JMCH Journal of Maternal and Child Health (2023), 08(04): 448-459
Masters Program in Public Health, Universitas Sebelas Maret

Original research
Open Access

Effect of Environmental Factors on the Acute Respiratory Infection Incidence Among Toddlers

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Received: 08 February 2023; Accepted: 13 May 2023; Available online: 16 July 2023

ABSTRACT

Background: Acute Respiratory Infection (ARI) is one of main public health problems found in Cirebon. Defining the factors governing this problem is crucial to reduce the burden of the disease. This study aims to analyze the effect of environmental factors on the incidence of ARI in toddlers in the territory of Gempol Community Health Center of Cirebon district.
Subjects and Method: This was a cross sectional study conducted at Gempol Community Health Center, Cirebon district, West Java, Indonesia. A total of 97 subjects were surveyed using questionnaire and direct measurement based on the Lemeshow formula. Independent variables taken into account were air pollution, exposure to cigarette smoke, air ventilation at subjects' house, humidity inside the house, and occupant density. Data were analyzed by Chi-Square test and Logistic Regression test.
Results: Multivariate results showed that air population (OR= 4.72; 95% CI= 1.65 to 13.46; p = 0.004); humidity in the house (OR= 8.95; 95% CI= 3.06 to 26.13; p = 0.001); humidity in the house (OR= 3.38; 95% CI= 1.15 to 9.87; p = 0.026) increased with the the acute respiratory infection incidence among toddlers, and there were statistically significant.
Conclusion: House humidity is the most significant factor governing the incidence of ARI in the territory of Gempol Community Health Center of Cirebon District.

Keywords: acute respiratory infection, toddler, environmental factors.

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Cite this as:
Shafira W, Khasanah U, Basyir PBS (2023). Effect of Environmental Factors on the Acute Respiratory Infection Incidence Among Toddlers. *J Matern Child Health*. 08(04): 448-459. https://doi.org-/10.26911/thejmch.2023.08.04.07.

BACKGROUND

Acute Respiratory Infection (ARI) is an acute respiratory disease with various symptoms that can be caused by many factors. ARI is classified as non-pneumonia, pneumonia and severe pneumonia (Widoyo, 2011).

ARI is still considered as one of the main public health problems as well as the main cause of infectious disease morbidity and mortality in the world. Nearly four million people die from ARI each year, and morbidity and mortality rates are very high in infants, children and the elderly (Suryani et al., 2018). ARI is the second largest killer of toddlers, according to World Health Organization (WHO) approximately 15% of toddlers

deaths were caused by ARI, particularly pneumonia. Around 15% of all toddlers deaths are caused by ARI in particular pneumonia (Disease Control Priorities, 2016).

Indonesia Health Profile in 2018 reported the results of the survey, found that the incidence of ARI (per 1000 toddlers) in Indonesia was 20.06% and West Java Province has the highest incidence of pneumonia which was 131,382 toddlers (Ministry of Health Indonesia, 2019). According to the results of the Basic Health Research (Riskesdas) The Ministry of Health of the Republic of Indonesia in 2018, the prevalence of ARI based on diagnosis by health workers in West Java Province is approximately 5.0%, this value is higher than the prevalence in Indonesia which is 4.4%. Whereas the prevalence of pneumonia in West Java Province according to Riskesdas increased from 2.0% in 2013 to around 2.5% in 2018 (Ministry of Health Health Research and Development Agency, 2018).

ARI has many risk factors including environmental risk factors, individual factors and behavioral factors (Sofia, 2017; Solomon et al., 2018). Environmental factors are one of the factors that greatly influence the incidence of ARI. The aforementioned environment is air pollution, both indoors and outdoors, as well as the physical condition of the house. Air pollution inside the house such as smoke from burning fuel for cooking with high concentrations, and cigarette smoke. While air pollution outside the house such as burning waste, transportation and industrial smoke disposal product (Belawan and Harsanti, 2016; Jayanti et al., 2018).

Air pollution both inside and outside the house in the form of pollutants can irritate the respiratory tract mucose making it more vulnerable to respiratory infections (Maharani et al., 2017). It is very dangerous for health especially for toddlers, toddlers are more susceptible to the impact of the surrounding air pollution because the toddler's lung and immune system are still in the developing stage (Darrow et al., 2014).

