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Early Detection of Risk Factor for Suicidal Ideation Among Senior High School Students in Jakarta: Updated Measurement

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Abstract

The key strategy to address suicide in adolescents is school-based suicidal prevention by adapting a screening instrument to the local culture and policymakers' perception of suicide. This study aimed to develop an instrument for the early detection of risk for suicidal ideation and identify influential risk factors for suicidal ideation among high school students in Jakarta, Indonesia. This study was conducted in 2018 with a mixed-method design (quantitative and qualitative approaches). It was found that 5% of students had suicidal ideation in July–November 2018, and 13.8% had a high-risk factor for suicidal ideation. The instrument developed in this study consisted of 16 items and had been proven valid and reliable for screening. Students with depression and those screened positive utilizing the developed instrument had 4.41 and 5.39 times the risk of developing suicidal ideation. A recommendation to the counseling teacher associations is to reduce suicidal stigma, encourage students to be open to talking about mental health issues, and prioritize adolescents at risk of suicide for further assessment.

Keywords: early detection, high school students, instrument, suicidal ideation

Introduction

Adolescents are the youth aged 10-19 years, while "youth" is defined as those aged 10 to 24 years. During adolescence, changes in physical maturity occur, particularly in the reproductive organs, followed by mental and social conditions changes.[1] According to the United Nations Children's Fund (UNICEF) in 2016, adolescent mortality slightly decreased from 126 deaths per 100,000 population in 2000 to 111 per 100,000 population in 2012.[2] World Health Organization (WHO) in 2017 noted that the top causes of death in male adolescents aged 15–19 years were traffic accidents, interpersonal violence, and self-harm; while, in female adolescents, the causes were maternal conditions and self-harm.[3]

According to the 2017 WHO Global Health Estimates, the highest global death rate from suicide in low and middle-income countries is at the age of 20. However, the WHO points out that many countries fail to make accurate counts of suicides, including Indonesia. Based on WHO Suicide Mortality Rate data, the reported suicide rate in Indonesia is only 3.4 suicide cases per 100,000 population, which is clearly an underreported figure.[4] A study by the Global School-based Student Health Survey (GSHS) in 2015 involving 10,837 junior and senior high school students resulted in 5.2% having suicidal ideation, 5.5% having a suicide plan, and 3.9% having attempted suicide.[5] A preliminary study with the Indonesian Ministry of Health purposively collected data from 1,014 adolescent respondents in the 10th and 11th grades in Jakarta who were frequently involved in trouble, such as brawls.

Screening using the Children's Depression Inventory (CDI) instrument showed that 30% of adolescents had potential depressive disorders, with 19% contemplating suicide but not committing it, and 1% committing suicide.[6] Another study

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identified that adolescents in urban areas were 1.66 times more likely to have suicidal ideation than those in rural areas.[7] A-accredited schools have a more positive and protective climate as a "safety net" that helps at-risk students from developing physical and mental health problems. On the other hand, A-accredited schools can serve as a protective net for adolescents at risk of suicidal ideation.[8]

Suicide can be prevented by reducing risk factors and increasing factors strengthening resilience or coping skills.[9] One of the key strategies to address suicide in adolescents is a school-based suicide prevention and intervention program. Screening instruments should be adapted to the local culture and policymakers' perception of suicide.[10] In 2015, the Indonesian Ministry of Health developed the Evaluation of Mental Health Case Services/*Evaluasi Pelayanan Kasus Kesehatan Jiwa* (EPK2J) instrument to measure adult suicidal tendencies. However, various literature shows that there are differences in risk factors for suicide between adolescents and adults.

A previous study was conducted to develop an instrument for adolescent's early detection of risk factors for suicidal ideation, but further study is needed to generate better validity and reliability levels.[11] Therefore, this study was a follow-up study to develop the instrument for early detection of risk factors for suicidal ideation adapted for adolescents. This instrument is expected to be utilized by the provincial government of Jakarta for early prevention of suicidal ideation through a screening process and various recommendations for stakeholders. Apart from that, this study aimed to determine risk factors for suicidal ideation among adolescents in high schools in Jakarta.

Method

This study applied step-wise qualitative and quantitative or mixed methods with a cross-sectional approach. The population in this study was all high school students in Jakarta by 2018, while the sample consisted of A-accredited high school students in Jakarta from 2013 to 2018. The inclusion criteria for this study were the A-accredited high school students aged 14-19 years in Jakarta. This study obtained 910 respondents from five public senior high schools and five public vocational high schools that were selected by stratified random sampling.

This study used a three-stage approach. The first stage was a qualitative approach in the form of a document study (to explore the risk factors for suicidal ideation of secondary school-aged adolescents), focus group discussion I (FGD I), and instrument drafting. The FGD I was managed by a group of experts in the process of modifying the EPK2J instrument into a derivative instrument that could be utilized in a self-report manner for adolescents. There were two validation processes: content validity to obtain input from subject field experts and face validity to obtain input from target experts.

The second stage was a quantitative study with instrument testing to produce a validated instrument for early detection of risk for suicidal ideation with the number of samples depending on the item numbers. Furthermore, construct validity with a factor analysis and reliability tests were also carried out to produce a simple, valid, and reliable instrument for early detection of risk factors for suicidal ideation in adolescents. This study used Exploratory Factor Analysis (EFA) to explore the relationship between several variables without determining the number of factors to be formed. The next phase was Confirmatory Analysis (CFA), with results illustrating theoretical constructs' convergence and discrimination validity.

Measure of Sampling Adequacy (MSA) and Kaiser-Meyer-Olkin (KMO) tests were conducted to determine the sample's adequacy for factor analysis. The KMO test tests sample adequacy and correlation by excluding collinear variables. The KMO value ranges from 0-1, and factor analysis is feasible if in the range of 0.5-1.0. The correlation strength test in factor analysis is determined from Barlett's test. It can also be seen from the Anti-image Correlation table if no MSA value is found.

After selecting several variables, they were extracted as one or several factors. Variables could be included in a factor if the factor loading >0.5 in the communalities table, explaining the proportion of variance of each variable in the factor to be formed. Then, it continued with the rotation stage when the factors formed did not describe differences between existing factors. Criterion validity was also tested by conducting a Receiver Operating Characteristic (ROC) analysis that describes the relationship between the observed and the predicted class through a curve or Area Under Curve (AUC) with a limit value of 0.5. The instrument is considered reliable if the Cronbach's Alpha value is >0.70.

In the quantitative approach, descriptive, bivariate, and multivariate analyses were also conducted using Poisson regression. The Patient Health Questionnaire-9 (PHQ-9) instrument was used to determine the severity of a student's depression. The research data results are presented in tables and figures to compare the validity and reliability values between the questionnaires with 27 and 16 items. In addition, the analysis of risk factors for suicidal ideation is also

presented in the form of tables containing the frequencies, percentages, and OR generated.

The qualitative method was applied again in the third stage through an FGD II with a group of cross-sector and cross-program informants to explore policies related to the potential utilization of early detection instruments of risk factors for suicidal ideation at the school level. The purpose of this FGD II was to make recommendations for the implementation of instruments for early identification of factors placing adolescents at high risk for suicidal ideation at the school level.

Results

Instrument Development Using a Qualitative Approach

FGDs were conducted in two stages. The FGD I conducted with three child and adolescent psychiatry consultants, one clinical psychologist, two psychiatrists, one methodological expert, three psychologists, and one activist. Meanwhile, FGD II was conducted with 12 cross-sector (government and non-governmental organizations) participants. The FGD I was conducted by focusing on the content and face validity of the instrument to be developed. The modified EPK2J instrument was reduced from 28 items to 27 items (19 unfavorable and 8 favorable statements). The FGD I also decided on the utilization of the PHQ-9-Adolescent instrument to be translated and validated as an instrument to assess the severity of depression among adolescents. A simple questionnaire on Psychosocial Stressors was also collaboratively developed to be used and validated during data collection.

Instrument Development with a Quantitative Approach

After the process focused on content and face validity through FGD I, the construct validity process was carried out and presented in Table 1.

Table 1. Example of the Table Construct Validity Test Using Factor Analysis and Reliability Test on Early Detection for Suicidal Ideation Risk Factors Instruments

Indicator	27 Items (KMO & Barlett's test = 0.927)				16 Items (KMO & Barlett's test = 0.931)			
	Factor Analysis			Reliability	Factor Analysis			Reliability
	Anti-Image	Communalities	Loading Factor	α-Cronbach If Item Deleted	Anti-Image	Communalities	Loading Factor	α-Cronbach If Item Deleted
C1	0.933	0.658	0.653	0.904	0.927	0.730	0.786	0.902
C2	0.927	0.689	0.696	0.903	0.918	0.749	0.766	0.900
C3	0.941	0.610	0.689	0.904	0.936	0.731	0.772	0.901
C4	0.946	0.505	0.622	0.905	0.944	0.614	0.549	0.903
C5	0.953	0.594	0.689	0.903	0.947	0.622	0.567	0.901
C6f	0.905	0.489	0.474	0.907	0.862	0.681	0.588	0.909
C7f	0.904	0.554	0.498	0.907	0.925	0.779	0.815	0.908
C8f	0.912	0.458	0.508	0.908	0.879	0.758	0.846	0.910
C9	0.934	0.579	0.583	0.905				
C10	0.918	0.485	0.555	0.906				
C11f	0.882	0.460	0.442	0.907				
C12f	0.877	0.399	0.493	0.909				
C13	0.732	0.723	0.532	0.910				
C14f	0.881	0.392	0.514	0.909				
C15f	0.751	0.721	0.687	0.909				
C16	0.911	0.571	0.577	0.905				
C17f	0.916	0.279	0.399	0.909				
C18	0.965	0.558	0.722	0.902	0.949	0.626	0.659	0.901
C19	0.952	0.525	0.679	0.904	0.957	0.625	0.726	0.902
C20	0.963	0.555	0.717	0.903	0.949	0.638	0.611	0.901
C21f	0.802	0.335	0.328	0.912				
C22	0.956	0.512	0.674	0.904	0.949	0.669	0.753	0.902
C23	0.944	0.536	0.646	0.904	0.940	0.631	0.606	0.902
C24	0.919	0.588	0.623	0.905	0.906	0.728	0.794	0.904
C25	0.919	0.655	0.671	0.904	0.903	0.771	0.808	0.902
C26	0.949	0.633	0.678	0.904	0.935	0.676	0.715	0.902
C27	0.946	0.410	0.457	0.908				

Notes: KMO = Kaiser–Meyer–Olkin, α-Cronbach= 0.909

KMO, MSA, Communalities, and Loading Factor values are eligible if the value is >0.5. The table shows that the KMO & Barlett's test in both models produces a value of 0.927 for the 27-item model and 0.931 for the 16-item model. All indicators in both models also generated a value of >0.5. Communalities and Loading Factor values on all 16-item model

indicators met the requirements with a value range of 0.61–0.779. In contrast, in the 27-item model, the Communalities value on eight indicators and the Loading Factor value on two indicators are still worth <0.5. Cronbach's Alpha value, if items are deleted, shows a value of >0.9 on all indicators of both models (Table 1).

Criterion validity was assessed using ROC. The ROC classification accuracy was done by calculating the AUC. In Figure 1, the AUC value of the 27-item model is 0.837 and 0.826 for the 16-item. AUC values in the good category were generated in both models.

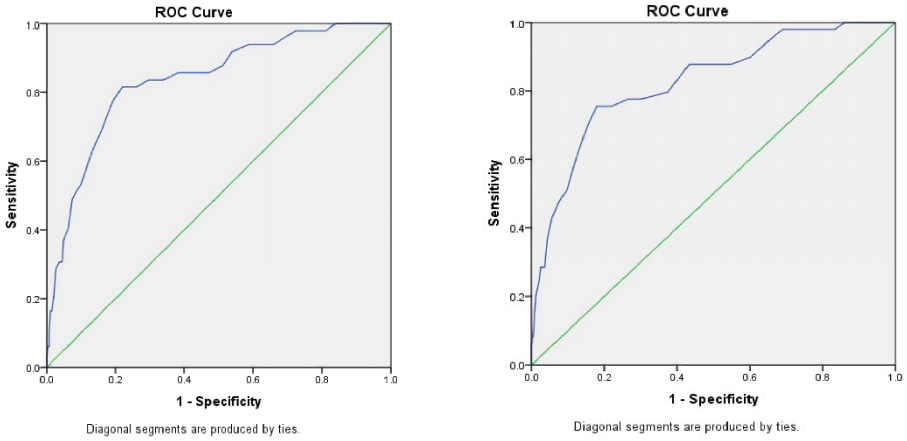

Figure 1. Receiver Operating Characteristic Curve of Early Detection for Suicidal Ideation Risk Factors Instruments to Suicidal Ideation

Table 2. Grouping of Item Components for Early Detection of Suicide Ideation Risk Factors Instrument

Indicator	27-Item Model's Component					16-Item Model's Component				
	1	2	3	4	5	1	2	3	4	5
C1	0.779	0.166	0.076	0.091	0.098	0.786	0.084	0.199	0.199	0.160
C2	0.796	0.101	0.055	0.141	0.157	0.766	0.011	0.211	0.298	0.170
C3	0.716	0.157	0.041	0.117	0.245	0.772	0.147	0.047	0.188	0.274
C4	0.611	-0.049	0.010	0.244	0.258	0.549	0.196	-0.206	0.449	0.172
C5	0.681	0.011	0.114	0.184	0.289	0.507	-0.026	0.096	0.567	0.185
C6f	0.236	0.574	0.077	0.313	-0.004	0.100	0.588	0.541	0.113	0.142
C7f	0.421	0.575	0.175	0.000	0.079	0.197	0.146	0.815	0.164	0.163
C8f	0.143	0.517	0.025	0.417	-0.026	0.093	0.846	0.102	0.144	0.053
C9	0.167	0.157	0.008	0.699	0.191					
C10	0.252	0.043	0.132	0.625	0.124					
C11f	0.122	0.261	0.223	0.570	-0.049					
C12f	-0.071	0.507	-0.051	0.335	0.160					
C13	0.073	-0.183	0.802	0.119	0.167					
C14f	0.131	0.382	0.384	-0.154	0.242					
C15f	0.056	0.193	0.816	0.071	0.106					
C16	0.156	0.183	-0.102	0.666	0.247					
C17f	0.055	0.434	0.010	0.280	0.055					
C18	0.435	0.155	0.006	0.483	0.333	0.244	0.309	0.056	0.659	0.182
C19	0.496	-0.021	0.027	0.412	0.322	0.206	0.145	0.096	0.726	0.162
C20	0.439	0.114	-0.032	0.425	0.411	0.252	0.338	-0.044	0.611	0.293
C21f	-0.089	0.538	-0.041	-0.042	0.173					
C22	0.494	0.005	0.015	0.403	0.327	0.201	0.015	0.176	0.753	0.172
C23	0.412	-0.034	0.155	0.187	0.553	0.157	-0.119	0.173	0.606	0.442
C24	0.207	0.198	0.150	0.141	0.679	0.127	0.035	0.178	0.221	0.794
C25	0.297	0.181	0.146	0.097	0.705	0.262	0.071	0.090	0.187	0.808
C26	0.297	0.174	0.105	0.152	0.694	0.239	0.165	0.007	0.284	0.715
C27	0.130	0.037	0.033	0.109	0.615					

Notes: 1 = Burdensomeness, 2 = Belongingness, 3 = Impulsiveness, 4 = Loneliness, 5 = Hopelessness

Based on the ROC results, the cut-off point of the early detection instrument for suicidal ideation risk factor was 33.5 with a sensitivity of 0.776 (77.6%) and specificity of 0.736 (73.6%). Furthermore, the final result of the 16-item instrument had a cut-off score of 33.5 from a range of 16 to 64. If the score is ≥34, it can be stated that to have a risk of suicidal ideation. This study also conducted CFA on the early detection instrument of risk factors for adolescent suicidal ideation. The grouping of items can be seen in Table 2.

According to Table 2, the Impulsiveness dimension (items C13, C14, and C15) previously in the 27-item model is missing in the 16-item model. However, item C7, with the statement "*I feel I am part of something useful,*" belonging to the Belongingness Dimension, was even stronger in the Impulsiveness Dimension.

Final Model of 16-Item Instrument

Table 3 shows that the 16-item model results in Average Variance Extract (AVE) values within the range of 0.39–0.54, while the CR is within the range of 0.64–0.85. The Construct Reliability (CR) range in the 16-item model was better than the 27-item model, with an AVE range of 0.30–0.54 and a CR range of 0.21–0.85.

Table 3. 16-Item Model of Early Detection for Suicide Ideation Risk Factors Instrument

Components	λ	AVE	CR
Burdensomeness		0.5398	0.8532
C1	0.7693		
C2	0.8173		
C3	0.7662		
C4	0.6237		
C5	0.6804		
Belongingness		0.3859	0.6440
C6	0.7852		
C7	0.5219		
C8	0.5185		
Loneliness		0.5301	0.8184
C18	0.7571		
C19	0.7123		
C20	0.7414		
C22	0.7000		
Hopelessness		0.5319	0.8181
C23	0.6068		
C24	0.7574		
C25	0.8149		
C26	0.7222		

Notes: AVE = Average Variance Extract, CR = Construct Reliability

Suicidal Ideation

Based on the PHQ-9-Youth questionnaire filled out by the respondents, the number of respondents with suicidal ideation in July–November 2018 was 5% of the total 910 respondents. Table 4 presents an overview of respondents according to risk factors for suicidal ideation at senior high schools in Jakarta.

Table 4. Description of Respondents Suicidal Ideation Risk Factors Among Adolescents in Senior High School/Equivalent in Jakarta 2018 (n=910)

Variable	Category	Frequency		Y1			
		N	%	%Y1	p-value	OR	95% OR
Parent's Divorce Status	Divorced	66	7.6	7.6	0.616	1.46	0.56–3.83
	Not Divorced	830	92.6	5.3			
Father Existence	Dead	55	6.1	3.6	0.767	0.64	0.152–2.72
	Alive	849	93.9	5.5			
Mother Existence	Dead	34	3.8	5.9	1	1.09	0.26–4.71
	Alive	870	96.2	5.4			
Depression	Very Severe	11	1.2	72.7	<0.01	338.7	49.52–2316
	Severe	49	5.4	22.4	<0.01	36.8	7.84–172.3
	Medium	161	17.7	5.0	0.018	6.6	1.39–31.68
	Mild	396	43.6	4.3	0.021	5.7	1.30–24.87
	Minimal/None	258	28.4	0.8	1		
Risk Factor	Risky	125	13.8	22.4	<0.01	10.4	5.69–19.06
	Not at Risk	779	86.2	2.7			
Stressor	High	340	39.2	7,6	<0.05	2.1	1.15–3.82
	Low	527	60.8	3.8			

Notes: OR = odds ratio, Y1 = dependent variable (suicidal ideation)

There are 11 respondents (1.2%) with very severe depression, 49 respondents (5.4%) with severe depression, 161 respondents (17.7%) with moderate depression, 396 respondents (43.6%) with mild depression, and 258 respondents (28.4%) with minimal/none depression. Respondents with high-risk factors for suicidal ideation were 125 respondents (13.8%), and 779 respondents (86.2%) were not at risk. Based on the cut-off point score of 4.5, respondents with high psychosocial stressors (>4.5) were 340 respondents (39.2%), and low (<4.5) were 527 respondents (60.8%). In bivariate

analysis, the influential variables to suicidal ideation were very severe depression, severe depression, detected risk factors for suicidal ideation, and high stressors, while other variables were not correlated with suicidal ideation.

Table 5 presents the results of multivariable analysis with Poisson regression analysis and shows that the instrument developed in this study can detect the risk of suicidal ideation. Of all the factors examined in this study, only the presence of depression and students detected to be at risk of suicide showed significant results after controlling the confounding variable. Students with depression were 4.41 times (p-value 0.048) more likely to have suicidal ideation than students without depression. Students detected to be at risk of suicide, compared to the students not detected, were 5.39 times (p-value <0.01) more likely to have suicidal ideation.

Table 5. Factors Associated with Suicidal Ideation (Y) of Adolescents in Senior High School/Equivalent in Jakarta (n=910)

Variable	Category	Y1		
		AOR	95% OR	p-value
Age	<17 years old	1.42	0.72–2.78	0.310
	>17 years old			
Sex	Male	1.12	0.55–2.29	0.759
	Female			
Education	SHS	1.67	0.85–3.28	0.139
	JHS			
Father's Education Level	High (>JHS)	1.04	0.44–2.47	0.923
	Low (<SHS)			
Father's Occupational Status	Employed	0.75	0.26–2.15	0.590
	Unemployed			
Mother's Education Level	High (>JHS)	1.49	0.67–3.29	0.327
	Low (<SHS)			
Mother's Occupational Status	Employed	1.63	0.81–3.30	0.171
	Unemployed			
Ethnicity	Betawi	0.63	0.28–1.41	0.261
	Other			
Religious Belief	Low	0.98	0.48–2.01	0.960
	High			
Parental Divorce Status	Divorced	0.84	0.29–2.43	0.743
	Not Divorced			
Father Existence	Dead	0.86	0.20–3.68	0.839
	Alive			
Depression	Yes	4.41	1.01–19.14	0.048
	No			
Risk Factor	Risky	5.39	2.76–10.51	<0.01
	Not at Risk			
Stressor	High	1.14	0.59–2.22	0.693
	Low			
Constant		0.01		<0.01

Notes: AOR = adjusted odds ratio, OR = odds ratio, JHS = Junior High School, SHS = Senior High School

Discussion

Instrument Development

The results of this study, using qualitative and quantitative methods to test construct validity, showed that the 16-item model was the optimal instrument model as it could fulfill the adequacy of factor analysis and reliability. The Cronbach's Alpha value in the previous study[11] was 88.2%, while this study produced a higher value of 90.9%. The previous study set the cut-off score at ≥31 with a sensitivity of 77.6% and specificity of 77.1%.[6] In contrast, in this study, the cut-off score ≥34 was set with a sensitivity of 77.6% and a higher specificity of 73.6%. Updated measurement of the developed instrument shows a better specificity value with fewer question items (16 items). In this study, the results of KMO, MSA, Communalities, Loading Factor, and Cronbach's Alpha if item deleted values also showed that the 16-item model met the requirements or value limits. Furthermore, criterion validity was carried out using ROC to evaluate the accuracy of sensitivity and specificity of the instrument for early detection of suicidal ideation risk factors visualized by using the ROC curve, the technique to visualize, organize, and classify a set of variables based on their performance.[12]

The 16-item model did not include an impulsiveness dimension. However, modeling was possible even without the impulsiveness dimension. Stress factor often precedes suicidal ideation. Rapid and sudden action in adolescents can occur with a short intervention time between the stressors and the time of the suicide attempt.[13] The Chinese study also sought to highlight the relationship between impulsivity and suicide. A person with dysfunctional impulsivity has a 14-fold higher risk of suicide than a person with low dysfunctional impulsivity, while functional impulsivity and education serve as protective factors.[14]

Impulsivity was measured with a 23-item scale called Dickman Impulsivity Inventory (DII), measuring functional and dysfunctional impulsivity as two distinct components. According to Dickman,[14] functional impulsivity is fast and performs inaccurately in optimal response situations; dysfunctional impulsivity is quick and performs inaccurately in non-optimal response situations. The two impulsivities have a low correlation to each other. Functional impulsivity is strongly associated with enthusiasm, high activity levels, and adventure, while dysfunctional impulsivity is related to mental disorders or health problems, such as making decisions without considering reality and worsening the problems caused by their actions. A study in South Korea showed that 48% of participants were driven by sudden tendencies to attempt suicide.[14]

Risk Factors of Suicidal Ideation

Variables of depression and adolescents detected at risk of suicide produced significant results for efforts to identify levels of suicidal ideation among adolescents. Suicide in adolescents is closely related to mental disorders such as depression.[15] A study by Baiden and Tadeo found that depressed adolescents have a 10.54 times (p-value <0.001) higher risk of suicidal ideation.[16] About 30% of adolescents experiencing suicidal ideation or suicide attempts meet the criteria for a major depression diagnosis that can also affect adolescents' ability to manage emotions and focus on the negative aspects of life.[17]

Im *et al.*[18] found similar results, with depressed adolescents having 5.7 times more likely to have suicidal ideation (p-value = 0.001). In a transitional period with unstable psychological development, adolescents are vulnerable to suffering from stress that can lead to depression or even suicidal ideation.[6] The higher the level of hope, the lower the suicidal ideation will be, and the higher the level of hopelessness, the higher the likelihood of suicidal ideation will be.[18,19] Therefore, strategic interventions need to be considered to prevent or reduce acute academic stress and help adolescents manage it.[19]

Yusuf found that emotional problems in female adolescents tend to be three times higher than in male adolescents.[6] In the "Multi-Factor Model of Suicide," individual biological factors such as genetics and sex can influence a person to have suicidal ideation or make suicide attempts.[20] Some of the independent variables of the multi-factor model of suicide boil down to parental factors as the respondents' social resources. In the bivariate analysis of this study, the independent risk factors influencing suicidal ideation were the father's education level and the mother's occupational status. Other variables were not correlated with suicidal ideation.

Students with fathers attaining higher education had a 2.38-fold risk for suicidal ideation compared to students with fathers attaining high school degrees.[21] Fathers who are absent from home, either for work or their role as single parents, also have an impact on physical and psychological problems in adolescents when compared to intact parents.[22] Students with employed mothers also have a higher risk (3.05 times) of having suicidal ideation when compared to students with unemployed or housewife mothers. Regardless of the type of mother's occupation, the parents' parenting strongly influences their children. Authoritative and rejecting-neglecting parents put children at risk of suicide.[23] Students having divorced parents had a 2.48 times higher risk of attempting suicide. Obeid *et al.*[24] found that parental divorce is associated with social fear and avoidance, higher depression, and suicidal ideation. Communication problems often occur in a period prior to divorce and can create an atmosphere of stress. This can lead to uncontrollable outbursts of anger and affect mental health, such as depression.[24]

In the stressor variable, students experiencing high stressors had a 2.1 times risk of having suicidal ideation when compared to students experiencing low stressors. However, on multivariate analysis, stressors were not significantly associated with suicidal ideation. Psychosocial stressors take a variety of forms, but there are psychosocial stressors prevalent in adolescents, such as pathological internet use associated with the development of suicidal thoughts. It has been reported that video games and internet use for more than five hours a day result in high levels of depression and suicidal tendencies among adolescents.[25]

Governmental Program Implications

The periodic utilization of early detection instruments for suicidal ideation risk factors could be considered at higher academic pressures. The instrument utilization might be employed as part of the "Report of My Health/*Rapor Kesehatanku* Program" by School Health Enterprises. In addition, the early detection of risk factors for adolescents' suicidal ideation can also be done simultaneously using another instrument named the Strengths and Difficulties Questionnaire. The only difference is that there is no input of the instrument score into *Rapor Kesehatanku* since it

contains the identity of the book owner. Consideration for inclusion in *Rapor Kesehatanku* is needed if there is a further study concerning stigma on suicide and the utilization of early detection instruments of risk factors for adolescents' suicidal ideation as individual assessment instruments. For Jakarta, further study should also be carried out to include the instrument in the e-Jiwa application. This is in accordance with the demands of the era of digital mental health developed by WHO to overcome the treatment gap in low- and middle-income countries.[26]

Knowledge Implications

The results of this study are expected to be a reference for further studies, specifically on the further development and utilization of instruments for early detection of risk factors for suicidal ideation in urban areas broadly, rural areas, junior high school students, the development of online instruments; on the association of impulsivity with adolescent suicide; and on how stigma affects suicide. The instrument can also be used for further study on approaches that are effective but do not worsen stigma for adolescents detected as potentially having suicidal ideation. Suicide and mental illness are still burdened by negative societal attitudes that can only be addressed by a change in the public perception of these issues. Follow-up of screening results may have particular risks if literacy about suicide is low and stigma towards suicide is high. This is related to a person's reluctance to seek help due to their risky condition. Mass media interventions can reduce the stigma of mental illness and play an essential role in suicide prevention.[27]

Strength and Limitations

This study combined quantitative and qualitative approaches, thus serving comprehensive and implementable results by implementing the existing central and local government policies and programs. The advantage of early detection of risk factors for suicidal ideation in adolescents is self-reporting so that adolescents' concerns about denying their condition can be overcome by the absence of eye contact with the assessor. In addition to being valid and reliable, the instrument for early detection of risk factors for suicidal ideation in adolescents is also relatively short, with a total of 16 items that are suitable for the short attention span of adolescents.

This instrument was pilot-tested only on a group of adolescents in the A-accredited senior high schools in Jakarta, an urban area of Indonesia that may have different risks from problematic schools. There has been no evidence of using the instrument for rural areas, often thought to have a lower risk for suicidal ideation. Therefore, risk factors essential for predicting suicidal ideation should be based on norms for rural and urban populations, as well as those linked to sex.[28] Besides, people's tendency to show a good self-image is called Socially Desirable Responding (SDR), which might create false or obscuring relationships between variables due to response bias.[29]

Conclusion

The 16-item model instrument for early detection of risk factors for suicidal ideation has a significant value of Cronbach's Alpha reliability and criterion validity to determine the magnitude of the problem to be followed up by the school in the form of aggregate data. Adolescent suicide can be prevented by incorporating screening of adolescent suicidal ideation with the utilization of the instrument developed in this study into school programs. Counseling teachers should reduce stigma towards suicide, encourage students to be open to talk about mental health issues, including depression and suicide, and prioritize adolescents at risk of suicide for further assessment. Future studies are suggested to explore the development of the instrument for rural areas.

Abbreviations

WHO: World Health Organization; EPK2J: *Evaluation of Mental Health Case Services/Evaluasi Pelayanan Kasus Kesehatan Jiwa*; FGD: focus group discussion; MSA: Measure of Sampling Adequacy; KMO: Kaiser–Meyer–Olkin; ROC: Receiver Operating Characteristic; AUC: Area Under Curve; PHQ-19: Patient Health Questionnaire; AVE: Average Variance Extract; CR: Construct Reliability; OR: odds ratio; AOR: adjusted odds ratio.

Ethics Approval and Consent to Participate

This study has been approved by the Commission for Research Ethics and Public Health Service, Faculty of Public Health, Universitas Indonesia Number: 134/UN2.F10/PPM.00.02/2018

Competing Interest

There are no significant competing personal, professional, or financial interests that may have influenced the performance or presentation of the work described in this manuscript.

Availability of Data and Materials

The data that supports the findings of this research is provided by the author and obtained directly from research informants and respondents.

Authors' Contribution

SP was involved in the research methodology, BJG directed the development of risk factors, and NRY was involved in the design study, analyzing data, developing instruments, and compiling the script.

