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LIVING ROOM VENTILATION AND URBAN ENVIRONMENTAL HEALTH: CASE IN DKI JAKARTA

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Abstract

In developing countries, on average, one out of five children die from pneumonia. Death from pneumonia is most prevalent in Southeast Asia, particularly in Indonesia. Many factors can cause pneumonia. In Jakarta, the prevalence period of pneumonia in toddlers reached 19.6‰, which is higher than the national prevalence period of only 18.5‰. This study used a cross-sectional research design to analyze the relationship between disease prevalence and risk factors simultaneously. Results showed that, out of 721 children under 5 years old investigated in this study, 31 toddlers suffered from pneumonia. Furthermore, bivariate analysis showed that two variables were related to the incidence of pneumonia, namely, low maternal education (odds ratio [OR] = 2.325, 95% confidence interval [CI] = 1.093–4.946) and living room ventilation <10% of the total space (OR = 3.223, 95% CI = 1.215–8.549). Maternal education influences the incidence of pneumonia in toddlers. Thus, to reduce the incidence of pneumonia in toddlers, maternal education needs to be improved. The lack of living room ventilation also, if not most prominently, influences the incidence of pneumonia in toddlers. The incidence of pneumonia in toddlers can be reduced by ensuring that the ventilation of the house is >10% of the total space because the lack of air circulation induces the transmission of pneumonia.

Keywords: maternal education; pneumonia; room ventilation; toddlers; urban.

1. Introduction

In developing countries, the general problem of indoor air pollution involves internal contamination from cooking or wood burning for heating without an adequate chimney. Other pollutants that have a negative effect on health are O_3, ionizing radiation, and cigarette smoke. The World Health Organization estimated approximately 3 million cases of indoor air pollution and 0.2 million cases of outdoor air pollution every year (World Health Organization,1997). Ventilation helps control indoor air temperature and remove or dilute pollutants from indoor sources. Consequently, the ventilation system reduces the contamination level and improves indoor air quality. The introduction of outdoor air is an essential factor in promoting good air quality (EPA, n.d.). Air circulates in a house in various ways, that is, natural ventilation (windows or doors), mechanical ventilation, and/or air conditioning systems. Air circulation also occurs through infiltration, a process by which air flows into houses through openings, joints, and cracks in walls, floors, and ceilings, and around windows and doors.

Natural ventilation is described as the flow of external air to an indoor space through open windows and doors. If used properly, natural ventilation helps reduce indoor air temperature. In some cases, indoor air temperature overheats a house with an improper cooling system. Moreover, natural ventilation improves indoor air quality by reducing pollutants. Meanwhile, the rate of ventilation airflow is calculated as the percentage of outside airflow to the building per unit of time and often expressed in units of cubic feet per minute (cfm) or liters per second (L/s). “Ventilation level” is usually calculated as the level of ventilation airflow divided by the number of people in the building (producing cfm/person or L/s/person), indoor air volume (resulting in hourly [h^{-1}] air changes), or indoor floor area (yielding cfm/ft^2 or L/s/m^2) (Berkeley Lab, 2018).

Pneumonia is an inflammation of the pulmonary parenchyma that usually occurs in children and clinically arises as a primary disease or a complication from other diseases (Hockenberry et al., 2016). The symptoms of pneumonia include fever >38°C and WBC >12,000/mm^3 or <6,000/mm^3, as well as mental changes in elderly patients (Kim et al., 2014). Pneumonia is responsible for 18% of approximately 7.6 million deaths of children under 5 years old worldwide (Liu et al., 2014). In 2015, pneumonia killed approximately 920,000 children under 5 years old, accounting for 16% of all deaths of children under 5 years old. Pneumonia is caused by the lack of exclusive breastfeeding, low nutrition, low birth weight, and lack of immunization (Noordam et al., 2015). Pneumonia affects children and families everywhere but is most prevalent in South Asia and Sub-Saharan Africa (World Health Organization, 2019). Pneumonia is caused by some infectious agents, including viruses, bacteria, and fungi, the most common of which are *Streptococcus pneumoniae*, *Haemophilus influenzae* type b, and respiratory syncytial virus (Ostapchuk, Roberts, & Haddy, 2004; Wardlaw et al., 2006). In infants infected with HIV, *Pneumocystis jiroveci* is one of the most common causes of pneumonia, responsible for at least a quarter of all deaths from pneumonia of HIV-infected infants.

