical record
Note: RT-PCR, real-time polymerase chain reaction

Hypertension was the most frequent comorbidity (24.2%), followed by DM (16.4%) and CKD (16%). Almost all participants (93%) suffered from moderate to severe COVID-19 (Table 3). Moreover, 44.5% of the participants were unvaccinated, and 36.4% received full COVID-19 vaccination. Most participants received an antiviral RdRp inhibitor (62.9%), and only 11.7% received an antiviral NA inhibitor. Additionally, 48.6% of the participants received oxygen therapy, and only 16% received anti-inflammatory drugs (Table 4).

Table 3. Type and Number of Comorbidities and Disease Severity of Participants During Admission

Variables	Frequency (n = 256)	Percentage (%)
Hypertension		
Yes	62	24.2
No	194	75.8
Diabetes Mellitus		
Yes	42	16.4
No	214	83.6
Cancer		
Yes	19	7.4
No	237	92.6
Chronic Kidney Disease		
Yes	41	16.0
No	215	84.0
Lupus		
Yes	8	3.1
No	248	96.9
Asthma		
Yes	6	2.3
No	250	97.7
Anemia		
Yes	19	7.4
No	237	92.6
Cardiovascular Disease		
Yes	21	8.2
No	235	91.8
Chronic Co-infection		
Yes	12	4.7
No	244	95.3
Others		
Yes	4	1.6
No	252	98.4
Number of comorbidities		
0	109	42.6
1	91	35.5
>1	56	21.9
Severity		
Moderate-severe	239	93.3
Asymptomatic-mild	17	6.7

Table 4. Vaccination Status and Therapy of Participants in Palembang City, Indonesia

Variable	Frequency (N = 256)	Percentage (%)
Vaccination status		
Unvaccinated	114	44.5
Partially vaccinated	49	19.1
Fully vaccinated	93	36.4
Antivirus therapy		
Untreated	65	25.4
RdRp inhibitor	161	62.9
NA inhibitor	30	11.7
Oxygen therapy *)		
Received therapy	125	50.6
Did not receive therapy	122	49.4
Anti-inflammatory drug		
Received therapy	41	16.0
Did not receive therapy	215	84.0

*) Missing data were found in oxygen therapy variables (9 cases)

Table 5. Bivariate Analysis to Obtain the Association Between Each Factor and Long COVID

Variable	Long COVID (+)	Long COVID (-)	RR (95% CI)	p-value
Age				
50–59	28 (48.3)	30 (51.7)	1.51 (0.97–2.33)	0.067
≥60	17 (43.6)	22 (56.4)	1.35 (0.77-2.37)	0.295
18–49	55 (34.6)	104 (65.4)	1.0	
Sex				
Male	44 (40.4)	65 (59.6)	1.06 (0.78–1.44)	0.713
Female	56 (38.1)	91 (61.9)	1.0	
Education				
<Junior high school	34 (30.6)	77 (69.4)	0.67 (0.48–0.94)	0.016
≥Junior high school	66 (45.5)	79 (54.5)	1.0	
Occupation				
Employed	24 (45.3)	29 (54.7)	1.21 (0.86–1.71)	0.297
Unemployed	76 (37.4)	127 (62.6)	1.0	
Ethnicity				
Non-Palembang	20 (30.3)	46 (69.7)	0.74 (0.48–1.15)	0.173
Mixed (Palembang and Non-Palembang)	42 (43.3)	55 (56.7)	1.06 (0.76–1.48)	0.734
Palembang	38 (40.9)	55 (59.1)	1.0	
Dyspnea				
Yes	45 (35.2)	83 (64.8)	0.82 (0.60–1.11)	0.200
No	55 (43.0)	73 (57.0)	1.0	
Nausea				
Yes	15 (40.5)	22 (59.5)	1.05 (0.68–1.60)	0.842
No	85 (38.8)	134 (61.2)	1.0	
Fever >36.5°C				
Yes	23 (22.3)	80 (77.7)	0.44 (0.30–0.66)	<0.001
No	77 (50.3)	76 (49.7)	1.0	
Cough				
Yes	43 (30.5)	98 (69.5)	0.62 (0.45–0.84)	0.002
No	57 (49.6)	58 (50.4)	1.0	
Weakness				
Yes	32 (50.8)	31 (49.2)	1.44 (1.06–1.96)	0.028
No	68 (35.2)	125 (64.8)	1.0	
Fatigue during admission				
Yes	85 (47.0)	96 (53.0)	2.35 (1.46–3.79)	<0.001
No	15 (20.0)	60 (80.0)	1.0	
Hypertension				
Yes	25 (40.3)	37 (59.7)	1.04 (0.73–1.48)	0.815
No	75 (38.7)	119 (61.3)	1.0	
Diabetes Mellitus				
Yes	17 (40.5)	25 (29.5)	1.04 (0.70–1.56)	0.864
No	83 (38.8)	131 (61.2)	1.0	
Cancer				
Yes	11 (57.9)	8 (42.1)	1.54 (1.02–2.34)	0.080
No	89 (37.6)	148 (62.4)	1.0	
Chronic Kidney Disease				
Yes	27 (65.9)	14 (34.1)	1.94 (1.45–2.59)	<0.001
No	73 (34.0)	142 (66.0)	1.0	
Lupus				
Yes	5 (62.5)	3 (37.5)	1.63 (0.93–2.86)	0.167
No	95 (38.3)	153 (61.7)	1.0	
Asthma				
Yes	5 (83.3)	1 (16.7)	2.19 (1.48–3.24)	0.025
No	95 (38.0)	155 (62.0)	1.0	
Anemia				
Yes	9 (47.4)	10 (52.6)	1.23 (0.75–2.04)	0.441
No	91 (38.4)	146 (61.6)	1.0	
Cardiovascular Disease				
Yes	11 (52.4)	10 (47.6)	1.38 (0.89–2.15)	0.192
No	89 (37.9)	146 (62.1)	1.0	
Chronic Co-infection				
Yes	8 (66.7)	4 (33.3)	1.77 (1.15–2.72)	0.045
No	92 (37.7)	152 (62.3)	1.0	
Number of comorbidities				
1	42 (46.2)	49 (53.8)	1.68 (1.15–2.44)	0.006
>1	28 (50.0)	28 (50.0)	1.82 (1.22–2.72)	0.004
0	30 (27.5)	79 (72.5)	1.0	
RT-PCR result at discharge				
Positive	45 (51.7)	42 (48.3)	1.59 (1.18–2.14)	0.003
Negative	55 (32.5)	114 (67.5)	1.0	

Variable	Long COVID (+)	Long COVID (-)	RR (95% CI)	p-value
Vaccination status				
Partially vaccinated	28 (57.1)	21 (42.9)	1.30 (0.95–1.79)	0.119
Fully vaccinated	22 (23.7)	71 (76.3)	0.54 (0.35–0.83)	0.002
Unvaccinated	50 (43.9)	64 (56.1)	1.0	
Antivirus therapy				
NA inhibitor	6 (20.0)	24 (80.0)	0.46 (0.22–1.00)	0.029
RdRp inhibitor	66 (41.0)	95 (59.0)	0.95 (0.68–1.33)	0.773
Untreated	28 (43.1)	37 (56.9)	1.0	
Oxygen therapy				
Received therapy	45 (36.0)	80 (64.0)	0.83 (0.61–1.13)	0.232
Did not receive therapy	53 (43.4)	69 (56.6)	1.0	
Anti-inflammatory drug				
Received therapy	18 (43.9)	23 (56.1)	1.15 (0.78–1.69)	0.488
Did not receive therapy	82 (38.1)	133 (61.9)	1.0	
Severity				
Moderate-Severe	93 (38.9)	146 (61.1)	0.88 (0.51–1.50)	0.643
Asymptomatic-Mild	8 (44.4)	10 (55.6)	1.0	
Body Mass Index	22.16±3.52	23.80±3.46		0.682
Underweight	11 (68.8)	5 (31.3)	1.64 (1.12–2.41)	0.040
Overweight	17 (30.9)	38 (69.1)	0.74 (0.48–1.15)	0.158
Normal	59 (41.8)	82 (58.2)	1.0	
Thrombocytosis				
Yes	15 (60.0)	10 (40.0)	1.59 (1.11–2.28)	0.031
No	85 (37.8)	140 (62.2)	1.0	
Thrombocytopenia				
Yes	32 (53.3)	28 (46.7)	1.49 (1.10–2.02)	0.016
No	68 (35.8)	122 (64.2)	1.0	
Erythrocytopenia				
Yes	59 (56.7)	45 (43.3)	1.38 (1.02–1.87)	0.033
No	35 (41.2)	50 (58.8)	1.0	

Notes: RR, risk ratio; CI, confidence interval; RT-PCR, real-time polymerase chain reaction; RdRp, rna-dependent rna polymerase; NA, neuroamidase.

Bivariate analysis evaluated the association between each factor and long COVID among hospitalized participants during the COVID-19 pandemic (Table 5). Based on all associations in the bivariate analysis, 19 risk factor variables with p-value <0.250 were selected to proceed to the final multivariate Cox regression analysis (table not shown). The final Cox model showed that the risk factors for long COVID in three hospitals of Palembang City were fatigue during admission (RR = 2.17; 95% CI: 1.24–3.78; p-value = 0.007), CKD (RR = 1.66; 95% CI: 1.05–2.61; p-value = 0.030), thrombocytosis (RR = 1.99; 95% CI: 1.13–3.49; p-value = 0.017), positive RT-PCR result upon discharge from the hospital (RR = 1.60; 95% CI: 1.07–2.40; p-value = 0.022), and being fully vaccinated (RR = 0.54; 95% CI: 0.54–0.89; p-value = 0.015) (Table 6).

Table 6. Final Cox Model Risk Factors of Long COVID

Characteristics	RR (95%CI)	p-value
Fatigue during admission	2.17 (1.24–3.78)	0.007
Chronic Kidney Disease	1.66 (1.05–2.61)	0.030
Thrombocytosis	1.99 (1.13–3.49)	0.017
RT-PCR result when discharged	1.60 (1.07–2.40)	0.022
Vaccination status		
Partially	1.05 (0.65–1.69)	0.836
Fully	0.54 (0.32–0.89)	0.015

Notes: RT-PCR, real-time polymerase chain reaction

Discussion

In this study, the proportion of long COVID among the hospitalized adults as the participants was 39.1%. Several studies reported long COVID proportions of 12.5%–35.5% for patients who experienced symptoms for ≥2 months.[11–13] A study in 2024 reported that the long COVID proportion in low- and middle-income countries was 42.4%, which was significantly lower than that in high-income countries, which was 69.7%.[14] The current health and economic burden of long COVID may have already exceeded that of other chronic diseases. The long-term guidelines concerning long COVID remain unavailable, and this could be a significant drain on businesses, third-party payers, the healthcare system, and society.[14] Therefore, these findings may provide valuable insights to help health providers address the importance of long COVID treatment and of other post-viral infections caused by other coronavirus or other viruses with similar characteristics.

Fatigue was the most common symptom among patients with long COVID (48.0%) in this study and several other studies.[9,15,16] Furthermore, 57.2% of the participants experienced fatigue during hospitalization, contributing to an increasing risk of long COVID 2.17 times compared to those without fatigue history during hospitalization. Moreover, other studies reported fatigue in the acute phase as a crucial predictor of long COVID.[17,18] This study's finding was strengthened by a meta-analysis concluding that fatigue in the acute phase may be used as a predictor for long COVID. Therefore, early fatigue management is critical to prevent long-term consequences of fatigue.[19] Fatigue occurs during the acute phase of COVID-19 because of systemic impairment[20] and could be the consequence of neuroinflammatory processes.[21] This phenomenon was also observed in other viral infections such as Epstein–Barr virus, SARS, AIDS, and enterovirus-infected diseases, wherein the pathogenic pathway in acute fatigue was similar.[22] Acute-phase fatigue in COVID-19 should not be taken only as an acute symptom but also as a clinical indicator or risk factor for chronic conditions.

Chronic Kidney Disease is characterized by decreased glomerulus filtration speed, uremic toxin accumulation, chronic systemic inflammation, and immunity dysregulation.[23] In long COVID patients with CKD, the existing immune response dysregulation may prolong the inflammation phase following acute infection, which leads to continuous chronic inflammation and increased risk of long COVID.[23] In this study, 16% of the participants had preexisting CKD upon hospitalization, which was consistent with previous studies that reported that CKD was found in 12%–20% of admitted patients with COVID-19.[23,24] The authors estimated that the risk of long COVID increased 1.66 times in patients with CKD compared to those without CKD. Another study also reported that COVID-19 patients with CKD had a significantly higher risk of experiencing persistent fatigue, cognitive disturbance, and cardiovascular disease, which were all the manifestations of long COVID than those without CKD.[25] In addition, CKD is associated with endothelial dysfunction and severe oxidative stress. The tropism of SARS-CoV-2 includes endothelial cells facilitated by the ACE2 receptor, which is expressed in numerous kidney tissue and vascular.[26] Predisposition endothelial damage and viral effects combination worsen vasculopathy, tissue hypoxia, and multi-organ dysfunction.[26] Moreover, coagulopathy is a concern owing to the higher risk of hypercoagulability among patients with CKD.[27]

Thrombocytosis may occur in patients with COVID-19; however, it is rare and related to serious health conditions. In this study, the percentage of participants with thrombocytosis was 9.7%, higher than that in a study in the United States, which reported that 7% of hospitalized patients with COVID-19 experienced thrombocytosis.[28] Moreover, the proportion of thrombocytosis cases among participants with long COVID in this study was 14.9%. It increased the risk of long COVID 1.99 times compared to those without thrombocytosis. Thrombocytosis may cause blood clots, which lead to myocardial infarction, stroke, and mesenteric ischemia.[29] Fibrinolysis-resistance microclots, thrombocyte activation, and persistent coagulation abnormality were found among patients with long COVID even months after the acute phase.[2,3,12,14] These findings indicated that thrombocytosis was not only a reactive phenomenon during acute infection but also a potential biological marker for long-term risk. Therefore, thrombocytosis may be an independent risk factor for long COVID.

In this study, the percentage of participants with positive RT-PCR tests upon discharge from the hospital was 33.9%. This was relatively higher than that in a previous study, which reported that 18% of patients had positive results with recovered clinical conditions upon discharge from the hospital.[30] This disparity may be due to the difference in viral variants, the RT-PCR method used, and the difference between the duration and criteria of patient discharge regulation in the hospital. Among participants with long COVID, the proportion of those with positive RT-PCR tests at hospital discharge increased to 44.6%. This result was consistent with a previous study in 2020, which reported that viral RNA was still detected in 47% of patients with persistent symptoms after weeks of admission.[31] This finding indicated that prolonged viral ribonucleic acid (RNA) was associated with a longer duration of the disease and its complications. This study also found that a positive RT-PCR test increased the risk of long COVID 1.6 times after treatment. Another study also reported the same findings, stating that persistent symptom was associated with prolonged viral shedding.[32] Viral or RNA persistence enhances prolonged immune activation, which leads to persistent symptoms such as dyspnea, fatigue, and muscle pain.[33,21] This study strengthened the hypothesis that a positive RT-PCR test at hospital discharge was not only a marker of viral replication but also evidence of the presence of RNA fragments, which reflected immunological dysfunction that led to long COVID risk.

The proportion of partially vaccinated participants was 19.1%, and 36.2% of fully vaccinated participants. Further analysis showed that being fully vaccinated was associated with a lower long COVID risk at almost 1.9 times as compared to being unvaccinated. This finding was consistent with meta-analysis studies showing full vaccination as more effective

in significantly reducing long COVID.[34] A similar result was also found in a cohort study showing that two doses of vaccine were associated with a decreased risk of long COVID, around 49%.[35] These results revealed that vaccination is crucial to protect individuals from experiencing post-viral persistent symptoms such as long COVID. The COVID-19 vaccine prepares the immune system by inducing an adaptive immune response, including activating B-cell memory and T-cell specific to SARS-CoV-2. This mechanism enhances viral elimination and reduces systemic inflammation burden during acute infection. Viral load decrement and shortening viremia duration were found to directly reduce the risk of long-term immune dysfunction and persistent tissue damage.