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Household Food Expenditure Typology and Its Association with Child Stunting and Anemia in Indonesia

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Household Food Expenditure Typology and Its Association with Child Stunting and Anemia in Indonesia

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Abstract

Stunting and anemia remain the coexisting nutritional problems among Indonesian children. However, evidence of household-level food expenditure and its association with child stunting and anemia is limited. This study aimed to observe the association between household food expenditure typology and child stunting and anemia in Indonesia. Data was obtained from the 2007 and 2014 Indonesia Family Life Survey (IFLS). The household food expenditure, child nutritional status, and anemia were observed in 2007 and 2014. Latent class analysis was taken to identify the food expenditure pattern. Binary logistic regression was applied to analyze the association between household food expenditure patterns and stunting and anemia status. A total of 2,296 children from 2,158 households were included in the study. Household food expenditure was identified into (1) higher processed food, refined grain, and purchased meals; (2) higher fish, seafood, plant protein, vegetables, and beans; and (3) balanced food purchases. Households with Pattern 2 had lower odds of anemia in 12–59-month-olds than Pattern 3 (AOR 0.78, p-value = 0.03, 95% CI). Households with Pattern 2 were likely to have stunted 8–12-year-olds compared to households with Pattern 3 (AOR 1.37, p-value = 0.09, 95% CI). Household food expenditure types may affect children's nutritional status.

Keywords: diet, food, nutrition, public health, purchasing

Introduction

Children are a vulnerable group to health and nutrition problems. Indonesia faces the triple burden of malnutrition, consisting of undernutrition, overweight-obesity, and micronutrient deficiencies.[1] Among a wide spectrum of nutritional problems, stunting and anemia co-occurrence have been widely reported.[2] The prevalence of stunted children under the age of 5 (the under-five) reached 30.8%, according to the 2018 Indonesian Basic Health Research.[3] The under-five with anemia in Indonesia increased to 38.5% in 2018 from 35.4% in 2014 compared to Malaysia, Thailand, and Brunei Darussalam at 29.85%, 26.6%, and 14.79%, respectively.[3,4] This comparison shows that anemia among children still needs to be a focus of public health issues, specifically in lower-middle-income countries (LMICs), including Indonesia. Stunting and anemia among children may prompt health risks in the short- and long-term. Stunting increases risks of infection and future noncommunicable diseases, poor development, and poor learning capacity.[5,6] Anemia may lead to decreased fitness levels, increased risk of infectious disease, cognitive decline, delayed motor development, morbidity, and mortality.[6,7]

Infancy and mid-childhood are periods of rapid growth. Despite the diverse manifestations, providing a nutritious diet in childhood is a major prevention of malnutrition.[8] Household food security and a healthy food environment are among the underlying determinants of child nutrition.[9] Based on the latest study on the food demand of the Indonesian population, households rely on home meal preparation and allocate their food spending budget primarily to home-cooked meals; however, in some higher socioeconomic groups, the trend also shifts to purchased meals.[10] Children's food consumption is often influenced by food choices at home, which could be represented by household food purchases. In several LMICs, household food expenditure patterns were associated with childhood anthropometry.[11,12]

Although the associations between food expenditure and stunting and anemia have not widely reported yet, some studies have suggested the association between food security in general and anemia and stunting. Food expenditure, as a proxy for economic access to nutritious food, is an element of food security, and according to the previous report, is known

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to affect nutrition and are considered prone to malnutrition.[9,13] A meta-analysis also shows that food insecurity was associated with anemia incidence among infants and toddlers.[14]

This study used a person-centered approach to determine the food expenditure pattern by classifying the household food expenditure traits or typologies. Household food expenditure typology can provide information on the general household food group purchase in the population. As food availability in the household determines children's consumption, it is important to understand further the association between the pattern of household food purchase and the prevalent nutrition problems in Indonesian children, which were stunting and anemia.[11] To date, analyses of the direct association between household food expenditure and stunting and anemia are still limited, particularly in Indonesia. This study aimed to analyze the types of household food expenditure patterns in the population and their association with stunting and anemia in different phases of childhood; under-five and school-age. By comprehending the association between food expenditure patterns and nutrition issues, this study could provide insights and evidence to design policies and interventions directed to food access and household purchasing patterns.

Method

Data were obtained from the Indonesian Family Life Survey (IFLS) from 2007 to 2014, a longitudinal study initiated in 1993. The target population of this study was children aged 12-59 months. The households' data were collected in 2007 when the children were at the age of 12-59 months, and the same households were revisited for data collection in 2014 when the children were at the age of 8-12 years old.[15] The IFLS data samples were taken from 13 provinces, representing 83% of the Indonesian population. A total of 321 areas for enumeration were randomly selected within the 13 provinces based on the National Socioeconomic Survey data sample frame. The households were then selected through random sampling based on the regional government statistics listings.

Based on prevalences among the under-five at the time of data collection at 27.7% anemia and 36.8% stunting, respectively, a minimum sample of 358 children was required after calculating the highest number of minimum samples for each case.[16] The inclusion criteria included children aged 12-59 months in 2007, followed up in 2014. There were 2,386 children followed up both in 2007 and 2014; however, 90 children were recorded without hemoglobin (Hb) and anthropometric data in 2007, thus leaving a total of 2,296 eligible children to be included in this study.

Dependent variables were stunting and anemia. Body height was based on standardized anthropometric measures by trained nurses, as explained in the IFLS protocol report.[17] Stunting was defined by height-for-age Z-score (HAZ) <2 SD, while others were considered not stunting. Anemia status was classified based on the Hb result measured by a trained operator using a point-of-care Hemocue™ Hb test device.[17] The cut-off value for anemia in children was Hb of less than 11 g/dL, based on the World Health Organization criteria for children's anemia. The anemia categories used in the study were divided into "anemia (Hb <11 g/dL)" or "no anemia (Hb >11 g/dL)".

The household's food expenditure was defined as the food expense made for all the members of the household during the past one week. The food group's expenditure was presented as the percentage of the food group expense per total food expenditure. The food categories were classified into staple foods (hulled, uncooked rice, sweet potato, potato, yam); meat (beef, lamb, water buffalo meat, and the like); poultry (chicken, duck, eggs, and the like); fish and seafood (fresh fish, oysters, shrimp, squid, and the like); plant-based protein (tofu, tempeh, mung beans, peanuts, soya beans, and the like); vegetables and beans (water spinach, cucumber, spinach, mustard greens, tomatoes, cabbage, sweet leaf, green beans, string beans, and the like); fruits (papaya, mango, banana, and the like); processed food and refined grains (instant foods, cakes, and the like); dairy (fresh milk, powdered milk, and the like); and purchased meal.

The household food expenditure percentage was compared to the child's food frequency questionnaire (FFQ) to evaluate the correlation between household food expenses and the child's consumption. The IFLS data FFQ contained limited food types, which are tuber, meat, fish, eggs, vegetables, and fruits. These food types were used as proxies for staple, meat, fish and seafood, poultry, vegetables and beans, and fruit consumption. This study limited its observation to the types of food in the context of meals and did not take condiments such as salt, sugar, and oil into observation. The pattern decided for the household food expenditure was based on the latent class analysis (LCA) conducted in the current study and further explained in the data analysis subsection.

Child basic characteristics, including sex (male and female) and age groups, were included as potential confounding variables. Records of birth weight (<2,500 grams and >2,500 grams) and compliance to public health recommendation programs were included as potential confounding variables; breastfed records (ever and never); vitamin A supplementation (ever and never); and basic immunization (incomplete and complete). Drinking water source variables

also included a possible intake-related risk (pipe water, well water with a pump, well water with no pump, spring water, bottled water, and others). The presence of other forms of malnutrition, including stunting, wasting, obesity, and anemia, was also included as a potential confounding variable to the dependent variable. Wasting and obesity were based on Body Mass Index-for-age Z-score (BAZ), with <-2 SD classified as wasting and >2 SD classified as overweight and obese. All data were obtained through interviews using the IFLS questionnaire, which is described elsewhere.[15,17]

The IFLS interviewers were trained a month prior to the data collection, consisting of classroom training and field training. The data collection method was also pretested. The data cleaning was started in the field to ensure that the questionnaires were as complete and accurate as possible, to then entered into a data-entry software (CSPro 7.7.3, free version) to detect illogical values of code input and cleaned the data from remaining errors. The data in this study were extracted from the IFLS database and cleaned for duplicates.

Statistical analyses were performed with STATA software version 17 (licensed under StataCorp). The household food expenditure proportion per week was compared with the child's consumption frequency per week to observe if there was any correlation between the household food expenditure and the child's consumption. Pearson's correlation was applied to observe correlation and the degree of correlation, with a higher coefficient correlation representing a higher degree of correlation. After confirming the correlation between children's consumption and their household food expenditure (Supplementary 1), the LCA was used to identify clusters of household food expenditure typologies. LCA allows the observation of the heterogeneity in the subgroups within the population and is considered a "person-oriented analysis."[18]

To decide on the number of cluster models, the Bayesian Information Criterion (BIC) was used as the parameter to find the optimum number of clusters, with a lower number representing better optimization. After testing the goodness of fit of the two, three, and four-class models, the three-class model was used as the class solution for the LCA model (Table 1). After obtaining the food expenditure patterns, a binary regression was performed to compare the odds ratio (OR) of the different patterns to the incidence of stunting and anemia among the under-five (2007) and the followed-up data as school-aged children (2014).

Table 1. Household Food Expenditure Pattern Latent Class Analysis Goodness of Fit

Number of classes	2007 Household Food Expenditure Pattern	2014 Household Food Expenditure Pattern
	BIC	BIC
2 class	20413.24	21154.31
3 class	**20321.34**	**21027.29**
4 class	convergence not achieved	21045.72

Note: BIC: Bayesian Information Criterion

Not all participants' data were available in all potential confounding variables; therefore, the presented data might not match the total subjects. The potential confounding variables to child nutritional and anemia status were presented in numbers and percentages. The association between potential confounding variables and dependent variables was assessed with Chi-square. The food group's expenditures were presented in percent of total food expenditure. A p-value of <0.1 showed a likelihood, while a p-value of <0.05 with a 95% confidence interval (CI) was considered statistically significant.

Results

A total of 2,296 children from 2,158 households' data were included in this study. The prevalence of anemia in children aged 12–59 months (baseline) was 29.9% and significantly decreased to 11.0% when they were aged 8–12 years (end-line) (p-value = 0.00, 95% CI). The average Hb level of 2,296 children in the baseline data (2007) was 11.44±1.12 g/dL (min-max: 7.0–15.40 g/dL), and in the end-line data (2014) was 12.35±1.16 g/dL (min-max: 7.50-15.50 g/dL). Stunting at the baseline was 36.8% and significantly decreased in the end-line to 24.5% (p-value = 0.00, 95% CI).

The household food expenditure was correlated to the children's consumption in most food groups, except for staple food expenditure in 2007 and 2014 and meat expenditure in 2014 (Supplementary 1). The typology of household food expenditure patterns in 2007 and 2014 is presented in Figure 1. Based on the three-class LCA solution, the household food expenditure in 2007 was divided into three distinct patterns. Pattern 1 was leaning toward processed food and refined grain and purchased meals; Pattern 2 was distinct in higher fish and seafood, plant protein, and vegetables and

beans household food purchase; and Pattern 3 was more varied in food groups except for meat and considered a balanced food expense model.

Meat expenditure percentage was low in all patterns. The typology of household food expenditure in 2014 showed a similar pattern to the typology in 2007, with slightly different percentages of household food expenditure adherence. The population distribution of the three-class household food expenditure pattern is described in Table 2. Pattern 1 was adhered to by 3.9% of the household in 2007 and increased to 8.4% in 2014. Pattern 2 was adhered to by 25.2% of the household in 2007 but decreased to 23.7% in 2014. Pattern 3 was the most adhered to household food expenditure pattern in 2007 (70.9%) and 2014 (67.9%). In 2007, Pattern 1 was higher in the urban population, while Pattern 2 was higher in the rural population. However, in 2014, Pattern 1 was higher in rural compared to urban, accompanied by decreased adherence to Pattern 2 and Pattern 3 in the rural population.

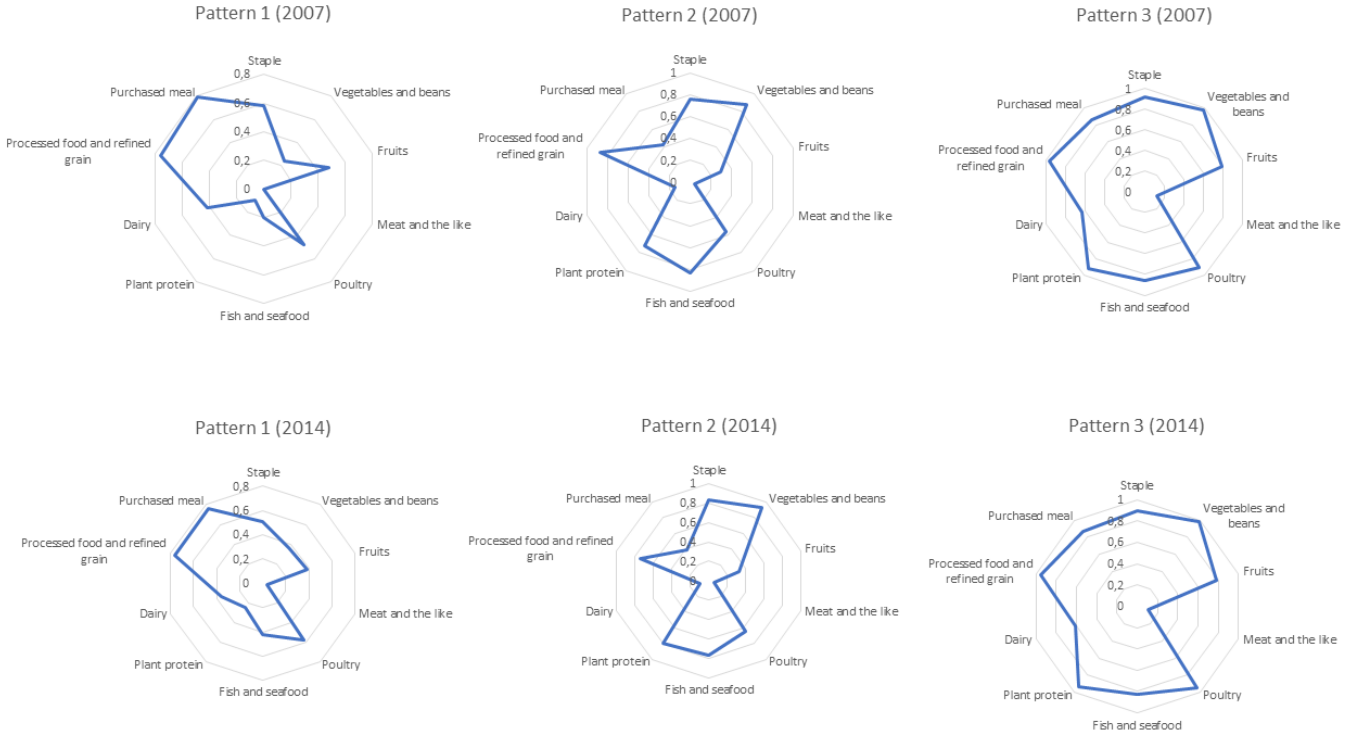

Figure 1. The Household Food Expenditure Pattern Classes Based on Latent Class Analysis

Table 2. Interpretation and Distribution of Household Food Expenditure Patterns (n = 2,296)

Pattern	Class Interpretation	2007			2014		
		n (%)	Urban n (%)	Rural n (%)	n (%)	Urban n (%)	Rural n (%)
1	Higher purchased meals and processed food	90 (3.90)	57 (5.20)	33 (2.70)	192 (8.40)	100 (7.80)	92 (9.00)
2	Higher fish and seafood, plant protein, and greens and beans	579 (25.20)	167 (15.40)	412 (34.00)	544 (23.70)	198 (15.50)	346 (33.90)
3	Balanced proportion	1,627 (70.90)	862 (79.40)	765 (63.20)	1,560 (67.90)	976 (76.60)	584 (57.10)

Some potential confounding variables to stunting and anemia in children are presented in Table 3. In the 12-59-month age group, HAZ and BAZ status are associated with anemia. Age group and BAZ status are still associated with child anemia in the 8-12 years old; however, HAZ status is no longer associated. Stunting is associated with drinking water sources, birth weight record, BAZ status, and anemia status in the 12-59 months; however, anemia is no longer associated with stunting in the 8-12 years old.

Household food expenditure pattern analyses with stunting and anemia among the 12-59 months old are shown in Table 4. Households with Pattern 2 food expenditure had significantly lower odds of having a child with anemia within the household compared to the households with adherence to Pattern 3 food expenditure (OR 0.78, p-value = 0.02, 95% CI). The significant association is retained after adjustment with the confounding variables, which are age group, HAZ

status, and BAZ status (AOR 0.78, p-value = 0.03, 95% CI). Stunting in 12–59 months is also observed to be lower in households with Pattern 2 (OR 1.43, p-value = 0.00, 95% CI) compared to Pattern 3 food expenditure; however, the association is no longer significant after adjusting with drinking water sources, birth weight record, BAZ status, and anemia status (AOR 1.26, p-value = 0.16, 95% CI).

Table 3. Potential Confounding Variables of Child Stunting and Anemia

Variable	2007				2014			
	Stunting	p-value	Anemia	p-value	Stunting	p-value	Anemia	p-value
Sex (n = 2,296)								
Male	38.30%	0.11	30.79%	0.33	25.20%	0.43	30.79%	0.33
Female	35.10%		28.94%		23.80%		28.94%	
Age (n = 2,296)								
12-36 months	37.50%	0.39	43.00%	0.00*	24.00%	0.34	12.12%	0.01*
36-60 months	40.10%		31.40%		25.90%		8.11%	
Drinking water source (n = 2,296)								
Pipe water	34.80%		25.54%		21.90%		11.73%	
Well water with pump	32.30%		31.33%		23.50%		12.29%	
Well water with no pump	45%	0.00*	32.28%	0.07	37.40%	0.00*	7.14%	0.19
Spring water	40.90%		24.19%		35.80%		8.42%	
Bottled water	24.30%		31.10%		17.90%		11.73%	
Other	33.10%		33.30%		46.30%		7.50%	
Breastfeed record (n = 1,147)								
Ever	34%	0.13	30.39%	0.15	23.40%	0.39	23.40%	0.39
Never	20%		44.00%		16.00%		16.00%	
Complete immunization (n = 2,296)								
Yes	36.80%	0.82	29.78%	0.76	35.30%	0.01*	11.76%	0.78
No	36%		30.81%		20.70%		10.68%	
Vitamin A supplementation (n = 1,798)								
Yes	36.80%	0.64	30.97%	0.52				
No	38.90%		28.18%					
Low birth weight (n = 1,032)								
Yes	55.90%	0.00*	39.71%	0.09	35.30%	0.01*	11.80%	0.78
No	31.10%		29.88%		20.70%		10.70%	
HAZ status (n = 2,296)								
Stunting			33.06%	0.01*			12.26%	0.28
No stunting			28.03%				10.62%	
BAZ status (n = 2,296)								
Wasting	25.50%		37.23%		43.80%		16.13%	
Normal	35.70%	0.00*	30.28%	0.03*	25.20%	0.00*	10.66%	0.04*
Overweight and obese	45%		25.62%		8%		9.57%	
Anemia status (n = 2,296)								
Anemia	40.70%	0.01*			27.30%	0.28		
No anemia	35.10%				24.20%			

Notes: HAZ = height-for-age Z-score, BAZ = Body Mass Index-for-age Z-score, +p-value <0.10; *p-value <0.05

Table 5 shows the household food expenditure pattern analyses with stunting and anemia in 2014 when the children turned 8-12. Stunting was observed to be significantly higher in households adhering to Pattern 1 and Pattern 2 compared to Pattern 3 (OR = 1.44, p-value = 0.04, 95% CI and OR = 1.74, p-value = 0.00, 95% CI, respectively). However, the association after adjusting for the drinking water source, complete immunization status, birth weight record, and

BAZ status was no longer significant for Pattern 1 (AOR 1.33, p-value = 0.32, 95% CI) and only showed a tendency for Pattern 2 (AOR 1.37, p-value = 0.09, 95% CI) compared to Pattern 3. Anemia in the 8-12 years old was not associated with household food expenditure patterns.

Table 4. Association between Food Expenditure Pattern and Child Anemia and Stunting in 2007 (N = 2,296)

	n	Anemia n (%)	OR	95% CI	p-value	AOR[a]	95% CI	p-value
Pattern 1	90	26 (28.89)	0.89	0.56-1.42	0.63	0.88	0.55-1.42	0.61
Pattern 2	579	151 (26.08)	0.78	0.63-0.96	0.02*	0.78	0.63-0.97	0.03*
Pattern 3	1627	509 (31.28)	1			1		
	n	Stunting n (%)	OR	95% CI	p-value	AOR[b]	95% CI	p-value
Pattern 1	90	25 (27.78)	0.72	0.45-1.15	0.17	0.62	0.31-1.25	0.18
Pattern 2	579	251 (43.35)	1.43	1.18-1.73	0.00*	1.26	0.91-1.75	0.16
Pattern 3	1627	568 (34.91)	1			1		

Notes: OR = odds ratio, AOR = adjusted odds ratio, CI = confidence interval
a: Adjusted with age, height for age, and weight for age categories
b: Adjusted with drinking water source, low birth weight, body mass index for age status, and anemia categories

Table 5. Association between Food Expenditure Pattern and Anemia and Stunting in 2014 (n = 2,296)

	n	Anemia n (%)	OR	95% CI	p-value
Pattern 1	192	16 (8.33)	0.69	0.40-1.18	0.17
Pattern 2	544	55 (10.11)	0.85	0.62-1.17	0.32
Pattern 3	1,560	182 (11.67)	1		

	n	Stunting n (%)	OR	95% CI	p-value	AOR[a]	95% CI	p-value
Pattern 1	192	54 (28.13)	1.44	1.03-2.01	0.04*	1.33	0.76-2.32	0.32
Pattern 2	544	175 (32.17)	1.74	1.40-2.16	0.00*	1.37	0.94-1.98	0.09+
Pattern 3	1,560	334 (21.41)	1			1		

Notes: OR = odds ratio, CI = confidence interval, AOR = adjusted odds ratio
a: Adjusted with drinking water, complete immunization, birth weight, body mass index for age status, and anemia status

Discussion

There were significant decreases in anemia and stunting between 2007 and 2014. The child's food consumption was correlated with the household food expenditure in most food groups but lower in the school-age compared to the under-five. The household food typology patterns were identified as three patterns: (1) higher in purchased meal, processed food, and refined grain; (2) higher in fish and seafood, plant protein, and vegetables and beans; and (3) higher in dairy, poultry, and fruits expenditures, with the latter was mostly adhered by the current population. After adjusting for the potential confounding variables, household food expenditure with higher fish and seafood, plant protein, and vegetables and beans was associated with lower odds of under-five anemia compared to balanced food expenditure. No association was found between food expenditure patterns and stunting in both age groups.

Nutrition deficiencies, especially iron, are a common risk factor for anemia. A lack of nutritious food intake and a diversified diet can lead to low iron intake.[19] There are several iron, folate, and vitamin B12-rich food sources, such as red meat, poultry, fish, eggs, green vegetables, and beans; also, foods with high vitamin C fruits and vegetables can promote iron absorption in the body.[20] However, heme-iron food sources such as red meat and eggs with high iron content are relatively more expensive than non-heme-iron food sources such as grain, beans, vegetables, and fruits.[12] In this study population, meat purchase was considerably low in all patterns, even for the balanced food expenditure pattern. Families with low income might have low purchasing power for these food groups, as also observed in another report on

Indonesian rural communities.[21] In addition, people in rural areas tend to have difficulty obtaining food other than self-produced food, one of which is animal protein, such as meat, especially when they have limited access to livestock products.[21] Therefore, lack of access to food might lead to low accessibility to meat products in the rural population.

Based on this study, the availability of non-heme iron, folate, and vitamin B12-rich food choices in households gave possible advantages to promote the nutritious intake required for Hb synthesis and red blood cell production. This idea is also supported by previous studies reporting the equal effect of fish and meat consumption on lower anemia.[22,23] Fish is one of the food sources with high protein, supporting erythropoiesis by allowing increased protein synthesis.[22] Another study also supports the role of non-heme iron from plant protein as a promising alternative iron source aside from meat.[24]

This study observed a different association across two periods: 12-59 months and 8-12 years. The household food expenditure pattern was associated with the children's anemia status when they were younger but not when the children turned older. This study also observed a higher prevalence of anemia in the baseline when the children were still under five years of age. Infant and young childhood feeding practices were associated with Hb concentration.[25] The low intake of iron-rich foods after weaning is also a risk factor for anemia among the 12-60 months old.[26]

Children aged five years to adolescence have the same iron intake requirements as adult men, and consuming iron-rich food is essential for children to balance their iron requirements.[27] Moreover, younger children rely on their parents or caregivers to provide food; therefore, household food may impact younger children more when they become older.[11] The prospective observation in this study also observed a lower correlation between household food and school-age children's consumption compared to when they were under five. In addition to feeding factors, illnesses such as fever incidence were also reported to be associated with anemia prevalence in under two years old, thus adding more risks of anemia in those under two years of age compared to older children.[28]

Previous reports in Indonesia have suggested the effects of food insecurities and lower-than-average food expenditure on nutritional status.[13,29] This population also shows a likelihood of an association between household food expenditure proportion patterns and stunting in school-aged children. Households with balanced food expenditure likely have a lower incidence of stunting compared to households with higher fish, seafood, plant protein, vegetables, and beans. The results were in contrast with the pattern association with anemia in the 12–59 months; however, it is supported by other studies suggesting that a more balanced diet in school-age gives benefits for better growth.[30] Further study on factors related to household food's effect on dietary patterns in school-aged children is necessary to draw conclusions related to the association between household food expenditure and stunting in 8–12-year-old children.

This study showed that higher household food expenditure on non-heme nutrient-rich foods was associated with a lower incidence of anemia in children of the household. Food expenditure in Indonesia is influenced by multiple factors, such as the Human Development Index (HDI), Gross Regional Development Product (GRDP), the number of family members, education, and household income.[31] Improving economic access to nutritious food sources will support the food-based and nutritional approach that has been conducted by the Indonesian government. An interdisciplinary approach through education, supplementation, and increased food purchasing power for nutritious foods is necessary to optimize efforts in reducing malnutrition.

Other variables were observed to be associated with stunting and anemia. Age, HAZ, and BAZ categories were associated with anemia while drinking water source, low birth weight, BAZ, immunization, and anemia categories were associated with stunting. Although this study did not explore these variables as dependent variables, these variables have been acknowledged as part of maternal and child nutrition framework determinants.[9] These variables possibly have their independent role in association with stunting and anemia in this population.

This study included children from all over Indonesia, spreading across various provinces and urban and rural areas, thus representing the Indonesian population. The multiple observations give a better understanding of the impact of household food in the different phases of childhood. This study proposed a novel analysis of food expenditure typology using the LCA. The typology allows for a better classification of the household's food purchasing pattern in the population compared to the general food-group variables.

However, this study observed each case of stunting and anemia independently. It did not observe groups that stayed stunted or anemic between 2007 and 2014, as well as groups having both stunting and anemia together at the same time. This study was taken from secondary data, causing a limitation in the availability of some supporting information, such as iron supplementation status and infectious diseases. This study also did not observe the children's food choices outside the household, such as when they bought food at school or had dinner at a friend's place. Other external factors, such as political and economic changes, were not included in the analyses. A further longitudinal study using a primary data

collection method observing wider socioeconomic variables is necessary to gain insight related to the decision-making process for household food purchases.

Conclusion

Household food expenditure is a factor associated with anemia. The evidence for food expenditure associated with stunting is still limited. The lower-than-median household spending on meat is associated with anemia compared to the higher spending in the category. In addition, children without anemia have significantly increased household food expenditure on almost all types of food. The evidence for food expenditure association with stunting remains limited; however, food security aspects at the household level cannot be disregarded in both anemia and stunting prevention. Economic access to iron-rich food should be part of the policy to support the current programs in response to undernutrition.

Abbreviations

LMICS: lower-middle-income countries; IFLS: Indonesian Family Life Survey; HAZ: height-for-age Z-score; FFQ: food frequency questionnaire; LCA: latent class analysis; BAZ: Body Mass Index-for-age Z-score; BIC: Bayesian Information Criterion; OR: odds ratio; CI: confidence interval; AOR: adjusted odds ratio.

Ethics Approval and Consent to Participate

Inform liscence obtained from institution and research subject. This study has acquired approval from RAND Corporation, the institute that conducted the survey and owned the IFLS data. The IFLS survey was reviewed and approved by Institutional Review Boards at the University of Gadjah Mada with ethical clearance number s0064-06-01-CR01.

Competing Interest

There are no significant competing personal, professional, or financial interests that may have influenced the performance or presentation of the work described in this manuscript.

Availability of Data and Materials

The datasets are available on the RAND Corporation's website as the institute that conducted the survey and owned the IFLS data: https://www.rand.org/well-being/social-and-behavioral-policy/data/FLS/IFLS.html.

Authors' Contribution

RADS, Y, SAP, and FW designed the study; RADS, RAW, and WMN conducted the data selection and cleaning; RADS and FW analyzed the data; RADS, Y, and FW wrote the manuscript. All the authors have read and approved the manuscript.

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Dietary Diversity as a Dominant Factor of Energy Intake Among Breastfeeding Mothers in Depok City, Indonesia

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Abstract

Maternal nutritional needs increase during lactation. However, the energy intake of breastfeeding mothers usually still falls short of the recommended adequacy levels. This study aimed to identify the dominant factor of energy intake in breastfeeding mothers in Sawangan District, Depok City, Indonesia. This quantitative study used a cross-sectional design from July 2022 to February 2023. Energy intake, dietary diversity, and eating frequency were collected using 24-hour food recall. Other variables were collected through interviews with structured questionnaires. Data were analyzed using the Chi-square test and binary logistic regression. A total of 217 breastfeeding mothers participated in this study. This study found that 78.3% of breastfeeding mothers had inadequate energy intake. Dietary diversity (p-value = 0.032) was the dominant factor associated with the energy intake of breastfeeding mothers. Breastfeeding mothers with non-diverse food consumption were at a 2.507 times higher risk of inadequate energy intake. Energy intake in breastfeeding mothers is related to the sustainability of breastfeeding. However, most breastfeeding mothers in Sawangan District still have insufficient energy intake. Therefore, it is suggested that food supplementation for breastfeeding mothers should be included in promoting exclusive breastfeeding.

