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Relationship Between Particulate Matter (PM_{10}) Concentration and House Environmental Factor with Symptoms of Acute Respiratory Infection (ARI) on Children Under Five in Rawa Terate Health Centre, Cakung Sub-district in 2017

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Abstract*— Acute Respiratory Infection (ARI) still become health problem for developing countries, especially in Indonesia. Children under five are the group with the highest incidence of ARI in Indonesia. DKI Jakarta Province is one of the provinces that have higher period prevalence of ARI than the national period prevalence. Rawa Terate village is an area where the oldest industrial area in Jakarta called Pulogadung Industrial Estate is located. Symptoms of ARI can occur due to air pollution both inside and outside the home. This study aims to determine the relationship between PM_{10} concentration and house environmental factors with symptoms of ARI on children under five in Rawa Terate Health Center. The design is cross sectional with quantitative approach and conducted from July to September 2017. The number of sample in this research is 115 children under five. The results showed that the proportion of ARI symptoms in children under five was 79,1%. PM_{10} concentration was significant relationship with ARI symptoms in children under five relatively (p<0,05). PM_{10} is a respirable particle so it can trigger the occurrence of ARI. While for the house environmental factors such as temperature, humidity, lighting, ventilation, kitchen location, kitchen smoke hole, occupancy density and smoking family members did not show a significant relationship with ARI symptoms in children under five (p>0.05). Some of variables in this research did not comply the requirements such as PM_{10}, ventilation, temperature, lighting, occupancy density and smoking family members. It is suggested to the community to improve the quality of air within the house by controlling the exchange of air inside the house by opening and closing the window at the right time, and maximizing natural lighting into the house.

Keywords*— PM_{10}; house environmental factor; symptoms of ARI; children under five

I. INTRODUCTION

ARI still become a major cause of infectious morbidity and mortality in the world. About 4 million people die each year due to ARI [1]. In Southeast Asia on 2013, ARI contribute for 17% cause of death in children under five [2]. While in Indonesia on 2013, ARI contibute for 16% cause of death in children under five. Based on Riset Kesehatan Dasar (Riskesdas) data in 2013, children under five are the age group with the highest ARI occurrence by 25.8% [3]. A person who have an ARI non-pneumonia can be known if there are one or more symptoms such as cold, cough, fever, sore throat, and hoarseness [1], [4]. ARI symptoms that often arise are cough and colds. Cough and cold episodes on children under five in Indonesia are estimated at 2 to 3 times per year [5].

ARI can occur due to air quality pollution both outdoors and indoors. Air pollution that occurs outside the room can also occur indoors, because outdoor pollutant particles can enter the house environment. In air pollutants there is a dangerous mixture of some particles and large amounts of gas emissions which coming from various sources of combustion, including vehicles and industries. These pollutant particles can be a risk factor for the development of respiratory diseases [6]. Epidemiological studies conducted by Fahimah et al., in Cimahi city showed a strong association between air pollutants by particulates (measures 10 microns and 2.5 microns) with respiratory diseases with a p-value of 0.002 and an OR value of 4.40 which means a children under five years living in the house with an ineligible PM_{10} would be 4.40 times more risky than children under five year who lives in the house with PM_{10} eligible [7].

Other risk factors that can affect the incidence of ARI in children under five are house environmental factors such as the physical condition of the house (ventilation, temperature, humidity, lighting, kitchen location, wall construction, floor type, and kitchen holes), occupancy density, and activities in the house (type of cooking fuel, use of mosquito coils, family members affected by ARI, family members who smoke, and the presence of domestic pets). Based on research of ARI occurrence in children under five in Wonosobo Regency, house physical environment factor such as ventilation, humidity, house wall, chimney, occupancy density, type of cooking fuel, smoking family members, family members affected by ARI, and the existence of pets at home show a significant association with ARI occurrence in children under five [8].

