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Residential Factors Association towards Pneumonia among Indonesian Toddlers: A Meta-Analysis

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Abstract: Pneumonia is widely known as an acute respiratory infection or inflammation that attacks the human lungs and has become The Forgotten Silent Killer of Children. UNICEF 2019 stated that 15% of toddler deaths are caused by pneumonia or around 802,000 child deaths under five years of age worldwide with a 10,4% Incidence rate. The incident of pneumonia occurs in Asia and Africa, specifically in the middle–low-income countries. One of the risk factors of pneumonia among toddlers was residential factors. This study aimed to determine the residential factors which were associated with pneumonia among toddlers through a meta-analysis approach. The meta-analysis was conducted by collecting 22 case-control studies from several journals. The combined effect of odds ratios was calculated through a fixed effect model and random effect model using Microsoft Excel Epiyudin. Based on the results of the analysis on 8 variables of residential factors which were associated with pneumonia among toddlers, it was found that odds ratio and confident interval of the house occupancy density 2,29 (95% CI 1,70–3,06); room occupancy density 1,94 (95% CI 1,41–2,68); humidity 1,87 (95% CI 1,35–2,59); the intensity of lightning inside house 11,12 (95% CI 8,45–14,64); ventilation 2,46 (95% CI 1,94–3,11); house temperature 1,93 (95% CI 1,42–2,64); house floor 2,18 (95% CI 1,59–2,97); and type of wall 1,92 (95% CI 1,37–2,68). These results can be used as a screening method and appropriate intervention for pneumonia among toddlers.

Keywords: Pneumonia, residential factors, meta–analysis, odds ratio.

1. Introduction

Respiratory disease is one of the leading causes of death in the world, pneumonia being one of them. The causes of the disease including inflammation of the respiratory tract organs, viral, bacterial (*Streptococcus pneumoniae, Haemophilus influenzae type B, Pneumocystis jiroveci*), fungal, and parasitic infections.[1,2] When someone has pneumonia, alveoli (tiny air sacs in the lungs which is filled with air, when a healthy person breathes) with fluid and pus, it causes pain while breathing and limits the level of oxygen in the body.The groups that have a tendency towards an enhancement risk of suffering pneumonia: infant, toddler, elderly people (65 years or older), active smoker, people with health problems such as asthma, heart, kidney or liver problem, and people with a weak immune system (HIV/AIDS, who are undergoing with chemotherapy, and taking medicine after an organ transplant).[3] Approximately 802,000 toddler deaths were the largest groups of infectious diseases in children worldwide with 10,4% of the incidence rate during 2018–2019.[2] In Indonesia, the number prevalence of pneumonia among children under five years is 446,525 with 307 deaths (Incidence rate 1,74%) and the number of Case Fatality Rate is 0,07%.[4] Risk factors of pneumonia among toddlers include the nutritional status, age, exclusive breastfeeding, and low birth weight (intrinsic factors). Besides, the extrinsic factors are the mother's education, socio-economic conditions, and physical environmental conditions.[5] The immune system in toddlers cannot be said to be mature or still weak, so they have a higher risk of developing pneumonia. Physical environmental or residential factors such as house occupancy density, indoor air pollution caused by cooking fuel (wood fuel), use of mosquito coils, house ventilation, type of walls & floors, house temperature & humidity, house lighting intensity, kitchen insulation facilities, and the existence of cigarette smoke in the house could increase the susceptibility of children under five to develop pneumonia.[6]

The development of new research methods are continuously being carried out, one of them is the method of quantitative systematic review or meta-analysis. Meta-analysis is a combination of various data from several relevant and independent main studies that also answers the same question to produce integrated findings.[7] The level of statistical significance and the resulting conclusion can be said to be more reliable and credible because it analyzes several studies with the same subject. Based on the explanation above, this meta-analysis study wanted to determine the residential factors which are association to pneumonia among Indonesian toddlers using a meta-analysis approach. By expanding the data beyond the available data without neglecting the trend of existing data of greater statistical significance can be used as a basis for health decision and/or policymaking.