Research conducted in Finland showed that pneumonia is exacerbated by sweet foods (Tapiainen et al., 2014). Meanwhile, studies conducted in Australia and China showed that age factors affect the incidence of pneumonia (Zhu., 2015; Chen., 2014). In India and Gambia, environmental pollution and malnutrition are two major risk factors for severe pneumonia and the associated deaths from pneumonia (Shah et al., 1994; De Francisco et al., 1993). Studies conducted in South Africa and Mozambique showed that demographics, virulent bacteria, and malnutrition increase the risk of poor pneumonia treatment outcomes (McNally et al., 2007; Sigauque et al., 2009). Furthermore, the latest research conducted in the Netherlands proved that people who live close to poultry are prone to pneumonia (Freidl et al., 2017). Pneumonia is not only an independent variable but also a dependent variable of disease progression, as pneumonia has become a risk factor for liver abscess disease in Taiwan (Ho et al., 2017).

In 2012, the number of pneumonia cases of children under 5 years old in DKI Jakarta reached 96,043, with a level of discovery and handling coverage of only 28% (26,910 case findings). Among the six administrative areas of Jakarta, only Seribu Archipelago showed the highest level of handling coverage, which is 71% of the total cases (Kemkes, 2012). In 2013, the prevalence of pneumonia in toddlers in DKI Jakarta exceeded the national prevalence period. The national prevalence period was only 18.5‰, whereas that of DKI Jakarta reached 19.6‰. This finding indicates that DKI Jakarta can be classified as one of the areas with the highest cases of pneumonia in children (Rikesdas, 2013). On the basis of these data, this study aims to determine the risk factors that cause the high rates of pneumonia in toddlers in DKI Jakarta.

2. Methods

This research used a cross-sectional research design to analyze secondary data from Basic Health Research (RISKESDAS) Year 2013. The dependent variable is pneumonia in children under 5 years old. The independent variables consist of house physical environment factors (i.e., occupancy density, house ventilation, house natural lighting, type of wall, and type of ceiling), family socioeconomic factors (i.e., maternal education and family economic status), characteristic factors of children (i.e., sex or gender, nutritional status, birth weight, and vitamin A supplementation), and air pollution factors in the home (i.e., family members' smoking habit and use of fire/electric mosquito repellent). The determination of the incidence of pneumonia is based on interviews with the mothers of children under 5 years old, operational limits used by health personnel to detect pneumonia, and symptoms of pneumonia within the last 12 months.

Limitations were set on the basis of the information obtained from the Basic Health Research (RISKESDAS) questionnaire. Data were obtained from the Health Research and

Development Agency (Balitbangkes), Ministry of Health, Republic of Indonesia. The total sample size was 1,059 toddlers; however, 721 toddlers were left after selection. Thus, the data processed had to be reduced. Incomplete data were not considered and processed. This study used bivariate and multivariate analyses. Bivariate analysis was performed to determine the relationship between the variables suspected or estimated to be associated with pneumonia and the incidence of pneumonia (odds ratio [OR]).

Bivariate analysis used the chi-square test with a p value of 0.05 and a confidence interval (CI) of 95%. Multivariate analysis was conducted to determine which risk factor has the most significant influence on the incidence of pneumonia in toddlers. Multivariate analysis used the logistic regression test because the independent and dependent variables were classified as categorical data. The statistical test was performed by SPSS 22.0 software. In the multivariate test, the variables included in the analysis were the variables of bivariate analysis with a p value of <0.25.

3. Results and Discussions

According to the responses to the RISKESDAS questionnaire, the results of bivariate analysis with chi-square test of socioeconomic characteristics (Table 1) indicate that the maternal education variable is related to the incidence of pneumonia in toddlers. In Table 1, the p value is 0.031, which indicates a relationship between maternal education and incidence of pneumonia in toddlers because it is <0.05. The OR is 2.325, which indicates that toddlers with less educated mothers are 2.325 times more at risk of suffering from pneumonia than toddlers with well-educated mothers. Meanwhile, the p value of the economic status variable is >0.05, which indicates that there is no relationship between economic status and incidence of pneumonia in toddlers.