Keywords: breastfeeding mothers, dietary diversity, energy intake, Sawangan District

Introduction

Globally, in 2021, malnutrition in women remains at a high level, including underweight (9.1%), overweight (32.5%), anemia (29.9%), and short stature (7%).[1] The Indonesian Basic Health Research reported 22.7% of adolescents and women of reproductive age suffering from anemia and 17.3% of pregnant women experiencing chronic energy malnutrition.[2] According to the United Nations Children's Fund (UNICEF) conceptual framework on the 2020 Maternal and Child Nutrition, inadequate food consumption was one direct cause of malnutrition.[3] Breastfeeding mothers need 330 kcal of additional energy in the first six months of breastfeeding, which is higher than the recommendation for pregnant women.[4] This is an essential period for breastfeeding mother to replenish their nutritional reserves after childbirth and ensure additional energy needs for breastfeeding are met.[1] Inadequate intake during this period can level up the risks of mother and infant for malnutrition, morbidity, and mortality.[5]

The breastfeeding mother's intake is related to the composition of breast milk. A diverse and adequate energy intake can help mothers to go through lactation without deficiencies.[6] A previous study found that consuming <2,100 kcal per day in breastfeeding mothers can affect the sustainability of breastfeeding.[7] Besides, if breastfeeding mothers do not meet their nutritional needs, they will be at risk of nutrient storage depletion and micronutrient deficiencies, thus worsening malnutrition problems.[8]

However, studies in West Java Province, Indonesia, have found that maternal energy intake still needs to meet Indonesia's Recommended Dietary Allowance/*Angka Kecukupan Gizi* (AKG).[9,10] Breastfeeding mothers' energy intake was lower than when pregnant, even though their nutritional needs were higher during breastfeeding than during pregnancy.[9] Several factors are related to energy intake, such as age, education level, household income, mother's attitude, husband's support, dietary diversity, and eating frequency.[9,11–15]

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Based on a previous study in Depok City, West Java Province, the energy intake of breastfeeding mothers still does not meet the AKG.[9] Infants exclusively breastfed get nutrients only from breast milk. Therefore, breastfeeding mothers' intake must be considered in stunting prevention.[16] However, existing interventions only target female adolescents, pregnant women, and toddlers, but not breastfeeding mothers.[17] Sawangan District has a higher stunting prevalence (5.7%) compared to the whole of Depok City (3.48%).[18] Therefore, this study aimed to identify the dominant factor of energy intake in breastfeeding mothers in Sawangan District, Depok City. This study's results may contribute valuable insight into the urgency of promoting dietary diversity, specifically for breastfeeding mothers, in promoting exclusive breastfeeding for stunting prevention in Indonesia.

Method

This quantitative study used a cross-sectional design conducted from July 2022 to February 2023 in Sawangan District, Depok City, West Java Province, Indonesia. The respondents for this study were breastfeeding mothers who met the following inclusion criteria: aged 15-49 years, living in the area of study, and willing to participate in the study process. The exclusion criteria were breastfeeding mothers with twin infants. This study used the total sampling method; hence, all the breastfeeding mothers who met the criteria were included. A total of 217 breastfeeding mothers participated in this study, with infants ranging in age from two days to three months. All the respondents in this study had signed an informed consent prior to data collection.

Energy intake was categorized as inadequate (if the intake was <90% AKG) and adequate (if the intake was ≥90% AKG). The AKG used in this study refers to Regulation of the Indonesian Minister of Health Number 28 of 2019.[4] Variables of energy intake, dietary diversity, and eating frequency were collected using 24-hour food recall. Dietary diversity was assessed using Minimum Dietary Diversity for Women (MDD-W) with 10 food groups: (1) grains, white roots and tubers, and plantains, (2) pulses, (3) nuts and seeds, (4) milk and milk products, (5) meat, poultry, and fish, (6) eggs, (7) dark green leafy vegetables, (8) other vitamin A-rich fruits and vegetables, (9) other vegetables, and (10) other fruits. Dietary diversity was calculated by summing the number of food groups an individual consumed ≥15 grams in a 24-hour recall period.[19] Eating frequency was assessed by counting the meal times an individual consumed food or beverages ≥50 kcal, separated from the previous meal time during the 24-hour recall period.[20]

Other variables such as age, maternal education level, household monthly income, attitude to breastfeeding mother's meal portion, and husband's support according to the mother's perception were collected through interviews with structured questionnaires. The questionnaire was validated using Cronbach's alpha of 0.611, considered acceptable. Age was categorized using the median. The attitude was analyzed based on "agree" or "disagree" responses to the statement, "A breastfeeding mother still wants to eat more according to the breastfeeding mother's portion, even though she feels full." The breastfeeding mother had a positive attitude if she agreed with this statement. Similarly, the husband's support was analyzed based on the breastfeeding mother's response to the statement, "My husband reminds me to eat nutritious food to increase breastmilk production." Data was then analyzed using the Chi-square test and binary logistic regression.

Results

A total of 217 breastfeeding mothers participated in this study. Table 1 shows the characteristics of the breastfeeding mother in this study. Respondents were mostly aged ≥29 years (53.5%), graduated from senior high school or higher (66.8%), having a high household income (50.7%), having a positive attitude to the breastfeeding mother's meal portion (73.7%), and receiving support from their husband (94.9%). Most breastfeeding mothers' food consumption was diverse (66.4%) and met the minimum eating frequency or ate ≥4 times a day (87.6%). The prevalence of inadequate energy intake in this study was 78.3%.

Table 2 shows the distribution of energy intake in breastfeeding mothers, ranging between 1788.17 kcal to 1948.01 kcal, which fulfills 70.64% to 76.98% AKG. This study found that the median energy intake in breastfeeding mothers was 1803.72 kcal and only met 70.49% AKG. Table 3 shows the bivariate analysis result. This study found that two variables were significantly associated with breastfeeding mothers' energy intake: dietary diversity (p-value = 0.006, OR: 3.018) and eating frequency (p-value = 0.005, OR: 8.306). Other variables such as age, maternal education level, household monthly income, attitude, and husband's support were not significantly associated with energy intake in breastfeeding mothers. Table 4 shows that higher energy intake is found in breastfeeding mothers with diverse food consumption and met the minimum eating frequency.

Table 1. Characteristics of the Breastfeeding Mother

Variable	n	%
Energy intake		
Inadequate (<90% AKG)	170	78.3
Adequate (≥90% AKG)	47	21.7
Age		
<29 years	101	46.5
≥29 years	116	53.5
Maternal education level		
Low (Junior high school or lower)	72	33.2
High (Senior high school or higher)	145	66.8
Household monthly income		
Low (<IDR3,000,000 or $191.05)	107	49.3
High (≥IDR3,000,000 or $191.05)	110	50.7
Attitude to breastfeeding mother's meal portion		
Negative	57	26.3
Positive	160	73.7
Husband's support according to the mother's perception		
No	11	5.1
Yes	206	94.9
Dietary diversity		
Not diverse (<5 food groups)	73	33.6
Diverse (≥5 food groups)	144	66.4
Eating frequency		
Not met (<4 times)	27	12.4
Met (≥4 times)	190	87.6

Notes: AKG = *Angka Kecukupan Gizi*/Indonesia's Recommended Dietary Allowances, IDR = Indonesian Rupiah

Table 2. Distribution of Energy Intake in Breastfeeding Mother

Variable	N	Min–Max	Median	SD	95% CI
Energy intake (kcal)	217	631.60–4,185.64	1,803.72	597.29	1,788.17 – 1,948.01
% AKG	217	24.48–168.78	70.49	23.71	70.64 – 76.98

Notes: AKG = *Angka Kecukupan Gizi*/Indonesia's Recommended Dietary Allowances, SD = standard deviation, CI = confidence interval

Table 3. Factors Associated with Energy Intake in Breastfeeding Mother

Variable	Energy Intake				p-value	OR (95% CI)
	Inadequate		Adequate			
	n	%	n	%		
Age						
<29 years	83	82.2	18	17.8	0.2	1.537
≥29 years	87	75.0	29	25.0		(0.794–2.975)
Maternal education level						
Low	61	84.7	11	15.3	0.108	1.832
High	109	75.2	36	24.8		(0.870–3.856)
Household monthly income						
Low	88	82.2	19	17.8	0.169	1.582
High	82	74.5	28	25.5		(0.821–3.047)
Attitude to breastfeeding mother's meal portion						
Negative	45	78.9	12	21.1	0.897	1.050
Positive	125	78.1	35	21.9		(0.502–2.198)
Husband's support according to the mother's perception						
No	9	81.8	2	18.2	1.0	1.258
Yes	161	78.2	45	21.8		(0.262–6.030)
Dietary diversity						
Not diverse	65	89.0	8	11.0	0.006*	3.018
Diverse	105	72.9	39	27.1		(1.328–6.860)
Eating frequency						
Not met	26	96.3	1	3.7	0.015*	8.306
Met	144	75.8	46	24.2		(1.097–62.905)

Notes: OR = odds ratio, CI = confidence interval, *p-value <0.05

Table 4. Energy Intake Based on Dietary Diversity and Eating Frequency

Variable	n	Min–Max	Median	SD	95% CI
Dietary diversity					
Not diverse	73	631.60–3,167.76	1,577.88	537.91	1,452.93 – 1,703.94
Diverse	144	800.04–4,185.64	1,939.84	573.28	1,920.50 – 2,109.37
Eating frequency					
Not met	27	631.60–2,967.66	1,041.73	505.74	1,024.98 – 1,425.11
Met	190	802.07–4,185.64	1,863.51	552.34	1,880.43 – 2,038.52

Notes: SD = standard deviation, CI = confidence interval

This study also analyzed the dominant factor of energy intake in breastfeeding mothers (Table 5). Variables with a p-value of <0.25 were included in multivariate analysis using binary logistic regression. Based on the results of the bivariate selection, five of seven independent variables in this study with a p-value of <0.25 were age (p-value = 0.2), maternal education level (p-value = 0.108), household monthly income (p-value = 0.169), dietary diversity (p-value = 0.006), and eating frequency (p-value = 0.015). These five variables would be included in the initial multivariate modeling. Two independent variables that were not candidates in the multivariate model were attitude to the breastfeeding mother's meal portion (p-value = 0.897) and husband's support according to the mother's perception (p-value = 1.0). The multivariate analysis showed that dietary diversity (p-value = 0.032) was the dominant factor of energy intake. Breastfeeding mothers with non-diverse food consumption had a 2.507 times higher risk of consuming inadequate energy than breastfeeding mothers with diverse food consumption after controlling for variables such as age, maternal education level, household monthly income, and eating frequency. No interaction was found between dietary diversity and other variables.

Table 5. Dominant Factor of Energy Intake in Breastfeeding Mother

Variable	p-value	OR	95% CI
Age	0.228	1.526	0.767–3.035
Maternal education level	0.288	1.556	0.688–3.521
Household monthly income	0.497	1.282	0.626–2.626
Dietary diversity	0.032*	2.507	1.084–5.800
Eating frequency	0.087	5.990	0.774–46.383

Notes: OR = odds ratio, CI = confidence interval, *p-value <0.05

Discussion

This study found that most breastfeeding mothers in Sawangan District had inadequate energy intake (78.3%). Meanwhile, only 21.7% of breastfeeding mothers had adequate energy intake. Breastfeeding mothers were estimated to consume around 1,803.72 kcal or 70.49% AKG. According to the mother's age, this intake was much lower than the daily recommended intake of 2,380 kcal to 2,580 kcal. In line with this result, a study in Cipayung District, Depok City, also found that the energy intake of breastfeeding mothers was lower than the recommended, with only 2,273 kcal.[9] A systematic review also found that the intake of breastfeeding mothers in Indonesia does not meet the recommended nutritional adequacy.[21]

Inadequate maternal energy intake during breastfeeding may impact the production of breast milk. A previous study found that breastfeeding mothers who failed to provide exclusive breastfeeding only consumed 1,502.6±434.1 kcal daily. In contrast, breastfeeding mothers providing exclusive breastfeeding had a higher energy intake of 2,004.7±304 kcal per day.[22] Another study stated the same findings, that breastfeeding mothers with energy intake <2,100 kcal per day are at higher risk of being unable to provide exclusive breastfeeding for up to six months.[7] These results showed that breastfeeding mothers in Sawangan District had a higher risk of being unable to provide exclusive breastfeeding for up to six months.

Six-month exclusive breastfeeding is a specific intervention program for accelerating stunting reduction in Indonesia. Unfortunately, the program has no intervention on breastfeeding mothers' food intake.[17] Several studies have found that inadequate intake in breastfeeding mothers could affect breastmilk composition and threaten the sustainability of exclusive breastfeeding.[6,22] Another study found that the energy intake of mothers in the sixth month of breastfeeding was even lower than in the first month, even though their nutritional needs increased as the months progressed.[23] In this study, breastfeeding mothers' food intake in several weeks to three months of breastfeeding was still deficient compared to the recommended nutritional adequacy, and they were at risk of becoming lower as the months progressed. This study further strengthens that the dietary intake of breastfeeding mothers still does not meet the recommended value and is essential to pay attention to in promoting exclusive breastfeeding.

This study found a significant relationship between dietary diversity and energy intake in breastfeeding mothers (p-value = 0.006). This result was in line with another study on Japanese adults.[14] The OR value was 3.018; thus, breastfeeding mothers with non-diverse food consumption will have a greater likelihood of inadequate energy intake than those with diverse food consumption. In this study, the median value of energy intake in breastfeeding mothers with various food consumption was 1,939.84 kcal. Meanwhile, energy intake in breastfeeding mothers with non-diverse food consumption was much lower at only 1,577.88 kcal. Improved food consumption diversity is associated with increased intake in nutrient-dense food groups, such as meat, fish, and fruit.[14]

Another variable significantly related to breastfeeding mothers' energy intake was eating frequency (p-value = 0.015). Breastfeeding mothers eating <4 times per day were 8.306 times more likely to have inadequate energy intake than breastfeeding mothers eating ≥4 times daily. The median value of energy intake in breastfeeding mothers with ≥4 times eating frequency was 1,863.51 kcal. This intake was much higher than breastfeeding mothers with a <4 time-eating frequency at only 1,041.73 kcal. In line with this result, a previous study stated that the higher the eating frequency of breastfeeding mothers, the more likely breastfeeding mothers can fulfill their increasing nutritional needs.[15] When the eating frequency increases once, the energy intake will increase by 301 kcal and 243.3 kcal.[20,24]

Although there was no significant relationship, inadequate energy intake was more prevalent in the age group <29 years (82.2%) compared to the older age group (75%). This result aligned with a previous study finding that inadequate energy intake is more common in younger breastfeeding mothers.[10] This may be related to the mother's experiences. Younger mothers, especially those who just had children, tend to be unaccustomed to taking off their children and paying little attention to themselves.[9]

Other than age, this study also found inadequate energy intake was more often found in breastfeeding mothers with low levels of education (84.7%) and household monthly income (82.2%) than their counterparts. Education is associated with the mother's ability to make better decisions for herself and her infant. Educated mothers, compared to uneducated ones, tend to be more careful in selecting the foods they consume.[25] Moreover, increased income is associated with the increased ability to purchase food. Low-income mothers may experience barriers to purchasing groceries.[26,27]

In this study, inadequate energy intake was more prevalent in breastfeeding mothers with negative attitudes to breastfeeding mother's meal portions (78.9%) than those with positive attitudes (78.1%). This finding might be related to the mother's assumption of the infant's nutritional needs. A study in Jakarta and Depok found that more than half of breastfeeding mothers disagreed that the nutritional needs of mothers increased during the breastfeeding period.[28] This finding is related to a mother's assumption that her infant needs more nutrients for its development while in the womb than after birth.[28]

This study also found that inadequate energy intake was more often found in breastfeeding mothers with unsupportive husbands (81.8%) than in mothers with supportive husbands (78.2%). The support of families, specifically from the husband, can be an intermediary to collect and convey information to the mother from close people, health workers, or other media.[29] A study in Bangladesh also found that husbands' participation in programs related to maternal nutrition can help increase maternal food intake.[27] The involvement of husbands can significantly increase awareness, knowledge, self-efficacy, and support to wives, which then affects the mother's food intake.[30]

A multivariate analysis was conducted in this study to analyze the dominant factor of energy intake in breastfeeding mothers. The multivariate analysis showed that dietary diversity was a dominant factor of energy intake in breastfeeding mothers (p-value = 0.032). After controlling for confounding variables (age, maternal education level, household monthly income, and eating frequency), breastfeeding mothers with non-diverse food consumption had a 2.507 times more significant risk for inadequate energy intake. Several studies have found a relationship between age and education level,[31] household income,[32] and eating frequency,[33] with dietary diversity. This showed that variables expressed as confounding could become confounding since they were related to dietary diversity or energy intake.

Breastfeeding mothers in this study were estimated to consume only 70.49% AKG. Further studies are still needed to investigate the impact of this inadequate intake on breastfeeding duration and the development of breastfeeding mothers' intake during breastfeeding. The source of nutrition for exclusively breastfed infants comes from breast milk, thus serving an urgency of breastfeeding mothers' intake for stunting prevention.[16] However, the existing interventions only target female adolescents, pregnant women, and toddlers.[17] This study's results suggested that the government needs to pay attention to breastfeeding mothers' intake when promoting exclusive breastfeeding for stunting prevention, such as food supplementation programs for breastfeeding mothers.

The limitation of this study is the implementation of a 24-hour food recall, which might not be sufficient to describe the individual's daily intake. However, the method is approved by the Food and Agriculture Organization (FAO) to assess food intake at the population level. Another limitation is the application of a cross-sectional study design. Therefore, it cannot determine causal effect relationships. The strengths of this study include the food intake obtained from quantitative data and the implementation of the FAO's advice for minimum intake requirements. The advice was not to include the food consumed <15 grams in the calculation of dietary diversity. In addition, the enumerators are trained so that fewer limitations related to food intake data are expected.

Conclusion

Energy intake in breastfeeding mothers is related to the sustainability of breastfeeding. However, most breastfeeding mothers in Sawangan District still have inadequate energy intake. Dietary diversity is found to be the dominant factor in breastfeeding mothers' energy intake after controlling for variables such as age, maternal education level, household monthly income, and eating frequency. It is suggested that food supplementation for breastfeeding mothers should be included in promoting exclusive breastfeeding. This intervention could be implemented with the help of multisectoral cooperation, including industry, the government, academics, and the community.

Abbreviations

AKG: *Angka Kecukupan Gizi*/Indonesia's Recommended Dietary Allowance; OR: odds ratio; SD: standard deviation; CI: confidence interval; IDR: Indonesian Rupiah; FAO: Food and Agriculture Organization.

Ethics Approval and Consent to Participate

This study was approved by the Research and Community Engagement Ethical Committee Faculty of Public Health, Universitas Indonesia (Letter of Approval No. 440/UN2.F10.D11/PPM.00.02/2023). All the respondents in this study had signed informed consent forms before the data was collected.

Competing Interest

The authors declare that they have no conflict of interest.

Availability of Data and Materials

This study's data can be provided upon reasonable request.

Authors' Contribution

CLS, the principal investigator, conceptualized and designed the study, conducted the data analysis and interpretation, prepared the draft of the manuscript, and reviewed the manuscript; RADS conducted the study, led the data collection, advised on the data analysis and interpretation, and reviewed the manuscript; SF, advised on the data analysis and interpretation, and reviewed the manuscript; FW, advised on the data analysis and interpretation, and reviewed the manuscript; PNP, led the data collection and reviewed the manuscript; and NHMS, advised on the data analysis and interpretation, and reviewed the manuscript.

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Assessment of Free Drinking Water Facilities and Its Potential Health Risks: A Study in the University X

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Assessment of Free Drinking Water Facilities and Its Potential Health Risks: A Study in the University X

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Abstract

University X offers free drinking water facilities. However, it has a significant problem in accessing safe drinking water. This study aimed to examine the microbial and chemical parameters of the free drinking water facilities at University X. The microbial quality was assessed by evaluating the total coliform bacteria, and the chemical parameter assessment, substances such as nitrate, iron, manganese, hexavalent chromium, and fluoride were analyzed across 12 water samples from various locations within the university. Among these, only total coliform and fluoride levels exceeded the guidelines of the World Health Organization (WHO) and the Indonesian Ministry of Health. An Environmental Health Risk Assessment was also conducted to discern potential health hazards among the 112 respondents. This study found no potential non-carcinogenic health risks associated with consuming water from the facilities. However, a sample in one location tested positive for total coliform, and the nitrate and manganese concentrations in another location did not meet the Indonesian Ministry of Health standards. The findings suggested that the free drinking water provided by University X is safe for consumption. Nonetheless, regular maintenance of the treatment facilities is needed to ensure that water quality remains suitable and clean.

Keywords: assessment, health, microbiology, risk, water

Introduction

Drinking water is an essential human necessity, and the importance of having access to safe drinking water cannot be overstated. According to the World Health Organization (WHO), safe drinking water is defined as water that does not present any health risks and is suitable for lifelong consumption.[1] To ensure that the water quality remains excellent, the processing, packaging, and dispensing of potable water must adhere to stringent hygiene and sanitation standards. Specifically, it must be free from microbiological, physical, chemical, and radioactive contaminants that pose potential health risks.[2] According to Sustainable Development Goals (SDGs) target 6, drinking water management aims to ensure its safe and affordable provision to safeguard human rights.[3] Based on the initial assessment, access to safe drinking water in the city where University X is located was only 15.45%.[4] A recent report on Household Drinking Water Quality Surveillance/*Surveilans Kualitas Air Minum Rumah Tangga* (SKAMRT) in 2020 revealed that only 11.8% of the population had access to safe drinking water.[5]

To determine if water is safe for consumption, it is crucial to examine two common parameters: microbial and chemical. Microbial pathogens, such as fecal coliform microbes, *Escherichia coli*, fecal *streptococci*, *Pseudomonas aeruginosa*, or *Staphylococcus spp*., are frequently found to contaminate drinking water.[6] These pathogens can adversely affect human health, with symptoms such as diarrhea, nausea, and vomiting.[7] In addition to that, chemical contaminants, including chromium (Cr), fluoride (F), lead (Pb), iron (Fe), arsenic (As), and nitrate (NO_3^-), have been detected in many water sources around the world, including India,[8] Nepal,[9] Peru,[10] and Denmark.[11]

Previous studies in Indonesia have consistently demonstrated widespread contamination of drinking water by microbial and chemical pollutants across various regions. For instance, investigations in the Special Region of Yogyakarta Province revealed elevated NO_3^- concentrations in well water, attributed to inadequate sanitation practices.

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The issue of high NO_3^- levels in drinking water is critical and requires further analysis as it poses potential health risks to the community.[12]

University X, the largest academic institution in the country, has been committed to providing free drinking water facilities. These facilities are strategically located in different faculties and public areas to reduce the use of disposable water bottles. However, there is a notable lack of comprehensive assessments or research on the microbiological and chemical composition of the drinking water provided by the university, a critical aspect in mitigating the risks associated with waterborne diseases. Therefore, this study aimed to conduct thorough microbiological sampling and analysis, as well as chemical health risk assessments, on the university's free drinking water facilities. Furthermore, potential health risks associated with consuming the water were evaluated using the Environmental Health Risk Assessment (EHRA).

Method

Twelve water samples were collected from free drinking water facilities available at University X. The variables measured were total coliform bacteria, nitrate (NO_3^-), iron (Fe), manganese (Mn), hexavalent chromium (Cr^{6+}), and fluoride (F). Biological parameters were not included in the risk calculation because drinking water suitable for consumption should have zero biological contaminants, following the Regulations of the Indonesian Ministry of Health and the WHO. These facilities are located in the Faculty of Public Health (A), Faculty of Nursing (B), Faculty of Mathematics and Natural Sciences (C), Faculty of Humanities (D), Faculty of Computer Science (E), Faculty of Law (F), Faculty of Psychology (G), Faculty of Economics and Business (H), Faculty of Engineering (I), Student Activity Center (J), Library (K), and Mosque (L) (Figure 1).

The sample collection and transportation followed the technical regulations of the Indonesian Ministry of Health. The procedures were carried out in the following orders: first, the sample was collected, stored, and carried in a sterile container to prevent contamination; second, the sample was labeled with detailed sample information; third, trained personnel conducted the sampling process; and finally, the sample was promptly delivered to the laboratory for testing.[2] The quality assessment included the microbiological analysis based on ISO 9308-1:2014, which specifies methods for bacterial counting using the membrane filtration method, followed by culturing on chromogenic coliform agar and counting the number of target organisms in the samples.[13]

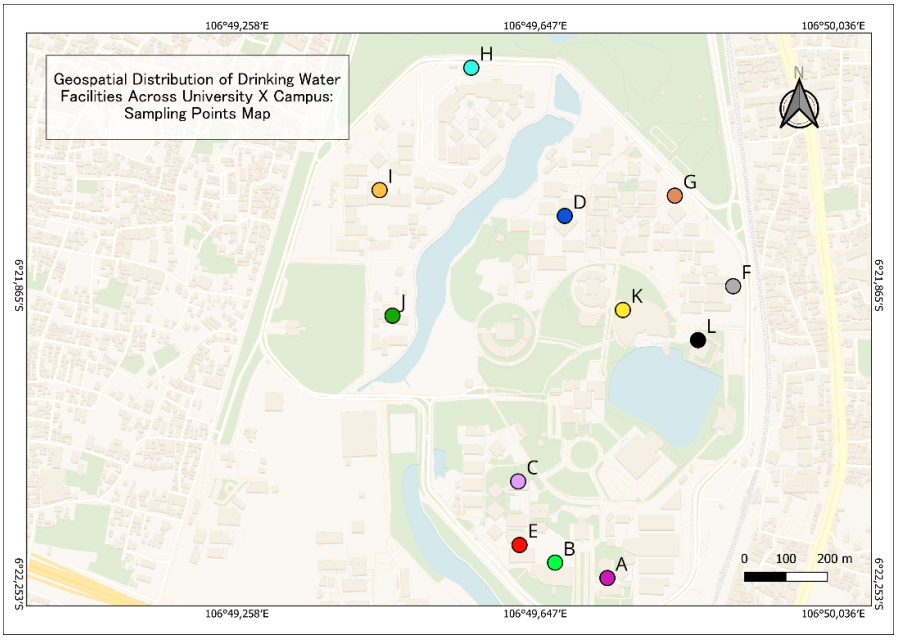

Figure 1. Sampling Points Map (Source: Authors' Collection)

The potential health risks were calculated using the EHRA recommended by the United States Environmental Protection Agency. This study included 112 respondents from University X who met the inclusion criteria: university students and staff (educational and non-educational), aged >18 years, using free drinking water facilities, and willing to be interviewed. The exclusion criteria were students and staff (educational and non-educational) who were pregnant, breastfeeding, or had diabetes. To calculate potential health risks, the chronic daily intake was first determined (Eq. 1) to estimate the average exposure in the body. Next, the risk quotient (RQ) was calculated to determine whether the risk level was safe or unsafe.

$$CDI_{(ingesti)} = \frac{C \times R \times fE \times Dt}{Wb \times Tavg} \quad \text{..... Eq. 1}$$

The CDI means the chronic daily intake or intake value (mg/kg x day), C means the concentration of the risk agent (Ingestion: mg/L, mg/kg. inhalation: mg/m^3), R means the intake rate (ingestion: liters/day, grams/day. Inhalation: m^3/hour), fE means the exposure frequency (days/year), Dt means the exposure duration (years), Wb means the body weight (kg) and Tavg means the averaging period for carcinogenic or non-carcinogenic effects (days). After obtaining the intake value, risk characterization was conducted by dividing the intake value by the reference dose (RfD) of the risk agent being analyzed.[14] The RfD represents the estimated daily oral intake for the human population (including sensitive subgroups), which is not expected to pose a health risk, even with lifetime exposure.[15] The risk characterization was determined using Eq. 2:

$$RQ = \frac{CDI}{RfD} \quad \text{..... Eq. 2}$$

Results

Table 1 presents the levels of microbial and chemical parameters of free drinking water facilities in University X. Chemical parameters that exceeded the average were NO_3^- at 21.18 mg/L and Mn at 0.1325 mg/L, while the biological parameters showed 3 colonies/100 ml. Microbiology analysis at location B detected coliform bacteria. In addition, the concentrations of NO_3^- and Mn at location E were found to exceed the chemical quality standards.

Table 1. Microbial and Chemical Parameters of Free Drinking Water Facilities at University X

Characteristics	Mean±SD	Min-Max	WHO reference value[15]	Indonesian MOH reference value[2]
Biological (colony/100 ml)				
Total coliform bacteria	0.25±0.87	0.00-3	0	0
Chemical (mg/L)				
Nitrate	4.70±5.93	0.00-21.18	50	20
Iron	0.01±0.04	0.00-0.1300	0.3	0.2
Manganese	0.01±0.04	0.00-0.1325	0.4	0.1
VI-Valent Chromium	0.00±0.00	0.00-0.0030	0.05	0.01
Fluoride	0.01±0.03	0.00-0.12	1.5	1.5

Notes: SD = standard deviation; WHO = World Health Organization; MOH = Ministry of Health

The calculation of potential health risks among 112 respondents was performed. Table 2 tabulates the characteristics of the respondents. The measurements showed an average body weight of 61.60 kg, an exposure duration of 1.93 years, an intake rate of 1.10, and an exposure frequency of 250 days/year.