This study contributed to a better understanding of the association between clinical effects (hospitalized patients' symptoms, comorbidities, hematology abnormality, RT-PCR status at hospital discharge, and vaccination and therapy status) and long COVID. To assess fatigue during hospitalization, a translated, valid, and reliable FAS questionnaire was utilized to recall the participants' memories using a probing technique. To assess long COVID, the information from the participants and clinical data in medical records were combined. The temporality of the association between determinants and long COVID could be ascertained by using a cohort design.

This study had several limitations. First, almost all the participants were admitted with moderate severity; therefore, the number of followed long COVID patients in the mild and severe stages was sufficient. Second, phone interviews were conducted; therefore, only those who had a phone and were willing to participate in the study could be observed, and thus, results may not be generalized to the whole population. Third, recall bias may have occurred when asking about fatigue history; however, the bias may be minimal as the fatigue history was asked when the participants were hospitalized during the COVID-19 pandemic. The validity of the response was strengthened by using the standardized FAS questionnaire.

Conclusion

Five significant risk factors are identified in this study. Four of them (fatigue during hospitalization, CKD, thrombocytosis during admission, and viral RNA still being detected at discharge from hospital) increase the risk of long COVID. Meanwhile, one risk factor, full COVID-19 vaccination, decreases the risk of developing long COVID. Fatigue is the strongest risk factor for long COVID. Early identification of these five risk factors and their adequate corresponding clinical intervention or management in Indonesian health facilities can prevent or reduce the possibility of the occurrence of long COVID, which is estimated to contribute significant long-term health problems globally. Therefore, future studies are warranted to develop dynamic modeling to estimate and project health impacts of long COVID.

Abbreviations

COVID-19: coronavirus disease 2019; FAS: Fatigue Assessment Scale; BMI: body mass index; DM: diabetes mellitus; CKD: chronic kidney disease; CVD: cardiovascular disease; RR: risk ratio; CI, confidence interval; RT-PCR: real-time polymerase chain reaction; RdRp: rna dependent rna polymerase; NA: neuroamidase; RNA: ribonucleic acid.

Ethics Approval and Consent to Participate

The patients' data was obtained from the medical records of Mohammad Hoesin General Hospital after being approved by the Health Research Ethics Committee, Faculty of Public Health, Universitas Indonesia No. Ket-5/UN2.F10.D11/PPM.00.02/2024 and Mohammad Hoesin General Hospital No.DP.04/03/D.XVIII.6.8/ETIKRSMH/04/2024. Subjects gave their consent to participate in text messages.

Competing Interest

The authors have no conflicts of interest to declare.

Availability of Data and Materials

The datasets are not publicly available but are available from the corresponding author upon reasonable request.

Authors' Contribution

Conceptualization: HMLH, MKS, AAP, TYMW, NAS; Data curation: HMLH, MKS; Formal analysis: HMLH, MKS; Funding acquisition: HMLH, MKS; Investigation: HMLH, MKS, AAP, NAS; Methodology: HMLH, MKS, AAP; Project administration: HMLH, MKS, TYMW; Resources: HMLH, MKS ; Software: HMLH, MKS; Supervision: MKS, AAP; Validation: MKS, AAP, TYMW; Visualization: HMLH, MKS, AAP; Writing–original draft: HMLH, MKS; Writing–review & editing: all authors.

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Food Hygiene and Sanitation of the University Canteens in South Sumatra Province, Indonesia

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Abstract

Food safety is a critical public health issue, especially in institutional settings such as university canteens, where large populations are served daily. Inadequate hygiene and sanitation practices by food handlers can lead to foodborne illnesses, placing students and staff at risk. This study evaluated hygiene and sanitation conditions in the canteens of a leading public university in South Sumatra Province, Indonesia, known for its active food service facilities. This study examined food handlers' knowledge, attitudes, and practices and assessed the microbiological safety of chicken curry by testing for *Escherichia coli* (*E. coli)* contamination and total plate count. Using a cross-sectional design, data were collected from 35 food handlers and 7 chicken curry samples across multiple canteens. Structured questionnaires and microbiological analysis were employed. Results revealed that although most food handlers demonstrated good knowledge and positive attitudes, 57.1% exhibited poor hygiene practices. Several chicken curry samples exceeded acceptable *E. coli* levels, indicating potential health risks. These findings underscore the urgent need for ongoing hygiene training, strict supervision, and standardized certification for food handlers to mitigate microbial hazards and ensure food safety in university settings.

Keywords: *Escherichia coli*, food handlers, Hygiene, Sanitation, Total Plate Count

Introduction

Food and beverage hygiene remains a major public health issue in Indonesia. According to data from the National Agency for Drug and Food Control, the incidence of food poisoning increased from 45.29% in 2019 to 46.62% in 2020. More strikingly, in 2022, poisoning cases related to drugs and food rose significantly compared to 2021, reaching 65%.[1] This trend indicates inadequate hygiene and sanitation practices, which affect not only snacks but also food served in institutional settings, including universities.

The largest and most reputable public university located in Palembang City and Ogan Ilir District, South Sumatra Province, Indonesia, was selected as this study's location. The canteen is a primary food source for students and staff. Poor hygiene and sanitation in this environment can lead to serious health issues. Contamination often results from untrained or non-compliant food handlers, increasing the likelihood of foodborne illnesses.[2] Notably, the university has recorded several food poisoning incidents linked to snack consumption, with four cases reported in 2020 and nine in 2021.[3]

Inadequate hygiene endangers student health and may harm the university's reputation. Given the high volume of food transactions in university canteens, poor practices can potentially spread illness to a wide population. Therefore, there is a pressing need to evaluate hygiene and sanitation practices in such environments.[4,5] A common issue is the insufficient knowledge and understanding among food handlers regarding hygiene and sanitation principles. This gap often leads to unsafe food handling, improper storage, and an unhygienic working environment. Furthermore, attitudes and behaviors toward hygiene procedures critically influence food sanitation outcomes.[6]

From a microbiological perspective, contamination is a key concern. *Escherichia coli (E. coli)* is a pathogen frequently found in improperly processed or handled food, and it can cause severe gastrointestinal illness.[7] Therefore, assessing *E. coli* contamination in canteen food is essential to ensuring load in the food or beverages. A high total plate count (TPC)

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value indicates microbial contamination and reduced food quality.[8]

This study aimed to assess hygiene and sanitation practices at the university canteens by evaluating food handlers' knowledge, attitudes, and practices (KAP) and conducting microbiological analysis of chicken curry for *E. coli* contamination and TPC. The chicken curry was selected due to its popularity and potential for microbial growth if improperly prepared or stored. The dish also includes ingredients supporting microbial growth, making it a suitable indicator for assessing food safety risks.

Although food hygiene has been extensively studied, there remains a notable gap in the literature regarding hygiene and sanitation practices in university canteens, particularly in Indonesia. A previous study has primarily focused on the general food industry, often overlooking the unique conditions of academic institutions.[9] Furthermore, most studies have limited their scope to evaluating food handlers' knowledge and attitudes without integrating microbiological analysis of the food itself.[10,11] This study addresses this gap by assessing hygiene practices and conducting microbiological evaluations of a commonly consumed dish, such as chicken curry, thus offering a more comprehensive perspective on food safety in university settings.

Method

This study employed a quantitative approach with a cross-sectional design. Data was collected in November 2023 at a University in Palembang City and Ogan Ilir District, Indonesia. A total of seven canteens from the Faculty of Public Health, Faculty of Law, Faculty of Education, Faculty of Political and Social Sciences, Faculty of Engineering, Faculty of Agriculture, located in Ogan Ilir District, and Faculty of Economics, located in Palembang City, were identified. Although 10 canteens were situated within the university complex, only 7 were selected due to their consistent operation; the remaining three were temporarily closed due to the COVID-19 pandemic.

The inclusion criteria for canteens were: (1) serving food via a buffet system; (2) employing food handlers responsible for preparing chicken curry on the day of observation; and (3) management under faculty administration. Canteens without on-site food preparation and serving facilities or those not operating during data collection were excluded. The study population comprised food handlers working in university canteens. A total of 35 food handlers were selected using a cluster random sampling method to ensure representation across different faculties. Although the microbiological analysis specifically focused on chicken curry, only food handlers involved in the preparation and serving of this dish were included. The inclusion criteria for food handlers were: (1) having worked for at least three months and (2) directly handling food. The exclusion criterion was the presence of specific diseases among food handlers.

These criteria were designed to ensure the relevance and consistency of hygiene practices and microbiological assessments across canteens. Microbiological analysis focused on *E. coli* contamination and TPC in chicken curry. Samples were collected using proportional random sampling from the seven selected canteens that sold chicken curry. This dish was chosen due to its popularity, frequent consumption, and high risk of contamination when improperly handled. Additionally, its ingredients provide an environment conducive to microbial growth, making it suitable for assessing food safety.

The primary independent variables were the KAP of food handlers. A descriptive and analytical observational method was applied to evaluate the microbiological safety of chicken curry sold in the canteens, specifically concerning *E. coli* contamination and TPC. Data on food handlers' knowledge and attitudes were collected using a questionnaire comprising 15 and 10 questions, respectively. Hygiene and sanitation practices were measured as the dependent variable using a 22-item questionnaire. Both the independent and dependent variables were categorized as "Good" if the total score exceeded 75%, and "Not Enough" if the score was ≤75%.

This questionnaire was developed based on food safety guidelines and tested for validity and reliability. Knowledge was measured using multiple-choice questions, attitudes with a Likert scale, and practices through direct observation using a checklist. Each component was scored and classified as good, fair, or poor. Chicken curry samples were analyzed at the Laboratory of the Industrial Service Standardization Center in Palembang City using standard methods to detect *E. coli* and calculate TPC.

The control variables included age, sex, education level, and years of service. Age was calculated from the respondent's date of birth and categorized into late adolescence (17–25 years), early adulthood (26–35 years), middle adulthood (36–45 years), and early elderly (46–55 years), using an ordinal scale. Sex was regarded as male or female based on biological characteristics, using a nominal scale. Education level was categorized as low (uneducated or elementary school), medium (junior to senior high school), and high (higher education), using an ordinal scale. Years of

service were categorized as ≤5 years (new) and >5 years (experienced) using a nominal scale.

Data were analyzed using univariate and bivariate techniques. Univariate analysis was conducted to determine the frequency and percentage of each variable. Bivariate analysis was performed using the Chi-squared test to assess the association between food handlers' knowledge and attitudes and their hygiene and sanitation practices. Spearman's correlation and continuity correction tests were used to assess statistical significance for numeric and categorical data, respectively. Microbiological test results were analyzed descriptively, reporting *E. coli* contamination and TPC in chicken curry samples as colony-forming units per gram (CFU/gram). Data analysis was conducted using SPSS software (free version).

Results

A total of seven canteens were included in the study, located in the Faculty of Public Health (A), Faculty of Law (B), Faculty of Education (C), Faculty of Social and Political Sciences (D), Faculty of Engineering (E), Faculty of Agriculture (F), and Faculty of Economics (G). Based on Table 1, the canteens across the seven faculties differed in terms of year of establishment, the number of food portions sold daily, the number of food handlers, and compliance with sanitation hygiene standards.

The years of establishment for the canteens were as follows: Faculties of Public Health (2022), Law (2016), Economics (2016), Education (2017), Social and Political Sciences (2003), Engineering (2007), and Agriculture (2010). Each canteen provided between 10 and 20 portions of food per day, which were consistently sold out. The number of food handlers varied: the canteen at the Faculty of Teacher Training and Education had the highest number (10 people), while the others averaged 3–5 handlers. Only the canteens at the Faculties of Public Health, Social and Political Sciences, and Engineering had sanitation hygiene certificates. However, all canteens received hygiene socialization education or socialization.

Interview results indicated that food preparation typically began at 09:00 a.m. in the canteen. Food was served until it ran out or until the canteen closed. Ingredients were purchased around 06:00 a.m. Any leftover food was taken home, consumed, or shared. Protein sources were not stored or were left in containers directly from the market. Most canteens served food buffet style. Observations of the canteens revealed that most food handlers did not wear Personal Protective Equipment (PPE) and had long fingernails. Although food tongs were available, handwashing stations were not separated from the food preparation area. In addition, toilets were separated from the handwashing areas, although food was served in closed containers.

Table 1. Characteristics of the Canteens

Question	Answer						
	A	B	C	D	E	F	G
Started selling at the canteen	Around 2022 (1-2 years)	Around 2016 (8 years)	Around 2017 (7 years)	Around 2003 (21 years)	Around 2007 (16 years)	Around 2010 (14 years)	February 2016 (8 years)
Number of portions provided in a day	Twenty servings (always sold out)	Not more than 12 servings (always sold out)	Not more than 10–20 servings (always sold out)	Fifteen servings (always sold out)	Not more than 12 servings (always sold out)	Fifteen servings (always sold out)	100–150 servings
Number of food handlers	3	3	10	4	9	5	5
Obtain a hygiene sanitation certificate	Yes	No	No	Yes	Yes	No	No
Participate in hygiene and sanitation socialization	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Chicken curry processing finish time	09:00 a.m.	09:00 a.m.	10:00 a.m.	09:00 a.m.	09:00 a.m.	07:00 a.m.	08:00 a.m.
Chicken curry processing completion area	In the canteen	In the canteen	In the canteen	In the canteen	In the canteen	In the canteen	In the canteen
Chicken curry serving time	Until the canteen closes or until the chicken curry runs out	Until the canteen closes or until the chicken curry runs out	Until the canteen closes or until the chicken curry runs out	Until the canteen closes or until the chicken curry runs out	Until the canteen closes or until the chicken curry runs out	Until the canteen closes or until the chicken curry runs out	Until the canteen closes or until the chicken curry runs out
Water sources for food processing	Tap water	Tap water	Tap water	Tap water	Gallon water	Gallon water	Gallon water
Groceries purchasing time	06:30 a.m.	06:00 a.m.	06:00 a.m.	05:30 a.m.	06:00 a.m.	06:00 a.m.	06:00 a.m.
Groceries purchasing place	traditional markets	traditional markets	traditional markets	traditional markets	traditional markets	traditional markets	traditional markets
Treatment of the leftovers	Take home, eat, and share	Stored in the refrigerator and processed again	Take home, eat, and share	Always out of stock	Take home, eat, and share	Take home, eat, and share	Take home, eat, and share
Protein source for food storage	None or just left in the container from the market	None or just left in the container from the market	None or just left in the container from the market	In container	None or just left in the container from the market	None or just left in the container from the market	None or just left in the container from the market
Way of serving food	Buffet style	Buffet style	Buffet style	Buffet style	Buffet style	Buffet style	Buffet style
Use of Personal Protective Equipment such as (mask/ mouth cover, gloves, apron) while serving food	Apron	Apron	No	No	No	No	No
Food handlers have long nails	No	No	Yes	No	Yes	Yes	Yes
Availability of food tongs on the food served	Yes	No	Yes	Yes	Yes	Yes	Yes
Hand washing station for food handlers	Yes	Yes	Yes	Yes	Yes	Yes	Yes
The hand washing station is separate from the food washing station	No	No	No	No	No	No	No
Availability of soap at the hand washing place and food washing station	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Toilet availability	Yes	Yes	Yes	Yes	Yes	Yes	Yes
The toilet is separate from the hand washing, equipment, and food ingredients station	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Food served in closed containers	No	Yes	Yes	No	Yes	Yes	Yes

Source: Primary Data, 2023

This study involved 35 food handlers. Their demographic characteristics, age, sex, educational level, and years of service are shown in Table 2. Most food handlers were women (32 respondents, 91.4%) in their middle adulthood (aged 36–45 years), comprising 14 respondents (40.0%). Most food handlers belong to the medium educational level (26 respondents, 74.3%), while only 2 respondents (5.7%) had low educational attainment (uneducated or elementary school). In terms of work experience, 21 (60%) had been working for five years or less, and 14 (40%) had more than five years of experience.