Rawa Terate Village is one of the village located in Cakung sub-district, East Jakarta. The number of ARI cases in infants from January to May 2017 at Rawa Terate Public Health Center reaches 686 cases, with prevalence rate of 382 per 1000 children under five. The incidence of ARI in Rawa Terate village can be affected by several factors, that is agent, host, and environment. Physical agent factors such as PM_{10} concentration can be a risk factor for ARI in children under five, because the location of Rawa Terate Village is closed to Pulogadung industrial area and highway that can increase the risk of residents around the area to have a respiratory health problems. The increasing number of industries, transportation and highways will increase the concentration of pollutants such as particulates and Total Suspended Particulate (TSP). It is estimated that in TSP concentration there is 60% of PM_{10} content [9], so if TSP concentration in air is higher then PM_{10} concentration is also higher.

Based on preliminary study conducted on 30 respondents in Rawa Terate Village, 23 respondents (76,7%) have symptom of ARI in children under five, with most complaints are cold (46,7%), cough (40%), and fever (33.3%). Meanwhile, preliminary studies for home environment conditions such as house temperature and humidity do not meet the established requirements. In addition, as many as 63.3% or 19 respondents have densely populated. Based on the description above, the researchers are interested to know the relationship between PM_{10} concentration and house environmental factors such as ventilation, temperature, humidity, lighting, kitchen location, the existence of kitchen smoke holes, occupancy density, and family members who smoke with complaints of Acute Respiratory Infection (ARI) symptoms in children under five at Rawa Terate Health Center in 2017.

II. METHOD

The design is cross sectional with quantitative approach. This research was conducted on July to September 2017 at Rawa Terate Public Health Center, Cakung District, East Jakarta. The samples in this research were households with children aged 1-59 months, have Kartu Menuju Sehat (KMS) or Kesehatan Ibu dan Anak (KIA) book and routinely visit Posyandu or clinic. The number of sample in this research is 115 respondents.

Sampling of respondents using systematic random sampling. Sample frame used refers to data of children under five at Posyandu RW 4, 5, and 6. Variables in this research are indoor PM_{10} concentration, ventilation, temperature, humidity, lighting, existence of kitchen smoke hole, kitchen location, occupancy density, and family member who smoking as independent variable and ARI symptoms as dependent variable. The collected data were analyzed with two analysis. Univariate analysis using frequency distribution, and bivariate analysis using chi square test.

III. RESULT

A. Characteristics of children under five

Selected children under five in this study were 115 person, consisting of 52 women and 63 men. The oldest children under five age is 59 months and the youngest is 1 month. Based on nutritional status, most of the toddlers have good nutritional status (80,9%). Generally have received complete immunization, ranging from Hepatitis, BCG, DPT-HB, Polio and Measles. Based on the status of Light Birth Weight (LBW), most of the children under five did not have LBW (93.9%).

B. ARI symptoms in children under five

ARI symptoms in children under five at Rawa Terate Health Center in 2017 still quite high. The results showed that 91 out of 115 children under five (79,1%) had symptom of ARI.

TABLE I
DISTRIBUTION OF ARI SYMPTOMS IN CHILDREN UNDER FIVE

Symptoms of ARI	Frequency (N)	Percentage (%)
Not ARI	24	20,9
ARI	91	79,1
Total	115	100

ARI symptoms that often occurs were cold (61.7%), cough (53%), fever (34.8%), and sore throat (12.2%). The duration of ARI symptoms experienced by children under five years in Rawa Terate Public Health Center is 2-3 days.

C. Indoor PM_{10} concentration

Indoor PM_{10} concentrations in children under five are measured in places where they were often sleep. Based on univariate analysis result, PM_{10} concentration in children under five at Rawa Terate Health Centre about 89 children under five (77,4%) still exceeded the set limits.

TABLE III
DISTRIBUTION OF INDOOR PM_{10} CONCENTRATION IN CHILDREN UNDER FIVE

Indoor PM_{10} concentration	Frequency (N)	Percentage (%)
Eligible ($\leq$70 µg/m^3)	26	22,6
Not eligible (>70 µg/m^3)	89	77,4
Total	115	100

The average concentration of PM_{10} in the children under five room which often sleeping at 106.65 µg / m^3. In addition, the lowest concentration of PM_{10} in the children under five room which often sleeping 59 µg/m^3 and the highest is 808 µg/m^3.

D. House environmental condition

Housing ventilation of most respondents (78.3%) still not eligible (<10% of floor area and ventilation is not opened every morning). Most of the temperature and lighting in the children under five's room has not been eligible. A total of 66 from 115 houses have densely populated with a percentage of 57.4%.