2. Method

In conducting this research, the researcher used a systematic review method with a meta-analysis approach by collecting data in some research from several journals and databases. A manual search association to the research articles on the residential factors associated with pneumonia among toddlers was carried out in this study. The case-control observational study in terms of the feasibility and completeness of the data included in the meta-analysis included; research respondents were children under the age of five years or 0–59 months; the span of the publication articles were 8 years (2012–2019); articles came from PubMed, BioMed Central, Google Scholar, Sinta 2, Sinta 3, and Garuda Dikti databases; full-text articles and an open accessed. There were 22 studies included in the meta-analysis originating from PubMed, Google Scholar, Sinta 2, and Garuda Dikti Portal. The research article was excluded because the research article did not discuss residential factors with the incidence of among toddlers; the residential factor variable was less than equal to 2 variables; articles written using a languange that was neither Indonesian nor English; and research articles was only available in abstracts, as well as several other things that was presented in the Figure 1. Eight variables were included in this study, these variables were housing density, room occupancy density, house humidity, lighting intensity, ventilation area, temperature conditions floor type, and wall typ

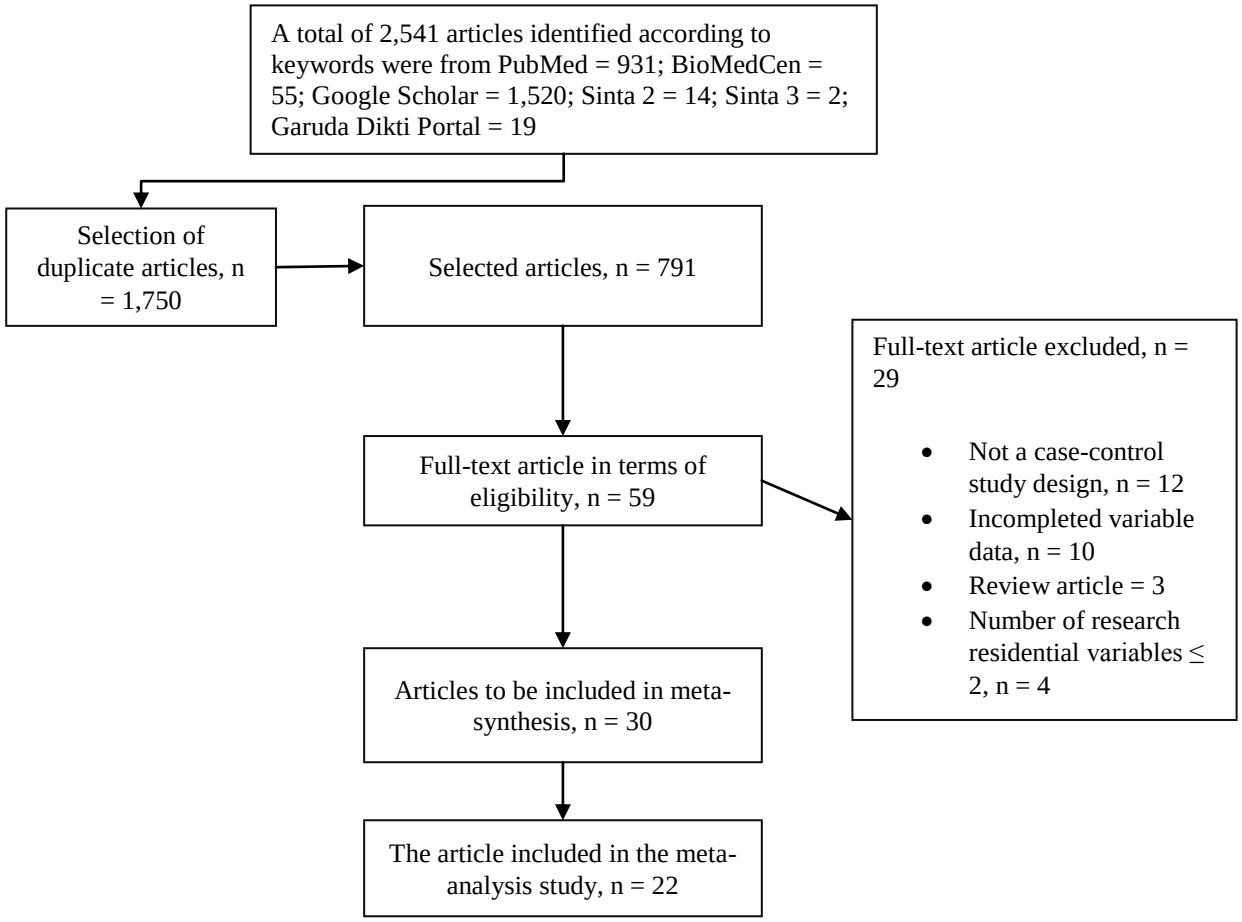

Figure 1: Flow chart for Bibliographic search

Data analysis in this study used Microsoft Excel Epiyudin software and the statistical measure studied was the odds ratio (OR). A heterogeneity test used to see the variation between studies through the p-value or the I^2 value. The variation between studies ignored or the results of the study were homogeneous with a p value>0.05 or a small I^2 value using a combined effect of a fixed-effect model, while a p-value<0.05 or an I^2 value using a combined effect random effect model or heterogeneous research results. Furthermore, the combined effect odds ratio and confidence interval were obtained which then interpreted as a result of the analysis of the data from the study included in the meta-analysis.[8]