Table 1. Relationship between socioeconomic characteristics in the series of pneumonia cases

Variable	Pneumonia in Toddlers						OR (95% CI)	p value
	Non-pneumonia		Pneumonia		Total			
	n	%	*n*	%	*N*	%		
Maternal Education								
High	430	97.3	12	2.7	442	100		0.031

Variable	Pneumonia in Toddlers						OR (95% CI)	p value
	Non-pneumonia		Pneumonia		Total			
	n	%	*n*	%	*N*	%		
Low	262	93.9	17	6.1	279	100	2.325 (1.093–4.946)	
Economic Status	533	96.7	18	3.3	551	100		0.074
High	159	93.5	11	6.5	170	100	2.049 (0.948–4.428)	
Low								

N, number of populations; *n*, number of samples; OR, odds ratio; CI, confidence interval

Source: Authors (2020)

The results of the analysis of the relationship between the characteristics of toddlers and the incidence of pneumonia are shown in Table 2. Four variables, namely, infant birth weight, sex or gender, infant nutritional status, and history of vitamin A supplementation, were investigated. None of the four variables exhibited a relationship with the incidence of pneumonia in toddlers because the p value obtained was >0.05. The results of this study are consistent with those obtained in a study conducted in China in 2015, which showed that sex or gender is unrelated to the incidence of pneumonia (Zhu et al., 2015). By contrast, a research conducted in Japan determined that the occurrence of pneumonia is associated with sex or gender (Manabe et al., 2015).

Table 2. Relationship between the characteristics of toddlers in the series of pneumonia cases

Variable	Pneumonia in Toddlers						OR (95% CI)	p value
	Non-pneumonia		Pneumonia		Total			
	n	%	*n*	%	*N*	%		
Gender	354	96.5	13	3.5	367	100		0.572
Female	338	95.5	16	4.5	354	100	1.289 (0.611–2.720)	
Male								
Weight at Birth	651	96.2	26	3.8	677	100		0.413
Normal	41	93.2	3	6.8	44	100		

Variable	Pneumonia in Toddlers						OR (95% CI)	p value
	Non-pneumonia		Pneumonia		Total			
	n	%	*n*	%	*N*	%		
Low							1.832 (0.532–	
Nutritional	532	95.9	23	4.1	555	100	6.306)	1.000
Status	160	96.4	6	3.6	166	100		
Good							0.867 (0.347–	
Bad	469	95.5	22	4.5	491	100	2.167)	0.421
Provision of	223	97.0	7	3.0	230	100		
Vitamin A							0.669 (0.282–	
Yes							1.590)	
No								

N, number of populations; *n*, number of samples; OR, odds ratio; CI, confidence interval

Source: Authors (2020)

The statistical test results shown in Table 3 indicate the relationship between air pollution characteristics in a house and occurrence of pneumonia. Two variables, namely, the presence of family members who smoke and the use of mosquito coils in the house, were analyzed. However, the chi-square test results showed that the p values of the two variables are all >0.05. This finding indicates that the two variables are unrelated to the incidence of pneumonia in toddlers.

Table 3. Relationship between air pollution characteristics in the series of pneumonia cases

Variable	Pneumonia in Toddlers						OR (95% CI)	p value
	Non-pneumonia		Pneumonia		Total			
	n	%	*n*	%	*N*	%		
Presence of a Smoker								
No	256	95.5	12	4.5	268	100		
Yes	436	96.2	17	3.8	453	100	0.832 (0.391–1.770)	0.696

Variable	Pneumonia in Toddlers						OR (95% CI)	p value
	Non-pneumonia		Pneumonia		Total			
	n	%	*n*	%	*N*	%		
Mosquito Repellant Coil Usage								
No	526	95.5	25	4.5	551	100	0.507 (0.174–1.478)	0.180
Yes	166	97.6	4	2.4	170	100		

N, number of populations; *n*, number of samples; OR, odds ratio; CI, confidence interval

Source: Authors (2020)

The results of the analysis of the relationship between physical environment characteristics of a house and the incidence of pneumonia are shown in Table 4. The physical environment characteristics of a house consist of seven variables. Out of the seven variables, the variable related to the incidence of pneumonia in toddlers is living room ventilation. Its p value of 0.018 (<0.05), with the OR of 3.223 (95% CI = 1.215–8.549), indicates that toddlers living in a house with less than standard living room ventilation are 3.223 times more likely to suffer pneumonia than toddlers living in a house with adequate ventilation space. The Decree of the Minister of Health of the Republic of Indonesia No. 829/Menkes/SK/VII/1999 states that house ventilation should be >10% of the floor area. In addition to the living room ventilation variables, the statistical test results show that the other variables are unrelated to the incidence of pneumonia in toddlers because their p values are >0.05.