And most of the respondents have family members who smoke is 77.4%.

While the humidity in the children under five's room, kitchen location, and the existence of kitchen smoke hole has been eligible. A total of 96 houses (83.5%) have a separate kitchen with other rooms. And there were 61 houses have a smoke hole in the kitchen to remove the smoke.

E. Results of Bivariate Analysis

The result of bivariate analysis from PM_{10} concentration variable, house environmental factor and symptoms of ARI are presented in Table III. Most of children under five house condition has not fulfilled requirement such as ventilation, temperature, lighting, occupancy density, and still have a family member who smoke. Out of 91 children under five with symptoms of ARI, there were 71 children (78.9%) who stayed at home with unqualified ventilation and 87 children (79.8%) living at home with the kitchen merges with another room. In addition, there is 87 homes with temperatures that did not meet the requirements have an ARI symptoms in children under five. Out of 91 children under five with symptoms of ARI, there were 78 children (80,9%) who lived in the house with less lighting and 55 children (83,3%) who live in crowded house.

For indoor humidity variable, there are 40 homes with unqualified humidity and their children under five have an ARI symptoms. The existence of kitchen smoke hole in 91 homes, there are 41 homes that did not have a kitchen smoke hole and condition of children under five have an ARI symptoms. The existence of family members who smoke also has an impact on the occurrence of ARI symptoms. Out of 91 children under five with ARI symptoms, 72 children under five (80.9%) lived with family members who smoked. However, the house environmental factor variables has no significant relationship with the occurrence of ARI symptoms in children under five.

A total of 84,3% children under five with ARI symptoms who lived in houses with not eligible PM_{10}. Supported with statistical result that there is significant relationship between PM_{10} with ARI symptoms in children under five.

TABLE IIIII
DISTRIBUTION OF CHILDREN UNDER FIVE BY PM_{10} CONCENTRATION, ENVIRONMENTAL FACTORS IN HOUSE AND SYMPTOMS OF ARI

Variable	Symptoms of ARI				Total		OR (95% CI)	P-value
	Not ARI		ARI					
	N	%	N	%	N	%		
PM_{10}							3,348 (1,263-8,873)	0,025
Eligible	10	38,5	16	61,5	26	100		
Not eligible	14	15,7	75	84,3	89	100		
Ventilation							0,934 (0,310-2,815)	1,000
Eligible	5	20	20	80	25	100		
Not eligible	19	21,1	71	78,9	90	100		
Temperature							1,977 (0,340-11,500)	0,603
Eligible	2	33,3	4	66,7	6	100		
Not eligible	22	20,2	87	79,8	109	100		
Humidity							1,569 (0,610-4,033)	0,480
Eligible	16	23,9	51	76,1	67	100		
Not eligible	8	16,7	40	83,3	48	100		
Lighting							1,579 (0,502-4,971)	0,527
Eligible	5	27,8	13	72,2	18	100		
Not eligible	19	19,6	78	80,4	97	100		
Kitchen location							5,671 (0,717-44,831)	0,118
Separate	23	24	73	76	96	100		
Not separate	1	5,3	18	94,7	19	100		
Kitchen smoke hole							0,694 (0,281-1,712)	0,572
Eligible	11	18	50	82	61	100		
Not eligible	13	24,1	41	75,9	54	100		
Occupancy density							1,806 (0,730-4,469)	0,291
Not dense	13	26,5	36	73,5	49	100		
Dense	11	16,7	55	83,3	66	100		
Family member who smoking							1,560 (0,565-4,306)	0,556
Not have	7	26,9	19	73,1	26	100		
Have	17	19,1	72	80,9	89	100		

IV. DISCUSSION

A. Symptoms of ARI on children under five

Based on the results of research, there are 79,1% of children under five had an ARI symptoms and 20.9% of children without ARI symptoms. Viewed from the proportion it can be said that most of children under five have symptom. In addition, the most common symptoms of ARI was experienced by children under five in Rawa Terate urban area, is cold (61,7%), cough (53%), fever (34,8%), and sore throat (12,2%). Similarly, data from Survei Kesehatan Nasional (Susenas) in 2014, that health complaints are often experienced by children under five in Indonesia are cold (58.32%), cough (57.62%), and heat (53.90%) [10].