The physical condition of the house including ventilation, temperature, humidity, occupant density and lighting can affect the health of the occupants of the house, especially in toddlers who interact a lot in the house. Poor house ventilation can affect the air flow from outside into the house, this causes the bacteria in the house can not get out. Temperature, humidity and lighting in the house that is lacking will be a good medium for the breeding of bacteria that cause ARI (Jayanti et al., 2018; Mahendra and Farapti, 2018). A dense occupants will increase the temperature of the room caused by the release of body heat which will increase humidity due to moisture from the breathing. Thus, the more dense occupants, the faster the air will get polluted, and the worse it is for the health (Taha and Ryzdayani, 2018).

Research conducted by Khadijah, Ika and Ida in 2014 revealed that air pollution contributed to particulate dust levels (PM2.5) and ARI events in infants in Kayuringin Jaya, Bekasi (Azhar et al., 2016). According to the results of a study conducted by Arista and Titik (2013), it was found that environmental factors such as poor ventilation and density affect the incidence of ARI in East Nusa Tenggara Province in 2013 (Belawan and Harsanti, 2016). The results of the study are in line with Suryani et al. (2018), that environmental risk factors affecting URI, especially pneumonia in infants in the working area of the Bengkulu City Health Office were house ventilation and occupancy density (Suryani et al., 2018)

The subject of this research was the people living in the territory of Gempol Community Health Center of Cirebon District. The territory of Gempol Community Health Center of Cirebon District is traversed by the

Cirebon - Bandung national road and is an area located in the lowlands and there are several factories such as limestone factories, cement factories, and smelting of used community batteries which are one of the contributors to air pollution other than motor vehicle fumes (Cirebon, 2018).

Seen from the roof of a house full of white dust, it can be used as an indicator that the level of air pollution in the territory of Gempol Community Health Center is higher than that of other Community Health Center working areas, and will greatly affect the community. based on the results of interviews with health workers at the Gempol Community Health Center, ARI is one of the most common diseases experienced by children under five years in the territory of Gempol Community Health Center. Therefore, it is important to study the influence of environmental factors on the incidence of ARI, especially in children under five in the territory of Gempol Community Health Center of Cirebon District.

SUBJECTS AND METHOD

1. Study Design

This was a cross sectional study conducted from February 2020 to March 2020, at the Gempol Community Health Center, Cirebon, Indonesia.

2. Population and Sample

The study population was toddler parents and toddler who come to the Gempol Health Center, Cirebon. A total of 97 subjects were surveyed using questionnaire and direct measurement based on the Lemeshow formula. A sample of 97 toddler parents and toddler was selected by consecutive sampling.

3. Study Variables

The dependent variable was ARI. The independent variable was air pollution, exposure to cigarette smoke, house ventilation, humidity in the house, and the occupancy.

4. Operational Definition of Variables

Air pollution was the condition seen from the size of dust particles (PM2.5) in the house based on WHO quality standard 25 µg / m^3. Data was obtained through measurement by Air Quality Detector HT-9600. The measurement scale is categorical, coded 0 for not polluted, if $PM_{2,5} \leq 25$ µg/m^3 and 1 for polluted, if $PM_{2,5} > 25$ µg/m^3.

Exposure to cigarette smoke was the condition of toddler to exposure to cigarette smoke in daily activities. Data was obtained through interviews and questionnaires to parents. The measurement scale is categorical, coded 0 for not exposed and 1 for exposed.

Air ventilation of the house was the air hole, which is assessed by comparing ventilation area with floor area with quality standards based on the Ministry of Health Republic Indonesia, good ventilation of at least 10% of the floor area. Data was obtained through measurement by measuring tape and calculator. The measurement scale is categorical, coded 0 for good, if ≥ 10% of the floor area and 1 for not good, if <10% of floor area.

Humidity inside the house was the parameter values indicating the physical condition of the air inside the house, with quality standards based on the Ministry of Health Republic Indonesia required levels of 40-60% Rh. Data was obtained through measurement by Air Quality Detector HT-9600. The measurement scale is categorical, coded 0 for good if 40-60% Rh and 1 for not good if <40% Rh or > 60% Rh.

Occupant density was the quotient of the area of a toddler's room divided by the number of people occupying the room, with quality standards based on the Ministry of Health Republic Indonesia, qualify the occupancy density ≥ 4m^2/ person. Data was obtained through measurement by measuring tape, calculator, interviews and questionnaires. The measurement scale is categorical,

coded 0 for not crowded if ≥ 4m²/ person and 1 for crowded if < 4m²/ person.