Table 2. Anthropometric Characteristics of Respondents

Variables	Mean±SD	Min-Max
Wb (kg)	61.60±4.81	55.55-69.42
Dt (years)	1.93±0.57	0.86-2.84
CDI (mg/kg x day)	1.10±0.28	0.84-1.76
fE (days/year)	250±0.0	250-250

Notes: SD = standard deviation, Wb = body weight, Dt = duration of exposure, CDI = chronic daily intake, fE = frequency of exposure

Table 3. The Chronic Daily Intake, Reference Dose, and Risk Quotient of the Chemical Parameters

Location	Parameters	CDI	RfD	RQ
A	NO_3^-	0	1.6	0
	Fe	0	0.007	0
	Mn	0	0.14	0
	Cr^{6+}	0	0.003	0
	F	0	0.06	0
B	NO_3^-	0.002	1.6	0.001
	Fe	0.00019	0.007	0.027
	Mn	0	0.14	0
	Cr^{6+}	0.000004	0.003	0.001
	F	0.0002	0.06	0.003
C	NO_3^-	0.002	1.6	0.001
	Fe	0	0.007	0
	Mn	0	0.14	0
	Cr^{6+}	0	0.003	0
	F	0	0.06	0
D	NO_3^-	0.006	1.6	0.004
	Fe	0	0.007	0
	Mn	0	0.14	0
	Cr^{6+}	0	0.003	0
	F	0	0.06	0
E	NO_3^-	0.024	1.6	0.015
	Fe	0	0.007	0
	Mn	0	0.14	0
	Cr^{6+}	0	0.003	0
	F	0	0.06	0
F	NO_3^-	0	1.6	0
	Fe	0	0.007	0
	Mn	0	0.14	0
	Cr^{6+}	0	0.003	0
	F	0	0.06	0
G	NO_3^-	0.002	1.6	0.001
	Fe	0	0.007	0
	Mn	0	0.14	0
	Cr^{6+}	0	0.003	0
	F	0	0.06	0
H	NO_3^-	0.001	1.6	0.001
	Fe	0	0.007	0
	Mn	0	0.14	0
	Cr^{6+}	0	0.003	0
	F	0	0.06	0
I	NO_3^-	0.010	1.6	0.006
	Fe	0	0.007	0
	Mn	0	0.14	0
	Cr^{6+}	0	0.003	0
	F	0	0.06	0
J	NO_3^-	0.010	1.6	0.006
	Fe	0	0.007	0
	Mn	0	0.14	0
	Cr^{6+}	0	0.003	0
	F	0	0.06	0
K	NO_3^-	0.002	1.6	0.001
	Fe	0	0.007	0
	Mn	0	0.14	0
	Cr^{6+}	0	0.003	0
	F	0	0.06	0

Location	Parameters	CDI	RfD	RQ
L	NO_3^-	0.003	1.6	0.002
	Fe	0	0.007	0
	Mn	0.0001	0.14	0.0004
	Cr^{6+}	0	0.003	0
	F	0	0.06	0

Notes: CDI = chronic daily intake, RfD = reference dose, RQ = risk quotient, NO_3^- = nitrate, Fe = iron, Mn = manganese, Cr^{6+} = hexavalent chromium, F = fluoride

Table 3 presents the CDI, RfD, and RQ from chemical parameters. The results showed that the RQ values of NO_3^-, Fe, Mn, Cr^{6+}, and F were all less than one. This indicated that the free drinking water facilities of University X did not pose any health concerns and were thus deemed safe for consumption. Moreover, the combined risk also showed RQ<1.

Discussion

This study found that inadequate equipment maintenance is determined to be one of the critical contributors to this contamination. This finding aligned with Sulistiawan's study, which demonstrated that the lack of maintenance for filter devices can reduce the water filtration efficacy.[16] On top of that, the surrounding conditions of the water sources, especially groundwater, are inhabited by various types of bacteria, such as fecal indicator bacteria, pathogenic bacteria, human enteric viruses, and parasitic protozoa.[17,18] The biological quality of drinking water should be free from coliform bacteria contamination. Hence, to achieve this goal, the raw water must be sanitized to ensure its cleanliness for consumption.[19] Among the chemical parameters examined, this study's analysis revealed that the NO_3^- and Mn levels surpassed the threshold values set by the Indonesian Ministry of Health.

The EHRA findings indicated the absence of potential health hazards, as the calculated values did not exceed the threshold of 1. Thus, this study suggests that drinking water offered by the facilities at the University of Indonesia poses no discernible health risks. However, despite the significance of this investigation, several limitations should be acknowledged. First, not all chemical parameters were analyzed. Second, the sampling process was conducted only once; therefore, future studies are recommended to perform repeated assessments.

Conclusion

Based on the microbial and chemical parameters examined at free drinking water facilities at University X, positive total coliform is detected in one location, and nonstandard nitrate and manganese concentrations are detected in another location. However, the risk quotient value of the chemical parameters of the free drinking water facilities is considered safe. It is anticipated that constant monitoring, routine maintenance of the free drinking water facilities, controlled cleaning, regular water quality checks, and ongoing evaluations will significantly reduce contaminants. This study can serve as part of a prevention program for those responsible for drinking water facilities at University X and other educational institutions.

Abbreviations

WHO: World Health Organization; EHRA: Environmental Health Risk Analysis; RQ: risk quotient; RfD: reference dose; SD: standard deviation; Wb: body weight; Dt: duration exposure; CDI: chronic daily intake; fE: frequency of exposure.

Ethics Approval and Consent to Participate

This study has been approved by the Research and Community Engagement Ethical Committee of the Faculty of Public Health Universitas Indonesia (Letter of Approval Number 587/UN2.F10.D11/PPM.00.02/2023).

Competing Interest

There is no conflict of interest in this study.

Availability of Data and Materials

Available on request.

Authors' Contribution

Research conceptualization: IAZL, BW, MNIA; Methodology design: IAZL, BW, MNIA, SF; Data collection: MAA, NF, KMH, FA; Data analysis: IAZL, ASH; Manuscript drafting: IAZL, MAA, NF; Manuscript review and editing: BW, FK, SF; Supervision and project administration: MNIA, GL; Funding acquisition: BW, MNIA, SF, GL.

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Risk Factors of COVID-19 Infection Among Health Workers Post-Vaccination in Jakarta

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Risk Factors of COVID-19 Infection Among Health Workers Post-Vaccination in Jakarta

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Abstract

One of the best approaches to stop the COVID-19 pandemic is vaccination. In Indonesia, the first round of vaccinations was prioritized for health workers on January 14, 2021 (first dose) and March 1, 2021 (second dose). However, some health workers who have been vaccinated were found to be reinfected after receiving the second dose. This cross-sectional study examined the risk factors for COVID-19 infection among health workers after vaccination using secondary and primary data. The data analysis was carried out in univariate (examining the frequency distribution and proportion of independent variables), bivariate (Chi-square test to explore the relationship between independent and dependent variables), and multivariate (Logistic Regression to assess the strength of the relationship between independent and dependent variables). The results showed that the variables associated with post-vaccination infection included COVID-19 infection history (PR: 2.16, p-value <0.05), age (PR: 0.64, p-value <0.05), hypertension (PR: 1.52, p-value <0.05), direct contact with patients (PR: 2.02, p-value <0.05). It is recommended that health workers aged >37 years with a history of diabetes mellitus, hypertension, or previous COVID-19 infection, working directly with patients, and using Personal Protective Equipment level 1 daily should be prioritized for booster vaccinations.

Keywords: COVID-19, health workers, infection disease, pandemic, vaccination

Introduction

Coronaviruses belong to a large family that includes the Middle East Respiratory Syndrome (MERS) and severe acute respiratory syndrome (SARS). Coronavirus disease 2019 (COVID-19) is a novel disease that has not been previously identified in humans and is zoonotic, indicating it can be transmitted between animal and human.[1] COVID-19 is primarily transmitted between individuals through droplets generated by coughing or sneezing rather than airborne particles. Consequently, those in close contact with COVID-19 patients are at the highest risk of infection. To mitigate the spread of the virus, standard preventive measures include hand washing with soap and clean water, practicing proper cough and sneeze etiquette, and implementing infection prevention and control (IPC) measures in health facilities, particularly in emergency units are essential.[2] In Wuhan City, China, a case of pneumonia with an unknown cause was identified as a new type of coronavirus on January 7, 2020. World Health Organization (WHO) declared it a Public Health Emergency of International Concern (PHEIC) on January 30, 2020. During that period, the number of COVID-19 cases increased rapidly, spreading from China to other countries.[3]

One of the biggest hopes for stopping the COVID-19 pandemic is the use of vaccines.[4] According to a previous study of 5,455 health workers at the University of California, San Diego (UCSD) and 9,535 health workers at the University of California, Los Angeles (UCLA) who received the second dose of the COVID-19 vaccine, 1.19% at UCSD and 0.97% at UCLA were infected with COVID-19.[5] Similarly, another study showed that out of 4,081 health workers who received the Pfizer-BioNTech COVID-19 vaccine, 22 (0.54%) were infected with COVID-19 within 1 to 10 days after vaccination.[6] Since then, efforts to develop a vaccine against the SARS-CoV-2 etiological virus have so far been a remarkable success, with various vaccine modalities produced in a very short time.[7] The primary objectives of COVID-19 vaccination are to

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reduce the transmission of the virus, decrease morbidity (disease severity) and mortality (death rate) from COVID-19, and achieve herd immunity in the community, which can only be accomplished by ensuring high vaccination coverage, maintaining an even distribution of vaccination throughout the region.[7,8]

Given the lack of publications addressing the significant risk of COVID-19 reinfection among health workers, both globally and in Indonesia, the authors are motivated to investigate the risk factors associated with COVID-19 infection in post-vaccination health workers. The primary aim was to expedite the administration of booster vaccines to health workers, particularly those at higher risk. Unlike previous studies,[5-6] this study specifically examined the rate of COVID-19 reinfection among health workers.

Although the COVID-19 pandemic has diminished in severity, new variants continue to emerge. This study reviewed the evolution of these variants, the efficacy of vaccines developed for earlier strains, and their impact on infections caused by newer variants. Understanding long-term vaccine protection is crucial, as the effectiveness of vaccines and post-vaccination risk factors will inform the need for revaccination, booster doses, or tailored vaccination strategies for health workers.

As frontline defenders against infectious diseases, health workers play a vital role in preventing future pandemics, making this study essential for ensuring their protection not only during the COVID-19 pandemic but also in preparation for future outbreaks. The findings may inform policies that safeguard health workers in the long term. In a broader context, building resilience against infectious diseases remains a priority, and this study could enhance understanding of effective risk mitigation strategies, particularly within the healthcare sector.

Method

This cross-sectional study involved collecting data on both exposure and outcomes at a single point in time. Data processing was conducted using STATA version 14.2 with licensed and serial number 10699393. This study compared two groups of health workers who were reinfected by COVID-19 and those who were not, aiming to identify risk factors associated with a higher likelihood of COVID-19 infection after receiving the second dose of vaccination. The dependent variable was COVID-19 infection following the second dose, while independent variables included age, sex, history of COVID-19 infection, diabetes mellitus (DM), hypertension, coronary heart disease (CHD), chronic obstructive pulmonary disease (COPD), direct patient contact, use of public transportation, close contact with COVID-19 cases at work and home, use of personal protective equipment (PPE), and working hours.

This study was conducted from March to July 2021, utilizing case data from March 20 to May 30, 2021. The population included all health workers in the Special Capital Region of Jakarta Province who had received the complete second dose of the COVID-19 vaccine. The sample comprised active health workers, regardless of age, sex, or medical history, including those with or without close patient contact. Inclusion criteria required participants to have received both vaccine doses and active WhatsApp contacts listed in the COVID-19 Handling and National Economic Recovery Committee (CHNERC) data. Exclusion criteria included health workers unwilling to complete the questionnaire via Google Forms by May 30, 2021, as well as those with inactive WhatsApp numbers despite being registered in the CHNERC data.

The sample size used was determined based on the hypothesis test formula for the difference between two proportions, as outlined by Lemeshow S (2008).[9]

$$n = \frac{\left(z_{1-\alpha/2}\sqrt{2\overline{P}(1-\overline{P})} + z_{1-\beta}\sqrt{P_1(1-P_1)+P_2(1-P_2)}\right)^2}{(P_1-P_2)^2}$$

After being adopted from Stanley Lemeshow's formula, the results of the minimum sample size for each independent variable are presented in Table 1.

Table 1. Sample Size Calculation Table

Variable	P1	P2	n - Group	2n
Age	0.402	0.224	105	210
Sex	0.447	0.27	114	228
History of COVID-19 infection	0.0008	0.08	96	192
Diabetes mellitus	0.78	0.36	20	40
Hypertension	0.53	0.36	133	266
Coronary heart disease	0.25	0.37	232	464
Chronic obstructive pulmonary disease	0.2	0.39	89	178
Use of transportation	0.38	0.62	66	133
Close contact with COVID-19 patients	0.073	0.227	83	166

Based on the calculation of the sample size for independent variables, the largest number of samples was 240 per group of health workers infected with COVID-19 after vaccination and 328 groups of health workers who were not infected with COVID-19 after vaccination, with a total of 568 samples. Primary data was collected through Google Forms questionnaires and distributed to health workers who received a complete second dose between March 2020 and May 2021 through WhatsApp contacts listed in CHNERC data. Secondary data consists of the Special Capital Region of Jakarta Provincial Health Office report regarding health workers who were fully vaccinated in the same period. To assess post-vaccination COVID-19 infection, the authors asked two key questions: "After receiving the complete second dose of the COVID-19 vaccine, were you reinfected with COVID-19?" and "Before receiving the complete second dose of the COVID-19 vaccine, had you ever been infected with COVID-19?"

These questions aimed to clarify whether respondents were infected before or after their second vaccination. Data analysis was conducted in three stages: univariate (examined the frequency distribution and proportion of independent variables in both reinfected and non-infected groups), bivariate (employed the Chi-square test to explore relationships between independent and dependent variables, with a p-value threshold of 0.05 indicating statistical significance), and multivariate (assessed the strength of associations between independent variables and the dependent variable using Logistic Regression) analysis.

The use of PPE was categorized into three levels, as defined by the Directorate General of Pharmaceuticals and Medical Devices, Ministry of Health of the Republic of Indonesia.[10] These levels are based on the risk associated with health workers' activities and their potential exposure to aerosols. Level 1 is for health workers with low-risk activities that do not generate aerosols. The required PPE includes surgical masks, gowns, and gloves. Level 2 is for health workers in patient care areas or handling non-respiratory samples. The required PPE includes head coverings, eye protection, surgical masks, gowns, and disposable gloves. Level 3 is for health workers in direct contact with suspected or confirmed COVID-19 patients or performing aerosol-generating procedures. The required PPE includes head covering, face protection, eye protection, N95 mask, cover-all, surgical gloves, and waterproof boots.[10]

Results

Most health workers were not reinfected with COVID-19 (57.75%). They were generally aged ≤37 years (63.38%), female (78.35%), and had no history of previous COVID-19 infection (70.25%). Most health workers also did not have comorbid conditions such as DM (88.73%), hypertension (82.92%), CHD (99.12%), or COPD (98.59%). Most health workers worked directly with patients (70.07%) and did not use public transportation (72.71%). They had close contact with COVID-19 patients at work (77.29%) but had never been in close contact with COVID-19 patients at home (70.77%). Regarding PPE usage, more health workers used level 2 PPE (38.91%) and level 1 PPE (38.38%). Additionally, many health workers worked more than 8 hours daily (52.82%) (Table 2).

Table 2. Description of Respondent Characteristics

Variable	n	%
Post-vaccination infection		
Yes	240	42.25
No	328	57.75
Age		
>37 years	208	36.62
≤37 years	360	63.38
Sex		
Male	123	21.65
Female	445	78.35

History of COVID-19 infection		
No	399	70.25
Yes	169	29.75
Diabetes mellitus		
Yes	64	11.27
No	504	88.73
Hypertension		
Yes	97	17.08
No	471	82.92
Coronary heart disease		
Yes	5	0.88
No	563	99.12
Chronic obstructive pulmonary disease		
Yes	8	1.41
No	560	98.59
Face-to-face or directly with patients		
Yes	398	70.07
No	170	29.93
Use of public transportation		
Yes	155	27.29
No	413	72.71
Close contact with COVID-19 in the work environment		
Yes	439	77.29
No	129	22.71
Close contact with COVID-19 in the home environment		
Yes	166	29.23
No	402	70.77
Use of Personal Protective Equipment		
Level 1	218	38.38
Level 2	221	38.91
Level 3	129	22.71
Business hours		
>8 hours	300	52.82
<8 hours	268	47.18

Table 3. Post-Vaccination Risk Factor Analysis

Risk Factor	Post-Vaccination COVID-19 Infection				PR (95% CI)	p-value
	Infectious		Non-Infectious			
	n	%	n	%		
Age						
>37 years	77	37.02	131	62.98	0.81 (0.66-1.01)	0.054
<37 years	163	45.28	197	54.72		
Sex						
Male	52	42.28	71	57.72	1.00 (0.79-1.26)	0.995
Female	188	45.25	257	57.75		
History of COVID-19 infection						
Yes	39	23.08	257	57.75	2.18 (1.63-2.92)	<0.000*
No	201	50.38	198	49.62		
Diabetes mellitus						
Yes	40	62.5	24	37.5	1.57 (1.27-1.99)	0.000*
No	200	39.68	304	57.75		
Hypertension						
Yes	56	57.73	41	42.27	1.47 (1.20-1.81)	0.000*
No	184	39.07	287	60.93		
Coronary heart disease						
Yes	1	20.0	4	80.0	0.47 (0.08-2.73)	0.312
No	200	39.68	304	57.75		
Chronic obstructive pulmonary disease						
Yes	3	37.5	5	62.5	0.88 (0.36-2.170)	0.784
No	200	39.68	304	57.75		
Directly with patients						
Yes	189	47.49	209	52.51	1.58 (1.23-2.04)	0.000*
No	200	39.68	304	57.75		
Use of public transportation						
Yes	64	41.29	91	58.71	0.96 (0.78-1.21)	0.776
No	200	39.68	304	57.75		
Close contact with COVID-19 in the work environment						
Yes	190	43.28	249	56.72	1.12 (0.79-1.56)	0.361
No	200	39.68	304	57.75		
Close contact with COVID-19 in the home environment						

Yes	72	43.37	94	56.63	1.04 (0.84-1.28)	0.726
No	200	39.68	304	57.75		
Use of Personal Protective Equipment						
Level 1	103	47.25	115	57.25	1.46 (0.94-2.28)	0.093
Level 2	88	39.82	133	60.18	1.08 (0.69-1.69)	0.743
Level 3	49	37.98	80	62.02	Reff	Reff
Working hours						
>8 hours	127	42.33	173	57.67	1.00 (0.83-1.22)	0.967
≤8 hours	200	39.68	304	57.75		

Note: *p-value <0.05

Table 3 explains that the proportion of health workers aged >37 years who were reinfected with COVID-19 (37.02%) was lower than those aged ≤37 years (45.28%). The prevalence ratio (PR) was 0.81 (95% CI 0.66-1.01), indicating that health workers aged >37 years were 0.81 times less likely to be reinfected compared to younger workers. There was no significant difference in the reinfection rates between male (42.28%) and female (42.25%) health workers, with a PR value of 1.00, suggesting equal risk for both sexes.

Health workers without a previous COVID-19 infection had a higher infection rate (50.38%) after vaccination than those with a history of infection (23.08%). The PR value of 2.18 indicated that those without prior infection were 2.18 times more likely to be infected. Health workers with a history of DM had a reinfection rate of 62.5%, compared to 39.68% for those without, with a PR of 1.57. The reinfection rate for those with hypertension was 57.73%, higher than 39.07% for those without, yielding a PR of 1.47.

Workers with a history of coronary heart disease had a lower reinfection rate (20%) than those without (42.45%), with a PR of 0.47. The reinfection rate for health workers with COPD was 37.5%, lower than 42.32% for those without, resulting in a PR of 0.88. Health workers who had direct contact with patients had a higher reinfection rate (47.49%) than those who did not (30%), with a PR of 1.58, indicating a significantly increased risk for those in direct contact.

The reinfection rate among health workers using public transportation (41.29%) was similar to those who did not (42.62%), with a PR of 0.95, suggesting comparable risks. The reinfection rate for workers in close contact with COVID-19 patients at work was 43.28%, higher than 38.76% for those not in close contact, with a PR of 1.12. The reinfection rate for those in close contact with COVID-19 patients at home was 43.28%, nearly the same as 41.79% for those not in contact, with a PR of 1.04.

The reinfection rate was higher among health workers using level 1 (47.25%) compared to those using level 2 (39.82%) and level 3 PPE (37.98%). The PR for level 1 PPE was 1.46, indicating a higher risk than level 3 PPE, while the risk for level 2 PPE was similar to that of level 3. There was no difference in the reinfection rates for health workers working more than 8 hours (42.33%) compared to those working 8 hours or less (42.16%), with a PR of 1.00, indicating equal risk regardless of work hours.

Table 4. Early Complete Model

Variable	p-value	PR	95% CI
Age	0.006	0.64	0.47-0.88
Sex	0.855	1.03	0.75–1.41
History of COVID-19 infection	<0.000	2.16	2.53–3.05
Diabetes mellitus	0.002	1.85	1.26–2.70
Hypertension	0.009	1.54	1.11–2.12
Coronary heart disease	0.495	0.50	0.06–3.62
Chronic obstructive pulmonary disease	0.953	1.03	0.32–3.27
Directly with patients	<0.000	2.00	1.42–2.80
Use of public transportation	0.780	0.96	0.71–1.28
Close Contact with COVID-19 in the work environment	0.717	1.06	0.76–1.46
Close Contact with COVID-19 in the home environment	0.962	1.01	0.76–1.33
Use of Personal Protective Equipment Level 1	0.033	1.48	1.03–2.13
Use of Personal Protective Equipment Level 2	0.619	1,09	0.76-1.56
Working Hours	0.991	1.00	0.77-1.29

The analysis aimed to identify the best model for predicting post-vaccination COVID-19 outcomes using a backward elimination method. Independent variables with weak relationships to the infection, indicated by p-values >0.05, were systematically removed, starting with the variable that had the largest Wald X^2. This process continued until a suitable model was formed, where all remaining variables had significant Wald X^2 values (p-value <0.05). The findings from this model analysis are presented in Table 5.

Table 5. Analysis Fit Model Table

Type	Information
Model 1	
Put out variables Working hours	There are still some variables with insignificant Wald X^2 values. The COVID-19 close contact variable in the home environment has the largest Wald X^2 value.
Model 2	
Put out variables COVID-19 close contact in the home environment	There are still some variables with insignificant Wald X^2 values. The COPD variable has the largest Wald X^2 value.
Model 3	
Put out variables Chronic obstructive pulmonary disease	There are still some variables with insignificant Wald X^2 values. The sex variable has the largest Wald X^2 value.
Model 4	
Put out variables Sex	There are still some variables with insignificant Wald X^2 values. The public transportation user variable has the largest Wald X^2 value.
Model 5	
Put out variables Use of public transportation	There are still some variables with insignificant Wald X^2 values. The COVID-19 close contact variable in the work environment has the largest Wald X^2 value.
Model 6	
Put out variables COVID-19 close contact in the work environment	There are still some variables with insignificant Wald X^2 values. The coronary heart disease variable has the largest Wald X^2 value.
Model 7	
Put out variables Coronary heart disease	All remaining variables in the model have significant Wald X^2 values, including age, diabetes mellitus, hypertension, history of infection, PPE use, and direct patient contact.

From the table above, the best-fit model to predict the occurrence of COVID-19 infection in post-vaccination health workers is obtained, namely a model that includes six variables: age, diabetes mellitus, hypertension, history of infection, use of PPE, and face-to-face. The following is the fit model in this study:

Table 6. Fit Model Table

Variable	p-value	PR	95% CI
Age	0.004	0.634	0.46–0.86
Diabetes Mellitus	0.002	1.823	1.24–2.66
Hypertension	0.001	1.529	1.11–2.10
Infection history and PPE use	<0.000	2.160	1.53–3.05
Level 1	0.027	1.494	1.04–2.13
Level 2	0.619	1.1	0.77–1.55
Face-to-face or direct contact with patients	<0.000	2.02	1.45–2.82

From Table 6, the best-fit model to predict the occurrence of COVID-19 infection in post-vaccination health workers includes six variables: age, DM, hypertension, history of infection, use of PPE, and direct contact with the patients. The analysis identified that among six independent variables, the most significant factor in predicting outcomes was a history of COVID-19 infection. This variable exhibited the highest beta coefficient (0.770) and the largest PR of 2.16, indicating that health workers with a prior COVID-19 infection had a 2.16 times higher risk of reinfection than those without such a history after adjusting for other variables.

Discussion

Age was a protective factor, as indicated by a PR value <1 (0.63) with a 95% CI of 0.46–0.86. Statistically, health workers aged >37 years showed a reduced risk of contracting COVID-19 after vaccination by 37% (1–0.63 = 0.37 or 37% relative protection). Angiotensin-converting enzyme 2 (ACE2) activity or expression can increase, especially in older adults or males, who are more likely to have higher ACE2 expression. Higher levels of ACE2 can increase cell susceptibility to SARS-CoV-2 because the virus enters and replicates by binding to ACE2.[11]

This study did not align with the literature stating that age is a protective factor against COVID-19 infection.[11] This study determined that the proportion of health workers aged ≤37 years was higher (63.38%) than those aged >37 years, so it can be postulated that these older health workers were aware that they were at higher risk of exposure to COVID-19, and this caused them to follow the health protocols more strictly. The finding aligned with the Health Belief Model (HBM) theory of behavior change, where it has been suggested that a person will act more obediently to treat or prevent if they feel susceptible to the disease.[12] Following this perspective, older individuals with family responsibilities are expected to be more motivated to comply with health measures due to greater responsibility.[13]

Diabetes mellitus was a risk factor for health workers reinfected with COVID-19, with a PR value of 1.82 (CI 95%: 1.24-2.66). Statistically, health workers who had a history of the disease were at 1.82 times greater risk of being reinfected with COVID-19 than those without. This result was in line with a previous study stating that DM is a risk factor for COVID-19 infection.[14] Another previous study stated that DM increases susceptibility to infections due to chronic hyperglycemia, marked by elevated HbA1c levels.[15] This condition hampers the function of mononuclear and polymorphonuclear phagocyte cells (PPC), particularly affecting the respiratory burst needed to eliminate microorganisms within monocytes and neutrophils. Prolonged high blood sugar leads to the formation of Advanced Glycosylation End Products (AGEs), which further impair PPC function (neutrophils). Consequently, individuals with diabetes have a reduced ability to phagocytize microorganisms compared to those without the disease, as the intracellular killing process is disrupted.[15]

The mobilization and chemotaxis of polymorphonuclear (PMN) cells in DM patients are diminished, affecting their movement toward infection sites.[16] Mononuclear cells, such as monocytes, also show abnormalities; specifically, the quantity of monocytes is lower in diabetic patients, and their ability to detect microorganisms is impaired due to decreased sensitivity of their membrane receptors.[16] In addition, patients with the diseases have higher ACE2 receptors, especially in the lungs, liver, and pancreas.[17] Since ACE2 is a SARS-Cov-2 receptor in the human body, this higher expression contributes to increased infectivity of SARS-CoV-2 in DM patients compared to non-diabetic patients.[17]

Hypertension was a risk factor predicting the probability of health workers reinfected with COVID-19, with a PR value of 1.52 (CI 95%: 1.11-2.10). Statistically, health workers with a history of hypertension had a 1.52 times greater risk of being reinfection COVID-19 than those without. Previous studies in China support this result, stating that hypertension is a risk factor for COVID-19 infection.[14,18,19]

Hypertension is linked to COVID-19 infections, as uncontrolled blood pressure can further disrupt the immune system.[11] Hypertension can also alter the number of circulating lymphocytes. Although antihypertensive medications, such as ACE inhibitors (ACEI) and angiotensin receptor blockers (ARB), are used to treat hypertension, they can increase the risk of SARS-CoV-2 infection. This is because these medications boost ACE2 expression, increasing the availability of receptors for SARS-CoV-2 to bind to, thereby making it easier for the virus to attach to target cells and increasing patient susceptibility to infection.[20]

Personal Protective Equipment was a risk factor that can predict the probability of health workers reinfected with COVID-19, with a PR value of 1.49 (CI 95%: 1.04-2.13). Statistically, health workers using level 1 and 2 PPE had a 1.49- and 1.10-times greater risk of being reinfected to COVID-19 than those who use level 3 PPE after controlling other variables. A previous study stated that PPE is a risk factor for COVID-19 infection, with an OR value of 0.20 (95% CI: 0.11-0.37).[21] In this study, it was explained that using surgical or N95 masks by health workers can reduce the risk of respiratory virus infection by up to 80% compared to not using a mask.[21]

According to the WHO, COVID-19 transmission can also occur through direct contact with an infected person or indirectly through contaminated objects (e.g., stethoscopes, thermometers), as droplets can settle on surfaces where the virus can survive.[3] To reduce this risk, WHO recommends using PPE to protect against splashes, aerosols, and direct contact. The ideal PPE should be lightweight, comfortable, flexible, safe, durable, standard-compliant, easy to maintain, and not restrict movement.

History of COVID-19 infection was the most significant determinant or risk factor for predicting COVID-19 infection in health workers after vaccination, with a PR value of 2.16 (CI 95%: 1.53-3.05). Statistically, health workers without previous COVID-19 infection were 2.16 times more likely to be infected by COVID-19 after vaccination than those with a history of previous infection after controlling other variables. A previous study at the Howard Hughes Medical Institute's Molecular Laboratory of Immunology indicates that immunity to SARS-CoV-2 in COVID-19 survivors can last for six months or more after recovery.[22] Six months post-infection, antibodies become stronger and more effective against mutated virus strains. While antibodies remain in blood plasma for several weeks or months, their levels significantly decline over time. The immune system employs memory B cells, which recognize pathogens and can rapidly produce new antibodies upon re-exposure rather than continuously generating antibodies.[22] This suggests that individuals previously infected may have a more robust immune response if re-exposed to the virus, as their immune system can quickly generate effective antibodies through memory B cells.

Direct contact with patients was a risk factor for predicting COVID-19 infection in health workers after vaccination, with the largest PR value of 2.02 (CI 95%: 1.45-2.82). Statistically, health workers who deal directly with patients were at 2.82 times greater risk of being reinfection COVID-19 compared to those who do not deal directly with patients after

controlling other variables. A bivariate analysis of health workers' workplaces and post-vaccination infection rates revealed a correlation between direct patient contact and infection. The data showed that a higher proportion of infected workers had direct patient contact in hospitals (67.5%), primary health cares (PHCs) (25.4%), and health offices (7.1%) compared to those without direct patient interaction.

For hospitals, the most infected workers were found in the emergency room (ER) (20.99%), followed by the intensive care unit (ICU) (17.28%), treatment room (16.67%), and polyclinic room (15.43%). For PHCs were found in the ER (34.43%), followed by the polyclinic room (27.87%). For health offices, were found in the Disease Prevention and Control Unit (35.29%). These findings suggested that direct patient contact increased the risk of post-vaccination infection among health workers. In addition, dealing directly with patients increases the risk of exposure to COVID-19 because there are still many patients who come to the hospital/public health department even though screening at the beginning of treatment has not been maximized. This condition increases the possibility that COVID-19 patients are still treated like ordinary patients.[14] Previous studies mentioned that direct contact with patients is a risk factor for COVID-19 infection.[14,23]

This study raised concerns about information bias, as the diagnosis of infected versus uninfected health workers was based solely on questionnaire responses without additional verification. Variability in educational backgrounds might lead to differing perceptions of questions, impacting the consistency of responses. Data collection via Google Forms further complicated standardizing perceptions. To mitigate biases, the authors applied uniform inclusion and exclusion criteria for health workers receiving the second dose of vaccine. However, there was misclassification regarding PPE use, as health workers might have varied understandings of PPE levels based on knowledge and environment.

This study's internal validity was strong, with no selection bias and only non-differential information bias, allowing for generalization to similar populations. Future research should be able to collect age data in ratio form rather than categorically to allow for median or mean cutoffs and validate the definition of post-vaccination infection using PCR data.