The high complaints of ARI symptoms in children under five can be influenced by the location of Rawa Terate village, which located around Pulogadung industrial area, and several other industries. In addition, access roads that are connecting between Bekasi and East Jakarta make the number of public and private transportation that passes can cause congestion at certain hours. Emissions from motor vehicles and industrial activities containing various pollutant, especially particulates can endanger human health, especially the respiratory tract. In addition to these pollutants, house environmental factors can also affect the occurrence of complaints of ARI symptoms.

B. PM_{10} concentration

In this research, the measurement of PM_{10} concentration in the house started at 08.00-16.00 WIB. PM_{10} measurements called spot sampling method is used to randomly check the condition of the air pollutant at checking points [11]. Through time measurements, researchers can obtain a potential picture of PM_{10} levels in each child's home. This is an indirect way to assess PM_{10} exposure [11]. PM_{10} concentrations were measured using EPAM 5000 for 1 hour in a room where children often sleep. The laying of EPAM 5000 at child's room often sleeps because children under five is more often engaged in activities at home and most of the time (12-14 hours) is done for sleep [12], [13].

The result of bivariate analysis at table III is known p-value 0,025, can be concluded that there is correlation between PM_{10} concentration in child's room with ARI symptoms on children under five in region of Rawa Terate Public Health Center. From the analysis also obtained the value of odds ratio 3.348, it means that children who live in the room with PM_{10} concentration does not meet the requirements (PM_{10} >70 μg/m^3) has more risk 3,348 to experience symptom of ARI than children under five who live in the room with PM_{10} content qualify.

Environmental conditions in the Rawa Terate area can be said to support the existence of PM_{10}. Rawa Terate village is surrounded by various industries ranging from chemical industry, iron smelting industry, to manufacturing industry. In addition, access to a traffic-intensive highway that connects two regions can create high concentrations of PM_{10} in that area. Several studies had shown that particulate concentration is higher in residential area around industrial area, so the risk of symptom of ARI in residence around industry is higher than residence in non-industrial area. Research conducted in residence around cement factory of PT. Indocement Citeureup showed that overall concentration of PM_{10} and $PM_{2.5}$ dust particle concentrations in homes around cement plants, inside cement plants, and on the roadside exceeded the national ambient air quality standard established by PP. 41/1999 [14].

The high concentrations of PM_{10} in house can occur due to inadequate ventilation, occupancy density, unbalanced temperature and humidity and smoking family members [15]. Therefore, efforts should be made to control the high concentration of PM_{10} at home. One of the things that can be done is to control the exchange of air inside the house such as opening and closing windows to reduce the concentration of pollutants in the house. To do so, the community was briefed an explanation of the impact of PM_{10} on health, the schedule of industrial activities that emit to the environment and the hours when traffic becomes crowded. So people can know the right time to open and close the window.

C. Ventilation

The result of bivariate analysis showed that there was no correlation between ventilation with symptom of ARI on children under five. This research is not in line with research conducted by Afandi (2012) in this study indicates a relationship between ventilation with ARI occurrence in children under five. Differences in results can occur due to different research locations and the home conditions of each respondent. However, seen from the value of odds ratio = 0.934 indicates that ventilation is a protective factor that is a factor that can reduce the risk of ARI symptoms in children under five. This is in accordance with the guidance of air health within the house that exist in Permenkes No. 1077/2011 that the house must be equipped with ventilation (at least 10% floor area) and open the window at least in the morning. Lack of ventilation will cause air exchange that is not eligible so it can cause the growth of microorganisms that can cause disruption to human health. So, the existence of ventilation in home can make air exchange and air quality in the house to be good so can not to cause health problems.

D. Temperature

In this research, indoor air temperature was measured using a thermohygrometer which placed in a room where children under five often slept. Measurement taken for 10 minutes. The results of the measurement of indoor temperature are categorized to be eligible and not eligible in accordance with Permenkes No. 1077/ 2011 on Guidelines for Air Sanitation in the Home Room. Eligible temperatures are within the range of 18°C-30°C while not eligible temperatures are below and above the range [16].