3. Results and Discussion

The meta-analysis of 22 studies conducted in various regions of Indonesia; 21 articles located in the Puskesmas working area and the other one in the Hospital. There were 8 variables of residential factors used in this study. The researcher found that the statistical test results of the all variable as presented in Table 1. Based on the results of the meta-analysis statistical test on the house occupancy density variable in 14 studies, the variation between studies was 8% with p-value = 0.365, it means that the variations between studies was not very meaningful so that the variations between studies were homogeneous, as presented in Table 2. The combined value of the odds ratio in the fixed effect model was 2.29 (95% CI 1.70–3.06), with the largest OR value and confidence interval obtained in Eka's (2014) study with 9.80 (95% CI 3.01). –31.95).[9] The results of field observations in the study stated that the density of residents in the house has met the requirements, namely 8 m2 per person, although there were houses over-occupants due to the number of residents which is more than the area of the house. The lowest data analysis results obtained from Amalia's research (2017) with OR and Confident Interval values of 0.18 (95% CI 0.02–1.62).[10] This house occupancy density variable was one of the residential factors which is associated with pneumonia in children under five years of age in the six studies included in the meta-analysis and it was the dominant residential factor associated with pneumonia in children under five in two of them. A house with a dense population closely associated with the lighting, the humidity, and the house ventilation. Population density accelerated and facilitated the transfer and/or transmission of disease, especially airborne disease to the children under five because they were vulnerable to a disease transmission. Indoor oxygen levels will automatically decrease in proportion to the number of densely populated homes and indoor carbon dioxide increases.

Table 1: The Analysis Results of the Association between Residential Factors with the Incidence of Pneumonia in Children Under Five Year of Age

Variables	OR	p–value	95%CI	Effect Size
House Occupancy Density	2,29	0,365	1,70 – 3,06	*Fixed effect model*
Room Occupancy Density	1,94	0,021	1,41 – 2,68	*Random effect model*
House Humidity	1,87	0,013	1,35 – 2,59	*Random effect model*
House Lighting Intensity	11,12	Undefined	8,45 – 14,64	*Random effect model*
House Ventilation	2,46	0,659	1,94 – 3,11	*Fixed effect model*
House Temperature	1,93	0,006	1,42 – 2,64	*Random effect model*
Type of Floor	2,18	0,209	1,59 – 2,97	*Fixed effect model*
Type of Wall	1,92	0,034	1,37 – 2,68	*Random effect model*

Table 2: The Results of the Association Analysis between House Occupancy Density with the Incidence of Pneumonia in Children Under Five Year of Age

									Each Study Results				Fixed Effect Model		
No	Name, Year	N=a+b	a	N2=c+d	c	df	I^2	*p*	OR	Min	Max	Bobot	OR	Min	Max
1	LY, 2012	46	16	46	12	13	8%	0,365	1,51	0,62	3,70	10,7	2,29	1,70	3,06
2	ZY, 2013	52	30	52	17				2,81	1,26	6,24	13,5			
3	DAR, 2013	40	39	40	38				2,05	0,18	23,59	1,4			
4	ELS, 2014	45	22	45	4				9,80	3,01	31,95	6,2			
5	DU, 2015	51	28	51	13				3,56	1,54	8,22	12,3			
6	IIW, 2016	43	16	43	13				1,37	0,56	3,36	10,7			
7	MK, 2016	44	6	44	2				3,32	0,63	17,43	3,1			
8	SF, 2016	38	14	38	26				0,27	0,10	0,70	9,5			
9	HT, 2017	42	15	42	15				3,24	1,33	7,91	10,8			
10	NAP, 2017	21	17	21	10				4,68	1,17	18,69	4,5			
11	AMH, 2017	45	1	45	5				0,18	0,02	1,62	1,8			
12	DKS, 2018	40	7	40	1				8,27	0,97	70,74	1,9			
13	GP, 2019	26	19	52	23				3,42	1,23	9,54	8,2			
14	YM, 2019	32	13	32	4				4,79	1,35	16,94	5,4			
												100,0			