Acute Respiratory Infection (ARI) was status of toddler related to ARI obtained from the diagnosis results of doctors at the community health center. The measurement scale is categorical, coded 0 for not ARI and 1 for ARI.

5. Study Instruments

Air pollution is obtained through measurement by Air Quality Detector HT-9600. Exposure to cigarette smoke is obtained through interviews and questionnaires to parents. House ventilation is obtained through measurement by measuring tape and calculator. Humidity in the house is obtained through measurement by Air Quality Detector HT-9600. Occupancy density is obtained through measurement by measuring tape, calculator, interviews and questionnaires. Acute Respiratory Infection (ARI) obtained from the diagnosis results of doctors at the community health center.

6. Data analysis

Data were analyzed by Chi-Square test and Logistic Regression test.

7. Research Ethics

The research ethical clearance approval letter was obtained from Research Ethics Committee at the Faculty of Medicine Swadaya Gunung Jati University, Cirebon, Indonesia, No. 32/EC/FKUGJ/II/2020, on February 25, 2020.

RESULTS

1. Univariate Analysis

Table 1 shows the characteristics of the subjects in this study. It can be seen that within the territory of Gempol Community Health Center, most of the subjects (66%) live in West Palimanan village, while Gempol village exposed with high air pollution is a home for 16.5% people.

2. Bivariate Analysis

Table 2 shows the correlation between the environmental factors in this study and the ARI incidence. Out of 5 factors, air pollution, exposure to cigarette smoke, air ventilation, and house humidity significantly affect the incidence of ARI with p value (p), 0.001, 0.001, 0.005, 0.001, respectively. Only occupant density is not correlated with ARI incidence.

3. Multivariate analysis

Based on Table 3 shows the final results of multivariate logistic regression analysis, it can be seen that air population (OR= 4.72; 95% CI= 1.65 to 13.46; p = 0.004); humidity in the house (OR= 8.95; 95% CI= 3.06 to 26.13; p= 0.001); humidity in the house (OR= 3.38; 95% CI= 1.15 to 9.87; p = 0.026) increased with the acute respiratory infection, and there were statistically significant.

Table 1. Characteristics sample

Characteristics	Category	Frequency (n)	Percentage (%)
Address	Gempol village	16	16.5
	Palimanan Barat village	64	66
	Walahar village	10	10.3
	Cupang village	7	7.2
Age (month)	2 – 12	32	33
	13– 24	30	30.9
	25 – 36	16	16.5
	37– 48	18	18.6
	49– 59	1	1
Gender	Male	52	53.6
	Female	45	46.4
	11 kg – 15.9 kg	52	53.6
	16 kg – 21 kg	4	4.1
Height	47 cm – 67.9 cm	15	15.5

Characteristics	Category	Frequency (n)	Percentage (%)
	68 cm – 88.9 cm	49	50.5
	89 cm – 109 cm	33	34
Air pollution	Not polluted	47	48.5
	Polluted	50	51.5
Exposure to cigarette smoke	Not exposed	37	38.1
	Exposed	60	61.9
House ventilation	Good	49	50.5
	Not good	48	49.5
Humidity in the house	Good	38	39.2
	Not good	59	60.8
Occupancy density	Not crowded	54	55.7
	Crowded	43	44.3
Incident Acute Respiratory Infection (ARI)	Not ARI	40	41.2
	ARI	57	58.8

Table 2. The effect of air pollution, exposure to cigarette smoke, house ventilation, humidity in the house, the density of occupancy of Incident ARI

Variable	Incident ARI		OR	95% CI		p
	Not ARI	ARI		Lower limit	Upper limit	
Air pollution						
Not polluted	29	18	2.81	1.59	4.95	0.001
Polluted	11	39				
Exposure to cigarette smoke						
Not exposed	23	14	2.19	1.37	3.53	0.001
exposed	17	43				
House ventilation						
Good	27	22	2.04	1.19	3.45	0.005
Not good	13	35				
Humidity in the house						
Good	27	11	3.23	1.92	5.43	0.001
Not good	13	46				
Occupancy density						
Not crowded	26	28	1.48	0.89	2.47	0.121
Crowded	14	29				