Table 2. Characteristics of Food Handlers

Variable	Frequency	Percentage
Age		
Late adolescence (17-25 years)	7	20.0
Early adulthood (26-35 years)	6	17.1
Middle adulthood (36-45 years)	14	40.0
Early elderly (46-55 years)	8	22.9
Sex		
Male	3	8.60
Female	32	91.4
Educational level		
Low	2	5.7
Medium	26	74.3
High	7	20.0
Years of service		
New	22	62.9
Experienced	13	37.1

Source: Primary Data, 2023

Table 3. Frequency Distribution of Knowledge, Attitude, and Practice of Food Handlers in the University Canteen

Variables	Frequency	Percentage
Knowledge		
Good	19	54.3
Not enough	16	45.7
Attitude		
Good	19	54.3
Not enough	16	45.7
Practice		
Good	15	42.9
Not enough	20	57.1

Source: Primary Data, 2023

Table 3 shows that most food handlers had good knowledge regarding sanitation and hygiene (19 respondents, 54.3%). Similarly, 19 respondents (54.3%) demonstrated a good attitude. However, only 15 food handlers (42.9%) had good sanitation and hygiene practices, while 20 (57.1%) had poor practices.

Table 4. Relationship between Food Handlers' Knowledge and Attitudes and Their Hygiene and Sanitation Practices in the University Canteen

Food Handlers' Knowledge	Food Handlers' Hygiene and Sanitation Practices						PR (95% CI)	p-value
	Not enough		Good		Total			
	n	%	n	%	n	%		
Not enough	7	43.8	9	56.3	16	100		
Good	13	68.3	6	31.6	19	100	0.639 (0.339–1.205)	0.260
Total	20	57.1	15	42.9	35	100		
Food Handlers' Attitudes	**Food Handlers' Hygiene and Sanitation Practices**						**PR (95% CI)**	**p-value**
	Not enough		**Good**		**Total**			
	n	**%**	**n**	**%**	**n**	**%**		
Not enough	14	87.5	2	12.5	16	100		
Good	6	31.6	13	68.4	19	100	2.771 (1.394–5.509)	0.003
Total	20	57.1	15	42.9	35	100		

Source: Primary Data, 2023, Notes: PR = prevalence ratio, CI = confidence interval

As shown in Table 4, a higher proportion of respondents with good hygiene and sanitation practices was observed among those with poor knowledge (56.3%) compared to those with good knowledge (31.6%). The continuity correction analysis yielded a p-value of 0.260 (p-value >0.05), indicating that the null hypothesis could not be rejected. These results suggested no significant relationship between food handlers' knowledge and their hygiene and sanitation practices at the university canteens. The prevalence ratio (PR) was 0.639 (95% CI = 1.394–5.509), implying that respondents with poor knowledge had a 0.639 times greater likelihood of engaging in poor hygiene and sanitation practices than those with good knowledge.

In contrast, more respondents with good hygiene practices were found among those with a positive attitude (68.4%) than those with a poor attitude (12.5%). The analysis using continuity correction produced a p-value of 0.003 (p-value <0.05), indicating a statistically significant relationship between food handlers' attitudes and their hygiene and sanitation practices. The PR was 2.771 (95% CI = 1.394–5.509), showing that respondents with poor attitudes were 2.771 times more likely to exhibit poor hygiene and sanitation practices.

Table 5. *E. Coli* Bacteria Content and Total Microbial Plate Count in Chicken Curry Samples from Seven Faculty Canteens

Results of *E. Coli* Bacteria Examination in Chicken Curry Samples			
Canteen Sample	**Test Results (CFU/gram) (1)**	**Repetition (2)**	**Average (CFU/gram)**
A	38.0	38.0	38.0
B	36.0	38.0	37.0
C	36.0	38.0	37.0
D	75.0	75.0	75.0
E	64.0	64.0	64.0
F	23.0	23.0	23.0
G	2.3	2.3	2.3
Results of the Total Microbial Plate Count Examination in Chicken Curry Samples			
Canteen Sample	**Test Results (CFU/gram) (1)**	**Repetition (2)**	**Average (CFU/gram)**
A	1.4×10^5	1.3×10^5	1.35×10^5
B	1.8×10^5	1.8×10^5	1.8×10^5
C	1.2×10^5	1.2×10^5	1.2×10^5
D	2.1×10^5	2.1×10^5	2.1×10^5
E	2.1×10^5	2.2×10^5	2.15×10^5
F	7.5×10^4	8.2×10^4	7.5×10^4
G	5.1×10^5	5.1×10^5	5.1×10^5

Source: Primary Data, 2023, Notes: CFU = colony-forming units per gram

As shown in Table 5, chicken curry samples in most canteens had *E. coli* levels of more than 3 CFU/gram, indicating that they did not meet the required microbial contamination limits for food. However, sample G had a slightly lower value of 2.3 CFU/gram. Although this result was still above the acceptable limit, typically <1 CFU/gram for ready-to-eat foods, the lower value may suggest better handling or storage conditions than the other samples. Nevertheless, it remains unacceptable according to food safety standards, as outlined in SNI 7388:2009 on Maximum Limit of Microbial Contamination in Food.

TPC test on six samples, A, B, C, D, E, and G, showed counts greater than 10^5 CFU/gram, exceeding the maximum acceptable limit according to SNI No. 7388:2009, which sets the Total Plate Count limit for ready-to-eat foods at ≤1×10^5 CFU/gram. However, the TPC for sample F was below 10^5 CFU/gram, thus meeting the required standard for microbial contamination in food based on the same regulation.

Table 6. Correlation Between Food Handlers' Knowledge, Attitude, and Practice and *E. Coli* and Total Plate Count Test Results

Variables	***E. coli* Test Results**		**TPC Test Results**	
	p-value	**r**	**p-value**	**r**
Knowledge	1	0	0.894	0.023
Attitude	0.738	0.059	0.689	−0.070
Practice	0.676	−0.073	0.037	−0.354

Source: Primary Data, 2023, Notes: TPC = total plate count

According to Table 6, the Spearman correlation test revealed no significant relationship between food handlers' knowledge, attitude, or practices and *E. coli* contamination. The knowledge yielded a p-value of >0.05 and an r of 0, indicating no association between knowledge and the presence of *E. coli* on food handlers. Similarly, the attitude variable

showed a p-value of 0.738 and r = 0.059, while the practices variable had a p-value of 0.676 and r = −0.073. Although the letter was a negative correlation, it was very weak and statistically significant, suggesting only a slight tendency for better practices to reduce *E. coil* count.

However, a different trend was observed for the TPC result. Among the three variables, only hygiene and sanitation practices demonstrated a statistically significant relationship with TPC values (p-value = 0.037; r = −0.354). This moderate negative correlation indicated that better hygiene and sanitation practices were associated with lower microbial counts on eating utensils. In contrast, knowledge and attitude did not significantly correlate with TPC results, showing p-values of 0.894 and 0.689, respectively, and very weak correlations. These findings underscored the critical role of actual hygiene practice over knowledge or attitude in minimizing microbial contamination on eating utensils.

Discussion

This study's results indicated that the hygiene and sanitation practices in university canteens varied across faculties. These variations were evident in aspects such as the year of establishment, the quantity of food portions provided, the number of food handlers, and compliance with hygiene certification. Canteens under the Faculties of Public Health and Social and Political Sciences possess hygiene certificates, while others do not, despite ongoing socialization efforts. Hygiene certification ensures compliance with established standards, thereby allowing students, lecturers, and staff to consume safe food.[12]

Food handlers generally demonstrate good knowledge and attitudes regarding hygiene practices. However, approximately 57% still exhibit poor hygiene behaviors. This data suggests that while knowledge is important, actual implementation relies heavily on awareness and training.[13,14] Despite efforts at socialization, effective field supervision remains critical to ensure that knowledge is translated into action. Therefore, stricter supervision and regular training are necessary to improve food sanitation quality.[15]

This study found a significant association between food handlers' attitudes and sanitation hygiene practices. Positive attitudes—such as regular handwashing, the use of PPE use, and maintaining cleanliness—were associated with better hygiene behavior. These results supported previous findings that proactive attitudes positively affect sanitation quality.[16,17] However, no significant relationship was found between knowledge and hygiene practice, suggesting that knowledge alone is insufficient. It highlights the need to cultivate a culture of workplace cleanliness through continuous training.[18,19]

One of the key findings of this study was the presence of *E. coli* contamination and TPC values exceeding the threshold established by SNI No. 7388:2009 in several food samples. For example, a chicken curry sample from the Faculty D contained 75 CFU/gram of *E. coli*, surpassing the permissible limit (<3 CFU/gram). These results indicated a serious risk of bacterial contamination in canteen food, potentially endangering consumer health. The primary cause of such contamination is poor hand hygiene, particularly when food handlers fail to wash their hands properly after using the toilet or handling contaminated items.[20,21] Additionally, using unclean water for washing food ingredients, cooking utensils, or kitchen surfaces also contributes to contamination. *E. coli* in food is a key indicator of contamination by pathogenic bacteria that can cause gastrointestinal illnesses, such as diarrhea. These findings underscore that E. coli contamination remains a common issue in food service environments, especially those lacking hygiene certification.[22]

TPC test results further revealed that most samples, particularly from the Faculties of Engineering and Social and Political Sciences, had microbial counts exceeding safety thresholds. The TPC test measured the number of microorganisms in food or beverages to evaluate their safety and quality. Elevated microorganism counts often indicate a decline in product quality or pose potential health risks.[23,24] This reflects inadequate food sanitation and storage practices, which may foster microbial growth. High TPC levels are often linked to unsanitary food handling, including unclean equipment and poor kitchen hygiene.[25] Consistent with earlier studies, the lack of proper storage and handling procedures in educational institution canteens may significantly contribute to the proliferation of pathogenic bacteria.[25]

This study highlighted the urgent need to implement stricter hygiene and sanitation protocols in the canteen environment, particularly in food preparation and serving processes. Proper use of PPE, such as masks and gloves, and separating raw and cooked ingredients are important in preventing cross-contamination. Observations revealed that most food handlers in the university canteens inconsistently use PPE and do not regularly wash their hands with antiseptics. This practice must be addressed to ensure that the food served is free from bacterial contamination. Emphasizing the importance of PPE and regular monitoring can reinforce proper hygiene behaviors.[26] Adhering to established hygiene standards makes PPE usage essential to maintaining sanitation during food processing. Furthermore, this helps food

service providers comply with health regulations and mitigate the risk of disease transmission. Therefore, PPE plays an important role in ensuring consumers' food safety and hygiene.[27,28]

Although food handlers possess adequate knowledge and positive attitudes, their hygiene practices remain suboptimal. To bridge this gap, it is crucial to introduce more intensive training and routine supervision to uphold hygiene and sanitation standards across all faculty canteens. Supervision not only ensures compliance with regulations set by authorities such as the Health Office and the National Agency for Drug and Food Control but also raises awareness among canteen managers about the importance of food safety. Additionally, it enables periodic evaluation of canteen service quality, including cleanliness and food presentation, both of which impact consumer satisfaction.[29-31] Prioritizing hygiene certification for canteens that have not yet been obtained is essential for enhancing food safety on campus.

The strength of this study lies in its mixed-methods approach, which integrates behavioral and microbiological assessments to provide a comprehensive perspective. This methodology captures both the cognitive and practical aspects of hygiene and their implications for food safety. However, this study has several limitations, including time constraints, a limited number of research personnel despite multiple food handlers in each canteen, and restricted access to observe food handling processes. Another limitation was the narrow scope of the food sample, which included only chicken curry.

Conclusion

This study reveals that hygiene and sanitation practices in the university canteens require further improvement, particularly regarding implementation by food handlers. Although the food handlers possess adequate knowledge, their application is insufficient, and several canteens fail to meet hygiene certification standards. Microbiological test results indicate a risk of food contamination, emphasizing the urgency of these concerns. Regular monitoring, structured training programs, and certification are necessary steps to enhance food hygiene standards and reduce the risk of foodborne illnesses within the university setting.

Abbreviations

E. coli: Escherichia coli; TPC: Total Plate Count; KAP: knowledge, attitudes, and practices; CFU: colony-forming units; PPE: Personal Protective Equipment; PR: prevalence ratio;

Ethics Approval and Consent to Participate

This study was ethically approved by the Health Research Ethics Committee, Faculty of Public Health, Sriwijaya University (Approval No: 211/UN9.FKM/TU.KKE/2023).

Competing Interests

The authors declare no financial, professional, or personal conflicts of interest that could have influenced the conduct or reporting of this study.

Availability of Data and Materials

The data and materials used in this study are available from the corresponding authors upon reasonable request.

Authors' Contribution

AR and Y were responsible for data collection, processing, analysis, and interpretation. FF, FE, IPS, M, ESP, and VPS contributed to manuscript drafting and critical revision.

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Machine Learning for Preeclampsia Prediction: Enhancing Screening in Primary Health Care

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Machine Learning for Preeclampsia Prediction: Enhancing Screening in Primary Health Care

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Abstract

Preeclampsia is a leading cause of maternal morbidity and mortality worldwide, with early detection being critical for reducing adverse outcomes. This study aimed to develop a machine learning model for predicting the risk of preeclampsia using readily available maternal characteristics such as body mass index, mean arterial pressure, and clinical history of hypertension or diabetes mellitus. Secondary data from 2,250 pregnancies were analyzed, addressing challenges such as missing data and class imbalance through preprocessing. Various algorithms, including support vector machines, random forest, and logistic regression, were evaluated. Herein, a support vector machines model with threshold adjustment showed the best performance, with a sensitivity of 67.5%, specificity of 57.23%, and an area under the curve of 0.68. These findings indicated the promising potential of scalable and interpretable prediction models for enhancing preeclampsia screening in primary health care settings. However, further refinement and validation of the proposed model are required for broader clinical integration to improve maternal and neonatal health outcomes.