Furthermore, the results of the heterogeneity test in ten studies with room occupancy density variables

obtained a value of I^2 of 54 percent and p-value = 0.021 so that the variation between studies were heterogeneous or the weight of each study ignored. The pooled OR output value in the random effect model was 1.94 (95% CI 1.41–2.68), and the odds ratio values of the ten studies in this variable were not much different from each other so that the results of this meta-analysis was quite consistent if they do in several regions and different populations. It also stated that toddlers who live in a crowded room occupancy 1.94 has a greater risk of developing pneumonia. The highest OR value in this variable is Farida's (2019) research of 4.89 and a confidence interval of 0.96–24.97, but the smallest number of cases and controls was from other studies.[11] Meanwhile, the lowest OR value obtained from Annisa's research (2014) was 0.55 (95% CI 0.21–4.67). Annisa's (2014) study had the smallest OR value while the number of cases and controls was quite a lot, namely 12 and 17 respondents, respectively.[12] Similar to the concept of home occupancy density, rooms that were not large enough and coupled with the number of unsuitable occupants will have an impact on decreasing oxygen supply so that it affects the body's resistance of the residents of the house, especially it will affect the health of toddlers who live in the house.

Humidity was a representation of the water vapor in a room. The higher level of humidity the faster bacteria will breed in the air. The p-value of the heterogeneity test on the house humidity variables of the twelve studies was smaller than 0.05, which was 0.013 so that statistically there was a relationship between residential factors and the occurrence of pneumonia in children under five. The combination value of the odds ratio from the random effect model output was 1.87 and the confidence interval 1.35–2.59. In the two studies included in this meta-analysis test, the house humidity variable was the most dominant residential factor and was one of the residential factors which was associated with pneumonia in children under five years of age in eight studies. The highest odds ratio value in this variable was found in research conducted by Eka (2014) which was 8.73 (95% CI 1.84–41.46) and research conducted by David (2015) produces the OR value of 0, 26 (95% CI 0.09–0.76) which was a protective factor.[13]

Fifteen studies with lighting intensity variable obtained the I^2 value = 132% and the p-value was undefined, this is because the unit of variation between studies can only read from 0% to 100%, while the value generated by the heterogeneity test exceeds 100%. The pooled odds ratio of the fifteen studies was 11.12 (95% CI 8.45–14.64), with the OR output value making the residential lighting intensity variable the highest OR value among the seven other residential factor variables. This variable becomes the residential factor which isassociated with pneumonia among toddlers in twelve studies and the most dominant of the residential factor association to pneumonia among toddlers in the eight studies included in the meta-analysis. Research in this variable that has the highest and lowest OR values is Kholilah's research (2019) and Novi's research (2017), the odds ratio and confidence interval values for each study were 12.83 (95% CI 1.61-102.31) and 0.31 (95% CI 0.08–1.26).[14,15] In the research conducted by Kholilah, it was found that after field observations, the lighting in the house was still lacking due to the location of the toddler's room in the middle and behind another room, there were no windows in the room, and the residents of the house were densely packed with each other so that sunlight was not maximum entry into the house. The insufficient supply of sunlight that enters the house can cause discomfort and become a place for the proliferation of pathogenic bacteria from one of the microorganisms that cause pneumonia.

The results of this house ventilation variable heterogeneity test in 17 studies showed p-value = 0.659 and the variation between studies was small so that the variation between studies was homogeneous. In the fixed-effect model, the OR value of the house ventilation variable was 2.46 (95% CI 1.94–3.11). This means that statistically, toddlers who spend days in the house with poor ventilation conditions at home has a 2.46 times greater risk of developing pneumonia. The variable of house ventilation became a variable of residential factors associated to pneumonia in eight studies and six of them were the dominant residential factor associated with the incidence of pneumonia in children under five. The research conducted by Suryani (2018) became the research with the highest OR value, namely 7.59 (95% CI 3.51–16.44), and research conducted by Annisa (2013) became the research with the lowest OR value of 0.31 (95 % CI 0.08–1.31).[16] Residential ventilation is useful for air exchange in the house and also functions to keep airflow in the house comfortable. Ideally, the existence of air ventilation is at least 10% of the floor area of the house and can always be opened every day for better air circulation in the house.

The Variation between studies in the house temperature variable in the twelve studies included in this meta-analysis resulted was p = 0.006 and I^2 = 58 percent. The combined value of the odds ratio in the random effect model was 1.93 (95% CI 1.42-2.64), so it can be interpreted that children who live in a house with a temperature condition that does not met the requirements for a healthy home has a risk of 1.93 times greater suffering from pneumonia. The results of the meta-analysis also stated that the occupancy temperature variable was a residential factor for pneumonia in children under five in four studies and two studies as the most dominant factor of the residential factor's variable. The highest odds ratio value was obtained from research conducted by Eka (2014) of 12.57 (95% CI 1.53-102.97) and research with the same variable had the odds ratio was the research conducted by Safira (2016) of 0.30 (95% CI 0.12–0.77) was a protective factor.[17] The highest number of cases and controls in this variable is in the research of Kholilah (2019) with the number of cases of 69 houses and 68 houses of respondents who do not met the requirements for healthy housing, as presented in Table 3. The humidity in the

house affects the condition of the air temperature in the house so that if the air temperature in the house is low, the humidity will increase, meaning that pathogenic microorganisms can live well because they are supported by a good media to growth.