Table 3. The result logistic regression of air pollution, exposure to cigarette smoke, house ventilation, humidity in the house, the density of occupancy of Incident ARI

Independent Variables	OR	CI (95%)		p
		Lower Limit	Upper Limit	
Air pollution	4.72	1.65	13.46	0.004
Humidity in the house	8.95	3.06	26.13	0.001
Exposure to cigarette smoke	3.38	1.15	9.87	0.026
n observation= 97				
Adj R-Squared= 0.46				
p<0.001				

DISCUSSION

1. Effect of air pollution on ARI incidence

Based on the results of bivariate analysis in Table 2 states that air pollution has a significant influence on the incidence of ARI. From these results, there is an OR= 2.81 meaning that toddlers whose air pollution is polluted have a risk of experiencing ARI 2.81 times than toddlers whose air pollution is not polluted. The results of this study are in line with research conducted by Liu et al. (2017) which stated that exposure to PM2.5 (Particulate Matter 2.5) significantly influences respiratory diseases, especially in children who are exposed at high concentrations of PM2.5 (Liu et al., 2017). The results of this study are supported by research conducted by Khadijah et al. (2014) which revealed that the average levels of PM2.5 of air in a toddler's house had reached twice the PM2.5 quality standard (Azhar et al., 2016).

Particulate matter (PM) consists of a complex mixture of solid and liquid particles of organic and inorganic substances suspended in the air. The main components of PM are sulfate, nitrate, ammonia, sodium chloride, carbon black, mineral dust, and water. Particulate dust can come from soil abrasion, road dust, aggregation of combustion residual particles. WHO set PM2.5 quality standards are 10 µg/ m3 (average per year) and 25 µg/ m3 (average per 24 hours) (Azhar et al., 2016; WHO, 2016). Several studies show strong evidence of a relationship between air pollution by particulates (PM10 and PM2.5) with human diseases, especially cardiovascular and respiratory diseases. PM2,5 is more dangerous to health compared to larger sized particulates because with its small size, the potential to enter the respiratory system is bigger and deeper. When PM2.5 can enter the body, especially in the human respiratory system, these particles can be deposited into the alveoli and can even enter the blood-gas barrier which can cause air bubbles to form in the blood. PM2.5 can cause asthma, inflammation of the respiratory tract, and endanger lung function. Long-term exposure to particulates can disrupt the body's immune system, including the immune response to infections caused by bacteria and viruses (Azhar et al., 2016; Xing et al., 2016).

Toddlers and children breathe faster than adults so they breathe more pollutants. Under normal conditions, lung growth and development in infants is divided into 2 stages. The first stage is the first 3 years of life when new alveoli develop. The next stage the lungs will develop rapidly in childhood until the age of 10 years. The presence of inhaled particulates will cause lung damage and inflammation. The effects of exposure to the environment that are too early in infants can be more damaging and permanent so that toddlers are at higher risk (Azhar et al., 2016).

From the results of this study, it can be concluded that there is a correlation between air pollution and the incidence of ARI. From the analysis of characteristics in this study showed that the age between 2 months - 12 months was 32 toddlers (33%), the highest number compared to other age ranges. At that age according to theory, new alveoli develop, so that they are vulnerable to the effects of environmental exposure. The high air pollution that does not meet the quality standard requirements in this study, the particles can come from road dust, the combustion of factory combustion and the surrounding community activities.

2. Effects of cigarette smoke exposure on ARI Incidence

Based on the results of bivariate analysis in Table 2 states that exposure to cigarette smoke has a significant effect on the incidence of ARI. From these results, there is an OR= 2.19 meaning that toddlers who are

exposed to cigarette smoke have a risk of experiencing ARI 2.19 times than toddlers who are not exposed to cigarette smoke. The results of this study are in line with previous studies conducted by Sofia (2014) showing the results of research conducted from 100 samples of toddlers, 72 toddlers were found to experience ARI and there are family members who have a smoking habit at home. Based on the results of statistical tests found for smoking habits of family members in the home with the incidence of ARI obtained p=0.001 these results indicate that there is an effect between smoking habits of family members in the home with ARI incidence in toddlers (Sofia, 2017). The results of other comparable studies are studies conducted by Baladiah et al. (2019) showing that the statistical test results obtained p= 0.001. These results state that smoking in the home is a risk factor for ARI events.