Table 4. Relationship between physical environment factors in the series of pneumonia cases

Variable	Pneumonia in Toddlers						OR (95% CI)	p value
	Non-pneumonia		Pneumonia		Total			
	n	%	*n*	%	*N*	%		
Residential Density								
Not Dense	394	96.8	13	3.2	407	100	1.627 (0.771–3.435)	0.200
Dense	298	94.9	16	5.1	314	100		

Variable	Pneumonia in Toddlers						OR (95% CI)	p value
	Non-pneumonia		Pneumonia		Total			
	n	%	*n*	%	*N*	%		
Bedroom	185	96.4	7	3.6	192	100		
Ventilation	507	95.8	22	4.2	529	100		0.834
Adequate							1.147 (0.482–	
Less							2.729)	
Living Room	278	98.2	5	1.8	283	100		
Ventilation	414	94.5	24	5.5	438	100		0.018
Adequate								
Less							3.223 (1.215–	
Natural Lighting	396	95.7	18	4.3	414	100	8.549)	
in the Bedroom	18	96.4	11	3.6	307	100		0.703
Adequate								
Less								
Natural Lighting	513	96.4	19	3.6	532	100	0.818 (0.380–	
in the Living	179	94.7	10	5.3	189	100	1.757)	0.289
Room								
Adequate	633	96.2	25	3.8	658	100		
Less	59	93.7	4	6.3	63	100		0.309
Wall Types							1.508 (0.688–	
Wall	655	96.0	27	4.0	682	100	3.305)	
Not a Wall	37	94.9	2	5.1	39	100		0.666
Ceiling's								
Existence							1.717 (0.578–	
Exist							5.099)	
Not Exist								
							1.311 (0.300–	
							5.726)	

N, number of populations; *n*, number of samples; OR, odds ratio; CI, confidence interval

Source: Authors (2020)

Each independent variable is associated with the dependent variable (bivariate analysis). If the result of bivariate analysis yields a p value of <0.25, then the variable can be directly incorporated into the multivariate analysis stage. If an independent variable shows a bivariate result with a p value of >0.25 and has substantial importance to be tested, then the variable can be incorporated into the multivariate test model. The results of bivariate selection are listed in Table 5.

Table 5. Independent variable's bivariate selection

Independent Variables	OR	p value	Explanation
Maternal Education	2.325	0.031	Continue
Economic Status	2.049	0.074	Continue
Gender	1.289	0.572	Discontinue
Weight at Birth	1.832	0.413	Discontinue
Nutritional Status	0.867	1.000	Discontinue
Provision of Vitamin A	0.669	0.421	Discontinue
Presence of Smokers	0.832	0.696	Discontinue
Mosquito Repellant Coil Usage	0.507	0.180	Continue
Dwelling Density	1.627	0.200	Continue
Bedroom Ventilation	1.147	0.834	Discontinue
Living Room Ventilation	3.223	0.018	Continue
Natural Lighting in the Bedroom	0.818	0.703	Discontinue
Natural Lighting in the Living Room	1.508	0.289	Discontinue
Type of Wall	1.717	0.309	Discontinue
Type of Ceiling	1.311	0.666	Discontinue

Source: Authors (2020)

The results of bivariate selection show that the variables with a p value of <0.25 are maternal education, economic status, use of mosquito coils, occupancy density, and living room ventilation. These variables are used for the multivariate analysis. The logistic regression test was used for the multivariate analysis because the independent and dependent variables were classified as categorical data.In the multivariate modeling stage, all of the independent variables were analyzed simultaneously. The independent variables included in multivariate modeling were maternal education, economic status, use of mosquito coils, occupancy density, and living room ventilation. The variables were gradually modeled by selecting the variable with the most significant p value until all variables have a p value of <0.05. Table 6 shows the results of multivariate modeling.