Keywords: machine learning, maternal health, preeclampsia prediction, primary care screening

Introduction

Preeclampsia (PE) is a multifactorial syndrome and a leading cause of maternal morbidity and mortality globally.[1] Pregnancy-induced hypertension causes one-fifth of maternal deaths worldwide, and PE/eclampsia alone is estimated to cause 60,000 to 80,000 maternal deaths annually.[2,3] PE is characterized by elevated blood pressure and multisystem manifestations, and its etiology is poorly understood. The prevalence and incidence of PE vary globally, with the global incidence rate of severe PE estimated between 2% and 10% of all pregnancies.[4-6] Later evidence showed an increase in the incidence of hypertension during pregnancy over time, which included PE.[7]

Early detection is critical for preventing the morbidity and mortality associated with PE. Preventive interventions, such as low-dose aspirin and calcium supplementation, have been found to reduce adverse outcomes.[6,8] As its etiology, pathogenesis, and pathophysiology of PE are not fully understood, PE is challenging to predict.[6,9,10] Previously, PE prediction based on combinations of multiple features has been actively investigated. In a meta-analysis published in 2015, models based on a combination of maternal characteristics and several biomarkers have been found to exhibit better predictive performance than models based on individual biomarkers.[11]

The advantages of biochemical and biophysical marker examination with Doppler ultrasound have been demonstrated in many studies, but with limited markers practically used in clinical practice.[12,13] However, obtaining biochemical markers is often expensive, thus limiting their applicability in primary health care (PHC), where women are first encountered for antenatal care (ANC). At the same time, models based on several simple features, such as body mass index (BMI) and other routinely collected maternal characteristics such as age, ethnicity, parity, history of hypertension, and history of PE, have shown promising predictive performance.[14-16]

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Machine learning (ML) is a novel approach to PE prediction by analyzing patterns in complex datasets without relying on explicit causal mechanisms.[17] Previous studies have leveraged prior work, aiming to develop prediction models that would be both effective and accessible for primary care.[14,16-18] Particularly, a study showed that a model based on biophysical (mean uterine artery pulsatility index) and biochemical markers (placental growth factor) is clinically superior to a simple feature model, but the difference is not statistically significant.[14]

This study aimed to develop an ML model for predicting PE based on readily available limited maternal clinical characteristics such as maternal history of primary hypertension and diabetes mellitus (DM), family history of hypertension and DM, primigravidity, mean arterial pressure (MAP), BMI, and history of smoking, all of which can be gathered in primary care settings. Herein, the authors evaluated the predictive performance (sensitivity, specificity, and area under the curve (AUC)) of various models and addressed the challenges associated with applying the developed prediction tools in low-resource environments. The concise and practical approach is expected to support early surveillance and prevention of PE, improving maternal and neonatal outcomes in PHC.

Method

This retrospective cohort study used secondary data on 2,250 pregnant women visiting a private Mother and Child Hospital and its branch in Jakarta from July 2012 to April 2015. The data were collected from a previous study by Savitry et al. from the Julius Center for Health Sciences and Primary Care, Julius Global Health, University Medical Center Utrecht, Utrecht, Netherlands.[19,20] Anonymous data from routine hospital checks were used; thus, this study was ethically approved as nonhuman research. All the 2,250 pregnant women whose data were collected and followed up until delivery. This analysis was a part of the Prediction Modeling of PE in Pregnant Women using an ML study conducted by the author during the doctorate program at the Faculty of Public Health, Universitas Indonesia, in 2024.

All the collected data were preprocessed, during which 584 entries were identified as null and 1,028 as duplicates. The results of Little's Missing Completely at Random (MCAR) test (p-value >0.05) showed that all missing data were missing completely at random. Thus, all the missing values and duplicates were removed from the dataset, leaving 638 data entries (Figure 1). The available features are shown in Table 1.

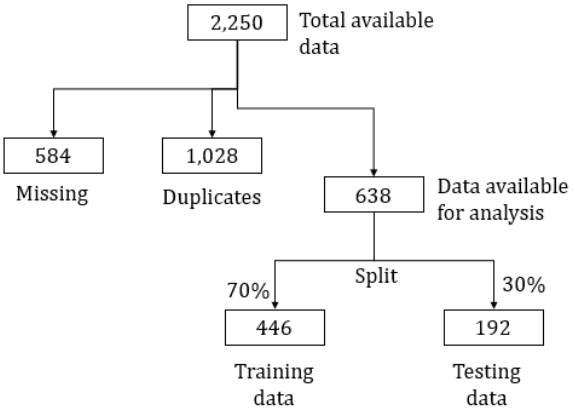

Figure 1. Flow Chart of Data Preprocessing

Data were collected during routine ANC visits by midwives, including maternal history (hypertension, DM smoking, and the family history of hypertension/DM), pre-pregnancy weight, obstetric history (gravida and miscarriage), and height (measured at the first ANC visit). Blood pressure was recorded every visit, with mean arterial pressure calculated for the first and second trimesters. Pre-pregnancy BMI was calculated from weight (kg) and height (m). PE was defined according to the International Society for the Study of Hypertension in Pregnancy (ISSHP) criteria: gestational hypertension (≥20 weeks) with ≥1 new-onset condition (proteinuria, organ dysfunction, etc.).[1]

Using Kelsey's formula, the calculated sample size for each group should be 683 subjects to achieve a statistical power of 80%.[21] In addition, the rule of 10 or 20 for the number of observations and features was considered. A common recommendation is that at least 10 events per predictor should be used to prevent overfitting and ensure robust training.[22,23] This recommendation on sample size calculation surely requires further refinement through feature selection and dimensionality reduction by identifying the best-performing features and generating synthetic data because of the lack of systematic validation.[24] Based on both considerations, all of the collected 2,250 data entries were included in the analysis.

Data analysis was conducted in Python (permissive open source license version 3.9.7) using the scikit-learn library (BSD3 license version 1.5.0) as the primary framework for ML and statistical modeling. The analysis involved several key steps, including data preprocessing, feature selection, model selection, resampling (under sampling or oversampling), hyperparameter tuning, model evaluation, model implementation, and the interpretation of results.[8,16,17] Data preprocessing included the handling of missing values, the removal of duplicates, and normalization or standardization to ensure comparability across features. Ordinal scaling and one-hot encoding were used for categorical variables. The missing mechanism was first investigated when handling the missing data. Specifically, Little's MCAR test was performed to determine whether the missing values were missing completely at random.[25] The test showed that the missing data were missing completely at random; thus, the missing data were removed.

Feature selection was performed based on a feature correlation matrix. When the correlation matrix did not adequately show a strong association (correlation coefficient <0.3), features were selected using domain knowledge. A literature review was conducted to assess the association between the features and the outcome. Several ML algorithms were considered herein: support vector machines (SVM), logistic regression, random forest (RF), decision tree, and K-nearest neighbors (KNN). The models were chosen based on their suitability for the dataset and research objectives. To optimize the model performance, hyperparameter tuning was performed using grid search with cross-validation. The dataset was split into training and testing sets (70:30 split). The model performance was evaluated on the test set, with cross-validation employed to ensure the robustness of the results. Accuracy, recall positive, specificity positive, precision positive, F-1 score weight, and the area under the receiver operating characteristic curve (AUC-ROC) were used as performance metrics to identify the best-performing model.

The analysis was implemented using scikit-learn alongside supporting libraries such as pandas for data manipulation, NumPy for numerical computations, and matplotlib/seaborn for data visualization. Custom scripts and functions were developed to streamline the analysis and ensure reproducibility. The predictive performance of the selected models was analyzed, and its implications were interpreted in the context of the research question. To improve the predictive performance of the model, the classification threshold was adjusted from the standard 0.5 to a value that balances sensitivity and specificity. This adjustment, guided by Youden's Index, helped optimize the overall performance of the model.[26] Insights derived from feature importance and model outputs were integrated into the broader discussion of the findings. In addition, the SHapley Additive exPlanation (SHAP) method was applied to some data points to determine the contribution of each studied feature.

Results

All variables representing risk factors in the study population (n = 638) are provided in Table 1. Key variables included DM, hypertension, family history, smoking status, BMI, and the prevalence of PE (16.45%). Data imbalance is observed in most of the variables in the study population, which could introduce bias. Notably, DM (1.73%), hypertension (9.88%), and obesity (11.92%) have been identified as strong predictors in many studies.[4,5,6,8,13]

The data distribution indicated a substantial imbalance between the two groups, with 533 cases of no PE and 105 cases of PE. These results suggested the need for resampling during data analysis to mitigate potential bias and ensure robust model performance. Several ML algorithms were evaluated with and without resampling techniques (oversampling and under sampling) to identify the algorithm that best addresses the research objectives.

Table 1. Variable in the Study Population

Feature	No n (%)	Yes n (%)
Type 2 diabetes mellitus	627 (98.27)	11 (1.73)
Hypertension	575 (90.12)	63 (9.88)
Family history of diabetes mellitus	458 (71.78)	180 (28.22)
Family history of hypertension	351 (55.01)	287 (44.88)
Active Smoking	355 (55.64)	283 (44.35)
Primigravidity	399 (62.54)	239 (37.46)
Mean Arterial Pressure in the 1st trimester ≥90 mmHg	409 (64.11)	229 (35.89)
Body Mass Index underweight	351 (55.02)	287 (44.98)
Body Mass Index normal weight	533 (83.54)	105 (16.45)
Body Mass Index overweight	468 (73.35)	170 (26.65)
Body Mass Index obese	562 (88.08)	76 (11.92)
Preeclampsia	533 (83.54)	105 (16.45)

Table 2. Performance Metrics of the Models Without/with Resampling

2. a. Models Without Resampling						
MODEL	**Accuracy (%)**	**Recall Positive (%)**	**Specificity Positive (%)**	**Precision Positive (%)**	**F1-score Weight (%)**	**AUC**
RF	79.17	10.00	97.37	50.00	73.21	0.62
Logistic regression	79.17	0.00	100.00	0.00	69.96	0.49
SVM	79.17	0.00	100.00	0.00	69.96	0.59
Decision tree	79.17	0.00	100.00	0.00	69.96	0.55
KNN	78.65	12.50	96.05	45.45	73.50	0.57
2. b. Models with Oversampling						
MODEL	**Accuracy (%)**	**Recall Positive (%)**	**Specificity Positive (%)**	**Precision Positive (%)**	**F1-score Weight (%)**	**AUC**
RF	67.19	35.00	75.66	27.45	68.55	0.56
Logistic regression	63.02	52.50	65.79	28.77	66.17	0.66
SVM	48.44	85.00	38.82	26.77	51.53	0.66
Decision tree	65.63	20.00	77.63	19.05	65.93	0.48
KNN	54.17	27.50	61.18	15.71	57.91	0.36
2. c. Models with Under Sampling						
MODEL	**Accuracy (%)**	**Recall Positive (%)**	**Specificity Positive (%)**	**Precision Positive (%)**	**F1-score weight (%)**	**AUC**
Random forest	58.33	47.50	61.18	24.36	62.07	0.62
Logistic regression	63.02	55.00	65.13	29.33	66.24	0.65
SVM	70.31	35.00	79.61	31.11	70.94	0.68
Decision tree	53.13	80.00	46.05	28.07	56.85	0.65
KNN	60.94	47.50	64.47	26.03	64.26	0.57

Notes: AUC = area under the curve, RF = random forest, SVM =support vector machine, KNN = K-nearest neighbor

In the initial analysis conducted on the cleaned dataset without resampling, all models showed poor performance (sensitivity and specificity) in PE prediction. In addition, all models showed low discriminatory power equivalent to random guessing (AUC <0.5). In this analysis, RF and KNN showed better sensitivity (10.00% and 12.50%, respectively) and specificity (97.37% and 96.05%, respectively) than the other models (Table 2.a).

With oversampling, the RF classifier showed the highest accuracy (0.67) among the evaluated models (Table 2.b). This approach addressed some issues observed in the logistic regression model, particularly in classifying positive cases. Hyperparameter tuning was performed using HalvingGridSearchCV (Successive Halving Grid Search Cross-Validation) to optimize the model configuration. However, even after hyperparameter tuning, the RF classifier still showed limited sensitivity for positive cases and suboptimal overall performance, with an AUC of 0.56 and recall positive of 0.35

Under sampling was further employed to balance the class distribution and improve predictive performance. Specifically, under sampling was performed to reduce the dominance of the negative class and improve the detection of positive cases. With under sampling, SVM showed the best performance, achieving an accuracy of 70.31% (Table 2.c). The ROC curve for this SVM model exhibited the trade-off between sensitivity and specificity across various prediction thresholds. An AUC of 0.68 indicated that the model outperforms random guessing (AUC = 0.50); however, its overall performance was still suboptimal, as an ideal model would have an AUC close to 1.0.

The ROC curves and AUC values for the considered models are shown in Figure 2. The ROC curves showed the predictive performance of the five models (SVM, logistic regression, RF, decision tree, and KNN) in binary classification, with AUC values indicating predictive accuracy (compared to the diagonal line representing random guessing, AUC = 0.5). SVM showed the best predictive performance (AUC = 0.68), and KNN was the worst (AUC = 0.57).

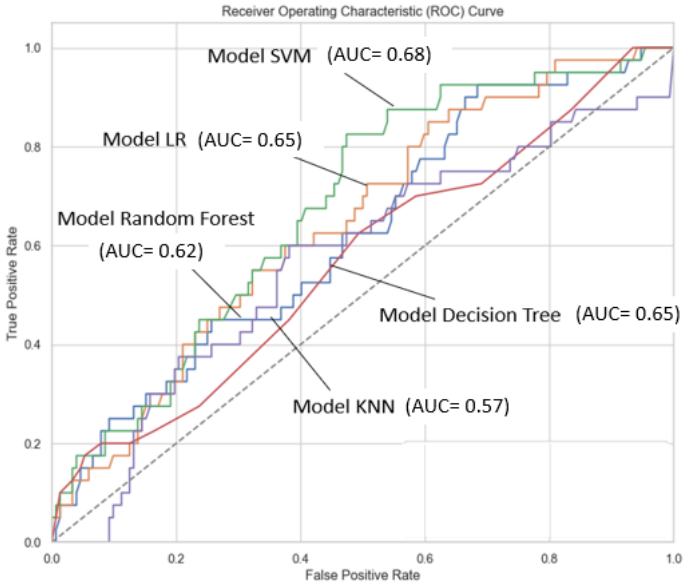

Figure 2. Comparison of Receiver Operating Characteristic Curve Among Different Algorithms
Notes: SVM = support vector machine, LR = logistic regression, KNN = K-nearest neighbor, AUC = area under the curve

Further analysis was conducted to improve the predictive performance of the SVM model. The SVM model, with an accuracy of 59.37%, showed a sensitivity of 67.5%, a specificity of 57.23%, and an AUC of 67%, indicating moderate discriminatory power compared to other algorithms (Table 3). A low precision (high number of false positives) indicated problems with the compensation data and the limitations of feature engineering.

Table 3. Performance Metrics of the Considered Models with Under Sampling and a Classification Threshold of 0.43

MODEL	Accuracy (%)	Recall Positive (%)	Specificity Positive (%)	Precision Positive (%)	AUC	Best YI
RF	48.96	75.00	42.00	25.42	0.62	0.17
Logistic regression	54.17	67.50	51.00	26.47	0.65	0.18
SVM*	59.37	67.50	57.23	29.34	0.67	0.24
Decision tree	53.13	80.00	46.05	28.07	0.65	0.26
KNN	53.64	62.50	51.31	25.25	0.56	0.13

Notes: AUC = area under the curve, YI = Youden's Index, RF = random forest, SVM = support vector machine, KNN = K-nearest neighbor
*SVM is the best-performing model on the employed dataset; furthermore, it performs better than the models from a systematic review by Ranjbar et al., who reported a recall of 0.420 and accuracy of 0.740 for RF, and a recall of 0.789 and precision of 0.447 for EGBM (Extreme gradient boosting model) using maternal characteristics similar to those employed herein and biochemical and biophysical markers.[16]

In addition, the SHAP analysis on 100 data points showed that mean arterial pressure in the first trimester has the greatest impact on outcomes, with smoking, history of hypertension and DM, and family history of hypertension and DM showing a lower impact. A case illustration was provided involving a 17 -17-year-old primigravida with a MAP of 92 mmHg and a BMI of 26. Overall, the subject had no documented history of hypertension or DM prior to pregnancy but had a family history of hypertension. The subject data were input into the best-performing classifier, the SVM model, with a sensitivity of 67.5%, a specificity of 57.23%, and a classification threshold of 0.43 (supported by Youden's Index of 0.24). The model predicted a 53.73% probability of developing PE (high-risk pregnancy).

Discussion

In this retrospective study, sparse multivariable models developed for predicting the probability of PE showed their ability to balance predictive performance with an acceptable rate of false positive predictions. Such models are crucial for enhancing the predictive capacity of existing PE screening programs outlined in the Maternal and Child Health (MCH) handbook. Although a systematic review has shown that adherence to the MCH handbook improves maternal service utilization, improved mitigation of complications such as PE could further improve outcomes.[27,28] A predictive model can assist doctors in PHC in identifying high-risk pregnant women and making informed decisions about providing preventive treatments for PE.