Exposure to cigarette smoke is a significant cause of health problems such as ARI or other respiratory diseases. Cigarettes that are burned will release various substances that are harmful to health such as nicotine, carbon monoxide gas, nitrogen oxides, hydrogen cyanide, ammonia, acrolein, acetilene, benzole dehide, urethane, methanol, peryline and others (Wahyuningsih et al., 2017). In toddlers usually often around family members who smoke, smoke from burning cigarettes can be inhaled by toddlers so that the harmful substances mentioned earlier can enter the toddler's respiratory tract. In addition to being a direct cause of respiratory disease in toddlers, smoking can also be an indirect factor which can weaken a toddler's immune system. Cigarette smoke can reduce the ability of macrophages to kill bacteria. Cigarette smoke is also known to damage local pulmonary endurance, such as the ability to cleanse mucociliaries, and can also irritate the respiratory tract (Sofia, 2017; Wahyuningsih et al., 2017; Suryani et al., 2018). This study showed that a smoking family member is a risk factor that can cause respiratory symptoms in infants.

3. Effect of home ventilation on ARI incidence

Based on the results of univariate analysis in Table 1 it was shown that most subjects are well ventilated. Although the univariate results showed that some subjects were well ventilated, based on the results of the bivariate analysis, it was stated that the ventilation of the house had a significant influence on the incidence of ARI, but from observations the majority of subjects always closed ventilation, especially the house window. Based on the results of bivariate data analysis in table 2 states that home ventilation has a significant influence on the incidence of ARI, from these results there is an OR= 2.04 meaning that toddlers who ventilate the house poorly have a risk of experiencing ARI 2.04 times greater than toddlers whose home ventilation is good.

The results of this study are in line with research conducted by Safrizal (2017) p = 0.032, from these results meaning that there is a significant relationship between home ventilation and ARI events in infants. This study also indicates that someone who has poor house ventilation has a risk of experiencing ARI 2.59 times than someone who has ventilated the house well (Safrizal, 2017). The results of other studies that support this study are studies conducted by Suryani, et al. Stated that the risk factors that are proven to be associated with ARI pneumonia in infants are ventilation area with an OR = 5.99 (Suryani et al., 2018).

Lack of ventilation will cause the humidity in the room to rise, caused by the process of evaporation of fluid from the skin and absorption. This humidity will be a good medium for the growth of pathogenic microorganisms or microorganisms that cause di-

sease, for example bacteria that cause pneumonia. With ventilation there is always a constant flow of air so that bacteria are carried away by the air through the circulation. Besides ventilation can also be a medium for sunlight into the room. Apart from being useful for lighting, sunlight can also reduce room humidity, repel mosquitoes, kill germs that cause certain diseases such as tuberculosis, influenza, pneumonia and others (Wulandari et al., 2016). So, it can be concluded that ventilation that does not meet the requirements affects the incidence of ARI in infants.

4. Effect of indoor air humidity on ARI incidence

Based on the results of the univariate data analysis test in table 1 shows 67% of subjects have houses with bad air humidity. From the results of data analysis on the bivariate stated that air humidity has a significant influence on the incidence of ARI. From these results, there is an OR= 3.23 meaning that toddlers whose air humidity in their homes is not good have a risk of experiencing ARI 3.23 times greater than toddlers whose air humidity in their homes is good.

From the results of statistical tests show that the humidity of some subjects is not good and has an influence on the incidence of ARI in infants, this can be due to good ventilation but always closed which can cause the level of humidity in the house to be high. The results of this study are in line with previous studies conducted by Belawan et al. (2016) which showed from the Chi-square statistical test results that the value of p = 0.011, which means that from the test results there is a relationship between humidity and the incidence of ARI in infants (Suharno et al., 2019). Another comparable study is a study conducted by Sofia, based on statistical tests obtained p= 0.039, so that there is a relationship between the level of humidity in the house with the incidence of ARI in infants (Sofia, 2017).

Moisture outside the house can naturally affect humidity inside the house. Humid space allows the growth of pathogenic microorganisms, one of which is the microorganism that causes ARI. To get a good level of humidity should regulate so that the air exchange is always smooth and sunlight can enter (Wulandari et al., 2016). So, it can be concluded that humidity affects the incidence of ARI in infants.