The result of bivariate analysis showed that there was no correlation between indoor air temperature with symptom of ARI on cjildren under five with p-value of 0.603. Although statistically no relationship was found, but the OR value of 1.977 showed that unqualified temperature had a risk of 1.977 times for ARI symptoms compared with eligible temperatures. That means indoor temperature can affect the health of residents, especially children under five. Indoor temperature is influenced by outdoor temperature and occupancy density [17], [18]. The high outdoor temperature will increase indoor temperature, so it will feel hot in the room. Increased indoor temperatures can also occur due to body heat exposure if the number of occupants in the house is too dense [19]. High room temperatures will make air circulation stagnant, it can cause pollutants or dust to be trapped in the air and may cause respiratory problems [20].

So, to adjust the indoor temperature remains stable, residents should maintain a balances of air circulation by opening and closing windows and doors.

E. Humidity

The indoor humidity in this research was measured using a thermohygrometer. The measurement taken for 10 minutes in a room where children under five often sleep. The result of cross table analysis in table III shows that respondents who have indoor humidity did not meet the requirements and the children have ARI symptoms by 83,3% (40 houses). The result of bivariate analysis showed no correlation between indoor humidity with symptom of ARI in children under five. However, the OR value is 1.569 indicates that air humidity is a risk factor for ARI symptom in children under five.

Naturally, outdoor humidity can affect indoor humidity. The room which damp, can allows the growth of pathogenic microorganisms [21]. Ventilation of houses is related to the humidity of the house, which supports the life of viruses and bacteria [22]. Sunlight be able to kill bacteria disease, viruses, and fungi [23]. So, to get a good level of humidity, respondents should arrange the air exchange fluently and sunlight can enter into the house.

F. Lighting

The measurement of lighting in room using luxmeter. Lighting's variable is categorized to be eligible when ≥ 60 lux and is not eligible when <60 lux. The measuring light in this research is natural light.

The result of cross table analysis in table III showed that most of respondent with illumination do not fulfill the requirement have an ARI symptoms on children under five by 80,4% (78 houses). The lack of lighting in the Rawa Terate area is influenced by the densely populated house condition, and the absence of glass roof or glass fiber. So, it can make less sunlight entering the house. Meanwhile, the result of bivariate analysis shows the p-value = 0,527, statistically means there is no correlation between the lighting in the room with symptom of respiratory infection in children under five. However, the OR value of 1.579 indicates that indoor luminous is risk factor which can cause an ARI symptoms.

The condition of houses around this research is too dense and closed, causing sunlight cannot enter into the house. So most of the lighting at this research is not eligible (<60 lux). Therefore, to maximize the lighting with the condition of that houses, respondents can open a window or door in the morning or late afternoon or when industrial activity and traffic has not been congested. In addition, the use of glass tiles or glass fiber is also recommended for dense home conditions or coincide with each other.

G. Kitchen location

In this study to determine the existence of the kitchen location in the respondent's home is done by asking directly to the respondent and observed in the respondent's home to ensure its existence. The result of bivariate analysis in table III showed that p-value = 0.118, statistically means there is no correlation between the kitchen location with ARI symptoms on children under five in Rawa Terate village.

In a house there's should have kitchen which separate from other room, because smoke from burning can have an impact on health. Kitchen room should have good ventilation. So that can make smoke or air from the kitchen can be channeled into outdoor [8].

By maintaining Bromelia and Sanseveira (Lidah Mertua) plants, their can be used as a barrier to pollutants. Bromelia and Sanseveira plants can absorb pollutant compounds from vehicles and cigarette smoke and dirty air from pollution inside the house. In addition, respondents should always clean the kitchen or house after use to reduce the dust that is in the house and close the kitchen smoke holes when not doing activities in the kitchen so that dust or microparticles do not go into the kitchen area or in the house.

H. Kitchen smoke hole

The result of bivariate analysis in table III shows p-value = 0,572, statistically means there is no correlation between kitchen smoke hole with ARI symptoms on children under five in Rawa Terate area. This is because the cooking fuel used by most respondents is gas/LPG, so the presence or absence of kitchen smoke holes is not very influential because the smoke pollution caused by uses of gas/LPG is less than the smoke pollution emitted by solid fuels such as firewood [24].