The analysis of various ML algorithms revealed key insights into their strengths and limitations in PE prediction. Logistic regression showed the best performance in the initial analysis on the cleaned dataset without resampling, achieving an accuracy of 67%. However, its discriminatory ability, as reflected by an AUC of 0.49, was suboptimal, indicating performance slightly worse than random guessing. This limitation highlighted the challenges of the use of traditional statistical models for datasets with considerable class imbalance, as reflected in most cases (533 out of 638) being classified as no PE.

To address data imbalance, random resampling was performed. With oversampling, the RF model showed the highest accuracy (67.9%). However, despite its improved accuracy, the model showed limited sensitivity, suggesting that oversampling alone does not fully address the issue of identifying positive cases. At the same time, undersampling was performed to reduce the dominance of the majority class. The SVM emerged as the best-performing model in this scenario, with an accuracy of 63% and an AUC of 0.68, indicating moderate discriminatory power. These results underscored the importance of considering various resampling techniques to enhance model performance.

The selection between oversampling and undersampling for addressing class imbalance depends on several factors, including the dataset size, class distribution, and the potential impact on model performance, as observed herein. Oversampling, which increases the representation of the minority class by duplicating existing samples or generating synthetic ones via simple random oversampling or other advanced techniques (e.g., systematic minority oversampling technique (SMOTE)), is generally used on small datasets.[29] In such cases, oversampling is preferred because it does not discard existing data, which might be valuable for training.

Undersampling reduces the representation of the majority class by randomly selecting its subset.[29] It is used on relatively large datasets or when the majority class is excessively overrepresented. Undersampling is also preferred when the majority class contains redundant or less informative data. A combination of oversampling and undersampling (e.g., Tomek Links or SMOTE+ENN) may also be used to effectively balance the dataset while minimizing the risk of overfitting or information loss. However, no strict rule guarantees success, so it is advisable to try all the above methods and evaluate model performance using appropriate metrics such as recall, specificity, and AUC-ROC.[29]

In addition to resampling, feature selection may be used to optimize the predictive performance. A prospective cohort study in Uganda stated that maternal characteristics such as history of PE, maternal age ≥35 years, nullity, BMI, diastolic blood pressure, and simple laboratory tests can predict PE in clinical settings with 77% accuracy.[30] A systematic study of 128 citations highlighted four ML-based studies based on maternal characteristics, medical history, obstetric history, and simple laboratory and ultrasound examination results, obtaining AUC values of 0.860–0.973.[31] The best-performing models in the above two studies included Elastic net, stochastic gradient boosting, extreme gradient boosting, and RF. These findings support the methodology of the present study, albeit with limited features.[31]

One of the most important findings of this study was the impact of threshold adjustment on the model performance. A reduction in the classification threshold from the default 0.5 to 0.43 improved the balance between sensitivity and specificity for the SVM model. This adjustment, guided by Youden's Index (0.24), allowed the SVM model to achieve a sensitivity of 67.5%, specificity of 57.23%, and precision of 29.34%. Although this adjustment increased the rate of false positives, it also enhanced the detection of high-risk pregnancies, which is critical in clinical settings where missing cases of PE can have severe consequences.

Threshold adjustment is a practical strategy for addressing the inherent trade-off between sensitivity and specificity. In PE prediction, high sensitivity is particularly valuable for ensuring early PE detection and timely intervention for at-risk pregnancies.[32] However, careful evaluation beyond sensitivity and specificity needs to be considered. The increased rate of false positives necessitates careful consideration of the burden on healthcare systems, including the cost and psychological impact of additional follow-up testing. A good threshold should reflect the clinical context, and additional adjustments should be considered to develop an optimal and valid prediction model.[32] In practice, context-specific and shared decision-making among clinicians and policymakers should be considered.[33]

Performance can vary based on the specific features used, the quality of data, and the chosen model. A systematic review found that highly accurate predictions may be made based on data from routine ANC checks.[34] The AUC-ROC values of such models range from 0.64 and 0.96, sensitivity from 29% to 100%, and specificity from 26% to 96%, which are similar to those obtained herein.[34]

Another systematic review showed robust predictive performance of various algorithms using similar sets of features. The most frequently used algorithms are RF, SVM, and neural networks.[30] Nevertheless, it should be emphasized that previous studies in the systematic review in which accuracy was above 90% suffered from several limitations.[30] A Stochastic gradient boosting (SGB) model achieved an accuracy of 0,97% with a lack of trimester data and a small number of PE incidents (474 out of 10.532 cases) which was also experienced by this study.[35]

Herein, typical secondary data analysis challenges were encountered, including missing values (584 entries) and duplicates (1,028 entries). The MCAR test indicated that the missing data were entirely random, necessitating the removal of these entries to ensure the integrity of the analysis. This resulted in a reduced dataset of 638 records, with an imbalance between the no PE (533 cases) and PE (105 cases) classes.

In a retrospective cohort study of 16,370 mothers who gave birth at Stanford, ML was used for the early prediction of PE using ML.[8] After cleaning, a dataset with 5,245 entries was obtained, among which only 561 were PE cases (10.7%). Despite the larger sample size, their predictive accuracy matches that of other studies, even though initial sample requirements were not specified. This mirrors the limitations of the present, suggesting that better data quality could improve performance.[31]

Class imbalance can cause a bias toward the majority class. Thus, both oversampling and under sampling were employed in this study. Oversampling improved accuracy but reduced the specificity of the RF model, whereas under sampling improved the sensitivity/specificity balance of the SVM model at the cost of dataset size. Therefore, a more advanced technique might be more appropriate to handle data imbalance and tiny data sets such as that used herein. This particular restriction may complicate the interpretation of the model outcomes. Class imbalance can be prevented using synthetic minority oversampling, particularly by handling the missing data based on the data distribution.[27] A previous study also addressed imbalance through oversampling, demonstrating its effectiveness alongside under sampling and cost-sensitive algorithms for rare medical outcomes.[36]

A detailed comparison of the performance metrics of different models under various resampling strategies provided valuable insights. Without resampling, logistic regression and SVM showed similar performance metrics, including low sensitivity. Oversampling improved the accuracy of RF but failed to substantially increase sensitivity, which is critical for identifying high-risk pregnancies.[31] With undersampling, the SVM model showed the highest AUC (0.68), making it the most balanced model in terms of overall predictive power. These findings underscored the importance of tailoring the resampling and modeling strategies to the specific requirements of the prediction task. For example, models with high sensitivity, such as SVM, are better suited for clinical applications where identifying positive cases is a priority, even at the cost of increased false positives. In contrast, models with higher specificity may be more appropriate in scenarios where minimizing unnecessary interventions is critical.[34]

The development of models for predicting PE is of great clinical importance, particularly in resource-constrained settings. These models may complement the existing screening protocols in the MCH handbook by providing additional risk-stratification capabilities. For instance, the SVM model with the optimized threshold could be utilized by PHC to facilitate the identification of high-risk pregnancies requiring preventive measures.

The implementation of such models in clinical practice can enable the early detection of at-risk pregnancies and, thereby, timely interventions, including the administration of low doses of aspirin and enhanced monitoring. However, the limitations of the models must also be considered, including their moderate discriminatory accuracy and potential false positive results, to prevent undue strain on healthcare infrastructure and unnecessary patient concern.

Although the developed models based on simple features derived from the MCH handbook showed decent predictive performance, feature selection and engineering could be further refined to enhance model performance. Although the SHAP analysis was employed as a promising method for feature interpretation, this study primarily focused on optimizing predictive performance. At the same time, the authors advise that future studies employ the features documented in the MCH handbook to preserve the simplicity and clinical applicability of the models.

This study has several limitations. First, reliance on secondary data restricted the inclusion of key predictors (e.g., biochemical markers and detailed clinical history), likely contributing to the moderate performance of the developed models. Second, substantial class imbalance necessitated resampling, which increased the risk of overfitting (oversampling) and reduced statistical power (undersampling). Third, the lack of external validation limited generalizability to other populations. Finally, the modest AUC scores and low statistical power (48.1% post-validation)

underscore the need for refinement before clinical implementation. Despite these limitations, the results indicated that PE can be predicted based on simple, primary care–compatible predictors. At the same time, further refinement of feature selection through advanced algorithms and external validation could enhance model performance.

Building on this study's findings, several future research directions can be proposed. First, improving the initial feature selection is critical. Although incorporating advanced predictors (biochemical or genetic markers) could enhance model performance, their implementation may be impractical for public health programs. Instead, a more systematic approach to the selection of simple features and reengineering could improve the predictive accuracy and align with findings from other studies.

Second, hybrid or ensemble methods (combining deep learning with SVM or RF) could show better forecasting accuracy and robustness. Third, prospective validation across diverse populations and clinical settings is essential for assessing the generalizability and practical utility of the developed models. Finally, the integration of these models into electronic medical record systems as decision-support tools could enable real-time risk assessments, enhancing the scalability and impact of PE screening programs.

The development of models for PE prediction is a critical step toward improving maternal and neonatal outcomes, particularly in low- and middle-income countries, where the burden of hypertensive disorders in pregnancy is disproportionately high. By enabling earlier identification of high-risk pregnancies, such models can improve the efficiency of resource allocation, reduce complications, and improve overall care delivery. Moreover, integrating ML models into maternal health research highlights the potential of data-driven approaches to address complex healthcare challenges. The increase in the amount of available data and the evolution of analytical techniques are expected to facilitate the development of robust, scalable, and clinically relevant models, driving further improvements in maternal health outcomes.

Conclusion

This study indicates the promising potential of sparse multivariable prediction models for PE prediction, thereby improving screening programs. Despite the challenges associated with data quality and class imbalance, the models developed, particularly SVM with threshold optimization, show promising performance with balanced sensitivity and specificity. However, additional refinement and validation are required to realize their potential for clinical application. Integrating these models into existing screening protocols can facilitate the detection and management of high-risk pregnancies, ultimately improving maternal and neonatal health outcomes.

Abbreviations

PE: preeclampsia; PHC: primary health care; ANC: antenatal care; BMI: body mass index; ML: machine learning, DM: diabetes mellitus; MAP: mean arterial pressure; AUC: area under the curve; MCAR: Missing Completely at Random; SVM: support vector machines; RF: random forest; KNN: K-nearest neighbors; AUC-ROC: area under the receiver operating characteristic curve; SHAP: SHapley Additive exPlanation; MCH: Maternal and Child Health;

Ethics Approval and Consent to Participate

Data was collected from the database of a previous study from hospital routine service data, with proper anonymization; thus, ethical approval was provided as a nonhuman research (no. 013-1/DIN/KEP.RSBK/LKBK/III/2024).

Competing Interest

All authors do not have any competing interest in the research.

Availability of Data and Materials

The data is available upon request to the corresponding author.

Authors' Contribution

DA conceived of the presented idea, developed the overall methods and concepts, and analysis, AAS and KNS provided expert guidance on the theory and evaluation of the computations and supervised the research, AAS, KNS, and DSN evaluated the main conceptual ideas and proof outline, thus contributed to the design and implementation of the research, to the analysis of the results and the writing of the manuscript, DA wrote the manuscript with support from AAS, KNS, DSN.

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Availability and Distribution of Stoma Bags for Colorectal Cancer Patients: A Case Study at National Referral and Private Hospitals

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Availability and Distribution of Stoma Bags for Colorectal Cancer Patients: A Case Study at National Referral and Private Hospitals

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Abstract

Stoma bags are essential for colorectal cancer (CRC) patients with stomas. However, access and affordability in Indonesia remain challenging as the National Health Insurance (NHI) does not fully cover these devices. This study aimed to describe the availability and distribution of stoma bags for patients with CRC in national referral and private hospitals, focusing on outpatient access. A qualitative case study was conducted through observations and in-depth interviews with four enterostomal therapy nurses and six patients across three national referral hospitals and one private hospital in the Jakarta Metropolitan Area, Indonesia. Notably, the availability of stoma bags was limited in both hospital types, especially for outpatients. Most patients faced financial barriers, as they had to purchase stoma bags independently at high prices because of limited hospital supply and lack of NHI coverage. Moreover, hospital policies restricted the number of bags distributed, worsening access issues. These challenges increase stoma-related complication risk and negatively affect patients' quality of life. Integrating stoma bags into NHI coverage, regulating prices, and improving distribution are recommended to reduce healthcare disparities and improve outcomes for CRC patients, aligning with Sustainable Development Goal 3.

Keywords: colorectal cancer, policy brief, stomas, stoma bag, sustainable development goals

Introduction

Colorectal cancer (CRC) is a chronic disease that has gained global attention. The projection is the increase in new cases, reaching 3.2 million and 1.6 million deaths by 2040, with most cases occurring in countries with high or extremely high Human Development Index. In Asia, the incidence of CRC has shown a significant increase, such as in Japan, South Korea, Singapore, Indonesia, and China, with some countries experiencing up to a 1.7-fold (73%) increase over about a decade.[1–3] In Indonesia, CRC cases are increasingly reported among younger populations, particularly in the age group of 30–39 years, as demonstrated by a cross-sectional study that used data from the Yogyakarta Population-Based Cancer Registry database for 1,295 CRC cases diagnosed between 2008 and 2019.[4] The increasing number of CRC cases has led to an increase in the prevalence of stomas.[5] In a systematic review of randomized controlled trials, CRC was the most common indication for stoma formation, regarded as the primary reason in 14 of 18 included studies conducted across Europe and Asia.[6] It was reported that 72.7% of stoma occurrences were due to cancer, with colostomy accounting for the highest proportion among these cases.[7]

The most common procedure performed in patients with CRC is stoma creation.[5,6] Stoma creation is a crucial life-saving procedure for patients who are unable to pass stool through the anus, one of the conditions caused by CRC.[8] Stoma patients require stoma bags to collect the stoma output (i.e., feces or urine). However, in Indonesia, the availability of stoma bags to meet the needs of stoma patients remains challenging. The issue is well-documented in recent study that

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Indonesian colostomy patients frequently face significant challenges in fulfilling self-care needs, with many resorting to improvising stoma bags from household materials because of limited access to appropriate commercial products.[9] Some patients reported making their own stoma bags using plastic and tape, highlighting the lack of affordable and suitable stoma appliances.

Stoma bags maintain the skin's health around the stoma and enable patients to carry out their daily activities as usual.[10] A key factor for effective self-management is the availability of stoma bags as a critical equipment resource, which enhances self-care, self-efficacy, the ability to replace bags, self-management behavior, quality of life, attitude toward self-care, self-care behaviors, and stoma proficiency.[11,12] It is associated with Sustainable Development Goal (SDG) 3, which emphasizes the importance of access to essential healthcare services and reducing mortality from noncommunicable diseases.

Common complaints include insufficient stoma bags at affordable prices. The fact that most stoma patients come from lower socioeconomic backgrounds exacerbates this issue.[13,14] Access to high-quality stoma bags is variable, particularly for patients living in remote areas or low- and middle-income countries. Limited availability and high costs often force patients to reuse single-use stoma products or create improvised devices from materials such as plastic bags, bottle caps, and tape. These adaptations can compromise appliance performance and increase risks of skin complications, infection, and reduced quality of life.[9,15] An ideal stoma bag should be able to accommodate stoma output (i.e., feces, urine, and gas), protect the stoma and surrounding skin (skin-friendly), reduce or eliminate odors, and boost patient confidence and quality of life and be easy to use, durable, affordable, and widely available.[16–19] However, patients covered by National Health Insurance (NHI), in this matter, *Badan Penyelenggara Jaminan Sosial* (BPJS) Healthcare Security, often use stoma bags that do not meet these criteria, including repurposed large plastic bags or medication pouches secured with double-sided tape.