Table 6. Multivariate modeling

First Multivariate			Second Multivariate			Third Multivariate			Last Multivariate		
Variable	OR	p value	Variable	OR	p value	Variable	OR	p value	Variable	OR	p value
ME	1.907	0.117	ME	1.925	0.111	ME	2.146	0.050	ME	2.079	0.060
ES	1.397	0.437	ES	1.443	0.386	MCU	0.453	0.149	LVR	2.928	0.032
MCU	0.450	0.148	MCU	0.446	0.142	LVR	3.036	0.027			
DO	1.177	0.682	LVR	2.907	0.034						
LVR	2.839	0.040									

OR, odds ratio; ME, maternal education; ES, economic status; MCU, mosquito coil usage; DO, density of occupancy; LVR, living room ventilation

Source: Authors (2020)

The results of the first multivariate modeling showed that the variable with a p value of <0.05 is living room ventilation (LVR) and the variable with the largest p value is density of occupancy (DO). Thus, the variable DO was removed and the model was retested. The second multivariate modeling showed that three variables had a p value of >0.05, except for LVR (0.034). Moreover, economic status had the largest p value (0.386). Thus, economic status was removed in the third multivariate modeling. The third calculation showed that MCU had the largest p value. When this variable was removed and the model was retested, two variables remained, namely, ME and LVR. In the last multivariate modeling, LVR had a p value of 0.032. The analysis determined that LVR exhibited the most significant influence on the incidence of pneumonia in toddlers in DKI Jakarta. The results further showed that LVR had an OR of 2.928, which indicated that children who live in houses with living room ventilation <10% of the floor area are 2.928 times more likely to suffer from pneumonia than children who live in houses with adequate ventilation.

Pneumonia is the primary cause of childhood morbidity and mortality, causing approximately 1.4 million deaths annually (Rudan et al., 2008; Zar et al., 2014). In this study, 15 independent variables were investigated, and bivariate analysis of the statistical test results showed that maternal education and living room ventilation are the risk factors for pneumonia cases in Jakarta. Families with less educated mothers are 2.325 times more at risk of suffering from pneumonia than those with well-educated mothers. Similar results were obtained in Bangladesh where more children of poorly educated mothers suffered from pneumonia (Ferdous et al., 2014; Saha et al., 2016). This finding indicates that improving maternal education is an essential strategy to decrease childhood morbidity and mortality caused by pneumonia.

This research determined that living room ventilation has a significant influence on the incidence of pneumonia in toddlers. DKI Jakarta has a dense neighborhood; thus, ambient air quality in houses is poor. Moreover, nonstandard living room ventilation will aggravate the air quality inside the house, particularly the kitchen and other adjacent rooms without the appropriate separators (Buchner et al., 2015; Naz et al., 2017). The statistical analysis conducted in this study showed that living room ventilation is the variable that most significantly influences the incidence of pneumonia in toddlers.

Toddlers who live in houses with living room ventilation <10% of the floor area is 2.928 times more likely to suffer from pneumonia than those who live in houses with living room ventilation >10% of the floor area. The transmission of pneumonia is also high if a toddler frequently engages with other members of the family in a living room with ventilation that does not meet the standards. Therefore, a solution to prevent pneumonia is compliance with ventilation standards when building a house. Pneumonia and other illnesses can be prevented by improving air circulation (Bruce et al., 2013). Moreover, the authorities of DKI Jakarta can grant renovation assistance for people in poor residences. Another research conducted in Southeast Asia determined that a high occupancy density influences the incidence of pneumonia (Turner er al., 2013).

The results of this study showed only 2 related variables out of the 15 variables investigated. This finding can be attributed to the limited number of cases, that is, out of 721 children examined, only 31 suffered from pneumonia. In further research, the number of samples needs to be increased to obtain more comprehensive and visible perspectives

4. Conclusion

This study concluded that the lack of living room ventilation affect the incidence of pneumonia for toddlers. Furthermore maternal education level is another risk factor to the pneumonia occurrence. The strategy to fill the gaps is the minimum requirement for the ventilation of the house is more than 10% of the total space, considering insufficient of airflow circulation in the house area induces the transmission of pneumonia, and improve education level of mothers. Finally, result of this study proposes the policymaker to develop regulation to improve public health in urban, especially for the toddlers.

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Author Contribution

Evi Frimawaty and Muhammad Mundzir Kamiluddin conceived the idea. Muhammad Mundzir Kamiluddin collected and analyzed data, under Evi Frimawaty supervision. All authors discussed the results and contributed to the final manuscript.

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