Recommendations for the Special Capital Region of Jakarta Provincial Health Office include preventive policies for health workers with diabetes or hypertension, restricting their direct patient contact to reduce post-vaccination infection rates, mandating level 3 PPE for health workers in direct patient care, especially in high-risk areas like the ER and ICU, and prioritizing booster vaccinations for health workers aged >37 years or with significant comorbidities. The suggestions for hospitals are enhancing infection prevention training for workers in high-risk areas, raising awareness about universal precautions through promotional efforts, conducting annual health check-ups for workers with comorbid conditions, and considering shift schedules for those aged >37 years. For the health workers, the authors advise regular health check-ups, particularly for those with comorbidities, and strict adherence to health protocols, including wearing at least Level 2 PPE, maintaining hydration, and avoiding communal eating and conversation while unmasked.

Conclusion

Of the 13 variables, 6 are related to the incidence of post-vaccination COVID-19 infection in the Special Capital Region of Jakarta Province's health workers. These include age, diabetes mellitus, hypertension, history of COVID-19 infection, PPE use (at level 1), and direct contact with the patient. In this study, the most significant determinant or predictor factor of post-vaccination COVID-19 infection is the history of COVID-19 infection. Additionally, health workers aged >37 years, have a history of diabetes mellitus, hypertension, and COVID-19 infection, deal directly with patients, and use level 1 PPE in daily work should be prioritized to get booster vaccinations.

Abbreviations

SARS: severe acute respiratory syndrome; COVID-19: coronavirus disease 2019; PPE: personal protective equipment; WHO: World Health Organization; UCSD: University of California, San Diego; UCLA: University of California, Los Angeles; DM: diabetes mellitus; CHD: coronary heart disease; COPD: chronic obstructive pulmonary disease; PPE: personal protective equipment; CHNERC: COVID-19 Handling and National Economic Recovery Committee; PR: prevalence ratio; ACE2: angiotensin-converting enzyme; PPC: polymorphonuclear phagocyte cells; ER: emergency room, ICU: intensive care unit; PHC: primary health care.

Ethics Approval and Consent to Participate

The authors guarantee the confidentiality of the Special Capital Region of Jakarta Provincial Health Office's data solely for research purposes and the confidentiality of respondents' identities. This research has passed the ethical consideration of the Faculty of Public Health, Universitas Indonesia, with ethics letter number 432/UN2. F10. D11/PPM.00.02/2021.

Competing Interest

The author declares that no significant competing financial, professional, or personal interests might have affected the performance or presentation.

Availability of Data and Materials

Data are not available due to the ethical restrictions of the research. Participants of this study did not agree that their data should be shared publicly.

Authors' Contribution

NAP: Guides researchers on appropriate research methods, helps determine variables, and assists in selecting suitable data analysis techniques. MKS: Aids researchers in correcting inaccurate or inconsistent results and ensures compliance with research methods. YD: Supports researchers in data collection, questionnaire distribution, data sorting, analysis, and overall research process assistance. NWDA: Helps researchers locate research sources, such as relevant national and international journals, distributes questionnaires, and interprets research findings. RM: Assists researchers with precise data analysis and interpretation of results, as well as journal registration.

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Home Births Among Ethnic Minority Communities in Bokeo Province, Lao People's Democratic Republic

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Home Births Among Ethnic Minority Communities in Bokeo Province, Lao People's Democratic Republic

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Abstract

Home births among ethnic minorities in developing countries pose significant risks to maternal and neonatal health. In Lao PDR, the government has taken steps to manage home births through training traditional birth attendants, improving transportation, and establishing referral systems. However, high home birth rates in regions like Bokeo remain concerning. This review emphasized the need for more skilled birth attendants and better access to emergency obstetric care in rural, ethnic minority areas. This review used 40 articles published between 2000 and 2023 and highlighted gaps in research regarding healthcare access, cultural practices, socioeconomic barriers, and the role of traditional birth attendants. Suggested strategies included scholarships for midwifery training, expanding telemedicine, enhancing emergency transport, and partnering with NGOs for culturally sensitive outreach. Although each strategy has limitations, collectively, they can improve maternal and newborn health outcomes and reduce home birth risks. Addressing cultural beliefs and preferences is essential to encourage healthcare use, and community engagement plays a key role in promoting safer birth practices while respecting traditions. A holistic approach combining skilled healthcare, cultural sensitivity, and accessible services is crucial to improving maternal and newborn care in ethnic minority communities in Lao PDR.

Keywords: home birth, ethnic minority, community

Introduction

The Lao People's Democratic Republic (Lao PDR) is a low-income country[1] with a population of around 7 million people as of 2021.[2,3] Significant economic growth has been driven by natural resources, infrastructure investment, and tourism but Lao PDR is one of the poorest countries in Southeast Asia. The poverty rate is estimated at 23.2%,[3] and prevalent in rural areas where 80% of the population relies on subsistence agriculture.[4] The economy heavily depends on agriculture (19.1% of GDP), followed by the industrial sector (30.1%) and the service sector (40.4%).[3] Lao PDR is burdened with external debt, inadequate infrastructure, and the lack of a skilled labor force.[3,4] The COVID-19 pandemic negatively impacted the economy.[3] Factors contributing to poverty include limited access to education, healthcare, infrastructure, and non-agricultural employment opportunities.[5] Ethnic minorities like the Lao Theung and Lao Soung have higher poverty levels because of geographic isolation, language barriers, and limited access to resources.[6,7]

The Lao Government has recognized the importance of economic diversification in reducing dependence on natural resources and fostering sustainable development. Reforms and policy initiatives have been introduced to bolster manufacturing, tourism, and service sectors to create a more competitive and resilient economy.[8] Manufacturing has been targeted by establishing Special Economic Zones that provide incentives to attract foreign investment and stimulate production.[4] Tourism has been promoted as a priority sector, with various campaigns, investment in infrastructure, and a focus on preserving and promoting Lao PDR's cultural and natural heritage.[4,8] The service sector has also witnessed reforms aimed at liberalization to foster private sector participation alongside the development of human capital in fields such as information technology and finance.[3] These government-led initiatives are vital for ensuring sustainable and inclusive growth in Lao PDR through ongoing policy reforms, investment in infrastructure, and capacity building.[3,9]

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Lao PDR is home to a rich tapestry comprising 49 official ethnic groups contributing to the nation's diverse cultural heritage. These groups include the Lao Loum, Lao Theung, Lao Soung, and others such as the Khmu, Hmong, and Yao.[10] The Lao Loum predominantly inhabit the Mekong River Valley and are the largest ethnic group in Laos (53.2%).[10] Their culture is heavily influenced by Theravada Buddhism, which is evident in their customs, rituals, and architecture.[9] They practice wet-rice agriculture and have a deep connection to the land and the Mekong River, which provides sustenance and shapes their way of life.[11] The Lao Theung (24.9%) reside in the central mountainous region of Laos, where they practice swidden agriculture, a form of slash-and-burn farming. Animism and ancestor worship are integral to their belief system and guide their daily lives.[8,9] Lao Theung groups include the Mon-Khmer-speaking people, such as the Khmu, who are known for their skilled craftsmanship and expertise in weaving and basketry.[7]

The Lao Soung (10.6%) live in the northern and southern highlands of the country and encompass groups such as the Hmong and Yao, who are recognized for their unique artistic traditions, including intricate embroidery, silverwork, and batik.[8] Both the Hmong and Yao maintain strong clan structures and cultural practices, such as the Hmong New Year celebration and the Yao's rich oral storytelling tradition.[1,10] Other unclassified ethnic groups account for 11.3% of the population and contribute to the diverse cultural landscape of Lao PDR.[8] These groups include Tai-speaking people such as the Phu Thai and Lue, as well as the Sino-Tibetan-speaking Lahu and Akha.[8] Despite their cultural wealth, these ethnic groups face unique challenges related to poverty, healthcare, and education. Marginalized communities often have limited access to resources and social services, which exacerbates existing inequalities.[8,9] Addressing these challenges is essential for sustainable development and social cohesion in Lao PDR while promoting inclusive growth and preserving cultural heritage, which is the key to fostering unity among the country's diverse populations.[1,6]

This study focused on the major ethnic groups in Bokeo Province, including the Akha, Lahu, and Lao-Tai, to increase data availability concerning the unique challenges these groups face. These three groups represent a significant portion of the population and highlight the diverse circumstances related to home birth practices in the province. The absence of detailed information for all 49 groups reflects the limited scope of previous studies, which predominantly focused on larger ethnic communities. Home births are common in rural Lao PDR, with limited access to health facilities and skilled birth attendants. Factors contributing to high home birth prevalence include distance to health facilities, transportation difficulties, financial constraints, language barriers, and cultural preferences.[10]

The inadequate infrastructure and communication systems in remote areas further exacerbate these challenges.[12,13] Traditional birth attendants (TBAs) who assist women during labor and delivery in rural Lao PDR lack formal training and knowledge of modern obstetric practices. [1,12,13] They provide vital support, but their limited training hinders their ability to effectively manage birth complications. The home birth rate among rural Lao women is 76%, with 62% attended by TBAs.[10] The Lao Theung and Lao Soung have higher home birth rates compared to the Lao Loum, attributed to their geographic isolation and cultural practices.[12]

Home births increase the risk of maternal and neonatal mortality due to the lack of emergency obstetric care, and complications like postpartum hemorrhage, infection, and birth asphyxia can be life-threatening.[12,14] In many instances, the timely referral of women and newborns with complications to health facilities is critical for their survival, but this is often hampered by poor access to transport and communication.[15] Traditional practices and beliefs can also contribute to harmful outcomes.[12,16] Some cultural rituals involve unhygienic practices such as using unsterilized instruments or cutting the umbilical cord with non-sterile tools, thereby increasing the risk of infection for both mother and baby. Certain customs may also delay the initiation of breastfeeding or promote the use of prelacteal feeds, which can increase the risk of malnutrition and illness in the newborn.[12,13]

Addressing the issue of home births is crucial to achieving the United Nations Sustainable Development Goal (SDG) 3, which aims to ensure healthy lives and promote well-being for all at all ages. Specifically, SDG 3.1 targets a global reduction in maternal mortality, and SDG 3.2 focuses on ending preventable deaths of newborns and children under five years of age.[17] The government of Lao PDR has been working to improve maternal and child health by increasing access to skilled birth attendants, upgrading health facilities, and promoting antenatal care.[1,10] However, more targeted interventions are needed to address the unique needs and challenges faced by rural and ethnic minority populations to reduce the negative impacts and potential harm associated with home births. The analysis in this review brings a new perspective by integrating a broader understanding of how cultural beliefs specifically interact with healthcare access. Unlike previous literature, which often addressed these aspects independently, this study demonstrated the complex, intertwined relationship between cultural norms, socioeconomic factors, and healthcare barriers that lead to high home birth prevalence. Additionally, this review emphasized community engagement strategies as an effective means of

improving maternal health, an aspect underrepresented in the other studies.

For the past few decades, the World Health Organization (WHO) has tried to enhance maternal health in less developed countries by encouraging women to give birth in health facilities rather than at home. The WHO believes that hospital births lead to better outcomes for mothers and newborns than home births.[18] However, despite these efforts, a substantial proportion of births in developing countries still occur at home rather than in hospitals. This ongoing preference for home births can be explained by women's personal choices and systemic obstacles that prevent pregnant women from accessing or utilizing healthcare services. Home births without properly trained attendants present and locations unreachable by medical professionals have been tied to higher rates of maternal and newborn mortality as well as delivery complications.[18,19]

In developing countries, home birth services are typically not offered or supported by healthcare systems. Rather, cultural norms and sociodemographic attributes within communities shape home-birthing practices. The lack of official home birth assistance programs, paired with cultural beliefs and population attributes, leads to high rates of non-hospital deliveries in these nations.[18,20] Studies have revealed that women without any formal education exhibit the greatest likelihood of giving birth at home.[12,14] Moreover, there are substantial discrepancies in home birthing prevalence between the least and most educated women. Rural dwellers and individuals from lower socioeconomic backgrounds also demonstrate a higher tendency to deliver children in the home versus a health facility.[18]

As stated in the report by Hernández-Vásquez *et al.*, analysis of individual countries revealed that home births exceeded 50% of all deliveries in 12 nations.[19] Of those 12, 7 were in Sub-Saharan Africa. The countries with the highest rates of home birthing were Chad (78% home births), Ethiopia (73%), Niger (70%), and Yemen (69%). The first three countries with the highest home birth prevalence were from Sub-Saharan Africa, while Yemen is part of the Middle East and North Africa region.[19] Of all the regions, Europe and Central Asia had the lowest percentage of home births. In that region, Azerbaijan had the highest home birth rate at 22%, while all other countries were below 15%. As for other regions, Lao PDR (East Asia and Pacific) and Myanmar had the highest home birth proportions at 85% and 63%, respectively. Outside those regions, Haiti (Latin America and the Caribbean) had a 60% home birth rate, and Afghanistan (South Asia) had a 51% rate.[18]

Home births are common in developing countries like Lao PDR, especially among ethnic minority groups, posing significant challenges to maternal and neonatal health due to limited access to skilled birth attendants and facilities. This article analyzed the contributing factors to high home birth rates in Bokeo Province, Lao PDR, highlighting the complex interplay of cultural norms, socioeconomic issues, and healthcare barriers. The review identified strategies for improving maternal and child health through targeted, culturally sensitive interventions. It emphasized community-driven efforts as essential for addressing these challenges. Overall, the findings aimed to inform better health policies and support for vulnerable communities.

Method

Search Strategy: the literature search was conducted from October to December 2023, focusing on studies published within the past 10 years. The search terms included "home births in developing countries," "maternal health in ethnic communities," "healthcare access in rural areas," "cultural practices and maternal care," and "emergency obstetric care strategies." Searches were performed using academic databases such as PubMed/Medline, Scopus, and Google Scholar. Additionally, references from selected articles were examined to ensure comprehensive coverage and to avoid missing relevant studies. Only English-language articles were included to maintain consistency.

Selection of Studies and Data Extraction: this review targeted studies addressing factors influencing home births, maternal health challenges in ethnic communities, and interventions to reduce home birth rates in developing countries, particularly Lao PDR. Titles and abstracts were screened independently by the authors to identify relevant studies. Full-text reviews were conducted on shortlisted articles, and the final selection was determined by consensus among all reviewers. Data extraction involved evaluating each study for key themes, methodologies, and outcomes related to healthcare access, cultural practices, and community-based interventions. The extraction process was structured, with authors recording details of study characteristics, sample size, research design, and findings into a standardized template. This approach ensured consistency in documenting relevant information and minimized bias during the data extraction phase. Authors independently completed the template for each study and then cross-verified their entries. Discrepancies were discussed and resolved collaboratively to ensure accuracy. The extracted data were collectively analyzed to identify

gaps and inform the discussion on strategies to improve maternal and newborn health outcomes in rural and ethnic minority communities. Ultimately, from a pool of 61 studies, the authors independently selected 40 studies that met the criteria, extracted the data, and used them for writing this review article.

Results and Discussion

Home Birth Situation Among Ethnic Groups in Bokeo Province, Lao PDR

Home birth is a common practice among ethnic groups in many developing countries, including Lao PDR. Bokeo Province, located in the northwest of the country, can be partly attributed to the prevalence of home births. In this district, home births account for 70% of all deliveries.[20,21] A study conducted in 2020 examined the different rates of home births among various ethnic groups in Bokeo, revealing significant disparities.[22] The Akha and Lahu ethnic groups had notably higher home birth rates than the Lao-Tai ethnic group.[22] Among Akha women, 82% opted for home births, while 81% of Lahu women followed suit.[22] In contrast, the rate of home births among Lao-Tai women was considerably lower, at 44%.[22]

The Bokeo Province in Lao PDR has 163,000 residents, 73% of whom are ethnic minorities. This district has high maternal and newborn mortality rates that exceed national averages.[21] Most home births had no prenatal or postnatal care.[21] Factors linked to home births were young maternal age, less education, higher parity, and longer distance to health facilities.[21] This data indicates a need to improve Bokeo minorities' access to, awareness of, and education about healthcare services to lower maternal and newborn mortality rates.[21,22]

Several factors contributed to the high rate of home births in Bokeo Province, including the district's challenging geography, cultural beliefs and practices, and lack of awareness and education about the importance of giving birth in a health facility. The district's mountainous terrain and limited access to health facilities made it difficult for women to access antenatal and postnatal care and give birth in a health facility. The nearest hospital is located 20-30 km away, and many roads are impassable during the rainy season, which further compounds the challenges.[21,23] Cultural beliefs and traditional practices also played a significant role in the high rate of home births in the Bokeo Province. In many ethnic minority groups, home birth is considered a tradition and a way to maintain cultural identity.[21] Women are also expected to give birth at home to demonstrate strength and resilience.[21] This cultural expectation makes it difficult for pregnant women to seek care in a health facility, which may be perceived as a sign of weakness or inability to cope with childbirth. Another factor contributing to the high rate of home births was the lack of awareness and education about the potential risks associated with home birth and the importance of giving birth in a health facility. Many women and their families are not aware of the benefits of giving birth in a health facility or the risks associated with home birth.[24] Lack of knowledge and awareness can lead to a lack of trust in healthcare providers, further reinforcing the practice of home birth.

One of the significant concerns regarding home births was the lack of proper healthcare services and the absence of antenatal and postnatal care. The study by Kapheak *et al.* reported that the majority of women who gave birth at home did not receive any antenatal care, and only a small proportion received postnatal care.[22] In contrast, almost all women who gave birth in a health facility received antenatal care, and 46% received postnatal care.[21,22] The absence of antenatal care significantly increased the risk of maternal and neonatal mortality and morbidity, including complications such as pre-eclampsia, premature labor, and maternal hemorrhage. Similarly, postnatal care is essential for monitoring the health and well-being of both the mother and the newborn and identifying any complications early.[21,22]

Why do Ethnic Minority Groups in Lao PDR Choose Home Birth?

The reasons rural Laotians choose home birth are comfort, convenience, and proximity to family.[23,24] The influence of tradition should not be overlooked. Many generations of women have given birth at home, so why should the current generation choose differently? While complications and preventable deaths can occur during home births, it is important to remember that most births proceed without issues. This leaves women and their families with the impression that there is little benefit in making the often-difficult journey to a health facility where they will be mostly alone, without the support of relatives, and subjected to unfamiliar and unwelcome birthing practices.[14]

Consistent with previous studies on rural birth preferences worldwide, women and families in this study objected to certain hospital delivery methods like episiotomies, lying down to give birth, having male attendants, and exposing private anatomy to strangers. These procedures can cause embarrassment and distress while also conflicting with traditional postpartum practices like using a hotbed, a traditional heated surface, often made from a bed of coals or

heated stones placed under a sturdy surface, believed to aid in recovery and promote health by warming the body and facilitating blood circulation after childbirth.

Study participants also worried about inadequate privacy in facilities and discomfort with examinations by male staff, echoing similar feedback on Maternal Waiting Homes. Those results led authors to advise that vaginal exams only be conducted by female employees and that women's and families' privacy should be protected as much as possible.[14,25,26]

Inadequate access to health facilities poses another major obstacle to developing countries. Facilities are far from rural villages, roads can be poor, and travel costs are high. Previous studies on barriers to using Maternal Waiting Homes in southern Lao PDR found that the primary difficulties were transportation expenses, fees for facility-administered medicines, and income losses while away. The long distances, transportation hurdles, and financial burdens deter many rural women from seeking institutional deliveries.[14,27,28]

The Lao PDR Government's Measures to Manage Home Births Among Ethnic Minority Groups

In 1998, Lao PDR partnered with WHO to start the Safe Motherhood Program, which is intended to reduce maternal mortality and illness. This program strives to ensure women can access healthcare throughout life and newborns receive necessary medical services. Major program components encompass prenatal care, safe delivery, postpartum checkups, complication management, and family planning. Additionally, in 2008, Lao PDR's Ministry of Health launched the Maternal, Newborn, and Child Health Initiative in select provinces, with WHO and United Nations Population Fund (UNFPA) technical support. This initiative aims to train TBAs, provide transportation, establish referral systems, and promote community involvement.[12,29]

The TBAs are often the primary healthcare providers in rural areas, and they can play a crucial role in managing home births. However, TBAs often lack formal training and may not have the necessary skills to manage complications during childbirth. Training TBAs in essential skills, such as identifying and managing complications during childbirth, can help improve maternal and neonatal health outcomes. The Lao government has recognized the importance of training TBAs and has implemented a program to train and certify TBAs in essential skills.[28,29]

Lack of transportation is a significant barrier to healthcare services in rural areas. Providing transportation to expectant mothers can help ensure that they have access to healthcare services during childbirth. The Lao government has implemented a program to provide free transportation to pregnant women to encourage them to seek healthcare services during childbirth. A study conducted in Lao PDR found that providing transportation to pregnant women significantly increased the utilization of healthcare services during childbirth, which can contribute to improved maternal and neonatal health outcomes.[29]

In case of complications during childbirth, it is essential to have a referral system in place to transfer the mother and baby to a health facility for further care. This can help prevent adverse outcomes and ensure timely intervention. The Lao government has recognized the importance of establishing a referral system and has implemented a program to strengthen the referral system in rural areas. A previous study found that the referral system program has been successful in improving the availability and utilization of healthcare services among pregnant women and their families, which can contribute to improved maternal and neonatal health outcomes.[30]

Engaging the community in promoting safe and healthy childbirth practices can help increase awareness and support for home births.[21] This can be achieved through community outreach programs, where health providers can educate the community about the benefits of giving birth in a health facility and the risks associated with home births. The Lao government has implemented a program to promote community involvement in maternal and child health by training village health volunteers to educate and mobilize communities to promote maternal and child health.[12] The program has successfully improved community awareness and support for maternal and child health, which can contribute to improved maternal and neonatal health outcomes.[12]

Alternative Strategies for Home Births Among Ethnic Groups in Bokeo Province, Lao PDR

The alternative strategies for addressing home births in Bokeo, Lao PDR, should focus on addressing the geographic isolation and cultural practices unique to ethnic groups in the region. This includes increasing trained TBAs or midwives within these ethnic communities to overcome cultural and linguistic barriers better. This can be done through a variety of measures, such as, first, providing scholarships or incentives for ethnic minority students to become midwives or other skilled birth attendants, with a focus on training and recruiting individuals from within ethnic minority

communities.[30-32] One potential limitation is that it may not be sufficient to address the underlying factors that contribute to the prevalence of home births among ethnic minorities in Lao PDR. Even if there are more skilled birth attendants available, some women may still prefer to give birth at home due to cultural beliefs or lack of access to transportation or health facilities. Additionally, providing scholarships or incentives may not address other challenges, such as the shortage of health workers in rural and remote areas or the lack of resources to support the training and deployment of skilled birth attendants. It may also take time to see the results of such initiatives, as it takes time to train and build a workforce of skilled birth attendants.[32-34]

Second, expanding telemedicine and other digital health services are also solutions to improve access to emergency obstetric care and remote consultations with skilled birth attendants.[35,36] This strategy can be a valuable approach to improve access to emergency obstetric care and remote consultations with skilled birth attendants in remote and rural areas where ethnic minorities reside in Lao PDR. However, this approach has several limitations, including limited internet connectivity and technological infrastructure, cultural beliefs and preferences, and cost. Therefore, while telemedicine and digital health solutions can be useful, they should be accompanied by other measures, such as improving access to health facilities and transportation and engaging with communities to address cultural beliefs and preferences.[37]

Given the mountainous terrain of Bokeo, the third strategy better be increasing emergency transportation availability, which should involve off-road vehicles capable of navigating difficult terrain and, in extreme cases, helicopter services for life-threatening complications during home births.[36,38] This strategy can be useful to ensure timely access to health facilities for women experiencing complications during home births. However, if Lao PDR chooses this approach, there are several limitations to consider. For example, the lack of infrastructure and trained personnel to operate and maintain the transportation systems could limit the effectiveness of this approach. Additionally, providing emergency transportation may not address other underlying factors, such as cultural beliefs and preferences for home births, which may still prevent some women from seeking timely medical care. Finally, providing emergency transportation services may be costly, and Lao PDR may face challenges in sustaining this approach in the long term. Therefore, while increasing the availability of emergency transportation can be a valuable strategy to improve access to emergency obstetric care, it should be complemented by other measures, such as improving healthcare infrastructure and addressing cultural beliefs and preferences.[39]

The fourth, partnering with community-based organizations and ethnic leaders to provide culturally sensitive education delivered in the native languages of these groups, will be crucial in overcoming the deeply ingrained traditions of home births. It is to increase awareness of the risks and benefits of home births and encourage using skilled birth attendants and health facilities.[36,40] This strategy can be effective in raising awareness of the risks and benefits of home births while also encouraging the use of skilled birth attendants and health facilities. However, the limitations will be the lack of access to remote and rural areas, limiting the reach of education and outreach programs, making it difficult to communicate with targeted communities effectively. Additionally, cultural beliefs and preferences may still prevent some women from seeking skilled birth attendants and health facilities, even if they are aware of the risks associated with home births. Finally, partnering with NGOs and community-based organizations may require significant coordination and resources, which can be a challenge to sustain in the long term. Therefore, while partnering with NGOs and community-based organizations can be a valuable strategy, it should be accompanied by other measures, such as improving healthcare infrastructure and addressing cultural beliefs and preferences.[40]

By specifically addressing geographic isolation, cultural traditions, and limited access to healthcare in Bokeo Province, Lao PDR, these strategies can significantly reduce maternal and neonatal risks associated with home births. However, it is important to note that these measures will require a significant investment of resources and long-term commitment from the government and other stakeholders to be successful. It is because they involve enhancing healthcare infrastructure, recruiting and training a skilled workforce, and establishing reliable transportation systems in remote areas. Such improvements cannot be achieved quickly or without considerable financial resources. They require ongoing support and collaboration between the government, non-governmental organizations, and community leaders to maintain the quality and accessibility of healthcare services in the long term. Ensuring sustainability also means committing to community engagement initiatives addressing cultural beliefs to integrate these changes within the communities. Lao PDR can reduce the maternal and neonatal risks associated with home births, creating safer outcomes for ethnic minorities and vulnerable populations across the country with this sustained effort.

Conclusion

Home births are prevalent in Lao PDR, particularly among ethnic minorities, posing significant health risks. The government has implemented measures like training traditional birth attendants and providing transportation. However, more efforts are needed to address the complex factors contributing to high rates. An alternative strategy could be increasing skilled birth attendants and improving access to emergency obstetric care in rural areas. However, these measures require significant investment and long-term commitment.

Abbreviations

Lao PDR: Lao People's Democratic Republic; TBA: traditional birth attendants; SDG: Sustainable Development Goal; WHO: World Health Organization.

Ethics Approval and Consent to Participate

Not applicable.

Competing Interest

The authors declare that they have no competing interests related to the research, authorship, and publication of this article.

Availability of Data and Materials

Data and materials are available upon request to the corresponding authors.

Authors' Contribution

JW led the conceptualization, literature review, and manuscript drafting. RS contributed to the analysis and interpretation of the reviewed literature. KK and WR assisted with organizing the literature and refining the manuscript. JW provided critical revisions and academic feedback. All authors approved the final version.

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Economic Growth, Poverty Gap, and Health Inequality: Implications Based on Panel Analysis of Organization for Economic Cooperation and Development Data

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Economic Growth, Poverty Gap, and Health Inequality: Implications Based on Panel Analysis of Organization for Economic Cooperation and Development Data

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Abstract

This study investigated the impact of economic growth and income distribution on health inequality using data from the Organization for Economic Cooperation and Development (OECD). Employing a panel analysis, this study amalgamated 21 years of data (spanning from 2000 to 2020) from 37 OECD countries. The dependent variables (life expectancy and avoidable mortality) were scrutinized against independent variables (gross domestic product and poverty gap). Control variables encompassed body mass index, consumption patterns, smoking rates, health workers availability, number of beds in health facilities, national medical expenses, and unemployment rates. This study revealed significant associations between economic growth, poverty gap, and both life expectancy and avoidable mortality. This underscored the necessity of prioritizing not only income distribution but also overall economic growth to address health inequality effectively. This study established that an increase in the poverty gap corresponded to elevated life expectancy and reduced avoidable mortality rates, suggesting a mechanism distinct from a medical security system targeting lower-income individuals or an enhancement of societal welfare. Proposing policy measures to alleviate health inequality, this study advocates for policy interventions to mitigate the adverse impacts of income inequality within healthcare policies.

Keywords: fixed effect model, health disparity, health inequality, panel analysis

Introduction

The Gross Domestic Product (GDP), traditionally employed as a metric for national income, has historically served as an indicator for assessing the quality of life. Rooted in post-World War II conditions, this evaluation is predicated on the empirical assumption that income fundamentally impacts the quality of life, coupled with a pragmatic framework for enhancing living standards.[1] Income, as the primary material underpinning, is deemed pivotal for augmenting happiness levels, with economists positing an individual's happiness as contingent upon income. However, recent paradigms challenge this association, positing that a rise in absolute income does not necessarily correlate with increased happiness,[1] introducing nuances such as the Easterlin paradox, wherein incremental income reaches a saturation point in contributing to heightened happiness.

The authors agreed that the intricate interplay between income and health should be examined, given the manifold and unequal differences observed in both. Variances in health levels, attributed to diverse factors encompassing genetic predispositions and the social and economic status of individuals, persistently influence lives. Educational backgrounds further contribute to income differentials, impacting qualitative and quantitative aspects of medical services.

The debate over whether health outcomes primarily stem from individual behaviors or systemic issues remains contentious,[2] necessitating an exploration of reformist and historical materialistic perspectives. Reformism underscores the role of social and environmental determinants, advocating improvements in lifestyle and nutrition management. In contrast, historical materialism accentuates structural factors such as social inequality and poor living conditions, positing health outcomes as more systemic than individualized.[3,4] This dichotomy carries implications for the attribution of health responsibility, with reformist positions often neglecting socioeconomic factors in favor of individual behavior.