Based on Indonesian Ministry of Health Regulation No. 28 of 2014 and No. 3 of 2023 and BPJS Regulation No. 1 of 2014 on Health Service Tariff Standards, this problem occurs because of regulatory limitations regarding guaranteeing stoma bags as a routinely covered medical device.[20-22] Although the Indonesian Ministry of Health Regulation No. 28 of 2014 and BPJS Regulation No. 1 of 2014 state that participants are entitled to medical devices and consumable medical supplies as required, the appendices and list of covered medical devices do not specifically mention stoma bags as a routinely covered item. Furthermore, the Indonesian Ministry of Health Regulation No. 3 of 2023, which regulates Indonesian Case Base Groups (INA-CBGs) and capitation tariffs for health facilities, does not include a code or claim component for stoma bags as a daily requirement for outpatients. Thus, BPJS Healthcare Security only covers consumable medical devices during inpatient care. This condition often leads to ostomates purchasing stoma bags independently, outside of the benefits covered by BPJS Healthcare Security.

Therefore, this study aimed to examine the availability and distribution of stoma bags for patients with CRC in national referral and private hospitals in Indonesia. It assessed and compared access across hospital types, identified supply gaps for outpatients, and explored factors influencing distribution. This study intended to inform health policy, particularly regarding the inclusion of stoma bags in the essential medical supply list of BPJS Healthcare Security and the improvement of distribution systems to ensure equitable access for all ostomates. The significance of this study is its focus on institutional disparities in stoma bag provision, an area largely overlooked in existing literature which predominantly addresses clinical or psychosocial outcomes. This study aimed to fill a critical gap in the literature and support evidence-based policy improvements for equitable stoma bag provision. Additionally, ensuring the availability of sufficient and appropriate stoma bags to improve the quality of life of ostomates should be a key research priority.[16]

Method

This qualitative case study was conducted as part of the first author's dissertation to explore the availability, distribution, and regulation of stoma bag provision for patients with CRC in Indonesian hospitals. Data were collected through interviews and observations at three national referral hospitals (Hospitals A, B, and C), one private hospital (Hospital D), and an ostomate community in the Jakarta Metropolitan Area, which were selected for their role in caring for CRC patients. This study involved four enterostomal therapy (ET) nurses and six ostomates to note diverse institutional practices and patient experiences.

The inclusion criteria for nurses were certified ET nurses with at least 1 year of experience in stoma care, a Bachelor's degree in Nursing (S.Kep), and professional certification (Ners), and currently employed in referral hospitals in the Jakarta Metropolitan Area. Patients were included if they were ≥18 years old, diagnosed with CRC, living with a stoma for at least

3 months, physically stable, communicative in Indonesian, and residing in the Jakarta Metropolitan Area. Hospitalized patients were excluded.

Participants were identified through the Indonesian Ostomate Community and the Indonesian Wound, Ostomy, and Continence Nurse Association. Data were collected face-to-face from July to November 2024, including interviews with four ET nurses and observations within the ostomate community. Interviews lasted approximately 60 minutes and were conducted in Indonesian language and audio-recorded. Field notes were taken during and after each session. Observations included documentation of modified stoma bags, types of bags used (hospital-provided or self-purchased), and stoma care issues related to bag quality, functionality, and fit. The authors maintained a nondisruptive presence during the observations and ensured confidentiality by anonymizing data and securely storing identifiable information.

Interview recordings were transcribed and analyzed using thematic analysis with NVivo (licensed under QSR International, Melbourne, Victoria, Australia), a qualitative data analysis software. Coding was performed by two authors, followed by theme development through semantic grouping. Themes were refined by team consensus, and data collection was continued until saturation. This study adhered to the Consolidated Criteria for Reporting Qualitative Research.[23] Triangulation with patients, relevant policy documents, and prior studies were employed to confirm the validity of the findings.

Results

Table 1 presents the demographic and occupational characteristics of the study participants. The participants consisted of health workers and ostomate patients with diverse backgrounds. Table 2 presents the condition of each hospital's availability of stoma bags, highlighting the consistency of supply, types, procurement methods, and access barriers.

Table 1. Characteristics of Participants

Initial	Age (years)	Sex	Main Occupation	Education	Status
Ev	48	Female	Civil servant	Bachelor's degree	Nurse
It	45	Female	Civil servant	Bachelor's degree	Nurse
Te	45	Female	Civil servant	Bachelor's degree	Nurse
Ri	31	Female	Private employee	Bachelor's degree	Nurse
M	62	Female	Unemployed	High school	Ostomate patient
Si	61	Female	Unemployed	High school	Ostomate patient
Da	57	Male	Entrepreneur	High school	Ostomate patient
Ys	54	Male	Entrepreneur	High school	Ostomate patient
Rk	42	Male	Civil servant	Bachelor's degree	Ostomate patient
Hi	59	Male	Civil servant	Bachelor's degree	Ostomate patient

Figure 1. Inadequate Stoma Bags Commonly Used by Ostomates in Indonesia
(All photos used in this article are part of the nurse's personal documentation, taken with the patient's permission)

Table 2. Stoma Bag Availability in National Referral and Private Hospitals

Hospitals	Description of Availability and Distribution of Stoma Bags
A	Patients with CRC undergoing stoma treatment were typically hospitalized for up to 2 weeks, especially in cases involving complications. During this period, the use of stoma bags was strictly regulated, with one bag typically used per week and replaced by nurses, indicating limited patient independence in stoma care. Hospitals provide one-piece pouches because two-piece types were not yet available. Upon discharge, particularly for patients covered by BPJS Healthcare Security, only one stoma bag was provided due to cost and quality control policies. Limited BPJS Healthcare Security claims, combined with strict cost management, means patients must purchase additional bags independently, often online, due to hospital stock shortages. While trained patients may manage with four bags per month, untrained individuals often require more bags. For financially constrained patients, this condition caused a significant burden.
B	Patients with a stoma due to CRC undergoing surgery were usually hospitalized for 5–6 days, with or without complications. On days 1 and 2, patients underwent colonic preparation, followed by surgery on day 3. After surgery, patients typically experienced general improvement by day 4 and began mobilization on day 5 before being discharged on day 6. During hospitalization, the stoma bag was changed every 7 days unless it needed to be replaced sooner. At discharge, patients were usually given five stoma bags; although more could be ordered, they were given owing to the BPJS Healthcare Security patient limit. This policy applies even if the patient requests additional bags during hospitalization. The pouch used was the one-piece type. After surgery, if the patient returns for control or chemotherapy, they are also provided with five stoma bags. Normally, five pouches per month are considered sufficient if there are no complications. However, patients with ileostomies may require more bags due to higher fluid production, necessitating more frequent changes or emptying to prevent leakage. This hospital policy is designed to ensure that patients have sufficient supplies while considering cost and resource management.
C	CRC patients with stoma were typically hospitalized for 8–10 days after surgery if there were no complications. The first 3 days were spent fasting, followed by a liquid diet and further monitoring before discharge. If complications arise, the hospital stay may be extended to 3 weeks or 1 month. During hospitalization, stoma bags were usually changed every 5–6 days, depending on the condition of the wound and bag. Patients could request replacement bags from the pharmacy as needed. One-piece pouches were used. Upon discharge, doctors prescribed three stoma bags. Each month, colostomy patients typically require 4–5 bags, whereas ileostomy patients may need more due to higher fluid output, especially during the first week. Delayed emptying increases the risk of leakage and skin problems such as dermatitis. During follow-up, patients typically receive two bags and are advised to request additional supplies, such as antibacterial cleaning cloths, sodium chloride (NaCl), and gauze. However, these supplies may not always be in stock.
D	Patients with a stoma due to CRC who underwent surgery were usually hospitalized for a maximum of 5 days if there were no complications. Treatment duration depends on the patient's physical condition. If complications arise, the treatment duration will be adjusted according to each patient's specific condition. This hospital does not accept BPJS Healthcare Security patients; therefore, patients must purchase stoma bags without government subsidies.

Notes: Hospitals A, B, and C are national referral hospitals, and Hospital D is a private hospital.

Table 3 presents qualitative insights from both nurses and ostomate patients regarding the access, usage, and procurement of stoma bags in the context of Indonesia's healthcare system. The nurse's perspective highlights institutional policies, cost-control measures, and the process of obtaining supplies covered by BPJS Healthcare Security, including exceptions for financially vulnerable patients. In contrast, the patient's account highlights the practical challenges of maintaining adequate supplies, the role of out-of-pocket expenses, and the reliance on family support for procuring additional stoma bags. Together, these perspectives provide a comprehensive view of the administrative and personal realities surrounding stoma bag provision and access.

Private hospitals (Hospital D) did not accept BPJS Healthcare Security; therefore, patients must buy stoma bags at their own expense without subsidies. In contrast, national referral hospitals (Hospitals A, B, and C) limit patients to five bags at discharge, regardless of the number of bags ordered. Although nurses may provide additional bags during treatment, the total allowed at discharge remains fixed. During follow-up, patients can request stoma bags and receive three from the hospital pharmacy; however, the number often proves insufficient. Outside the hospital, patients manage their stoma care by purchasing supplies online and relying on support from family and the community, such as the Indonesian Cancer Foundation and the Indonesia Ostomate Community.

Due to shortages, some patients resort to improvised solutions, such as using plastic or requesting help from relatives during times of financial hardship. These coping strategies suggested limited institutional support and the need for patients to find their solutions. Nurses should remind patients to request necessary items during follow-up visits due to limited supply. The restrictive supply system and lengthy approval process highlight the gap between current practices in Indonesia and international standards for ostomy care. Nurses and patients were often forced to find workarounds, including negotiating for more supplies and correcting prescription errors, to ensure adequate care.

Table 3. Stoma Bag Provision Practices in National Referral Hospitals: Nurses' and Patients' Perspectives

Participant	Information
Hospital A nurse (Ev)	*"Yes, because of the hospital's policy, everything is calculated since we use quite expensive products. For surgical patients, the bag is immediately applied post-operation. That counts as one. Then, for replacements, it is aimed to last one week per bag because otherwise, the request for additional bags would have to go through the management process. This process can take 2 to 3 days, as it is calculated based on the surgery costs, total billing, and the BPJS Healthcare Security claim amount. Therefore, it is part of cost control and quality control unless we* (nurses) *argue, for example, that the patient is from the PBI* (subsidized group) *and is financially incapable. That is one of the possibilities where exceptions might be made. However, having a stock of more than four bags at home is not feasible because any additional claim beyond the BPJS Healthcare Security coverage would be outside the scope of living expenses."*
Hospital B nurse (It)	*"When the patient is discharged, they are prescribed five bags....we* (nurses) *only get five if we order 10 bags... Even if we request more, they will always receive five bags for discharge....when they* (the patient) *are discharged, they still receive five bags. The patient can receive more than five bags, even up to ten, depending on their needs and resourcefulness* (during hospitalization)*....patients are usually given five bags during each treatment session."*
Hospital C nurse (Te)	*"Recently, patients are given two bags during follow-up appointments... perhaps as a cost-saving measure. Previously, it was three bags. For instance, if the patient comes for a follow-up every two weeks, they used to get three bags, but now they only get two. That is why I always remind patients during their follow-ups, 'Sir, do not forget to ask for stoma bags, antibacterial cleaning cloths, NaCl, and gauze, if available because you can request these from the clinic, even if you do not get everything you need.'"*
Hospital D nurse (Ri)	*"*(Patient is discharged) *It depends... it depends on their physical condition. If there are no complications,* (recovery) *usually five days at the most. There are no BPJS* (patients) here*. We do not have any issues with the stoma bag."*
Ostomate patient (M)	*"Every time I go for a follow-up at the surgical clinic, I get three bags... The rest, I have to buy. Sometimes directly from the vendor, sometimes online. If my follow-up is only once a month, the bags from the hospital just are not enough. I have to change the bag every three to four days..."*
Ostomate patient (Si)	*"We can still buy the bags ourselves, and during follow-up consultations at the hospital, they still give us three. My youngest child usually orders the extra stoma bags online—and he pays for them too... We buy the same type as the one from the hospital* (one-piece)*. What matters most is that I always have bags available. When I am down to three, I tell my child, 'Please, I only have three left.' I spend around IDR 400,000 per month just to buy stoma bags."*
Ostomate patient (Da)	*"I bought stoma bags at YKI* (Indonesian Cancer Foundation) *Lebak Bulus... It was one hundred and ten* (IDR 110,000)*. One hundred for eight* (bags)*, ten thousand for the delivery cost, so one hundred and ten (thousand) for eight (bags), already arrived at home."*
Ostomate patient (Ys)	*"At first, when I was in a pinch, I made the stoma bag myself. I once used plastic like that. We usually ask our child for the bag. Just like the bag from KOIN* (Indonesian Ostomate Community)*, something like that. When I do not have any bags left, and money is also tight, that is what makes me stressed sometimes. You know, we usually ask our child for the bag, but it is not like we can keep asking all the time... the price is quite high, too. When I am down to just one bag and have no money, oh no... it really brings me down sometimes. I think, 'Why was I given this kind of life?'"*
Ostomate patient (Rk)	*"It is not that the cheaper ones do not suit my skin, but the adhesive just does not stick at all to my belly, which has always been kind of big. There is one that is the same as the one given by the wound care clinic, and that is the one that suits me. First, the adhesive does not cause skin irritation, and second, it is pretty strong. So, anything below the standard of what the clinic gives does not work for me. The adhesive keeps coming off; it comes off easily... I only use the one-piece* (type)*. I have never tried the two-piece either.* (To get stoma supplies besides what has given at the hospital during check-ups)*, I just buy them. What I need is just the bag. I buy it online."*
Ostomate patient (Hi)	*"When I go for a check-up, I can ask the doctor and get some from the hospital... From the hospital pharmacy, I get three bags.* (If the bags are not enough) *I buy them online... I order six bags online. Relying on the hospital alone is not enough."*

Notes: Hospitals A, B, and C are national referral hospitals, and Hospital D is a private hospital.

Discussion

Stoma bag provision faces challenges in meeting postoperative patient needs, as evidenced by a case study at three national referral hospitals and one private hospital in the Jakarta Metropolitan Area, Indonesia. During hospitalization, patients were typically allocated only three stoma bags, which were used for 5–10 days. Outpatient facilities generally provide only 1–5 bags when patients visit or leave. This situation is more complicated for ileostomy patients, whose stoma output is primarily liquid, requiring more frequent bag changes.[24] Furthermore, stoma bags were unavailable in primary health care as they are not on the procurement lists. Consequently, patients relied on bags provided by hospitals or purchased them independently online or from large pharmacies.

The choice and frequency of stoma bag use depend on the type of stoma and the individual's specific needs. For example, most patients with a colostomy use 30–90 closed stoma bags per month, changing the bag 1–3 times daily, whereas those with an ileostomy use 15–30 drainable bags per month, changing the bag every 1–3 days.[25] Moreover, the United Ostomy Associations of America (UOAA) guide recommends establishing a regular schedule for pouch changes, typically every 3–5 days, and emphasizes the importance of changing the pouch before leaks or skin irritation occur.[26] The appropriate use of stoma bags is crucial for maintaining hygiene and comfort, as well as for protecting the skin, enabling individuals to live active and confident lives.[26]

Stoma bags are critical for maintaining the health and quality of life of ostomates. However, current Indonesian NHI regulations do not address the long-term needs of these patients. A review of the Indonesian Ministry of Health Regulation No. 28 of 2014 and No. 3 of 2023, as well as the BPJS Regulation No. 1 of 2014, identified several regulatory limitations.[20-22] Although the Indonesian Ministry of Health Regulation No. 28 of 2014 and BPJS Regulation No. 1 of 2014 recognize the right of patients to receive medical devices and consumable supplies, their annexes do not include stoma bags as items covered on a routine basis. Coverage for consumable supplies is restricted to inpatient use within healthcare facilities and does not extend to the daily requirements of outpatients. Additionally, The Indonesian Ministry of Health No. 3 of 2023,

which regulates the standard tariffs for services under the national insurance scheme, does not assign a specific code or funding component for stoma bags as recurring outpatient needs. This condition prevents BPJS Healthcare Security from fulfilling the real and ongoing requirements of ostomates. Therefore, many patients purchase stoma bags on their own. This situation often causes financial strain and leads to inconsistent or inadequate stoma care.

