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The Determinant Factors of Acute Respiratory Infections (ARI) among Housewives in Allakuang Village, South Sulawesi, Indonesia

Haeranah Ahmad[1,2], Ririn Arminsih Wulandari[1], Zakianis[1], Fajrin Nur Azizah[1], and Yulia Khairina Ashar[1]

[1]Departement of Environmental Health, Faculty of Public Health, Universitas Indonesia, Depok, Indonesia
[2]Jurusan Kesehatan Lingkungan Politeknik Kesehatan Kementrian Kesehatan Mamuju

Corresponding Author:
Ririn Arminsih Wulandari
ririn@ui.ac.id

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Abstract

Acute respiratory infection (ARI) ranks first in the ten most frequent diseases occurring in Allakuang Village during the last five years. The physical conditions and the density of pollution inside houses are risk factors that cause ARI. Homemakers are particularly vulnerable to ARI because most of their time is spent inside their houses. The aim of this study is to determine the factors that affect the incidence of ARI among homemakers, including the physical condition of the house (temperature, humidity, lighting, ventilation, ceiling condition, floor, walls, and the location of the kitchen), the pollutants inside the house (PM_{10}, cooking fuel, tobacco smoke, and smoke mosquito coils), and the number of occupants. The sample used in this cross-sectional study comprised 103 homemakers. The analysis was conducted using chi-square and multiple logistic regression tests. The results showed that several factors had significant correlations with ARI, such as PM_{10} concentration, the type of cooking fuel, and the use of mosquito coils. Furthermore, the results of the multivariate analysis showed that the most influential factor that caused ARI was the type of cooking fuel. Homemakers who used firewood and kerosene as their cooking fuel were47times more at risk of suffering ARI compared with those who used gas fuel. Hence, people are recommended to reduce the use of cooking fuel that produces smoke, to the kitchen from the family room, and to eliminate the use of mosquito coils.

Keywords: PM_{10}, acute respiratory infections, cooking fuels, homemakers

1. INTRODUCTION

The WHO reported that in 2012, 4.3 million deaths were caused by household air pollution, which spreads throughout almost all low- and middle-income countries. South

East Asia and the Western Pacific, at 1.69 and 1.62 million people, respectively, are burdened by the most deaths. Globally, indoor air pollution was reported to be responsible for 4.6 million deaths due to acute lower respiratory disease, lung cancer, chronic obstructive pulmonary disease, stroke and ischemic heart disease [27].

At 17%, acute respiratory infection (ARI) is ranked the fourth main cause of death worldwide; 7.4% of females and 7.1% of males annually die because of respiratory infections. In low-income countries, ARI is the leading cause of death (11.2%). The highest mortality caused by respiratory diseases is in Africa, followed by Eastern Mediterranean and South East Asian countries [26]. In Indonesia, ARI was reported to be a public health problem with a period prevalence of 25% [13]. The Sidrap Agency ranked ARI first among the ten most prevalent diseases during the five years from2011 to 2015.

Among the major contributors to indoor air pollution is the burning of biomass fuels. Globally, more than three billion people or almost half the world's population use biomass energy (e.g., timber, crop residue, twigs, bush, dry waste, and charcoal) and coal to meet domestic needs, such as cooking, lighting, and heating [19, 20]. Smoke emission from biomass fuels is a primary factor in polluting indoor air. This emission contains pollutants that can affect health, such as particulate matter and polycyclic organic matter, which are carcinogenic, benzo[a] pyrene, and other gas pollutants such as carbon monoxide and formaldehyde [6]. In Allakuang Village, most people use biomass fuel for their domestic needs. Exposure to air pollutants increases the incidence of ARI by adversely affecting specific and nonspecific defenses of the respiratory tract against pathogens [21]. Another factor that contributes to polluting indoor air is the use of mosquito coils. Inhaling the smoke emitted by mosquito coils has been reported to cause difficulties in breathing, eye irritation, bronchial irritation, itchiness, cough, and asthma [11, 16, 17].

Indoor air pollution can also result from external factors. The dust produced by industries located near housing is a source of particulate pollution. Allakuang Village is well known as a center of the stone-carving craft. It has a very large distribution area that coversthe Southern Sulawesi region. The stone-carving industry is home based, producing gravestones, pestles and mortars. Most houses are located less than fifty meters from stone-carving workshops. In Allakuang Village, most houses are on stilts. The family home is in the top part, and the stone-carving operation is carried out in the bottom part. Most of these buildings are semi-permanent walls and constructed from zinc or boards. Because these home industries operate without regulated work hours, the occupants of the buildings are always exposed to dust particulate throughout the day. In addition, the construction of buildings near the home industries do not meet the required standards, so the occupants will be exposed to the dust particulate produced by cutting, shaping and grinding the stone. Particulate matter 10 (PM_{10}) is comprised of" coarse inhalable particles" that are larger than 2.5 micrometers and smaller than 10 micrometers [7]. PM_{10} enters the respiratory tract through the nose and throat from where it travels to the lungs [28].