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To comprehensively understand health, one must scrutinize the intricate relationship between health and the environment, spanning individual, community, and macro-political dimensions. Scholars like McKeown argue that changes in the socioeconomic environment hold more relevance for health than the quality of medical care.[5] The Black Report (1990)[6] and Acheson Report (1998)[7] are two of the most prominent reports on health inequalities published in the UK. Those reports emphasize the significant impact of living conditions, socioeconomic factors, cultural influences, and environmental conditions on health, challenging the predominant focus on income distribution. Despite empirical studies examining the link between health and income inequality, the relationship remains contentious.[6,7]

Income influences health in two key conditions: insufficient absolute income necessary for maintaining proper health conditions and negative effects of an intense income gap on health through various social side effects.[8] The absolute income hypothesis (AIH) posits a diminishing return effect, suggesting that the impact of income on health lessens as income increases.[8] In contrast, the relative income hypothesis (RIH) asserts that income inequality affects health independently of individual income levels, emphasizing contextual effects and group influences on health outcomes.[9-14]

The literature on the contextual effects of the RIH delves into diverse perspectives. Macinko, adopting a new materialistic perspective, asserts that income deficiencies, including poverty, influence health due to an increase in poor individuals as income inequality intensifies.[15] Additionally, social investment reduction in regions with heightened income inequality leads to underinvestment in human capital.[9] Moreover, social psychology perspectives posit that income inequality weakens social cohesion, adversely impacting social capital and mutual trust ultimately influencing public health.[10] The last, from a social psychology standpoint, income inequality's impact on social status exacerbates individual social status inequality, contributing to health deterioration due to heightened stress among individuals with lower social status.[13]

Numerous empirical studies have scrutinized the nexus between income inequality and health, consistently revealing a deleterious impact on health outcomes and key societal values such as trust and fairness.[10-14] This adverse influence on health assumes particular significance as a hindrance to global sustainable development. Recognizing this, the United Nations (UN) has prioritized health as a focal point in its Sustainable Development Goals (SDGs), specifically SDG-3, underscoring the imperative of mitigating health inequality for holistic sustainability.[16] Consequently, a comprehensive empirical exploration of diverse socioeconomic variables contributing to health inequality across varied dimensions emerges as a paramount concern within sustainable development.[17]

Several studies have delved into the relationship between income and health using national data, acknowledging healthcare systems' divergent characteristics and developmental trajectories in different countries. Rodgers conducted an analysis revealing a significant correlation between income levels and life expectancy, demonstrating that countries with equitable income distribution exhibit an average life expectancy of up to 10 years longer than those characterized by disparate income distribution.[18] Wilkinson substantiated this correlation by examining the relationship between the Gini coefficient and life expectancy in 11 the Organization for Economic Cooperation and Development (OECD) countries, elucidating that income distribution exerts a more pronounced impact on health inequality than GDP.[19]

Notably, the effect of GDP on life expectancy remains below 10%, while the income share of low-income families contributes to approximately 75% of life expectancy.[20-21] Le Grand found a close link between mortality rates and income redistribution across 17 countries.[22] Investigating the income of the lower 20% of the population and its proportion to the country's total income, Le Grand emphasized the pivotal role of income distribution.[22] Hill's study on the relationship between income and total mortality accounted for in 50 states in the United States underscored the significant correlation between income distribution and age-standardized mortality—a universal phenomenon, irrespective of sex.[23] In light of these insights, this study contributed to the discourse by undertaking a rigorous panel analysis utilizing OECD statistics spanning 21 years, from 2000 to 2020. Through this investigation, this study aimed to unravel the nuanced dynamics of how economic growth and distribution levels substantively contribute to the intricate landscape of health inequality.

Method

This study employed OECD statistical data to investigate health inequalities across OECD countries. The data was downloaded from the OECD's official website.[24] The OECD offers comprehensive annual data covering health, healthcare, and various fields such as employment, social policy, family, and pension. Pooled data spanning 21 years, from 2000 to 2020, were amalgamated into a time series for analysis. A total of 37 countries (countries provided by OECD), including Australia, Austria, Belgium, Canada, the Republic of Chile, Colombia, Costa Rica, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, South Korea (ROK), Latvia, Lithuania,

Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States, were included in the analysis.

This study empirically scrutinized factors influencing the growth and distribution of health inequality using OECD statistics. Dependent variables encompassed life expectancy and avoidable mortality (% per 100,000 people). Employing various variables as proxies for health inequality, life expectancy represented the average age individuals were expected to survive at 40, 60, 65, and 80 years. The avoidable mortality rate combined preventable mortality before accidents and diseases occurred with treatable mortality, calculated as the mortality rate per 100,000 people according to OECD population standards.

Independent variables included GDP per capita, measured in USD, as an indicator of a country's basic income. Distribution was assessed using a poverty gap based on the concept of relative poverty, calculated after taxes and income transfers based on 50% of the poverty line. To control for potential influences on health inequality, health-risk variables such as drinking, smoking, and obesity were considered. Drinking was measured as consumption per person aged 15 years or older, smoking as the smoking rate among the population aged 15 years or older (%), and overweight or obesity as the percentage of people with a body mass index (BMI) of 25 or more. The OECD uses the age of 15 as a benchmark.[24] Variables indirectly measuring healthcare resources, such as the number of health workers and beds per 1,000 people, health and medical expenses (% of GDP), and the share of government and compulsory schemes in national medical expenses, were also controlled. Additionally, the unemployment rate (%) was considered a major variable influencing health inequality, given its direct relationship with individual income and reported associations with increased mortality rates. The ratio of the unemployed to the economic population aged 15 years or older was controlled by OECD standards.

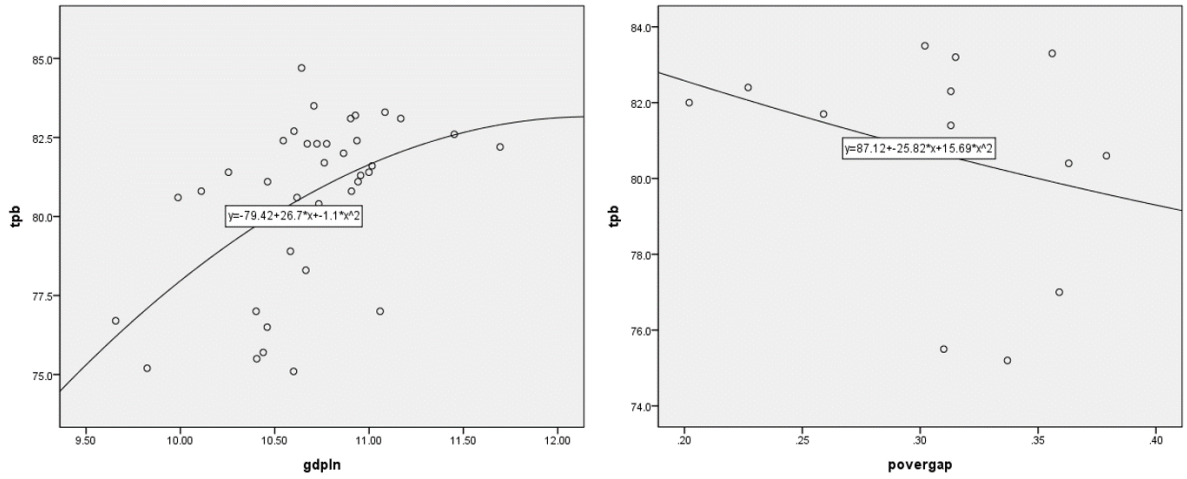
Data for this analysis were arranged by combining spatially and chronologically different cases (Number×Time). This combination allowed simultaneous analysis of cross-sectional and temporal fluctuations, increasing the degree of freedom. Panel analysis was conducted using generalized Ordinary Least Square (OLS). However, OLS could violate the basic assumptions of several estimates. First, combined data exhibited autocorrelation, a correlation between different time points, owing to the characteristics of independent observation values over time. Second, there was a heteroscedastic characteristic in which the dispersion of errors varied depending on the unit of time. Third, the errors tended to show contemporaneous correlations across spatial units at certain points in time. Fourth, the errors included both time and unit effects. Because OLS has biased, inefficient, or inconsistent estimation problems, this study considered the applicability of Generalized Least Square (GLS).

The analysis procedure was as follows: First, the average and standard deviation of the variable were reviewed using descriptive statistics of the major variables (Table 1). Second, the Lagrange multiplier test proposed by Breusch and Pagan was conducted to confirm the simultaneous correlation and determine the appropriate model between the pooled OLS and random effects models. Third, through an F-test, an appropriate model was identified between the pooled OLS model and the fixed-effect model. Fourth, to compare the suitability of the fixed effects and pooled OLS model, a Hausman test was conducted to determine a valid model. The final model, validated through these tests, was then utilized to identify factors influencing health inequality. The results of the analysis procedure are detailed below.

Results

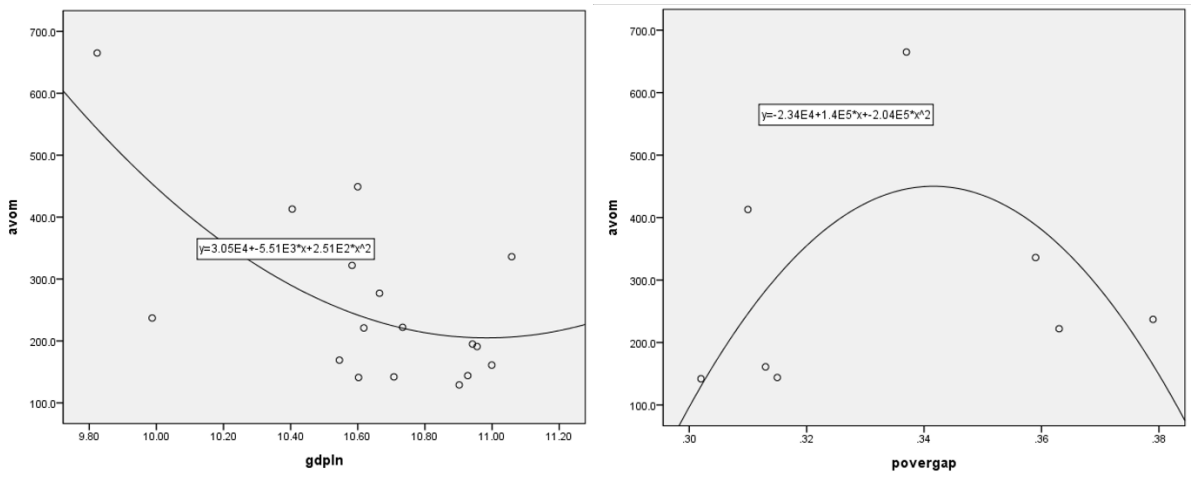
Figure 1 depicts the relationship between major variables based on the 2020 cross-sectional data. Concerning the link between economic growth and life expectancy, a country's life expectancy increases with rising GDP per capita. However, when a country's income reaches a certain level or higher, the increase in life expectancy becomes statistically insignificant. Conversely, the poverty gap does not intuitively correlate with life expectancy. Although life expectancy generally decreases as the poverty gap increases, the statistical significance of this trend is not apparent.

A regression analysis was conducted based on cross-sectional data to delve into these relationships further. The model, with an adjusted R2 of .196, explains approximately 19.6% of the variation in economic growth, poverty gap, and life expectancy. Notably, GDP per capita did not exert a statistically significant effect on life expectancy ($\beta = 0.508$, $t = 1.977$, p-value = 0.090). However, the relationship between economic growth and life expectancy was significant at the 0.1 level. As anticipated, the poverty gap exhibited no statistically significant effect ($\beta = -0.157$, $t = -0.581$, p-value = 0.574).



Notes: the circle represents individual countries; gdpln: the log of GDP per capita; povergap: the poverty gap; tpb: life expectancy.

Figure 1. Relationship Between Economic Growth, Poverty Gap, and Life Expectancy (2020 Data)

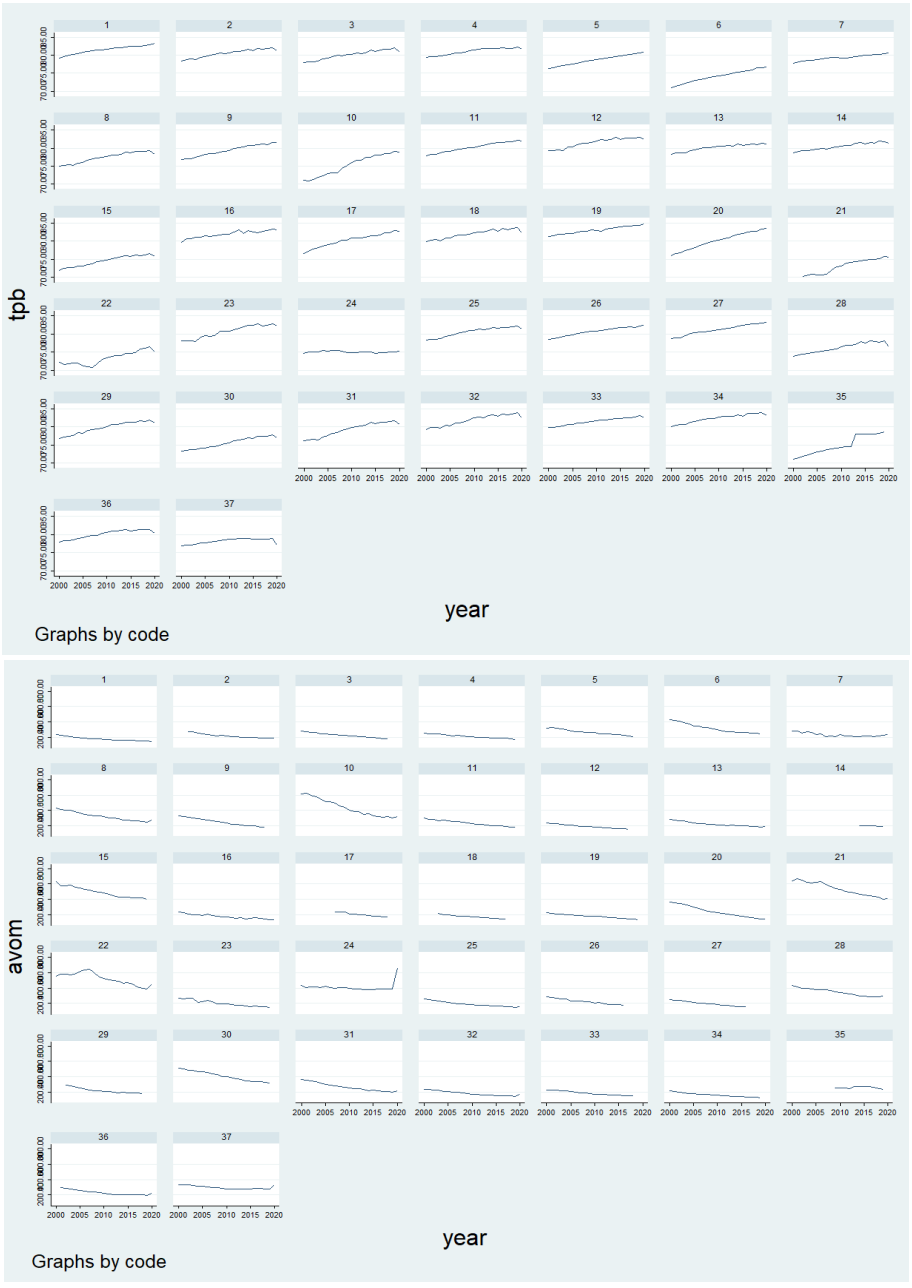


Notes: the circle represents an individual country; gdpln: the log of GDP per capita; povergap: the poverty gap; avom: avoidable mortality.

Figure 2. Relationship Between Economic Growth, Poverty Gap, and Avoidable Death (2020 Data)

Figure 2 explains the relationship between economic growth, the poverty gap, and avoidable deaths. As GDP per capita increases, the avoidable death rate of a country continues to decrease. Similar to life expectancy, it was confirmed that if a country's income reaches a certain level or higher, a flat section of avoidable deaths appears, even if income increases. However, the poverty gap did not intuitively reveal a relationship with the avoidable mortality rate. As the poverty gap increases, the avoidable mortality rate initially increases and then decreases when it reaches a certain level; however, this is not statistically significant. As a result of conducting a regression analysis based on cross-sectional data, both economic growth (β = -0.676, t = -1.929, p-value = 0.112) and the poverty gap (β = -0.056, t = -0.161, p-value = 0.879) could not confirm statistical significance in the avoidable mortality rate.

In brief, the analysis results using cross-sectional data provided variables with intuitive implications. However, in most cases, statistical significance was not observed. Individual-level data were verified based on the statistical data for each country. This approach was chosen to secure a larger number of samples than when using aggregated data. However, in this case, it became difficult to compare or control the level of social security, healthcare fiscal expenditure, and the influence of medical indicators in individual countries. Therefore, a panel analysis combining space and time data can offer more realistic and practical implications when analyzing country-specific data.



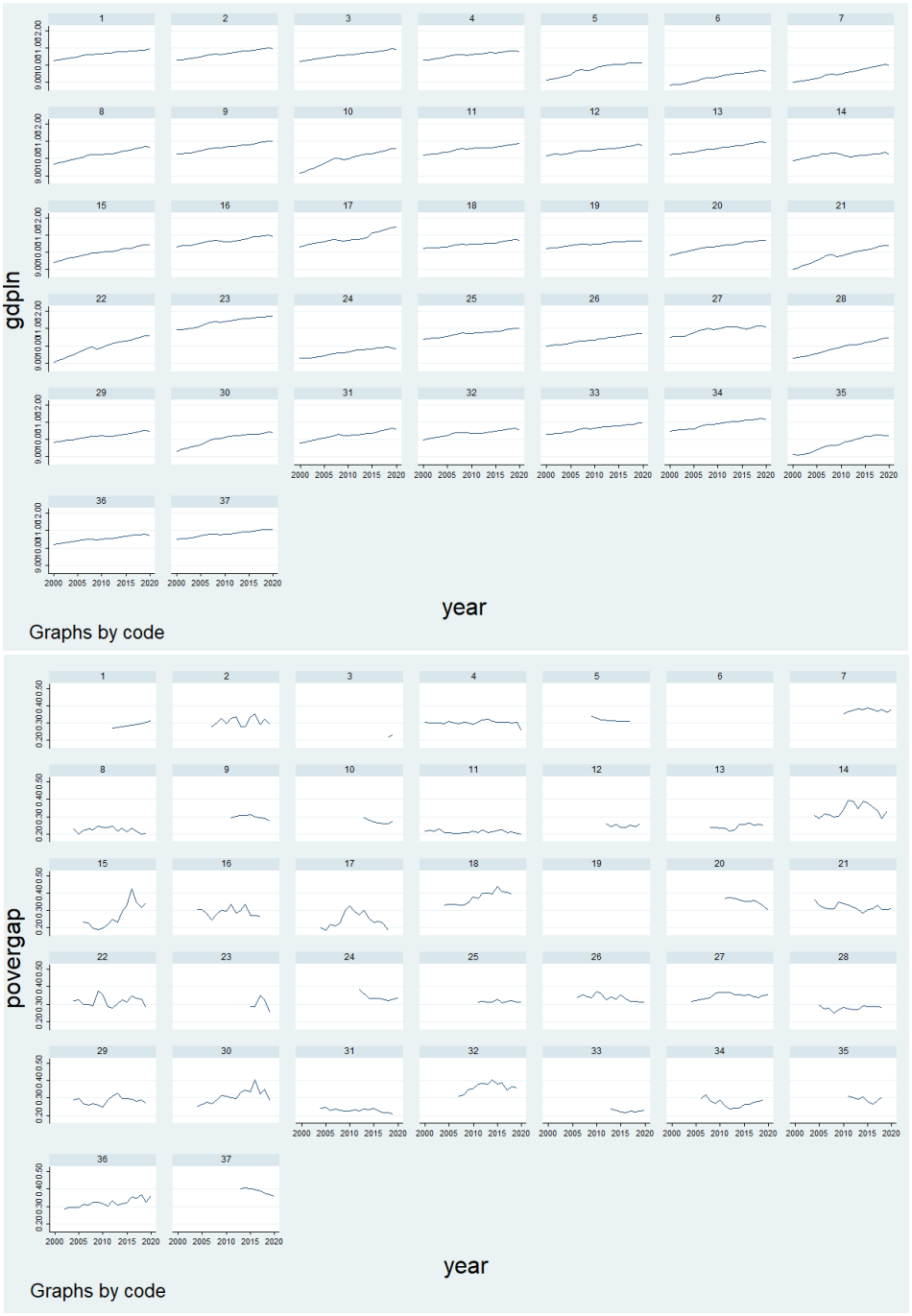
Notes: (1) Australia, (2) Austria, (3) Belgium, (4) Canada, (5) the Republic of Chile, (6) Colombia, (7) Costa Rica, (8) Czech Republic, (9) Denmark, (10) Estonia, (11) Finland, (12) France, (13) Germany, (14) Greece, (15) Hungary, (16) Iceland, (17) Ireland, (18) Italy, (19) Japan, (20) South Korea (ROK), (21) Latvia, (22) Lithuania, (23) Luxembourg, (24) Mexico, (25) the Netherlands, (26) New Zealand, (27) Norway, (28) Poland, (29) Portugal, (30) Slovakia, (31) Slovenia, (32) Spain, (33) Sweden, (34) Switzerland, (35) Turkey, (36) United Kingdom, (37) United States

Figure 3. Trends in Life Expectancy and Avoidable Mortality

Figure 3 illustrates trends in life expectancy and avoidable mortality rates in individual countries from 2000 to 2020. There is variation in life expectancy among countries; however, it has been confirmed that life expectancy continues to increase. This tendency is thought to reflect factors such as economic growth and improvements in medical services. Simultaneously, even in the case of the avoidable mortality rate, a relatively decreasing tendency was confirmed. This can also be interpreted as improvements in living standards, changes in the value of life, and enhancements in the quality and quantity of medical services.

From 2000 to 2020, the GDP per capita of individual countries continued to increase. However, determining uniform tendencies among countries was challenging. In general, the poverty gap (based on 50% of the poverty line) represents how much income people in the lower-income class must earn to escape poverty and the degree of insufficient income. Therefore, the lower the average income of the lower-income class, the greater the poverty gap. Confirming a tendency to increase or decrease in most countries is difficult. The observed tendency was evidence that individual countries have

prioritized economic growth in the direction of state affairs or have not implemented policies advantageous to the lower class, even if various social security systems and redistribution policies exist.



Note: See Figure 3. For the list of countries

Figure 4. Trends in GDP Per Capita and Poverty Gap

This study utilized a panel group comprising 37 countries for analysis, with a total of 798 observations. Descriptive statistics for the major variables are presented in Table 1. In terms of dependent variables, the average life expectancy was 79.14 years, with a minimum of 70.2 years (recorded in 2002 in Latvia) and a maximum of 84.7 years (noted in 2020 in Japan). The average avoidable mortality rate stood at 267.23%, with a minimum mortality rate of 124.0% (observed in Switzerland in 2019) and a maximum mortality rate of 667.0% (recorded in Latvia in 2021). Among the independent variables, the average GDP per capita was USD34,735, ranging from a minimum value of USD6,886 (observed in Colombia in 2000) to a maximum value of USD119,883 (noted in Luxembourg in 2020). The average poverty gap was 0.29%, with the minimum value at 0.18% (Ireland, 2005) and the maximum at 0.44% (Italy, 2015).

Table 1. Descriptive Statistics of Variables

Variables	N	Min	Max	Mean	SD
Life expectancy	795	70.2	84.7	79.14	3.08
Avoidable mortality	712	124.0	667.0	267.23	113.71
GDP per capita (Log conversion)	798	6,886.4 (8.84)	119,883.0 (11.69)	34,735.09 (10.34)	16,982.44 (0.56)
Poverty gap	436	0.18	0.44	0.29	0.05
Body Mass Index	127	23.7	75.2	52.41	16.37
Alcohol consumption	785	1.2	14.8	9.03	2.91
Smoking rate	435	7.3	40.0	19.71	5.89
Health workers	727	8.1	110.9	45.41	23.01
The number of beds in health facilities	744	0.95	14.69	4.89	2.60
The national medical expenses	798	3.89	18.81	8.33	2.17
Unemployment	747	2.01	27.46	7.57	4.01

Notes: SD = standard deviation; GDP = gross domestic product

Examining the proportion of individuals with a BMI of 25 or higher in various countries revealed an average of 52.41%, a minimum of 23.7% (Japan in 2012), and a maximum of 75.2% (Mexico in 2018). The average alcohol consumption per person aged 15 years and older was 9.03 liters, with the minimum observed in Turkey (1.2 liters per person in 2006 and 2020) and the maximum in Estonia (14.8 liters in 2007). Among the population aged 15 years and over, the average smoking rate was 26.67%, with a minimum of 7.3% (Iceland in 2020) and a maximum of 40.0% (Greece in 2006).

Indirectly measuring healthcare resources in OECD countries, the average number of health workers per 1000 people was 45.41, ranging from a minimum of 8.1 (Turkey in 2010) to a maximum of 110.9 (Norway in 2019). The average number of hospital beds per 1,000 people was 4.89, spanning from a minimum of 0.95 (Mexico in 2019) to a maximum of 14.69 (Japan in 2000). Regarding health and medical costs in OECD countries, the ratio of national medical expenses to GDP fell within the range of 8.33%, with a minimum of 3.89% (South Korea in 2000) and a maximum of 18.81% (the United States in 2020). The average unemployment rate was 7.57%, with values ranging from a minimum of 2.01% (Czech Republic in 2019) to a maximum of 27.46% (Greece in 2013).

The Lagrange multiplier test was employed for the two dependent variables to select the appropriate model for panel analysis. The objective was to discern whether the random effects or pooled OLS model was more fitting. For life expectancy as the dependent variable, the null hypothesis was decisively rejected at the 1% significance level, given the p-value (0.001) falling below 0.01. Consequently, it was deemed appropriate to estimate a probability effects model, considering the panel's individual characteristics, rather than opting for the pooled OLS model. In the case of avoidable mortality rate as the dependent variable, the p-value (0.036) being less than 0.05 led to the rejection of the null hypothesis at the 5% significance level.

An F-test, conducted on 798 observations and 37-panel groups (countries), aimed to validate that the estimated coefficients are in close proximity to zero. The p-value of the F-test, being less than 0.010, resulted in the null hypothesis being rejected at the 1% significance level. Thus, the fixed-effects model, which accounts for the individual characteristics of the panel, was deemed more suitable than the pooled OLS model.

Following the Lagrange multiplier test and F-test, which indicated the inadequacy of the pooled OLS model, the Hausman test was employed to determine the suitability between fixed- and random-effect models. The Stata command "sigmamore" was utilized to enhance the robustness of the test. The Hausman test outcomes where the null hypothesis was rejected at the 5% significance level, given that the prob>chi2 value (0.019) was less than 0.050. This result implied that the fixed-effects model might be considered more appropriate than the random-effects model.

For the avoidable mortality rate, the prob>chi2 value was 0.021, and the null hypothesis was not rejected. Consequently, the fixed-effects model was deemed a more appropriate analytical model. Similarly, the null hypothesis was rejected at the 1% significance level with a prob>chi2 value of (0.002) being less than 0.010. These results indicated that the fixed-effects model was more suitable than the random-effects model.

Hence, the final model for this study was estimated as a fixed-effects model, as illustrated in Equation 1, where "i" denotes the number of cross-sectional data, "t" is the number of time-series data, and "k" is the number of independent and control variables. β1yit-1 represents the incorporation of a lagged dependent variable into an independent variable to address autocorrelation.

$$y = a_1 + \beta_1 y_{-1} + \sum_{k=2}^{k} \beta_k X_{kit} + e,$$
$$(i = 1,2,\dots,n,\ \ t = 1,2,\dots,Ti)$$

In scrutinizing the influence of growth and distribution on health inequality, the impact on life expectancy was examined utilizing a fixed-effects model. While controlling for variables affecting life expectancy inequality, the findings revealed that GDP per capita significantly influenced life expectancy (β = 3.943, p-value <0.01). In essence, as GDP per capita increases, life expectancy improves. Additionally, the poverty gap exhibited a statistically significant impact on life expectancy (β = 5.711, p-value <0.01). These results may appear somewhat unconventional compared to prevailing social norms.

This result differs from the common perception that life expectancy gradually decreases as income inequality increases. However, the interpretation of income inequality may differ when measured as a poverty gap instead of the Gini coefficient. Unlike the Gini coefficient, which represents the overall income imbalance in society, the poverty gap focuses on the average income of the lower classes. Therefore, an increase in the Gini coefficient did not necessarily imply a poverty gap rise. Even with improvements in living conditions, increased access to medical services, and enhanced economic growth within a country, the lack of appropriate redistribution policies, particularly for the lower class, or the absence of effective social security measures could explain these results. These results were proved by the longitudinal graph, which did not confirm a decrease in the poverty gap despite the presence of national redistribution policies and a social security system.

A country's health and medical resources encompass hospital facilities (total hospital beds), health and medical workers (number of doctors and nurses), medical equipment, and medical technology (CT scanners and MRI equipment). Among these, health and medical workers (β = 0.089, p-value <0.05) significantly impacted the increase in life expectancy. Furthermore, the unemployment rate (β = 0.183, p-value <0.01) had a statistically significant effect on life expectancy. Unexpectedly, higher unemployment rates correlated with increased life expectancy. Moreover, the analysis of variables affecting the avoidable mortality rate corroborated that GDP per capita, poverty gap, and control variables such as health workers and unemployment had a statistically significant impact. As the economy grows and the number of health and medical workers increased, the socially preventable mortality rate decreased. Conversely, the avoidable mortality rate decreased as the poverty gap and unemployment rates rose.

Table 2. Analysis Results

Section		Variables	Life Expectancy	Avoidable Mortality
Independent variables		GDP per capita	3.943**	-137.647**
			(0.939)	(28.664)
		Poverty gap	5.711**	-120.890**
			(1.825)	(53.288)
Controlled variables	Health risk	Body Mass Index	0.012	0.391
			(0.018)	(0.531)
		Alcohol consumption	0.004	0.280
			(.079)	(2.188)
		Smoking rate	0.009	-0.640
			(0.031)	(0.893)
	Health care resources	Health workers	0.089**	-2.430**
			(0.026)	(0.766)
		Number of beds in health facilities	-0.030	1.682
			(0.051)	(1.420)
	Employment	The National Medical Expenses	0.095	0.097
			(0.112)	(3.381)
		Unemployment	0.183**	-5.238**
			(0.046)	(1.300)
A Constant			29.978**	1,844.684**
			(9.677)	(286.219)
F			55.05**	87.61**

Notes: GDP = gross domestic product, *p-value <0.05, **p-value <0.01

Discussion

This study delved into the significant correlation between a country's growth, distribution, and health inequality, utilizing a panel analysis spanning 21 years for 37 OECD countries. The key findings are summarized as follows. Variables that lacked significance in cross-sectional analysis revealed statistical significance in panel analysis. GDP per capita and the poverty gap, which showed no statistically significant effects on life expectancy and avoidable mortality in cross-sectional analysis, gained significance in the panel analysis of 37 OECD countries. The shift in results could be attributed to the relatively small sample size in cross-analysis and the fixed nature of social security, healthcare fiscal expenditure, and medical indicators in each country during cross-sectional analysis. Panel analysis, incorporating both spatial and

temporal data, proved to be more robust and offers practical implications for studying health inequality.