Stoma bag prices vary widely depending on the model or brand, with the lowest price ranging from USD 1.8 to USD 4.1 (approximately USD 1 = IDR 16,300) per bag online. This out-of-pocket economic burden is significant, especially for patients who require multiple bags each month and is related to SDG 1, which aims to end poverty in all forms by reducing out-of-pocket healthcare expenses. Therefore, addressing this regulatory and economic gap is critical for improving health outcomes for ostomates and advancing national and global commitments to poverty reduction and universal health coverage.

According to current hospital policy, postsurgical patients are initially provided with one stoma bag, and replacements are expected to last approximately one week. Additional requests for bags undergo a lengthy approval process, often taking 2–3 days. This strict distribution policy is implemented as part of the hospital's cost and quality control measures, with exceptions made for financially disadvantaged patients enrolled in the subsidized group. Stocking more than four bags at home is discouraged owing to limitations imposed by BPJS Healthcare Security claims regulations. These constraints are consistent with national policies, as stoma bags are not listed as routinely covered medical devices for outpatients under the Indonesian Ministry of Health No. 28 of 2014 and No. 3 of 2023, and BPJS Regulation No. 1 of 2014, which primarily cover consumable medical supplies for inpatient care and do not allocate specific funding or reimbursement codes for ongoing outpatient needs.[20,21] In contrast, international guidelines such as those from UOAA and Crohn's & Colitis UK recommend that ostomates change their stoma bags every 3–7 days, with many requiring 15–30 bags per month, depending on the stoma type and appliance used.[25,26]

Recent changes in hospital policies regarding stoma bag distribution have resulted in patients receiving fewer bags during follow-up visits. Nurses reported that patients were previously allowed to receive three bags but are now limited to two bags per visit. This policy shift is largely due to regulatory and reimbursement constraints, which do not include stoma bags as routinely covered medical devices for outpatients.[20-22] These regulations limit the provision of consumable medical supplies to inpatient care and do not allocate specific funding or reimbursement codes for stoma bags, which are considered an ongoing outpatient need.[20-22] Hence, hospitals restrict the number of bags distributed to each patient to remain compliant with BPJS Healthcare Security claims and budget limitations. Consequently, nurses now actively remind patients to request additional supplies—such as stoma bags, Killbak, NaCl, and gauze—during follow-up appointments to help them manage their needs despite policy constraints.

Moreover, the lack of information and support regarding the proper use of stoma bags exacerbates availability issues. Several patients struggle with self-care after surgery, leading to complications such as skin irritation, infections, and bag leakage.[27] These directly impact patients and their families' physical, psychological, social, and adaptive coping dimensions.[28] ET nurses play a crucial role by providing structured counseling as an innovative solution.[29] A previous study concluded that collaboration among families, communities, and nurses provides comprehensive support.[30] Unfortunately, the number of certified nurses in health facilities is limited. Improving healthcare education and training is critical for achieving SDG 4, which aims to ensure inclusive and equitable education and promote lifelong learning opportunities.

This issue has worsened due to the lack of a national database that records stoma patients with or without complications. Such data are crucial for supporting better healthcare planning and policy development. Imported stoma bags are necessary because no Indonesian pharmaceutical companies produce them, which results in higher and less affordable prices. This condition significantly impacts patients with stoma complications who require long-term care and incur higher costs. It strains the national health insurance system and diminishes patients' physical and mental well-being.

In Indonesia, a holistic strategy is warranted to improve the availability and distribution of stoma bags for CRC patients. Integrating stoma bags into BPJS Healthcare Security coverage would reduce financial burdens and ensure consistent access. Regulating prices and providing targeted subsidies can increase affordability, especially for low-income groups. Equitable access across all regions, including remote and underserved areas, is critical to prevent disparities. Supporting the local production of affordable, high-quality stoma bags can reduce dependence on imports and promote domestic innovation. Furthermore, research on actual demand and the development of a national ostomate database would strengthen policy, procurement, and clinical planning. These strategies can advance a more equitable and sustainable ostomy care system.

This study provided new insights by comparing the availability and distribution of stoma bags in public and private hospitals, highlighting disparities with significant policy implications. Moreover, it addressed a significant gap in the literature, particularly in the context of low- and middle-income countries. However, limitations included the case study design, a limited sample size, and reliance on self-reported data, which may affect the generalizability and accuracy of the findings. Additionally, this study did not capture temporal changes or broader socioeconomic influences. Despite these constraints, the findings provided valuable evidence to inform policies and guide future efforts aimed at improving access to essential ostomy care.

Conclusion

The availability and distribution of stoma bags for CRC patients remain limited in national referral and private hospitals, particularly for outpatient care. Inequities in access, inconsistent supply, and financial barriers continue to impact the quality of life for ostomates. Therefore, it is recommended that stoma bags be integrated into BPJS Healthcare Security coverage, with pricing and distribution better regulated and efforts made to ensure equitable access, particularly for outpatients and those residing in remote areas. Moreover, in Indonesia, strengthening local production and enhancing healthcare provider training is crucial to support sustainable and patient-centered ostomy care.

Abbreviations

CRC: colorectal cancer; SDG: Sustainable Development Goal; NHI: National Health Insurance; BPJS: *Badan Penyelenggara Jaminan Sosial;* ET: enterostomal therapy; NaCl: sodium chloride; UOAA: United Ostomy Associations of America.

Ethics Approval and Consent to Participate

The ethics committee granted ethical clearance under the Faculty of Nursing, Universitas Indonesia, with the reference number KET-171/UN2.F12.D1.2.1/PPM.00.02/2024.

Competing Interest

The authors have no conflict of interest regarding this article.

Availability of Data and Materials

The authors have not made the detailed research data available, but interested parties can request it from the corresponding author upon reasonable inquiry.

Authors' Contribution

RA and H designed the study and analyzed the data. RA, TJML, DD, EM, and SW composed the discussion. RA, DD, and SW drafted the manuscript. TJML, EM, and AYSH reviewed the manuscript.

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Kesmas

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Development of Audiovisual Media for Reproductive Health Education for Parents of Adolescents

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Development of Audiovisual Media for Reproductive Health Education for Parents of Adolescents

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Abstract

Parents are the primary source of information for adolescents, but many parents lack an understanding of health materials. For knowledge to be increased, health media, one of which is audiovisual media, are desirable. This study aimed to develop audiovisual media on adolescents' reproductive health. Media development utilized the analyze, design, develop, implement, and evaluate (ADDIE) model. The respondents in this study were parents of adolescents aged 10–14 years, comprising 10 parents in the small group evaluation, 20 in the field evaluation, and 10 in the implementation stage. The effectiveness of the media was tested through pretests and posttests. Using a questionnaire tested for validity and reliability, the data were collected. The effectiveness of the media was analyzed using N-gain. The results revealed that the seven audiovisual media were suitable for use. At the implementation stage, the N-gain value was 0.55, indicating that the video effectively increased parents' knowledge of reproductive health. Developing audiovisual media on reproductive health is effective for parents. To ensure parents truly grasp reproductive health information, health institutions should consider creating interactive audiovisual resources. This format would make the material more accessible and comprehensible.

Keywords: adolescent, audiovisual, parents, reproductive health

Introduction

Globally, the problem of adolescent reproductive health remains a stark concern, which is demonstrated by one of the Sustainable Development Goals (Goal 5), that is, gender equality and empowerment of women and adolescents. In Indonesia, one in four women aged 20–24 years were married before they turned 18.[1] Marriage at a young age can occur because of a lack of knowledge among adolescents regarding reproductive health.[1] In Indonesia, adolescents have less knowledge when it comes to reproductive health, such as puberty (61% of females; 55% of males) and efforts to prevent the transmission of human immunodeficiency virus (HIV) (26% of females and 36% of males).[1]

There remain adolescents who do not know that they can get pregnant after one sexual intercourse. Their ignorance indicates that 2% of female adolescents and 8% of male adolescents have engaged in premarital sexual activities.[2] Survey results in Indonesia show that 28% of female adolescents had their first period at 13, and 27% of male adolescents had their first wet dream at 14.[2] The age of first sexual intercourse in male and female adolescents is mostly 17 years (19%). There are already 11-year-old male adolescents who have engaged in premarital sex.[2,3] Hence, reproductive health education must be provided to adolescents from an early age, such as before puberty.[4]

The impact of premarital sexual behavior on adolescents caused 3.88% of Indonesian adolescents aged 15–19 years to be infected with HIV in 2022 and increased to 5.53% for the same age group in 2023.[5] Another impact is that 16.4% of female adolescents in Indonesia aged 15–19 years experience unwanted pregnancies.[2] Meanwhile, in Central Java Province, HIV cases, with an age range of 15–19 years, were 6.84% in male adolescents and 2.86% in female ones.[6] Surakarta is the second-ranked city in Central Java Province with new People Living with HIV (PLHIV) cases (6.88%, 2023).[7] Pajang Primary Health Care in Surakarta reported 0.02% cases of unwanted pregnancies in 2021 and are expected

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to increase up to 0.416% by 2023.[8,9] In 2023, in primary health care (PHC), 0.083% of adolescents had premarital sex, and 0.166% of adolescents under 20 years gave birth.[9] Between January and September 2024, PHC accounted for the third-highest percentage (0.083%) of adolescents giving birth.[10]

The adolescent groups are categorized into three age ranges: early (10–14 years), middle (15–17 years), and late (18–19 years).[11] Early adolescents are a vulnerable age group and must be educated about the prevention of reproductive health problems, including premarital sexual behavior, unwanted pregnancy, and HIV/AIDS.[1] Prevention efforts must be carried out before 15–19 years because this age group has the fourth highest number of HIV cases after ages 25–49, 20–24, and ≥50 years.[5] Vulnerability in adolescents takes place because of a lack of knowledge about reproductive health.[1] Therefore, adolescents' knowledge about reproductive health should be increased.[1]

Parents are one source of reproductive health information for adolescents. In Indonesia, 53% of adolescents discuss reproductive health with their mothers, and some discuss it with their fathers (4% of females and 8% of males).[2] A study in Surabaya and Surakarta Cities, Indonesia, showed that reproductive health communication between parents and adolescents can increase adolescents' knowledge, attitudes, and intentions regarding reproductive health.[12,13] Parents have an essential role in preventing risky sexual behavior in adolescents, such as by providing reproductive health information to adolescents.[14] A study conducted in Bandung indicated that effective parental reproductive health education for adolescents is associated with a reduced risk of their engaging in risky sexual behavior.[15]

A study in Surakarta City found that a considerable number of parents (52.67%) have not provided reproductive health education, primarily because of a lack of knowledge.[14] A study in Nigeria implies that parents are to provide reproductive health education.[16] Another study in Surakarta City revealed that parents' limited knowledge of reproductive health prevented them from answering their adolescents' questions. Consequently, parents in this study primarily discussed menstruation, given their lack of information on other reproductive health topics.[17] Supposed reproductive health communication between parents and adolescents is rarely carried out, which can negatively impact the trust of adolescents in their parents. Adolescents may assume that their parents do not know about reproductive health, so they look for other sources of information that may not necessarily be true.[18]

Parents need media to increase their knowledge about adolescents' reproductive health. The current media available are in the form of modules intended to enhance adolescents' knowledge about reproductive health issued by the Indonesian Government. Out-of-school adolescents and school teachers are the target audience.[19] However, there remains a lack of media that can assist in increasing parents' knowledge of reproductive health. Pocketbooks are the existing educational media for adolescent reproductive health, accessible to parents, which are issued by NGOs dedicated to caring for adolescents and NGOs working to fulfill their sexual and reproductive health rights.[20]

To help parents understand reproductive health material, audiovisual media are essential. A study in the United States reported that parents consider videos as the appropriate form of media for providing reproductive health information.[21] Moreover, parents trust the information they acquire from health workers in PHC.[21] If reproductive health information is presented to parents through media featuring liked and trusted personalities, it could significantly enhance understanding. In such a scenario, parents would likely engage more deeply with the content, consequently enhancing their knowledge.[22]

Increased parental knowledge can enhance parents' confidence in providing reproductive health information to their adolescents, thereby facilitating effective communication about reproductive health between adolescents and their parents.[17] This communication helps enhance the knowledge of adolescents about reproductive health, enabling them to avoid premarital sexual behavior and other HIV-risk activities such as drug use or having multiple partners.[23] Moreover, reproductive health communication from parents can increase adolescent literacy on reproductive health.[24]

Reproductive health education media is essential for parents to enhance their knowledge of adolescent reproductive health and encourage them to provide this information to their adolescents.[25] A study in the Special Region of Yogyakarta Province supports the idea that education can increase mothers' knowledge about reproductive health.[22] Longitudinal research in Tanzania on adolescents who received reproductive health education has not been successful in improving attitudes and behaviors related to reproductive health; hence, parents must be involved in educating adolescents.[26] Other studies to increase parental knowledge remain rare; existing research typically uses applications and training.[27] Another study focused on providing information and motivation directly to adolescent guardians without using media.[28] Among the forms of media, film was the predominant method previously used to convey adolescent reproductive health

information to parents.[29] Some initiatives leverage the internet to provide mothers with interactive reproductive health content, increasing their knowledge.[22] This study aimed to develop audiovisual media that involves health workers in PHC and experts in the video. A systematic review found that videos have the potential to promote health.[30] The audiovisuals developed are packaged as video podcasts because, according to a study in East Java Province, podcasts are an innovative medium that can reach diverse target audiences.[31]

Method

This research and development study was conducted in the working area of Pajang PHC of Surakarta City, Central Java Province, Indonesia, from July to August 2024. The respondents of this study were parents of adolescents aged 10–14 years. Using the analyze, design, develop, implement, and evaluate (ADDIE) model, the development of audiovisual media in this study was conducted.

The analysis stage was conducted qualitatively over 1 week, including a focus group discussion (FGD) with 30 parents of adolescents in the working area of Pajang PHC. The instrument employed was the FGD guidelines developed by the authors, which served as a reference to explore parents' thoughts on adolescent reproductive health education, materials, preferred media, how to package the media, and who parents trust to provide them with adolescent reproductive health information.

The product design stage was conducted over 1 week, involving interviews with village midwives, PHC officers, parents of adolescents, health promoters, and media experts, using pre-established interview guidelines. At this stage, indicators of success include the existence of a podcast name, a podcast scenario, a material title, and a resource person. Product development involved producing audiovisual media packaged in the form of a podcast (completed within one month). The output was a seven-video comprehensive reproductive health information draft with the following description.

Table 1. Video Description

Video	Theme	Speaker
A	Values, self-concept, and self-limitations related to ASRH	Psychologist
B	Limits on relationships with the opposite sex among adolescents	Expert in the field of religion
C	Adolescent development	The head of the PHC
D	Reproductive health problems in adolescents	Director of the Indonesian Planned Parenthood Association of the Central Java Province
E	Gender and violence prevention	The chairman of the board of the *Kepedulian untuk Kakak* (KAKAK) Foundation
F	The role of information and communication technology in ASRH	Health Promotion Officer
G	Youth care, support, and health services	Village midwife

Notes: ASRH = adolescent sexual and reproductive health, PHC = primary health care

The development stage consisted of three stages: media validation, a small-group evaluation, and a field evaluation. This stage was conducted in Setabelan PHC because it has the same adolescent sexual and reproductive health (ASRH) characteristics as Pajang PHC. Thus, before entering the implementation stage at Pajang PHC, the development stage was conducted in a PHC with the same ASRH characteristics. The first stage was media evaluation by media and material experts. Both experts held qualifications as practitioners in health promotion and possessed academic credentials in reproductive health. The authors revised the media (seven podcast videos) according to the experts' input. The media were then tested in the second stage, a small-group evaluation involving 10 parents selected through purposive sampling with the following inclusion criteria: parents with adolescents aged 10–14 years who use gadgets and messenger platforms. The media will be revised based on the input given in the second stage.