Many risk factors affect the incidence of ARI, such as indoor air pollution that results from using firewood or kerosene for cooking and mosquito coils. Another risk factor is the high concentration of PM_{10} inside houses that are exposed to the industrial activity in Allakuang Village and houses that do not meet the building standards. The high incidence rate of ARI was ranked first among the ten most prevalent diseases during the five years from 2011–2015.Therefore, research is needed to investigate the greatest risk factor causing the incidence of ARI among people who live near the stone-carving craft industry in Allakuang Village. Homemakers are at the highest risk for indoor air pollution because most of their time is spent inside their houses. Hence, this research focuses on homemakers. Therefore, the objective of this research is to identify the factor that poses the highest risk for ARI in homemakers who live near the center of thes tone-carving industry in Allakuang Village.

2. METHODS

This cross-sectional study was conducted in June 2016.The study sample comprises homemakers who spent most of their time inside their houses near the center of the stone-carving industry in Allakuang Village, Maritengngae sub-district, Sidrap Regency. The homemakers who participated in this study did not have jobs that exposed them to high levels of dust, such as in factories and roads. All participants consented to participate in the study. The study sample comprised 103 people who were chosen by purposive random sampling.

The variables used in this study were as follows: the physical condition of the house (PM_{10} concentration, temperature, humidity, lighting, floor type, ceiling condition, wall type, kitchen location, and number of occupants), behavioral factors (mosquito coil, cooking fuel, and smoking behavior of family members), and the incidence of ARI among housewives. The data were collected by measurements, observations, clinical examinations, and interviews. ARI among the homemakers was determined through clinical examination by a medical doctor. The PM_{10} concentration was measured using the Haz Dust^{TM} EPAM 5000 tool; temperature and humidity were measured by a thermohygrometer; lighting was measured by a lux meter and the ventilation was measured by a gage. Floor type, ceiling condition, and kitchen location were determined by observation. Data on occupant density, the use of insect repellent, cooking fuel, and smoking behavior were gained in interviews with the participants.

3. RESULTS

The results of the data analysis showed that environmental factors, the physical condition of the houses, homemakers' behavior, PM_{10} concentration, the use of mosquito coils, and cooking fuel were correlated with the incidence of ARI.

There was a significant correlation between PM_{10} concentration and ARI. Homemakers living in a house with a PM_{10} concentration that did not meet the standard were at 6.6-times higher risk of suffering ARI compared to homemakers living in a house with standard that met the building standards. The statistical analysis showed a significant correlation between the use of mosquito coils and ARI. Homemakers who dmosquito coil hada 4.4-times higher risk of suffering ARI compared to homemakers who did not use mosquito coils. There was also a significant correlation between the type of cooking fuel and ARI. Homemakers who used firewood or kerosene were at 18.1-times higher risk of suffering ARI compared to homemakers who used gas (Table 1).

Table 1: Environmental Factor, Housing Condition, Homemakers' Habits and Acute Respiratory Infections.

Variable	Acute Respiratory Infection				Total		OR (95% CI)	p value
	Yes		No					
	n	%	n	%	n	%		
PM_{10} Concentration								
>70 µg/m	16	51.6	15	48.4	31	100	6.6 (2.51- 17.5)	0.00
≤ 70 µg/m	10	13.9	62	86.1	72	100		
Humidity								
<40% or >60%	8	34.8	15	65.2	20	100	1.8 (0.67-5.02)	0.36
40-60%	18	22.5	62	77.5	80	100		
Temperature								
≥34°C	11	21.2	41	78.8	52	100	0.64 (0.26-1.58)	0.46
<34 °C	15	29.4	36	70.6	51	100		
Lighting								
<60 lux or >120 lux	13	27.1	35	72.9	48	100	1.2 (0.49-2.92)	0.86
60–120 lux	13	23.6	42	76.4	55	100		
Floor type								
Not Qualified	22	23.9	70	76.1	92	100	0.5 (0.15- 2.06)	0.46