Economic growth, as measured by GDP per capita, positively influenced life expectancy and avoidable mortality rates. A rise in GDP per capita correlated with increased life expectancy and decreased avoidable mortality. Individual-level income, as a socioeconomic indicator, directly impacted material resources affecting health. Economic growth at the national level influenced countries in diverse ways, such as improvements in living standards, shifts in individual values, advancements in medical services, and developments in medical technology—all contributing to increased life expectancy and decreased preventable deaths.

Contrary to the expected negative impact of income inequality on health, this study found that an increase in the poverty gap positively influences life expectancy and reduces the avoidable mortality rate. It illustrates Easterlin's proposed concept of a "flat section of life expectancy"—the idea that beyond a certain income level, the statistical relationship between life expectancy and income becomes negligible.[25] The poverty gap, focusing on the average income of the lower class, might indicate improved health inequality even when the Gini coefficient suggests otherwise. This study suggested that a growing poverty gap may prompt the establishment of new medical security systems for the deprived or expansions of existing systems. As the poverty gap grows, new healthcare programs targeting people experiencing poverty may be established in response, or coverage of existing programs may be expanded. It is important to note that income inequality does not necessarily negatively affect health inequality, as in this study, i.e., an increase in the poverty gap may trigger medical interventions for the poorest and the expansion of social security, leading to an improvement in health inequality. These findings are difficult to confirm in a cross-sectional analysis and can only be concluded from a panel analysis. It is crucial to differentiate between relative and absolute inequality variables in health inequality measurement. While GDP per capita represents an absolute inequality variable, the poverty gap functions as a relative inequality variable. Relative inequality variables alone cannot determine the intensity of health inequality in a country. This underscores the importance of utilizing both absolute and relative indicators in health inequality studies.

As COVID-19 has shown, pandemics exacerbate the relationship between socioeconomic vulnerability and poorer health outcomes, negatively impacting sustainability.[26] This study advocated increased attention to income inequality and healthcare policies targeting the lower class. Strengthening social protection systems, enhancing comprehensive medical services, and implementing effective poverty policies are essential. Policy interventions should aim to mitigate the adverse effects of income inequality and promote overall health equity. As health is intricately tied to basic rights and opportunities for participation in democracy, addressing health inequality becomes crucial for sustaining societal well-being.

Conclusion

Considering the intricate relationship between economic growth, income inequality, and health, future policies should prioritize social protection, comprehensive medical services, and poverty alleviation to address health inequality effectively. The study emphasizes the need for a holistic approach incorporating health and non-health policies to uplift vulnerable groups and bridge the gap exacerbated by income inequality. To derive more precise results on health inequality, future research should focus on improving health inequality measurement indicators and accumulating national-level data. Developing sophisticated indicators that directly measure health inequality and including observable indicators for social and psychological factors influencing health is imperative. Additionally, efforts should be directed towards designing health policies that reduce social gaps and promote equity, complementing macroscopic measures to reduce income inequality.

Abbreviations

GDP: gross domestic product; RIH: relative income hypothesis; SDG: Sustainable Development Goal; OECD: Organization for Economic Cooperation and Development; BMI: Body Mass Index; OLS: Ordinary Least Square.

Ethics Approval and Consent to Participate

Not applicable.

Competing Interest

The authors declare that they have no competing interests related to the research, authorship, and publication of this article.

Availability of Data and Materials

All data and materials are available through the website of OECD. Stat (OECD Statistics) Portal.

Authors' Contribution

SH conducted all procedures of this study.

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Social Determinants of Neonatal Health Outcomes in Indonesia: A Multilevel Regression Analysis

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Abstract

Indonesia's neonatal mortality rate remains alarmingly high. This study addressed the determinants of neonatal outcomes in Indonesia, including the effects of a decentralized health system, socioeconomic disparities, and geographic variations. The analysis used 2018 national survey data across 34 provinces, 513 cities/districts, and 300,000 households, with a sample of 73,864 women aged 10-54 years who have given birth in the preceding five years. The multilevel regression was used to assess the impact of social determinants and systemic inequalities on neonatal health. Key findings revealed a neonatal mortality rate that, despite being preventable in many cases, remained high with significant disparities. The final model, incorporating individual and community-level factors, reduced unexplained variance by 28% (PCV), with community factors explaining 16% of the variability (ICC 0.1600). The community-level risk variability also decreased, as shown by a reduction in the Median Odds Ratio from 2.43 to 2.13. These results highlighted the importance of targeting individual and community factors to reduce the risk of babies being born at risk. There is a critical need for targeted health policies and local-specific interventions to bridge the equity gap and improve neonatal health outcomes.

Keywords: disparities, Indonesia, multilevel regression, neonatal, social determinants

Introduction

Indonesia stands at a crucial juncture in its health trajectory as the 2005-2024 National Long-Term Development Plan nears its conclusion, paving the way for the new 2025-2045 era that focuses on achieving the ambitious "Golden Indonesia 2045" vision.[1–3] This vision hinges on resilient and competitive human capital and is anticipated to propel Indonesia from the middle-income trap toward economic prosperity. Hence, human capital investment is critical, and the country should start its development by investing in health and education. A healthy, well-educated population is a powerful driver of innovation, productivity, and overall economic well-being. This pivotal moment presents a golden opportunity to invest in the nation's most valuable asset – its people, especially the children, who will take over the nation in the era of 2045.[1]

Neonatal mortality, including stillbirths and maternal mortality, remains a substantial challenge for Indonesia despite significant progress concerning poverty reduction, education, and some health outcomes. The neonatal disorder has been one of the top ten mortality causes in the country for all ages since 1990.[4] Even though there is some improvement where the statistic decreased to 39.9% from 2008 to 2018, and its rank reduced from sixth to ninth, much can be done to alleviate the issue.[4] The severity of the problem is further highlighted by the fact that neonatal disorders ranked second as a cause of premature deaths measured by years of life lost in 2018 before being reduced to third place that same year.[4–6]

In 2018, Indonesia's neonatal mortality rate (NMR) was 12.7 deaths per 1,000 live births, which is equal to 72,400 deaths.[7] Indonesia is ranked at the eighth highest neonatal death number in the world, with other Asian countries such as India, Pakistan, China, and Bangladesh also included in the top ten ranks.[8,9] Several efforts continue to be sought by most stakeholders to end the preventable deaths of infants and children under the age of 5 (the under-five), of which 60% of deaths occurred during the first 28 days of life. Although Indonesia has currently met the Sustainable Development Goal (SDG) targets for under-five children, infant, and neonatal mortalities, its NMR remains higher than

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that of Singapore, Malaysia, Thailand, and Vietnam, all of which have an NMR of less than 10 deaths per 1,000 live births.[10]

The emphasis on decentralization in Indonesia's public health system is crucial to understanding the slow progress and persistent disparities in NMRs across different regions.[11] Decentralization was instituted as a strategic response to Indonesia's diverse geographic, socioeconomic, and cultural landscapes, which started in 2001 and encompassed numerous islands and remote areas. By redistributing authority and resources from the central to local governments, decentralization aims to allow tailored health interventions that are more aligned with the specific needs of local populations.[12,13]

This shift is particularly significant in addressing the stark differences in health outcomes highlighted by the 2017 Indonesia Demographic Health Survey, where NMRs significantly varied between socioeconomic statuses and regions.[14] The disparities reveal that centralized policies may not adequately address local challenges, making a strong case for why decentralization could potentially enhance the effectiveness of health service delivery by bringing decision-making closer to the point of need.[11,15] Such local empowerment is intended to improve responsiveness, enable better allocation of resources, and ensure that health programs are culturally appropriate and effectively implemented.[13] Hypothetically, decentralization should improve local health service delivery where devolution is applied, in which the local governments have autonomy for financial resource allocation and managing the human resources for health. However, neonatal mortality, along with maternal mortality, remains the major problem for nearly two decades after decentralization.[12]

Specific interventions referring to international guidelines have been introduced before and after decentralization.[16] These include adding more primary health care (PHC), providing a midwife for each village, building village maternity huts, setting more PHCs with basic emergency obstetric-neonatal care (BEMONC) capacity, and public hospitals with comprehensive emergency obstetric-neonatal care (CEMONC) capacity, among others.[13] Social protection programs in Indonesia have also improved significantly. However, even with the improvements, approximately 20% of families require a loan to pay their normal delivery costs. On top of that, the utilization of non-contributory (subsidized) participants is much lower than that of contributory memberships (less than 5% compared to about 25%).[17]

Despite the decrease in catastrophic expenditures among the poor due to social health insurance, affordability is not the only barrier to the utilization of maternal-neonatal health services. The revised 2017 National Health Account indicates that out-of-pocket spending reduced from 55% in 2010 to about one-third of the total health expenditure in 2017, which was later further reduced by 4% point in 2020.[18] Health illiteracy, high non-medical costs across regions, and socioeconomic groups limit the demand.[19,20] Due to their vulnerabilities, women face severe challenges in accessing health care. Low access, utilization, and quality of services resulted in poor health outcomes reflected by the slow progress of maternal and neonatal mortality.[21]

To deliver the quality of basic essential services and ensure a better outcome, a good quality of inputs, processes, and outputs is needed. In addition, a strong health system will be required to achieve the expected outcomes. However, after examining the current conditions of the available facilities, most of them are concerning since the focus is primarily on the demand side, only a portion of it.[22] Other than that, there is a lack of information and studies on the supply-side contributions to the stagnant outcomes, let alone studies using a health systems approach. Due to the complexity of determining the causes of neonatal mortality, this study aimed to identify the key factors contributing to neonatal health outcomes at different levels. By using a multilevel regression, this study aimed to capture the underlying supply and demand side factors on neonatal health outcomes within the hierarchical dataset.

Method

This study used a cross-sectional analysis designed to identify the key drivers of the determinant factors of neonatal health outcomes and their relative indicators. The goal was to improve the quality of integrated health services to achieve the Universal Health Coverage targets by strengthening health systems in the decentralization era. The study employed a multilevel regression, incorporating individual, district, and provincial levels. This study utilized multiple secondary data sources from 2018, including the 2018 Indonesian Basic Health Research, Village Potential Data, and the National Socioeconomic Survey. These data sources provided a comprehensive and diverse sample size, covering key variables such as household income, education levels, urban-rural residence, and regional healthcare infrastructure, which collectively offer valuable district-level data. Although no complementary national surveys beyond these were available to enrich district-level data, the analysis was enriched by incorporating other available surveys, routine

reports, and health profiles. Table 1 details the utilization of each survey, outlining their specific contributions to the study.

Table 1. Source of Surveys for Each Level of Characteristics

Variables	Survey(s) Used
Neonatal Characteristics	Indonesian Basic Health Research
Maternal and Household Characteristics	Indonesian Basic Health Research and National Socioeconomic Survey
District and Provincial Characteristics	Village Potential Data, Indonesian Basic Health Research, and National Socioeconomic Survey

This study analyzed data from the 2018 Indonesian Basic Health Research, Village Potential Data, and National Socioeconomic Survey; all datasets have disaggregated data at the cities/district level. The 2018 Indonesian Basic Health Research and National Socioeconomic Survey data used the same census blocks and households in their sampling, which enabled the data merging at the household level and analyzed a weighted total sample of 80,648 women aged 10-54 years who had birth or miscarriage within the 5-year period before the interview in 2018. Neonatal and intermediate health outcomes were examined for 73,086 live births among children aged 0-59 months, observed across 513 municipalities in 34 provinces throughout Indonesia. The data represents the diversity of Indonesia's population, areas, residences, geography, and other socioeconomic and cultural dimensions.

This study applied multilevel logistic regression analysis to define the key drivers of a specific neonatal health outcome. This approach estimated the sizes of the effects involved while accounting for the hierarchical structure of the data, where individual-level factors (maternal characteristics) were nested within geographic units (districts or provinces). It allowed for the simultaneous examination of individual and contextual factors influencing neonatal health outcomes. The models identified the main drivers of neonatal health outcomes as the basis for further policy, investment, and implementation strategy to accelerate the target achievements.

Results

Figure 1 describes the process of how the sample was obtained. Out of the eligible 80,648 childbearing mothers (aged 15-49 years who had a pregnancy in the last five years), 78,265 had live births, 1,912 had miscarriages, and 471 had stillbirths. Of the 73,086 observed live births, 24,372 were born prematurely, 2,476 were born with a low birth weight, and 523 had congenital anomalies.

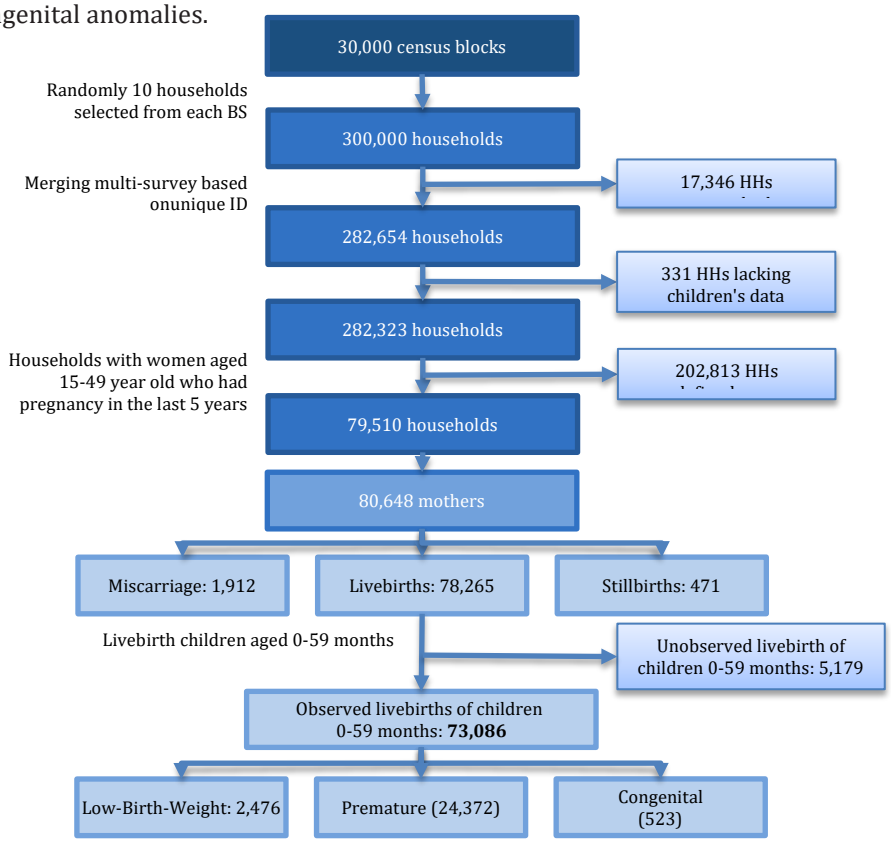

Figure 1. Sampling Tree

Table 2 presents around 17.06% of mothers had cesarean or other forms of delivery; about 8.6% of observed live births were from mothers who had their last births before age 21; 1.7% had unwanted pregnancies; 1.12% of mothers smoked; 1.6% had twins; 30.8% of the mothers experience pregnancy complications; 20.56% had complications during childbirth, and 3.48% had comorbidities. In addition, about half of mothers delivered at a health facility, even though skilled birth attendants assisted 98% of delivery.

The data set below was analyzed using a mixed-effects logistic regression model that examines various predictors' effects on neonatal health. The integration model used a multivariate adaptive Gauss-Hermite quadrature with seven integration points, a method suitable for handling non-nested random effects in logistic regression models (Table 3).

Table 2. Univariate Analysis of Neonatal, Maternal, District, and Provincial Characteristics

Variables	Obs.	
	Freq	(%)
Outcome		
Pregnancy outcomes		
Abortus	1,912	2.37
Stillbirths	471	0.58
Live birth	78,265	97.05
Total births	80,846	100.00
Neonatal outcomes		
Live birth	73,086	
Neonatal death	301	
Intermediate Outcomes		
Gestational age at birth	73,086	100
Pre-term	24,372	32,98
A-term	49,352	66.78
Post-term	179	0.24
Birth weight	73,903	100
Low Birth Weight	2,476	3.35
≥2,500 gram	71,427	96.65
Congenital disorders	73,903	
Blindness	64	0.09
Deafness	48	0.07
Speech impairment	75	0.10
Limb deficiency	116	0.16
Cleft lip	89	0.12
Down Syndrome	131	0.18
Newborn Conditions at Birth		
Sex		
Female	35,229	48.220
Male	37,857	51.80
Number of babies at birth		
Singleton	71,913	98.40
Twins	1,173	1.60
Birth Attendance		
Skilled Birth Attendance	66,416	90.87
Non-Skilled Birth Attendance	6,670	9.13
Institutional delivery		
Health facility	36,888	50.47
Home, etc.	36,198	49.53
Newborn Health Services		
Treatment for Low Birth Weight babies		
None	805	1.09
Incubation	1,003	1.36
Kangaroo Mother Care	574	0.78
Other to keep warm	94	0.13
Umbilical Cord Care	30,060	41.13
Received AB eye ointment	33,820	46.72
Neonatal visit coverage		
Postnatal Care 1	61,478	84.12
Postnatal Care 2	49,048	67.11
Postnatal Care 3	32,328	44.23
Proxy Quality of Postnatal Care 3	28,167	38.54
Mothers' Condition at Childbirth		
Age at the last childbirth		
Aged between 21-35	53,545	73.26
Aged <21 years	6,329	8.66
Aged >35 years	13,212	18.08
Complications during childbirth		
No complication	58,057	79.44

Variables	Obs.	
	Freq	(%)
Experienced complication	15,029	20.56
Delivery method		
Normal	60,620	82.94
Cesarean, etc.	12,466	17.06
Post-partum birth control	51,332	70.24
Mothers' Pregnancy Conditions		
Wanted/unwanted		
Wanted pregnancy	66,286	90.70
Wanted later pregnancy	5,540	7.58
Unwanted pregnancy	1,260	1.72
Experienced complications	22,540	30.84
Mother with comorbidities	2,540	3.48
Health Services During Pregnancy		
Antenatal Care		
Antenatal Care by Skilled Birth Attendants	69,866	95.59
≥4th times Antenatal Care	49,106	67.19
Proxy Quality of Antenatal Care		
<7 examination of 10 standards	14,563	18.56
≥7 examination of 10 standards	59,523	81.44
Mothers' Characteristic		
Mothers' education		
Higher education	9,869	13.50
High schools	40,468	55.37
Elementary school	15,793	21.61
Uneducated	6,956	9.52
Mothers' marital status:		
Union	71,296	97.55
Non-union	1,790	2.45
Mothers' employment		
Employed	32,781	44.85
Unemployed	40,305	55.15
Mothers' smoking habit		
Smoke	822	1.12
Ever smoked	707	0.97
Never smoked	71,557	97.91
Exposed as a passive smoker		
Yes, every day	29,025	39.71
Yes, sometimes	29,881	40.88
Never	14,180	19.40
Insurance ownership		
No insurance	26,530	36.30
Have insurance	46,556	63.70
Financing Source for Childbirth		
Insured	35,825	49.02
Out of Pocket	37,261	50.98
Financing source for referred services		
No need to be referred	58.057	
Not referred	6,857	
Referred cases	**8,172**	
Insured	5,456	66.76
Out of Pocket	2,716	26.63
Referral Systems		
Referral indication		
Referred	8,172	11.18
Not referred	6,857	9,38
No need to be referred	38,057	79.44
Time distance to Primary Health Care		
>1 hour	2,110	2.89
≤1 hour	70,976	97.11
Time distance to the nearest hospital		
>1 hour	19,243	26.33
≤1 hour	53,843	73.67
Households' Characteristics		
Residency		
Rural	43,232	59.15
Urban	29,854	40.95
Household size	73,086	
Expenditure per capita		
1st Poorest Quintile	14,643	20.04
2nd Quintile	14,592	19.97
3rd Quintile	14,617	20.00

Variables	Obs.	
	Freq	(%)
4th Quintile	14,703	20.12
5th Richest Quintile	14,531	19.88
Cities/Districts Characteristics		
Fiscal Capacity Index	513	100.00
Lowest	126	24.56
Low	128	24.95
Middle	126	24.56
High	89	17.35
Highest	44	8.58
Availability and accessibility of health facilities		
Doctor to population ratio	513	100.00
<1: 2,500 population	442	86.16
≥1: 2,500 population	71	13.84
Midwife to population ratio	513	100.00
<1: 1,000 population	267	52.05
≥1: 1,000 population	246	47.95
Primary Health Care to population ratio	513	100.00
<1: 16,000 population	263	51.27
≥1: 16,000 population	250	48.73
Number of hospitals by cities/districts	513	100.00
<1 hospital per city/district	15	2.92
≥1 hospital per city/district	498	97.08
Number of B/CEMONC by cities/districts	513	100.00
<1 CEMONC & 4 BEMONC	402	78.36
≥1 CEMONC & 4 BEMONC	111	21.64

*Pregnancy that was not initially wanted but eventually became wanted

The Wald Chi-square statistic of 692.63 with 40 degrees of freedom and a very small p-value (<0.000) indicated that the model fits and suggested that the variables included collectively had a strong predictive power. Conditional marginal effects were produced to estimate the change in the probability of the outcome associated with a one-unit change in predictor variables or a change from the base level for categorical variables that were mostly used in this data set.

Table 3. Multilevel Mixed-Effects Logistic Regression for Identifying Factors Associated with the Possibility of a Baby Being Born at Risk

a. Fixed Effect

Variables	Multivariate analysis*			
	Coefficient.	p-value >|z|	95% CI	
Neonatal Characteristics				
Sex				
Female				
Male	-0.0034	0.320	-0.0100	0.0033
Number of babies at birth				
Singleton				
Twin	0.2165	**0.000**	0.1903	0.2427
Birth order	-0.0029	0.054	-0.0059	0.0001
Mothers' Characteristics				
Age at the last childbirth				
Aged between 21-35 years				
Aged <21 years	0.0203	**0.002**	0.0075	0.0331
Aged >35 years	0.0079	0.114	-0.0019	0.0177
Exposed as a passive smoker				
No, never				
Yes, every day	-0.0005	0.923	-0.0102	0.0093
Yes, sometimes	-0.0077	0.111	-0.0172	0.0018
Intention to become pregnant				
Wanted pregnancy				
Wanted later pregnancy	0.0049	0.460	-0.0082	0.0180
Unwanted pregnancy	0.0455	**0.001**	0.0189	0.0721
Comorbidity				
Without comorbid				
With comorbid	0.0460	**0.000**	0.0276	0.0644
Pregnancy's complication				
Without complications				
Experienced complications	0.0305	**0.000**	0.0227	0.0382
Complications at childbirth				
Without complications				
Experienced complications	0.0190	**0.000**	0.0096	0.0285
Delivery method				
Normal		*(base group)*		
Cesarean, etc.	0.0157	**0.003**	0.0053	0.0261

Variables	Multivariate analysis*			
	Coefficient.	p-value >|z|	95% CI	
Insurance ownership				
Have insurance				
No insurance	0.0020	0.590	-0.0054	0.0094
Financing source for childbirth				
Insured				
Out of pocket	-0.0015	0.694	-0.0092	0.0061
Education				
Higher education				
High school	-0.0040	0.518	-0.0161	0.0081
Elementary school	0.0019	0.794	-0.0127	0.0166
Uneducated	0.0038	0.673	-0.0138	0.0214
Employment status				
Unemployed				
Employed	0.0087	0.023	0.0012	0.0161
Marital status				
Union				
Non-union	0.0012	0.9140	-0.0207	0.0231
Household Characteristics				
Region				
Java				
Sumatra	0.1178	**0.000**	0.0675	0.1680
Nusa Tenggara & Bali	0.0328	0.300	-0.0292	0.0948
Kalimantan	-0.0116	0.694	-0.0692	0.0461
Sulawesi	0.1209	**0.000**	0.0620	0.1799
Maluku Island	0.2084	**0.000**	0.1101	0.3067
Papua	0.0671	0.149	-0.0240	0.1583
Residency				
Urban				
Rural	-0.0002	0.973	-0.0090	0.0087
Household size	0.0014	0.197	-0.0007	0.0036
Expenditure per capita (log)	-0.0003	0.963	-0.0113	0.0108
Proportion of food expenses to total expenditure	-0.0001	0.822	-0.0006	0.0004
Head of Household Characteristics				
Sex				
Male				
Female	0.0073	0.207	-0.0040	0.0186
Education				
Higher education				
High school	0.0078	0.257	-0.0057	0.0212
Elementary school	0.0104	0.178	-0.0047	0.0255
Uneducated	0.0172	**0.040**	0.0008	0.0336
Employment status				
Unemployed				
Employed	-0.0007	0.918	-0.0137	0.0124
City/District Characteristics				
Fiscal capacity of the city/district	0.0049	0.351	-0.0095	0.0193
Percentage of ≥4th times Antenatal Care	-0.0016	**0.001**	-0.0025	-0.0007
Proportion of Health Exp to Gross Regional Domestic Product	-0.0009	0.523	-0.0036	0.0018
Proportion of Accredited Primary Health Care	-0.0005	0.315	-0.0013	0.0004
Proportion of Population with Poverty	-0.0009	0.552	-0.0039	0.0021
Proportion of Primary Health Care accessibility	-0.0014	0.167	-0.0035	0.0006
Proportion of Hospital accessibility	0.0009	0.128	-0.0002	0.0020
Average percentage of food expenditures	0.0022	0.159	-0.0009	0.0052
Supply side-readiness				
Availability	0.0237	**0.004**	0.0074	0.0400
Accessibility	-0.0084	**0.000**	-0.0129	-0.0040
Utilization	-0.0032	0.278	-0.0090	0.0026
Quality (proxy)	-0.0284	**0.000**	-0.0352	-0.0215
Pseudo R2		**0,048**		
Observation		**7308**		

b. Random Effect and Model Comparison for Factors Associated with Neonatal Risk

Parameter	Model 1 (Null Model)	Model 2 (Individual Level)	Model 3 (Community Level)	Model 4 (Full Model)
Intraclass Correlation Coefficient	0.2082	0.1708	0.1697	0.1600
Proportional Change in Variance	*Reference*	22%	22%	28%
Median Odds Ratio	2.43	2.19	2.19	2.13

Table 3 reveals multiple factors affecting health outcomes, particularly the probability of births under high-risk conditions. This variance suggested that geographic factors—such as healthcare infrastructure, service accessibility, and

regional socioeconomic conditions—played a significant role in shaping birth outcomes. The data supported targeted interventions at the municipal level to address disparities, suggesting that enhanced healthcare infrastructure, educational opportunities for mothers, and accessible, comprehensive prenatal care are critical in reducing neonatal risks. This analysis underlined the need for health policy frameworks that consider both individual and regional influences on neonatal health outcomes.

Four models were explored, each adding complexity by integrating individual and community factors to assess neonatal risks. The Null Model (Model 1), which excluded predictors, had an Intraclass Correlation Coefficient (ICC) of 0.2082, showing that 20.82% of risk variation was attributed to community-level differences. This high ICC highlighted the importance of community-level factors in neonatal outcomes. In the Individual-Level Model (Model 2), adding individual predictors like education and household income reduced the ICC to 0.1708, indicating that while community factors remain significant, individual factors also accounted for part of the risk, with a Proportional Change in Variance (PCV) of 22%.

The Community-Level Model (Model 3), focused on community-level predictors such as healthcare access, showed a slight reduction in ICC from 0.1708 to 0.1697. This implied that community factors alone explain the risk similarly to individual factors. Finally, the Full Model (Model 4), combining individual and community predictors, further reduced the ICC to 0.1600 and achieved the highest PCV (28%). The Median Odds Ratio (MOR) decreased from 2.43 in the Null Model to 2.13 in the Full Model, indicating a reduction in community-level variability and highlighting the effectiveness of the Full Model in providing a comprehensive understanding of neonatal risk. The Full Model thus captures the combined impact of both individual and community-level factors, offering a robust explanation of neonatal health risks.

These findings, based on the different models, suggested that policy initiatives should prioritize targeted interventions for at-risk groups and broader improvements in healthcare access and quality. Smoking cessation programs, support for unplanned pregnancies, and enhanced healthcare capacity and availability might reduce neonatal risk. Additionally, children's susceptibility to socioeconomic disparities, coupled with barriers to accessing quality healthcare, signified the importance of proactive healthcare support for expectant mothers. This data advocated community-specific health policies that address local socioeconomic disparities, promote comprehensive prenatal care, and strengthen healthcare accessibility to improve neonatal outcomes across regions.

Discussion

At the individual level, various biological and demographic factors significantly affect neonatal health outcomes. For instance, twin births increased the likelihood of neonatal risks by approximately 21.65%, emphasizing the inherent health challenges associated with multiple births.[23] Additionally, maternal age below 21 was associated with a 2.03% higher risk of adverse neonatal outcomes, underscoring the impact of young motherhood on neonatal health.[24,25] This is especially pertinent in Indonesia, where early marriage remains an issue, with 11.2% of women married before the age of 18 as of 2018. Early maternal age is generally linked with limited access to resources and health education, a critical consideration with potential adverse impacts on both maternal and neonatal health.[26,27]

Pregnancy complications also play a significant role in increasing neonatal risk, highlighting the importance of high-quality healthcare during critical periods. For mothers with pre-existing health conditions or complications during pregnancy, there was an additional 4.6% (p-value <0.000) risk increase for neonatal health issues.[28] Unplanned and unwanted pregnancies further elevated this risk by 5%, while cesarean deliveries presented a 0.8% higher probability of complications compared to natural births.[29] These findings suggest the need for comprehensive maternal healthcare that emphasizes managing pregnancy complications and providing adequate support for young or high-risk mothers. A well-rounded antenatal care (ANC) approach, with complete service coverage, can reduce neonatal risk by 1.1%, highlighting the importance of continuous and thorough prenatal care in improving outcomes.[30]

From a socio-environmental perspective, maternal employment has a minor association with neonatal risk (0.87%, p-value <0.02), which may relate to physical or emotional stress experienced during pregnancy.[31,32] Interestingly, while maternal education appeared to have limited direct impact, the educational level of the household head influences neonatal outcomes, with uneducated or less-educated heads increasing the risk by 1.7% (p-value <0.04).[33] This suggests that household awareness and understanding of health practices can be vital in prenatal care and health-seeking behavior. In comparison, the household head's employment status has a lesser impact on neonatal outcomes. In cities/districts with higher ANC rates (at least seven examinations), the neonatal risk was reduced by 0.16%, showcasing the importance of consistent and extensive maternal monitoring. This proves that enhancing access to ANC can mitigate

adverse neonatal outcomes and improve overall maternal and child health.[34]

The readiness of healthcare systems, indicated by a significant negative coefficient (-0.0388, p-value <0.000), was a strong predictor of improved neonatal outcomes. In particular, a greater supply-side readiness, reflecting availability, accessibility, and quality of healthcare services, reduces the risk of adverse neonatal outcomes.[35–37] Furthermore, cities/districts with higher percentages of accredited PHCs showed a 0.05% reduction in neonatal risk, and this emphasizes the importance of certified facilities that can ensure quality maternal and neonatal care.[35,38] These findings indicated that local healthcare infrastructure and service quality were crucial in reducing neonatal risks. The cities/district's healthcare environment directly impacted the birth outcomes, demonstrating that improving healthcare facility readiness and service accreditation can foster positive maternal and neonatal health outcomes.