The third stage was a field evaluation of 20 parents, selected using purposive sampling with the same criteria as those used in the small-group evaluation. If there were other inputs, it would be revised and continued to the implementation stage. The development stage instrument included picture (quality of shots, lighting, scene sequence, color, opening, image clarity and composition, and suitability of images to content), audio (audio packaging and clarity of words), material (material clarity and integration, ease of understanding, and references), language (diction and the use of simple language), appearance (speaker ability to explain the material, intonation, and articulation), and media persuasive quality (the media's ability to attract the target's attention). Using a 1–5 Likert scale instrument, the assessors (media and material experts, as well as 10 and 20 parents) assessed seven videos. The data were analyzed through a

quantitative descriptive method, which determined the media's eligibility level by percentage, and a qualitative method, which incorporated respondent feedback on the media.

The implementation stage was carried out with 10 parents of adolescents aged 10–14 years in the Pajang PHC working area, using a one-group pretest and posttest design and a purposive sampling technique. The criteria for parents who participated in the implementation stage were the same as those for parents in small groups and field evaluation. The parents were given knowledge of the ASRH questionnaire developed by the authors, which has been tested for validity and reliability on 30 parents in Setabelan PHC.

Nineteen questions with correct and incorrect answers were tested for validity and reliability with a Cronbach's alpha of 0.77. The steps taken were (a) measuring parents' knowledge about ASRH (pretest), (b) providing seven videos to parents, and (c) measuring ASRH knowledge in parents after being given seven videos (posttest). The parents participated in this study as respondents, and the purpose and benefits of the study were first explained to them. The parents were those who had agreed to participate without any coercion and were kept confidential or anonymous. The data were analyzed using the N-gain value with SPSS (free version). The following formula was used to determine the N-gain value. Classification of N-Gain score is high ($g>0.7$), moderate ($0.3<g\leq0.7$), and low ($g\leq0.3$).

$$\text{N-Gain} = \frac{\text{Posttest Score} - \text{Pretest Score}}{\text{Maximum Score} - \text{Pretest Score}}$$

The evaluation stage included a formative assessment to improve the media based on media validation results from the product development stage. A summative evaluation then determined the media's overall suitability, using effectiveness results from the implementation stage.

Results

This study involved developing reproductive health media in the form of audiovisual podcasts, following the ADDIE method. During the analysis stage, the authors investigated the problems and needs of parents concerning the desired media. The authors conducted FGDs with parents of adolescents aged 10–14 years. The parents expressed a desire for material on topics such as how to clean reproductive organs, puberty, how to consume blood supplement tablets to prevent anemia, the role of parents in reproductive health education, social limits for adolescents, sexual violence prevention, and factors influencing menstruation. The parents also hoped for educational methods tailored to their needs and requested that videos be presented by health workers or experts in the field, with a duration of 30–45 minutes.

The authors designed and arranged the media structure in order to determine the design scenario. The planned media is a podcast entitled "PAERESC NO PERES," formed from the words PAERESC—Parent-Adolescent Reproductive Health Communication, and NO PERES means "not lying." The topic chosen for the podcast is ASRH, with seven videos that align with parents' material needs. Each video addresses a different ASRH subtopic, ensuring parents receive a complete series covering all aspects of adolescent reproductive health. The podcasts are created through active discussions between a host and expert resource persons, each addressing the specific theme of a video. The third stage of media development involved making and recording audiovisual videos. Additionally, media validation was conducted with media experts (practitioners in the field of health promotion and media design) and material experts of ASRH, as planned, with the following media suitability assessment aspects.

Table 2. Percentage of Media Eligibility Level

Aspect (%)	Information
81–100	Very worthy
61–80	Worthy
41–60	Decent enough
21–40	Less eligible
0–20	Not feasible

Table 3. Results of Feasibility Assessments by Media and Material Experts

Aspect	Video A		Video B		Video C		Video D		Video E		Video F		Video G		Mean
	MED	MAT	MED	MAT	MED	MAT	MED	MAT	MED	MAT	MED	MAT	MED	MAT	
Picture	4.1	4.1	4.2	4.0	4.1	4.2	3.8	4.2	4.3	4.7	3.9	5.0	5.0	4.9	4.32
Audio	3.7	4.0	4.0	3.7	3.3	4.0	3.7	4.0	4.0	4.3	4.0	5.0	4.3	5.0	4.07
Material	3.4	4.0	3,9	3.8	4.5	4.0	4.1	4.8	3.9	4.9	4.8	5.0	4.5	4.9	4.32
Language	3.7	4.0	3,5	4.0	4.0	4.0	3.7	4.0	3.7	4.7	4.0	4.7	4.5	4.5	4.08
Appearance	4.6	4.8	4.0	4.8	4.0	4.8	5.0	4.2	4.4	4.4	5.0	5.0	5.0	4.8	4.55
Media persuasive qualities	3.3	4.7	3,7	4.0	3.7	4.7	4.7	5.0	3.7	5.0	4.0	5.0	4.0	4.0	4.25
Total score	22.8	25.6	23.5	24.7	23.6	25.6	25.0	26.2	23.9	28.1	25.7	29.7	27.3	28.1	
The average score for each video and each expert	3.8	4.3	3.5	4.0	3.9	4.3	4.2	4.3	3.9	4.7	4.2	4.9	4.5	4.7	
Average score for each video	4.0		3.7		4.1		4.2		4.3		4.5		4.6		
Eligibility Percentage	81%		79%		82%		85%		87%		92%		92%		

Notes: MED = value given by media experts, MAT = value given by material experts

Table 3 presents that six videos are very suitable for use. Video B was deemed suitable but required improvements in its audio and language. Based on validation by the two experts, the appearance aspect of the media received the highest average score. This was attributed to the excellent delivery of material by the host and speaker across all seven videos. The picture and material aspects received the second-highest score, indicating that the video quality was very good and accurately depicted the content.

Conversely, audio scored the lowest; its average was still above 4, indicating good quality, including background sound selection. The media's persuasive quality secured the third-highest average score despite some variations, demonstrating its effectiveness in encouraging desired behaviors. Based on expert assessments, six of the videos exceeded 80% suitability, indicating they are highly appropriate for the next stage. Video B was also suitable for continuation despite the score being below 80%. Notably, videos F and G achieved the highest suitability percentages in the expert media validation.

Table 4. Results of The Eligibility Assessment by 10 Parents and 20 Parents

Aspect	Video A		Video B		Video C		Video D		Video E		Video F		Video G		Mean	
	10P	20P	10P	20P	10P	20P	10P	20P	10P	20P	10P	20P	10P	20P	10P	20P
Picture	4.2	4.3	4.0	4.2	4.0	4.2	4.1	4.2	4.1	4.2	4.1	4.2	4.2	4.3	4.10	4.22
Audio	4.3	4.2	4.2	4.2	4.2	4.2	4.3	4.1	4.2	4.1	4.1	4.1	4.2	4.3	4.21	4.17
Material	4.3	4.3	4.3	4.2	4.3	4.2	4.3	4.3	4.2	4.4	4.2	4.4	4.3	4.4	4.27	4.31
Language	4.4	4.4	4.3	4.3	4.3	4.3	4.4	4.2	4.2	4.3	4.2	4.3	4.3	4.3	4.30	4.30
Appearance	4.1	4.3	4.3	4.2	4.3	4.2	4.3	4.3	4.4	4.2	4.0	4.2	4.3	4.2	4.24	4.23
Media Persuasive qualities	4.6	4.4	4.5	4.3	4.5	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.40	4.32
Total score	25.9	25.9	25.6	25.4	25.6	25,4	25.7	25.4	25.4	25.5	24.9	25.5	25.6	25.8		
The average score for each video	4.3	4.3	4.3	4.2	4.3	4.2	4.3	4.2	4.2	4.2	4.2	4.2	4.3	4.3		
Eligibility percentage	86%		85%		85%		85%		85%		84%		86%			

Notes: 10P = value given by 10 parents in the small group evaluation (the second stage, 20P = value given by 20 parents

Table 4 indicates that the percentage of eligibility for the seven videos is above 80%. The first- and second-highest percentage values of eligibility are the Videos A and G. In the small group evaluation (10 parents) and field evaluation (20 parents), the quality of the video for target persuasion is the aspect that obtained the highest average score in all videos. During a small group evaluation with 10 parents, their feedback indicated that the background music ended prematurely before the conclusion was complete and that the conclusion itself was too long. These issues were subsequently revised. Further input from a field evaluation with 20 parents requested the addition of information about the source at the beginning of the video. This input was also incorporated, and the revised media then proceeded to the implementation stage. The implementation was tested on 10 parents, who demonstrated a notable improvement in their average knowledge before and after watching the videos.

Table 5. Parents' Perceptions of Understanding of Material and Video Ability to Improve Communication Skills

Video	Parental Perception	
	Understanding the material after watching the video (%)	Video Ability to Improve Parent Communication Skills (%)
A	90	93.33
B	86.67	86.67
C	86.67	86.67
D	86.67	86.67
E	86.67	86.67
F	86.67	86.67
G	86.67	86.67

Table 5 shows that video A has the highest ability to provide knowledge to parents regarding the material in the video (90%). After watching the video, parents reported that their ability to communicate with adolescents about reproductive health increased by 93.33%. Table 6 indicates that the average score of parental knowledge increased before and after watching the seven videos about comprehensive reproductive health information. Based on the N-gain results, education with seven videos was effective in increasing parental knowledge of adolescent reproductive health.

Table 6. Result of the Implementation Stage

Parents Knowledge	
Pretest score	16.1
Posttest score	17.7
Maximum score	19.0
N-Gain	0.55*

*Moderate effectivity level

Discussion

Seven videos were successfully developed in podcast form in this study. The videos achieving the highest eligibility percentages were Video A, focusing on self-concepts and boundaries regarding ASRH, and Video G, addressing adolescent reproductive health services at the PHC. Video A's high score was primarily due to the speaker being a psychologist who was an excellent fit for the topic. Both videos also demonstrated an excellent ability to process persuasive sentences. Video G was also suitable for use because, according to the parents, the material presented was material that they had just learned about, which made them very interested in the topic. Video G also explained what is needed in order to access adolescent health services at the PHC. Attractive video packaging enables the target to gain new information without feeling patronized, so parents also believe that watching this video can entertain them while increasing their knowledge. This result confirms the study's findings conducted in Burkina Faso reported that enjoyable and entertaining media can catch people's attention to the material presented.[32]

The feasibility test with parents revealed that the audio aspect scored lowest among the seven videos, indicating a need for improvement in audio quality through the development of better tools. However, the media's persuasive ability received the highest average score from parents. These results suggested that parents found the video's message compelling, prompting them to consider adopting its recommendations. Conversely, experts rated the appearance of the material provider as the highest aspect. This result highlighted the critical role that the host and speaker selection plays an important role in determining the media's overall success. Parents also felt that Video A could help them understand the material on ASRH (90%) and understand how to communicate about ASRH (93.3%). In comparison, the other six videos generally received 86.67%, considering that the topic was more focused on self-concept and values in adolescents, which could help the parents better understand the characteristics of their adolescents and how to communicate with them. Conversely, Video E, which covered gender and violence prevention, was also highly favored by other parents, reflecting their desire to protect their adolescents.

Several factors likely contributed to the videos' success. Their multimedia nature, which combines visuals, audio, and expert commentary, likely catered to diverse learning styles, fostering greater parental engagement with the material. The inclusion of health professionals and experts also boosted the credibility of the information presented. Furthermore, the ease of accessing the videos likely increased engagement, as parents could watch at their convenience and revisit content as needed.[33]

This study also found that audiovisual content, in the form of podcasts about ASRH, was effective in increasing parents' knowledge about reproductive health, owing to several factors, including comprehensive material content, health

personnel, and credible speakers. The picture and audio increased parents' interest in viewing the video. Moreover, the inclusion of real-world examples of reproductive health problems that parents commonly encounter made the content highly relevant to their needs. These findings aligned with previous studies indicating that digital materials, videos, and expert sources can remarkably enhance parents' knowledge about health.[29,34,35] The audiovisual format, particularly the innovative seven-video podcast series, enhanced parents' knowledge about health. This is because the podcast fostered a two-way interaction between the presenter and resource persons, a key element of innovative health education.[36] Such engaging and novel media are crucial for health promotion, as they effectively capture audience interest in the material presented.[31]

This study also demonstrated that videos moderately increased parents' knowledge about reproductive health. The well-packaged video content was highly effective in increasing parents' awareness of this information. This finding was consistent with literature reviews indicating that visual media, such as pictures and videos, are an effective strategy for conveying health messages due to their memorability.[37]

Nonetheless, this study had limitations. The small sample size restricted the generalizability of the findings, and the lack of a control group made it challenging to definitively assess the effectiveness of the media. Furthermore, there was a potential for testing bias, in which respondents might have learned from the pretest, influencing their posttest answers. To address these issues, future research would benefit from including a control group.[38]

This study confirmed the effectiveness of videos in increasing knowledge about reproductive health. Therefore, the authors hope that parents will consistently access valid educational videos from health institutions. The health information gained can then empower parents to enhance their role in providing their adolescents with accurate health information. This is crucial because a strong parental role has been proven to improve adolescent health behavior and is essential for overcoming barriers adolescents face in accessing reproductive health information.[39,40]

Conclusion

Parents require media that can help them grasp adolescent reproductive health material and increase their overall knowledge on the topic. This study effectively demonstrates that audiovisual media improves parents' understanding of adolescent reproductive health. These videos enhance parental knowledge by presenting detailed material in an innovative format (podcasts), which effectively captures parents' interest. It is hoped that health institutions in Indonesia will develop health videos featuring resource persons who resonate with the target audience, encouraging parents to watch the videos in their entirety.

Abbreviations

SDGs: Sustainable Development Goals; HIV: Human Immunodeficiency Virus; PLHIV: People Living with HIV; PHC: primary health care; ADDIE: Analyze, Design, Develop, Implement, and Evaluate; FGD: Focus Group Discussion; ASRH: Adolescent Sexuality and Reproductive Health.

Ethics Approval and Consent to Participate

This study has been approved by the Health Research Ethics Committee, Faculty of Health Sciences, Universitas Muhammadiyah Surakarta Number 424/KEPK-FIK/VII/2024.

Competing Interest

The authors declare that there is no conflict of interest.

Availability of Data and Materials

All data collected during the study are presented in this manuscript, and no data from the study have been or will be published separately.

Authors' Contribution

TAIK: Conceptualizing, designing, the definition of intellectual content, conducting a literature search, experimental studies, data acquisition, data analysis, statistical analysis, manuscript preparation, editing, review, Guarantor; NLI and SA: designing, conducting experimental studies, manuscript editing, and review; AKU: editing and review; WL: designing, conducting a literature search, experimental studies, data acquisition, data analysis, statistical analysis, manuscript preparation, editing, and review; RNL: designing, conducting literature search, experimental studies, data acquisition, manuscript editing and review; T and RCD: designing, conducting experimental studies, data acquisition, manuscript review; YK: designing, conducting statistical analysis, manuscript review. IA: manuscript editing and review.

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