Variable	Acute Respiratory Infection				Total		OR (95% CI)	p value
	Yes		No					
	n	%	n	%	n	%		
Qualified	4	36.4	7	63.6	15	100		
Ceiling condition								
Bad	25	26.3	70	73.7	14	100	2.5 (0.29-21.34)	0.67
Good	1	12.5	7	87.5	87	100		
Wall Type								
Not Qualified	20	23.3	66	76.7	86	100	0.6 (0.18-1.69)	0.36
Qualified	6	35.3	11	64.7	17	100		
Ventilation								
Not Qualified	23	24.2	72	75.8	95	100	0.5 (0.12-2.40)	0.41
Qualified	3	37.5	5	62.5	8	100		
Occupant D								
Not Qualified	9	20.5	35	79.5	44	100	0.64 (0.25-1.60)	0.46
Qualified	17	28.8	42	71.2	59	100		
Use of Insect Repellent								
Mosquito Coils	23	31.9	49	68.1	72	100	4.4 (1.21- 15.9)	0.03
Other Types of Insect Repellent	3	9.7	28	90.3	31	100		
Cooking Fuels								
Firewood/Kerosene	11	78.6	3	21.4	14	100	18.1 (4.5-72.8)	0.00
Gas/Electric Stove	15	16.9	74	83.1	89	100		
Smoking behavior								
Family Member Smokes	23	29.5	55	70.5	78	100	3.1 (0.84-11.3)	0.14
No Family Member Smokes	3	12.0	22	88.0	25	100		
Kitchen Location								
Not Separated from Other Rooms	2	28.6	5	71.4	7	100	1.2 (0.22-6.6)	1.00
Separated	24	25.0	72	75.0	96	100		

The results of the multiple logistic regression analysis showed that the variables that had the highest effect on ARI among the homemakers were PM_{10} concentration, humidity, cooking fuel, and mosquito coils. Among these four variables, the highest factor was the use of cooking fuel, which had the highest B coefficient value and an OR of 46.7. Homemakers who used firewood or kerosene were 46.7-timesat higher risk of suffering ARI compared to homemakers who used gas or electric stoves.

Table 2: Final Model of Multivariate Analysis.

Variable	β	p value	OR	95% CI
PM_{10} Concentration	1.501	0.011	4.5	1.42-14.20
Humidity	0.857	0.196	2.4	0.64-8.62
Fuel cooking	3.844	0.001	46.7	5.01-435.6
Obatnyamuk	2.678	0.021	14.6	1.49-141.6
_cons	-4.686			

4. DISCUSSION

4.1. Cooking Fuels

Most homemakers living in Allakuang Village use firewood or kerosene to cook because it is easy to get firewood around their houses, and they assume that firewood is more economical than other cooking fuels are. Gas stoves are less frequently used because of the limited availability of 3 kg gas, which the government provides only to the poor community. In addition, some members of the community did not feel safe in using 3 kg gas because of the risk of explosion. Therefore, only a few homemakers used gas for their cooking.

The results of the analysis showed that among the thirteen variables, the highest risk factor was the use of a cooking fuel with the highest B coefficient value and an OR of 46.7. Homemakers who used firewood or kerosene to cook were 46.7 times-more-likely to suffer ARI compared to homemakers who used a gas or electric stove. This finding is in line with the theory that the smoke emitted from biomass fuels is the main cause of indoor air pollution, especially in villages indeveloping countries. This emission contains pollutants that affect health, such as particulate matter and polycyclic organic matter, which are carcinogenic, as well as benzo[a]pyrene and other pollutants such as carbon monoxide and formaldehyde [6].

The results of the present study were also in line with previous research done in Kenya, which found that the condition of housing and the type of fuel used were risk factors for indoor air pollution [15]. A previous study [22] showed that kerosene fuel was a source of pollutants such as PMs, aliphatic hydrocarbons, and polycyclic aromatic hydrocarbons, all of which affect lung function if they are inhaled. Other studies [5, 24] reported an association between exposure to biomass fuel smoke and upper respiratory tract infections. Animal studies have shown that similar to cigarette smoke, wood smoke condensates, thus damaging eyelens in rats and producing discoloration, opacity and particles of debris. The mechanism is thought to involve the absorption and accumulation of toxins, which leads to oxidation [2]. A study ARI in preschool children (<5 yrs. of age) in Zimbabwe reported that after adjusting for appropriate confounders, children in households using biomass fuels were more than twice (OR 2.2) as likely to suffer from ARI as were children in households that used clean fuel for domestic purposes [14].