5. Effect of occupant density on ARI incidence

Based on the results of univariate data analysis in Table 1 shows that 55.7% of the total subjects had a good occupancy density, the bivariate results stated that occupancy density did not have a significant effect on the incidence of ARI. From these results, there is an OR = 1.48 meaning that toddlers who live with crowded housing have a risk of experiencing ARI 1.48 times than toddlers who live with a density of uncrowded housing.

These results are in line with previous studies conducted by Sofia (2017) showing the statistical test results obtained p value = 0.645 so that there is no relationship between residential density in the home with ARI events in infant. Another study whose results are in line with this study is the study conducted by Dessy, showing the statistical test results obtained p = 0.247, so that there is no significant effect between the variable density of occupancy of ARI in toddlers (Jayanti et al., 2018).

Statistical analysis showed that occupant density is not a significant factor contributing to ARI incidence, this could be due to other factors that influence such as ventilation. The results of research conducted by Taha and Ryzdayani (2018), showed consistent results, which obtained p value = 0.281, which means there was no relationship between occupancy density and ARI incidence in infants. This is caused by good ventilation.

Good ventilation can cause good air circulation in the house and increased oxygen levels in the house so that the air quality in the house is good.

Another factor that can cause a meaningless relationship between occupant density and ARI incidence is due to small sample size. As in this study the results of the univariate analysis found for occupancy density of 55.7% of subjects the density of occupancy was not dense. Measurement of the density of occupancy of toddler rooms is done by calculating the length and width of a toddler's bedroom and then calculated its area and divided by the number of people sleeping in it. The density of the house will increase the temperature of the room caused by the release of body heat which will increase the humidity due to moisture from the breathing. Thus, the more residents of the house the faster the room air experiences gas or bacterial pollution. With so many inhabitants, the oxygen content in the room will decrease followed by an increase in room CO2 and the impact of an increase in room CO2 is a decrease in indoor air quality. The number of people living in one house can influence the spread of infectious diseases in the speed of transmission of microorganisms. The density of the occupants of the house is too high and lack of ventilation causes humidity in the house also increases and can increase pollution factors in the house (Wahyuningsih et al., 2017).

6. Effect of environmental factors on ARI incidence based on multivariate analysis results

Multivariate analysis was carried out to test environmental factors together against ARI events. Based on the results of the multivariate test analysis in table 3 for the variable humidity, the p= 0.001 indicates that there is an influence between the humidity and the incidence of ARI. The OR= 8.95, meaning that toddlers with bad air humidity in their homes are at risk of experiencing ARI as much as 8.953 times compared to toddlers with good indoor air humidity. For 95% CI values obtained= 3.07 to 26.14. In the multivariate analysis test results air humidity has the largest OR so it can be concluded that the humidity variable in the house is the variable that most influences the ARI. The humidity in the house can make the room moist and can cause the growth of pathogenic microorganisms, one of which is a pathogen that causes ARI (Wulandari et al., 2016). The level of humidity in addition to being influenced by the home environment is also influenced by weather. The weather in the rainy season can cause the humidity in the house to become humid (Sulasmi et al., 2019).

This research was conducted in the rainy season so that most of the subjects' houses were humid. Other factors that also affect humidity in the house are house ventilation, poor ventilation can cause poor air circulation and lack of sunlight entering the house so the room inside the house becomes humid (Wulandari et al., 2016). In this study based on the results of univariate analysis of 50.5% ventilation in good condition so if the ventilation should be good then the humidity inside the house is good. But based on observations, most subjects always close their ventilation, some subjects even have their ventilation covered by plastic. Therefore, even though the ventilation is good but it is always closed, the air circulation becomes poor.

Limitations in this study are the variables considered are still limited to environmental factors with 5 variables considered, while there are still many other factors such as individual factors and other unknown factors. Further study about these factors relating to ARI is needed.

AUTHOR CONTRIBUTION

Widya Shafira contributed in conception and design of study, drafting, analysis and inter-

pretation of data. Uswatun Khasanah contributed in conception and design of study, drafting and revisiting analysis, final approval. Pahmi Budiman Saputra Basyir contributed in conception and design of study, drafting and revisiting analysis, final approval.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

FUNDING AND SPONSORSHIP

None.

ACKNOWLEDGEMENT

The author would like to thank the parents of toddler and the toddler who have participated in this study.

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