Based on the OR value = 0.694, indicates that the kitchen smoke hole is a protective factor which is a factor that can reduce the risk of ARI symptoms in children under five. Accordance to the housing health requirements in Kepmenkes. 829 in 1999 that is a healthy kitchen should have a kitchen smoke hole. Kitchen that does not have a kitchen smoke hole will cause a lot of smoke pollution into the house and this condition will affect the incidence of ARI in children under five. Because the smoke will be able to irritate the respiratory tract. So it is advisable to have a kitchen smoke hole in his house to reduce smoke pollution.

However, based on the results of cross-table analysis showed that of the 61 children there are 50 children whose house has a kitchen smoke hole but the children has symptoms of ARI. This happens because the kitchen smoke hole is not the only factor that can affect the occurrence of ARI symptoms in children under five. The condition around the research location surrounded by industry, so it can makes the air quality around it become less good. Air pollution generated by industrial activity and heavy traffic which can produce a variety of pollutants and dust that can endanger human health [6]. Based on the researcher's assumption, the existence of kitchen smoke hole in the area around the industry needs to be considered of the shape. Because the kitchen smoke hole can be function as ventilation, that is as the air circulation in the kitchen.

Therefore, the existence of kitchen smoke hole can affect the entry of pollutants and dust into the house due to the exchange of air. A window-shaped kitchen hole can control the entrance of the air pollutant into the house, with closing the window in kitchen if an activity around the industry and traffic is denses and reopening when industry activity and traffic are not denses.

I. Occupancy density

Measurement of occupancy density in this research is the ratio between the width of the house with the number of family members who live in one house. Occupancy density is categorized to be eligible when ≥ 8 m^2/person and not eligible when <80 m^2/person in accordance to Kepmenkes. 829 in 1999 on Home Health Requirements. The results of cross table analysis in table III shows that from 66 children under five there are 55 children under five (83,3%) who have dense occupancy have symptom of ARI. However, the result of bivariate analysis shows that p-value = 0.291, statistically means there is no relation between occupancy density with ARI symptoms in children under five.

Density of occupancy that does not meet the requirements, will cause indoor high humidity so that the bacterium of the disease can multiply well and facilitate the occurrence of disease transmission either directly or indirectly. In addition, the number of densely occupant causes less space for each occupant, so that can make more frequent and longer contacts between occupants. As a result when there are patients with ARI in the house it will be easier to occur transmission to other occupants. This is likely to cause cross infection to other occupants [25].

J. Family members who smoking

The result of cross table analysis in table III shows that from 89 children under five, there's 72 children under five (80,9%) who have family member of smoker and their children have an ARI symptoms. However, the result of bivariate analysis shows

that p-value = 0,556, statistically there is no relation between family member who smoke with ARI symptom on children under five.

Although the results showed no relationship, the value of odds ratio = 1.560, indicates that family members who smoke are risk factors for ARI symptoms on children under five in Rawa Terate. These results are supported by the theory that parents who smoke can cause their children to be susceptible to have pneumonia [26]. Cigarette smoke is not a direct cause of pneumonia in children under five, but it is an indirect factor that can cause lung disease that will weaken the immune system of children under five [22]. Cigarette smoke contains many harmful substances such as carbon monoxide (CO_2), lead (Pb), tar and nicotine that have a yellowish brown color and attached. Cigarette Smoke (Environmental Tobacco Smoke) is a mixture of smoke that comes from burning cigarettes, pipes or cigars and smoke from smoker. The mixture of smoke is more than 40 compounds, among of them which cause cancer in humans and animals and most of that is a strong irritant. Humans who inhale ETS are called passive smokers. Children under five who living in homes with family members who smoke will become passive smokers. Impacts that will be inflicted on children under five are respiratory disorders with symptoms of shortness of breath, cough and excessive lenders [27].

Therefore, efforts to avoid exposure from cigarette smoke are needed. The best solution to do is that every family member should not smoke. However, if there are family members who smoke, then the effort should be done is by not smoking in the house and after finished smoking should wash hands and change the clothes which is used. This is to avoid residual from cigarettes inhaled by children under five when their parents hold or play with them.

V. Conclusions

1) Most of children under five had an ARI symptoms in by 79,1%.
2) There are variables in this research did not comply the requirements such as PM_{10}, ventilation, temperature, lighting, occupancy density and smoking family members.
3) There is a significant relationship between PM_{10} and ARI symptoms in children under five (p-value < 0,005).

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