Table 3: The Result of the Association Analysis between House Temperature with the Incidence of Pneumonia in Children Under Five of Age

									Each Study Results				**Random Effect Model**		
No	Name, Year	N=a +b	a	N2=c +d	c	df	I^2	*p*	OR	Min	Max	Bobot	OR	Min	Max
1	ZY, 2013	52	31	52	19	11	58%	0,006	2,56	1,16	5,65	11,5	1,93	1,42	2,64
2	DLC, 2014	35	29	35	23				2,52	0,82	7,75	8,8			
3	ELS, 2014	45	44	45	35				12,57	1,53	102,97	4,1			
4	IIW, 2016	43	30	43	22				2,20	0,91	5,33	10,7			
5	MK, 2016	44	34	44	28				1,94	0,76	4,95	10,3			
6	SF, 2016	38	12	38	23				0,30	0,12	0,77	10,2			
7	NAP, 2017	21	5	21	2				2,97	0,51	17,42	5,2			
8	AMH, 2017	45	24	45	22				1,19	0,52	2,73	11,2			
9	HANH, 2018	30	29	30	26				4,46	0,47	42,52	3,7			
10	DKS, 2018	40	8	40	7				1,18	0,38	3,63	8,8			
11	KS, 2019	71	69	71	66				2,61	0,49	13,94	5,6			
12	GP, 2019	26	16	52	15				3,95	1,46	10,64	9,8			
												100,0			

Based on the results of the heterogeneity test on thirteen studies with the variable type of house floor, the between study's variation value was 23%, and the p-value = 0.209. The combination odds ratio value on the combined effect of the fixed effect model was 2.18, thus it can be interpreted that toddlers who live in a house with floor conditions that does not met the requirements of a healthy house has a 2.18 times greater risk of pneumonia. The results of the odds ratios of each study on this variable were not much different from each other so that the results of the meta-analysis were said to be consistent enough to be applied in different regions and populations of respondents. The highest OR value in this variable was Eka's research (2014) which was 8.11 (95% CI 0.95–68.88) and the lowest OR value in Kholilah's (2019) study was 0.66 (95% CI 0.11– 4.06). Even though it has the highest odds ratio value, the number of cases and controls in this study was small compared to Amalia's (2017) study, which has a larger number of cases-controls. The results of the analysis also showed that the variable type of house floor as a residential factor associated with pneumonia in children under five years of agein one study and a residential factor was the most dominant factor in the three studies included in this meta-analysis study.

The results of the statistical test for the variable type of house walls in twelve studies showed a pooled OR value of 1.92 (95% CI 1.37-2.68), this means that statistically there was a significant relationship between the condition and the type of wall the house was occupied by toddlers 1.92 times more likely to develop pneumonia. The heterogeneity test stated that the variation between studies was 48 percent and p-value = 0.034, so it can be said that the variable test results from several studies were heterogeneous. The twelve studies that were included in the meta-analysis study, the highest odds ratio value was obtained in the research conducted by Yuyun (2019) and the lowest odds ratio value in Amalia's research (2017).[18] The semi-permanent walls of the house, such as not waterproof, flammable, and not equipped with ventilation, increase the vulnerability of children under five to pneumonia.

4. Conclusion

This meta-analysis study shows that theresidential factors (house occupancy density, room occupancy density, humidity, lighting intensity, ventilation area, temperature, floor type, wall type) were associated with pneumonia in children under five years of age.

5. Suggestions

Regarding the results of this study was expected that the community can enforce an activities that can prevent the transmission and incidence of pneumonia, especially people who have toddler such as always keeping rooms clean, cleaning the children bedroom daily, opening windows daily, and putting bedding to sunshine frequently. For the further research with the topic of the association between residential risk factors with pneumonia in children under five are anticipated to be useful for pneumonia prevention and screening method, the scope of the research articles can be more widely, and for the well-quality article searches can use PRISMA (*Preferred Reporting*

Items for Systematic Review and Meta-analysis) and/or MOOSE (*Meta-analysis of Observational Studies*) to make it more credible.

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