4.2. PM_{10} concentration

The PM_{10} concentration measured in the houses of the 103 homemakers who participated in this study ranged from 15 μg/m^3–158 μg/m^3 with an average of60.78 μg/m^3. Although the average PM_{10} concentration did not exceed the threshold stipulated by ministerial regulation: Health Ministerial Republic of Indonesia Decree No. 1077/Menkes/per/v/2011 (>70 μg/m^3), in more than thirty (30.1%) houses, the PM_{10} concentration exceeded the standard. Most houses that had a PM_{10} concentration above the threshold were located less than 50 meters from a stone-carving operation. Some houses functioned as both the family residence and the stone-carving operation. In buildings that not meet the construction standards, the dust particulate resulting from the cutting, shaping and grinding process permeates nearby houses. This particulate was observed in the air and on the floors of houses that were full of dust.

PM_{10} concentration and ARI incidence showed a significant correlation. According to the theory PM_{10} consists of a group of very small particulates that can be inhaled into the respiratory tract. Specifically, PM_{10} is respirable and a good predictor of health [10]. PM_{10} can enter the respiratory tract through the nose and throat from where it passes to the lungs [28].

The results of this study are in line with previous findings [18] that elevated levels of PM_{10} pollution were associated with increases in the symptoms of respiratory disease and the use of asthma medication. Associations between compromised respiratory health and elevated PM_{10} pollution were observed even when PM_{10} levels were well below the 24-h national ambient air quality standard of 150 μg/m.

4.3. Insect repellent

The use of mosquito coils inside the house was popular among the homemakers in Allakuang Village (70%).Although some homemakers felt disturbed by the smoke emitted by mosquito coils, but they still used them because they assumed that they were the most effective and efficient mosquito repellant. They did not understand that the smoke emitted by mosquito coils contains harmful pollutants. The main active ingredients in mosquito coils are pyrethrins, which comprise 0.3–0.4% of the coil mass [12]. The smoke emitted by mosquito coils during burning contains carcinogenic PAHs, including BAP, benzo[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene,dibenzo[a, h] antrachene, and indeno [1,2,3-cd] pyrene [4, 11]. When the mosquito coil burns, the insecticides evaporate in the smoke, which prevents mosquitos from entering the room. The remaining components of mosquito coils are organic fillers, binders, dyes, and other additives. The combustion of these additives generates large amounts of sub-micrometer particles and gaseous pollutants that can reach the lower respiratory tract [11].

The results of the present study showed that the homemakers who used mosquito coils were at 4.4-timeshigher risk of suffering ARI than homemakers who did not use mosquito coils or used another type of repellant. This finding is in line with a study conducted in Taiwan [23], which showed that people who used mosquito coils more than three times a week were 3.78 times more likely to suffer lung cancer compared with those who did not use mosquito coils.

In addition, previous research found that the gas phase of mosquito coil smoke contained carbonyl compounds, such as formaldehyde and acetaldehyde, which could produce strong irritating effects on the upper respiratory tract [3]. Epidemiological studies showed that long-term exposure to mosquito coil smoke induced asthma and persistent wheeze in children [1, 8, 9]. Another study identified a large suite of volatile organic compounds, including carcinogens and suspected carcinogens, finding that the particles were ultrafine and fine in the coiling smoke. The results showed that the emission of formaldehyde fromburning one coil could be as high as that released from burning fifty-one cigarettes [11].

5. CONCLUSION

This study found that the variables that affected the incidence of ARI among homemakers are PM_{10} concentration, humidity, cooking fuel, and mosquito coil, among which the highest variable was the type of cooking fuel used. Homemakers who used firewood or kerosene were 46.7 times more likely to suffer ARI compared to homemakers who used gas or electric stoves. The smoke emitted from firewood or kerosene, combined with the smoke emitted from mosquito coils and PM_{10} from industrial activities increased pollution levels, thus increasing the risk of ARI among house occupants, especially homemakers who spent most of their time inside their houses.

The most effective way to eliminate smoke exposure from solid fuel is to use a clean fuel, such as an electric stove, which, however, is not efficient. The most realistic alternative is to reduce the exposure level by using a gas stove. A government program that provides 3 kg gas to the poor community needs to be extended to the entire society so that gas is affordable for all. In addition, the government should be committed to maintaining the quality and the safety of the gas holders o that people will feel safe in using gas as their cooking fuel.

In addition, the Environmental Agency should monitor the air quality around informal industries, which potentially expose people to air pollution and decrease public health status. The Environmental Agency could disseminate information about environment quality assessment to local governments in order to overcome the problem of air pollution and the decrease in the quality of the environment in Allakuang Village. Although this is an extreme policy, it would significantly help in building a partnership between the village officer and the Environmental Agency in the effort to locate the stone-carving industry far away from the housing area and to encourage the industry owners to meet the environmental health standards in the workplace.

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