This study revealed several data limitations, including insufficient neonatal death records and limited postnatal care information. This study relied on estimates from organizations like the United Nations Inter-Agency Group for Child Mortality Estimation and the Institute for Health Metrics and Evaluation, as local data on neonatal conditions like asphyxia or infections was unavailable due to inadequate data recording. This highlights the need for better data prioritization to enable effective policymaking in neonatal health. Comprehensive national surveys like Indonesian Basic Health Research are valuable for examining birth outcomes but lack detailed neonatal mortality data, limiting the analysis to service-related variables rather than postnatal outcomes. Therefore, this study suggests that neonatal health data should be prioritized in policy frameworks to effectively guide targeted interventions.

Conclusion

Despite limitations in data availability and reliability, this study provides valuable insights into the social determinants of health equity affecting neonatal outcomes in Indonesia. The findings highlight significant disparities influenced by maternal age, pregnancy planning, delivery methods, and municipal-level healthcare access. Younger mothers, unplanned pregnancies, and cesarean deliveries were associated with higher risks, underscoring the need for comprehensive family planning, maternal education, and informed medical decision-making. Geographic and economic barriers further limit healthcare accessibility, emphasizing the need for equitable policies that enhance healthcare quality, affordability, and utilization. Strengthening local data collection on neonatal mortality is essential to support evidence-based policymaking and improve maternal and neonatal health outcomes.

Abbreviations

NMR: neonatal mortality rate; SDGs: Sustainable Development Goals; PHC: Primary Health Care; CEMONC/BEMONC: Comprehensive Emergency Obstetric and Neonatal Care/Basic Emergency Obstetric and Neonatal Care; ICC: Intraclass Correlation Coefficient; PCV: Proportional Change in Variance; MOR: Median Odds Ratio; ANC: Antenatal Care.

Ethics Approval and Consent to Participate

This study has been approved by the Commission for Research Ethics and Public Health Service, Faculty of Public Health, Universitas Indonesia Number: Ket-38/UN2.F10.D11/PPM.00.02/2024.

Competing Interest

There are no significant competing personal, professional, or financial interests that may have influenced the performance or presentation of the work described in this manuscript.

Availability of Data and Materials

The data sources or information used as research materials are available from the national survey data.

Authors' Contribution

RS managed, analyzed data, and drafted the first paper. ACS provided the context of health policy and reviewed the paper.

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Telemedicine Adoption in Developing Economies: A Systematic Review on the Enablers and Barriers

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Telemedicine Adoption in Developing Economies: A Systematic Review on the Enablers and Barriers

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Abstract

Telemedicine's adoption has been effective in certain contexts despite being controversial in certain settings because of its tendency to cause misdiagnosis and concerns about data privacy. This study aimed to synthesize the research findings on the factors leading to the adoption of telemedicine among developing economies. The study utilized Preferred Reporting Items for Systematic Reviews and Meta-Analysis methodology to analyze 27 related literature and the Unified Theory of Acceptance and Use of Technology to map out the factors considered enablers and barriers in adopting telemedicine. Results showed that performance expectancy, effort expectancy, social influence, and facilitating conditions were significant predictors. However, the study also underscored that the lack of information and communications technology support, lack of resources, lack of organizational effectiveness, lack of quality care, lack of motivation, lack of trustworthiness, and lack of user satisfaction were predominant hindrances at both individual and organizational levels. This analysis on the enablers and barriers of telemedicine adoption hopes to contribute strategic recommendations that practitioners in public health, decision-makers in global health policy, technology developers, and future research may explore to expand the existing knowledge on the optimal adoption of telemedicine in developing economies.

Keywords: barriers, enablers, technology adoption, telehealth, telemedicine

Introduction

Advancements in technology have paved the way for more innovative means of delivering health services. Using information and communications technology (ICT), telemedicine provides remote healthcare services to patients as it diversifies its delivery and improves patient access to health professionals in the communities.[1,2] Telemedicine is categorized as either clinical or non-clinical based on its application. The clinical application of telemedicine encompasses the diagnostics, treatment management, and other medical modalities involving patient care, while non-clinical application involves continuing medical education, medical meetings not involving patient care, and management or administrative conferences.[2,3] Discussions on telehealth initially started with the use of telephones to lessen unnecessary clinic consults and later progressed to the diagnosis and management of patients via radio.[4] Advancements in technology and telecommunication gave rise to the modernization of telemedicine, allowing healthcare providers to monitor patients with chronic illnesses remotely.[4] The incorporation of telemedicine in the global healthcare unit has been associated with increased quality of patient care, better access to health services, and better patient outcomes.[4]

The COVID-19 pandemic presented a challenge to health professionals in providing patient care, controlling and preventing diseases, and delivering health services during lockdowns and limited face-to-face interactions. The shift of paradigms from face-to-face consults to teleconsultations during the COVID-19 pandemic prompted specialized fields to expand their telemedicine services to connect patients with the healthcare team.[4-8]

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Before the pandemic, patients and health professionals hesitated to use telemedicine due to a preference for in-person consultations and the belief that healthcare technology was unnecessary and inferior to personal clinic visits. The resistance of users to change has also hindered the adoption of telemedicine in the pre-pandemic years,[4,5,8,9] indicating that numerous factors affect telemedicine adoption. Conversely, the use of digitized media has exponentially proliferated during the onset of the pandemic, and an increase in virtual visits was observed. The mandate for physical and social distancing has exposed disparities in healthcare access, prompting health professionals and patients to adopt telemedicine and recognize its cost and time-saving benefits.[7-9]

In developing economies such as Pakistan and Iran, the lack of government and financial support often results in poor healthcare delivery services. This further prevents developing economies from investing funds towards the establishment of telemedicine.[5,8] In 2020, driven by the COVID-19 pandemic, discussions on the opportunity and applications of telemedicine in a national interest vastly emerged.[10,11,12] However, due to a lack of technological infrastructure, support, and experienced health professionals, institutionalization and maintenance of telemedicine programs have been proven difficult.[10,11,13,14] These challenges have caught the attention of researchers who want to understand developing economies' struggles in adopting telemedicine.

There is also inadequate research on the comprehensive synthesis of telemedicine adoption among developing economies whose ICT infrastructure and healthcare systems are not as established as those in developed economies. This study aimed to synthesize research findings pertinent to telemedicine deployment by conducting a comprehensive review of telemedicine adoption and identifying factors influencing its adoption by intended users. This study contributes significantly to telemedicine by providing a comprehensive and in-depth review of telemedicine implementation in developing economies. By focusing on pre- and post-adoption phases, this study offers valuable insights that will enhance understanding among academic and information systems researchers, support public health practitioners, and inform decision-makers in public health policy. This ultimately leads to a broader goal of equitable healthcare access.

Method

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) methodology to determine qualified related literature that will serve as the basis for future scientific work and Venkatesh's Unified Theory of Acceptance and Use of Technology (UTAUT) to determine the behavior of users towards telemedicine adoption. The procedures used in identifying, selecting, processing, and interpreting information for the structured review were to critically assess the overall validity and reliability of the study. The 2020 PRISMA was utilized similarly to the previous review study on COVID-19, wherein the literature was mined to narrow the qualified articles used in this study (Figure 1).[10-11,15] Several keywords (including "Telemedicine*," OR "Telemedicine in developing economies*," OR "Telemedicine in developing economies during COVID-19*") were searched to determine the relevant articles. These words were often used by other researchers, and approximately 153,000 results were found using these search terms on Google Scholar.[5,13,14,15-18]

As this study serves as an overview of the pre- and post-adoption of telemedicine, only papers in English and published within the past 12 years (2013–2024) were included in the search and produced 17,600 results. The total number of publications was further reduced to 9,040 by limiting the study's focus to reviewed articles, thus yielding 152 articles. These were then stored in a Google Drive-created literature bank after matching the phrase to the article's abstract, title, or keywords. A journal assessment matrix in a tabular form was used as a tool to filter the journals by profiling their title, year, authors, hypotheses, problem statements, objectives, methodologies, results, and the merits of the researchers with regard to their respective journal to form a directory of qualified articles. The relevance of each article to the study's goals was then considered while choosing the 60 papers that were afterward categorized according to their themes. Moreover, upon verifying that each paper should be indexed in both Scopus and Web of Science (WoS) Journals, only 27 articles identified technology users as either patients, health professionals, or both.

The 27 journal articles were then profiled by the authors to create an overview of their backgrounds in the study. A ground-up approach was utilized through inductive coding. The codes were derived from filtering each journal article, starting with the abstract and then the conclusion, results, discussions, methodology, and introduction. Thematic groupings were created based on the data presented in the articles. This led to many groups, including telemedicine in the COVID-19 pandemic, telemedicine: healthcare professional perspective, organizational roles and barriers and implications on telemedicine adoption, ethical and legal issues in telemedicine, telemedicine in rural areas, and patient-centric telemedicine. To address the bias in conducting systematic reviews, a comprehensive literature search was done

utilizing multiple databases. More than two independent reviewers screened the studies for inclusion, extracted the data, and assessed for quality. Limitations of the study were reported.

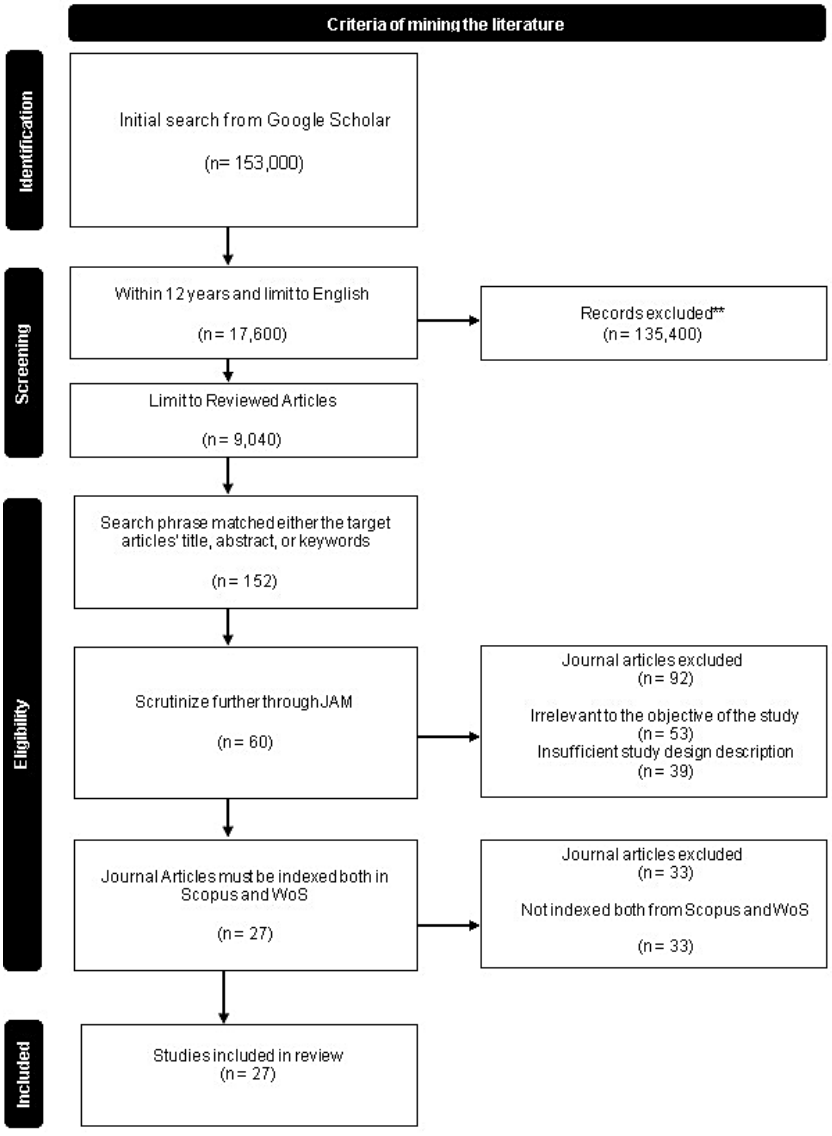

Figure 1. PRISMA Flowchart

After tallying the papers assigned to each thematic group, it was determined that several studies used Venkatesh's UTAUT.[10,16-18] However, these studies had not been synthesized. The UTAUT model was used to link the synthesized factors specified in the discussion section of each article. These factors were then grouped by identifying the enablers and barriers influencing telemedicine adoption. This was done by analyzing each discussion section of the research articles, storing enablers and barriers in separate boxes, and linking them in relation to the adoption of telemedicine. The UTAUT model is reliable and valid in the context of telemedicine systems since the model has been tested in numerous studies across various populations and technologies, showing consistent results and maintaining its key constructs, which are performance expectancy, efforts expectancy, social influence, and facilitating conditions that reinforce its applicability and robustness.[16-18]

After profiling and identifying the determinant factors for adopting telemedicine, the third goal of this study was to establish the gaps to develop potential research topics for future use. To address these gaps, inductive coding was performed by identifying patterns, themes, and categories in textual data to analyze the recommendation section of each research. This process was done to identify the common limitations of previous studies.[19] Mind mapping, a visual brainstorming technique for organizing and structuring ideas, was used to categorize the identified recommendations

into themes.[19] Mind mapping involves creating a diagram of interconnected concepts, words, or phrases that all relate to a central idea following the limitations explicitly stated by authors in their journals. This served as a guide for formulating possible future research topics which are needed to be further explored and are deemed to be both relevant and valuable in the field of telemedicine.[19-20] In examining the 27 journal articles, the authors focused on the conclusion section. The outcome of the results might depend on the conclusion section if the study's limitations and recommendations were specified.

Results

The determinant factors mentioned in most articles that influenced the intention and use of telemedicine among developing economies were performance expectancy, effort expectancy, facilitating conditions, and social influence. These determinant factors were noted to be of significance as they impacted users' behavior positively towards the use of telemedicine in seven studies reflecting the same results (Figure 2).[16-18,21-24] Demographic variables such as age, sex, experience, and voluntariness of use significantly impacted these factors, so healthcare organizations should consider them when targeting and promoting telemedicine services, as they may influence the effectiveness of key constructs.

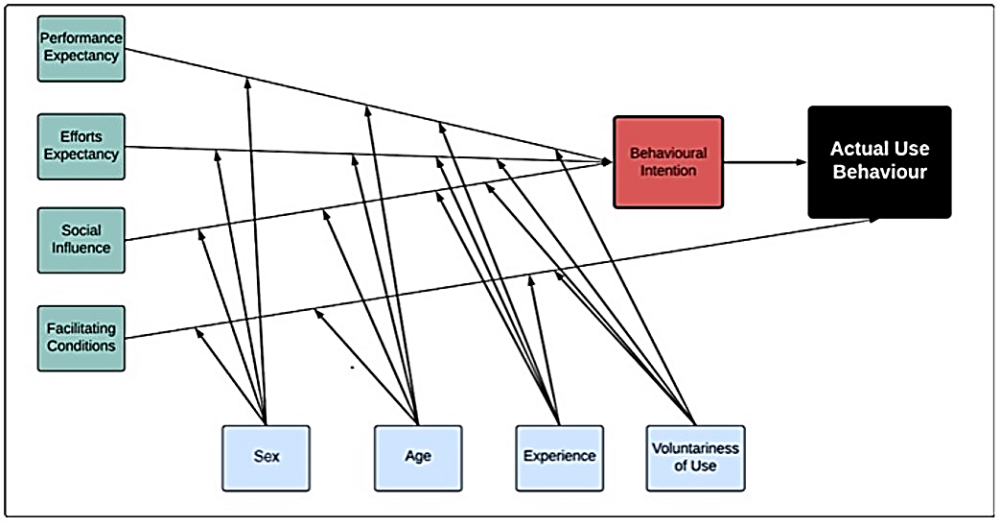

Figure 2. The Unified Theory of Acceptance and Use of Technology Developed by Venkatesh

This study identified four primary enablers (Table 1): performance expectancy and effort expectancy, having the highest count of seven, facilitating condition, and social influence. Performance expectancy is one's belief that using a particular technology will help them achieve their desired goals. Effort expectancy is concerned with the perceived convenience and ease of use of technology, while social influence reflects the extent to which one perceives the opinions of others regarding technology use. Facilitating conditions focuses on the perception of the availability of organizational support and technical infrastructure.

Table 1. Enablers of Telemedicine Technology Adoption in Developing Economies

Enablers	References	Count	Enablers	References	Count
Performance Expectancy	[16], [17], [18], [21], [22], [23], [24]	7	Attitude	[17], [27], [28]	3
Effort Expectancy	[16], [17], [18], [21], [22], [23], [24]	7	Computer self-efficacy	[17], [18]	2
Facilitating Condition	[16], [17], [18], [21], [22], [24]	6	Awareness	[19], [23]	2
Social Influence	[16], [17], [18], [21], [22]	5	Information Quality, System Quality	[17]	1
Self-Efficacy	[18], [20], [24], [27]	4	Service Quality	[17]	1
Perceived usefulness and perceived ease of use	[24], [25], [27], [28]	4	Perceived Vulnerability, Perceived Severity Response Efficacy	[17]	1
Legal and Ethical Concern	[25], [26], [30]	3			
Policy and Standard	[25], [26], [30]	3	Perceived Behavioral Control	[29]	1
Software Standards, National Policies, Data Security, Information and Communication Technology	[25], [26], [30]	3	Plasticity	[29]	1
Information Security	[25], [26]	2	Technological Characteristic	[18]	1
Information Privacy	[25], [26]	2	Task Characteristics	[18]	1
Information Policy	[25], [26]	2			

The determinant factors were further broken down into five enablers that have been shown to influence one's behavior toward adopting the technologies used in telemedicine. These enablers, as shown in Table 1, are as follows: self-efficacy, perceived usefulness and ease of technology use, legal and ethical concerns, policy and standard of practice, which involves information policy, information security, information privacy, software standards, national policies, data security, ICT, and user attitude.

Telemedicine has been gaining significant attention in the global healthcare sector, where it plays an essential role in improving healthcare access and outcomes. It is considered a complicated and multifaceted issue among developing economies as it is influenced by factors at the individual and organizational levels, as shown in Table 2. Several studies conducted in different developing economies have investigated the factors that acted as barriers to telemedicine. There were seven identified most common barriers to telemedicine adoption: lack of ICT support, lack of resources, lack of organizational support, lack of quality care, lack of staff motivation, lack of trustworthiness, and lack of user satisfaction. This review found that the lack of ICT support, including insufficient infrastructure, government assistance, training, and technical support, significantly hinders the adoption of telemedicine technologies because it restricts the users' capacity to utilize the said technologies.

Table 2. Barriers to Telemedicine Technology Adoption in Developing Economies

Barriers	References	Count	Barriers	References	Count
Lack of ICT support	[6], [7], [8], [9], [28], [33], [34], [35], [36], [37]	10	Social Risk	[9], [32], [36], [38]	4
Lack of Resources	[6], [7], [8], [9], [28], [33], [34], [35], [36], [37]	10	Legal and Ethical Concerns	[25], [26], [30], [37]	4
Lack of organizational support	[6], [7], [8], [9], [20], [33], [35], [36], [37]	9	Times Risk	[9], [32], [38]	3
Lack of Quality Care	[6], [7], [8], [9], [28], [33], [34], [35]	8	Technology Risk	[9], [32], [38]	3
Lack of staff motivation	[6], [7], [8], [9], [28], [33], [34], [35]	8	Resistance	[28]	1
Lack of Trustworthiness	[6], [7], [8], [9], [28], [33], [34], [35]	8	Threat	[28]	1
Lack of user Satisfaction	[6], [7], [8], [9], [28], [33], [34], [35]	8	Controllability	[28]	1
Financial Risk	[19], [20], [29], [36], [38], [39]	6	Reduced Autonomy	[28]	1
Government Support	[19], [20], [21], [30], [37]	5	Anxiety	[28]	1
Policy Standard	[20], [25], [26], [36], [37]	5	Cost	[28]	1
Security Privacy Risk	[9], [32], [34], [38]	4			

Discussion

Enablers of Telemedicine Adoption

Self-efficacy refers to the user's confidence in an individual's capacity to complete certain activities or use new technology. This significantly and directly influenced one's behavioral intention to adopt telemedicine.[17,18,25,26] This implies that the higher the level of self-efficacy, the more individuals are likely to accept the adoption of telemedicine. Furthermore, the strongest factors influencing the behavioral intention of individuals in terms of usage are perceived usefulness and ease of use since these reflect the users' beliefs on the usefulness and ease of the technology.[27,28,29] The result aligns with previous studies using the Technology Acceptance Model (TAM).[29] This study highlighted the need for the healthcare sector to simplify telemedicine systems to enhance user navigation, self-efficacy, and perceived usefulness. This simplification also includes offering training, technical support, and clear benefits communication. Understanding user needs can improve the effectiveness of telemedicine in delivering coordinated quality care.

The findings also indicated that legal and ethical issues, such as concerns on policy and standard practice, encompassing the following: information policy, information and data security, information privacy, software standards, national policies, and ICT, significantly influence the behavioral intention of using telemedicine services.[19,20,27,30] The legal and ethical concerns surrounding the rapidly evolving field of telemedicine included potential risks and liabilities related to privacy breaches, data security, and compliance with regulations, which health professionals might not fully understand and may approach cautiously. Health professionals are less likely to use technology when they perceive high

legal and ethical risks but are more accepting when safety nets are communicated; similarly, patients are less likely to trust and adopt systems with data privacy concerns, indicating that policies on data security directly affect user behavior. These factors are also included in three journal articles discussing how the lack of policy and standard of practice governing telemedicine could pose barriers to its adoption.[12,29,30] With client care being a highly specialized and individualized process, ensuring that data security and privacy are at the highest standards is crucial in healthcare to avoid errors and misdiagnosis.

Attitude was another influential determinant for using telemedicine. This result was similar to previous studies which revealed that users' attitudes toward technology significantly impact their intentions of use.[17,28,32] Individuals with positive attitudes toward technology are more likely to adopt telemedicine as they perceive it as useful and easy to use. These individuals are also influenced by social norms and others' perceptions, boosting their intention to use it. Moreover, factors influencing one's attitude are information and system quality, service quality, perceived vulnerability, severity, and response efficacy. Among these, service quality had the strongest influence.[17] Healthcare organizations prioritize service quality in telemedicine to enhance user satisfaction and support growth, as users are less likely to engage if they encounter technical issues or poor customer service. This ensures reliable equipment, regular maintenance, and efficient assistance can improve user attitudes.

Significant influence was also observed between perceived vulnerability, perceived severity, response efficacy, and users' attitudes toward adopting telemedicine.[17] Moreover, the previous studies revealed that computer self-efficacy, task technology fit, and technology characteristics significantly influence an individual's intention to adopt telemedicine.[17,18] This implies that if users believed telemedicine was a great fit for their needs and had higher levels of computer self-efficacy, the higher the chance they would use telemedicine services. Consequently, those users who lacked confidence in their abilities to use telemedicine technology were less likely to utilize telemedicine services. This suggests that factors such as perceived vulnerability, perceived severity, reaction efficacy, computer self-efficacy, task technology fit, and technology characteristics should be greatly considered when providing telemedicine services. Nevertheless, with the formulation of a policy and standard of practice, these factors can be readily addressed.[27,30,33]

Another important aspect of the result on the intention of using telemedicine systems is the positive impact of subjective norms. This result agrees with a previous study, which has shown that social influences, the perceptions of what others think or do, significantly affect users' intentions to adopt a technology.[25] Those who perceive that other users found telemedicine beneficial are more likely to adopt it. Moreover, if health professionals perceive that their colleagues are using telemedicine systems, they may be more likely to adopt it themselves to keep up with the latest developments in the field.[27] The remaining factors, such as perceived behavioral control, plasticity, technological character, perceived behavioral control, technological characteristics, and task characteristics, were also associated with the determinants that influence the adoption of telemedicine.[18,32]

Perceived behavioral control is the person's sense of control over the actions necessary to use a technology. This indicates that higher perceived behavioral control increases the likelihood of adopting telemedicine, while plasticity—an individual's adaptability to new ideas—also influences usage and attitudes. Additionally, technological characteristics like ease of use, accessibility, and functionality are crucial, as positive impressions of these features enhance adoption while negative perceptions hinder it.[29] Last, task characteristics are the users' actions in accomplishing a task using technology. Certain task characteristics like consultation for chronic diseases and client education align well with telemedicine's capabilities and advantages, facilitating its adoption and success.[18] Overall, the enablers of telemedicine adoption among developing countries should be optimized, maximized, and supported to meet users' needs.

Barriers to Telemedicine Adoption

Health professionals have difficulty integrating and efficiently employing telemedicine technology due to deficient resources such as funds, personnel, and equipment. The government plays a crucial role in providing resources and infrastructure, establishing policies, and developing educational programs by planning carefully and implementing telemedicine efficiently.[26,30,35] Difficulties securing financial support can lead to low patient satisfaction and efficiency, further obstructing adoption. Another barrier that hinders the adoption of telemedicine is the lack of organizational effectiveness. It refers to the absence of clear policies, procedures, and guidelines in the organization that support telemedicine. A lack of organizational effectiveness can hinder telemedicine implementation due to confusion and inconsistency.

The lack of quality care provided through telemedicine was also considered a barrier. Poor-quality services may cause hesitancy among users of telemedicine technology. This barrier covered the lack of defined clinical protocols, privacy, and security measures. Another barrier that hindered the adoption of telemedicine was the lack of staff motivation. This factor can be linked to employees' disengagement because of their reluctance to change, inexperience, and inadequate training.[6,34] This can result in a lack of satisfaction in the technology system, which can contribute to decreased quality of care and patient dissatisfaction. This barrier encompasses difficulty accessing telemedicine services and negative experiences with the technology. Furthermore, issues on security and privacy can lead to a lack of trustworthiness in the technology and system used.[9,38] Additionally, lack of trustworthiness can lead to limited patient engagement in the program, low adoption and utilization by health professionals.

Other factors considered hindrances to telemedicine adoption were insufficient financial, human, or technological resources available. It was also found that technology and security and privacy risks can deter users from adopting telemedicine in developing economies.[9,31] Uncertain privacy and security in telemedicine can lead to data privacy issues, patient safety concerns, and reduced quality of care, which may limit adoption and access to healthcare services. Additionally, social risk—shaped by the opinions of leaders, family, and peers[38]—affects the intention to adopt telemedicine, encompassing worries about quality, effectiveness, privacy, and security.

On the other hand, financial risk is still significant compared to other risks like the cost of technology investment, operating costs, and uncertainty around revenue generation.[13,38,40] Government support is essential for reducing anxiety and costs, alleviating perceived threats, and enhancing perceived controllability in telemedicine. Effective implementation of telemedicine relies heavily on governmental assistance and regulation. Without financial incentives for providers and established laws on security, privacy, and reimbursement, adoption rates will decline, creating uncertainty and challenges that hinder the growth of telemedicine. Consequently, the role of government support and regulation in promoting telemedicine cannot be overstated. A study conducted in Ethiopia found that reduced autonomy, anxiety, and costs of the ICT infrastructure were the cognitive sources of resistance because of increasing perceived threat and reduced perceived controllability.[29] Lastly, perceived risk, resistance to technology, and technological anxiety are significant barriers to telemedicine adoption.[5,7,8]

Common Limitations of the Journal Articles

Results indicated that some common limitations were encountered in telemedicine research due to the practical constraints. Results from studies in a single country may not be generalizable with others due to cultural, socioeconomic, and technological differences.[6,18,21,38] This underscored the need to consider the population's background when evaluating study findings, as neglecting this can make the results unsuitable for decision-making in different contexts. The cross-sectional studies cannot capture changes over time, potentially failing to reflect past developments or predict future trends.[18,29] Additionally, online surveys may bias results toward individuals with internet access[18,32] and may not represent the entire population, affecting validity and applicability.[32,35] Finally, high age heterogeneity among respondents limits generalizability, as different age groups may have varying attitudes toward telemedicine. Consequently, the findings may not accurately represent all age groups, thus limiting their practical applications to decision-makers in government and healthcare.

The authors recommend several future studies to improve the limitations of this current study. First, the UTAUT model may be replicated in other developing economies to generalize the result and evaluate the consistency of the results across different cultures and socioeconomic groups.[17,18,39] Second, any disparities between public and private telemedicine providers may be included in the study.[6,26] Third it is recommended to improve the representativeness of the sample population and enhance the generalizability of the UTAUT model through the use of a systematic and random-based sampling approach with a larger sample size.[18,32,35,38] Therefore, using a larger sample size would test the validity and generalizability of the findings and thereby accurately reflect the population.

A longitudinal design is recommended to examine how telemedicine adoption evolves and how crises influence it and to provide insights into changing user attitudes and behaviors.[18,29] Additionally, investigating adoption processes globally, considering the country of origin and culture, and the role of plasticity in technology acceptance could enhance understanding.[32] Finally, employing alternative methods to establish causal relationships between variables would deepen insights into the mechanisms that drive telemedicine, thereby improving the validity and generalizability of the findings through an acceptance model and various research techniques. This study's results do not fully represent all reviewed articles due to a lack of specific future research suggestions. Hence, future research should explore and expand upon the

findings to better understand the phenomenon.

Conclusion

While telemedicine in developing countries presents significant challenges, such as individual and organizational barriers and concerns regarding policies, information security, and privacy, it also offers opportunities for enhancing healthcare delivery. By fostering self-efficacy, ensuring user-friendly technology, and maintaining high standards of care comparable to in-person visits, telemedicine can be effectively integrated into healthcare systems, ultimately ensuring patient safety and improving clinician connectivity.

Abbreviations

ICT: information and communications technology; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analysis; UTAUT: Unified Theory of Acceptance and Use of Technology; WoS: Web of Science.

Ethics Approval and Consent to Participate

The study did not involve human participants.

Competing Interest

All authors report no competing interests.

Availability of Data and Materials

Data are available upon request to the authors.

Authors' Contribution

All authors contributed to the completion of this paper. Conceptualization, design, and search: ZM and LCV; analysis and interpretation of results: AI, RC, SLAC, FTO, ABE, and MLP; draft manuscript preparation: ZM and LCV; revision of the manuscript: AI, RC, SLAC, FTO, ABE, and MLP. All authors reviewed and approved the final version of the manuscript.

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