ORIGINAL ARTICLE

Association between Environmental Factors and the Incidence of Acute Respiratory Infection in Children under Five in East Nusa Tenggara, Indonesia

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ABSTRACT

Introduction: ARI (Acute Respiratory Infection) is one of the main causes of death among children under five in many countries worldwide. In Indonesia, 10% of ARI cases occur in East Nusa Tenggara, which is the highest prevalence of ARI in this country, with 90% of them leading to under-five mortality. There are various factors that cause the prevalence of ARI. In East Nusa Tenggara itself, environmental factors are suspected to be the risk factors for this disease. This study aims to analyse the association between environmental factors and the incidence of ARI among children under five years old in East Nusa Tenggara. **Methods:** A cross-sectional study was conducted by analysing secondary data sets obtained from DHS, with a total of 337 subjects examined in this study. Multivariate logistic regression was applied to investigate the association between ARI and various environmental factors. **Results:** This study found that the prevalence of ARI among children under five years old in East Nusa Tenggara was 9.04% of all subjects. ARI was significantly associated with the types of residence (OR 2.2, 95%CI 1.1-4.3) and passive smoking status (OR 4.7, 95%CI 1.8-12.4) as its risk factors. In addition, there was strong association between ARI and the types of roof (OR 3.3, 95%CI 1.3-8.9) as its protective factor. **Conclusion:** Based on the findings of this study, it can be concluded that the incidence of ARI in children under five years old was closely associated with residential area, smoke exposure, and roof materials.
Malaysian Journal of Medicine and Health Sciences (2022) 18(4):35-42. doi:10.47836/mjmhs18.4.6

Keywords: Respiratory Infections, Preschool Children, Smoke, Indoor Air Pollution

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INTRODUCTION

Acute respiratory infection (ARI) is an infectious disease triggered by acute viral or bacterial infection of the respiratory system which can cause a person to experience coughing, runny nose, sneezing, muscle pain, fever, and in severe condition may lead to shortness of breath and coughing up blood or haemoptysis (1,2). In 2017, ARI was reported as one of the leading causes of death among children under five years old worldwide (3). Approximately 1.3 million children die of ARI every year (4). There are various types of acute respiratory infections, including pneumonia. In 2018 alone, more than 800,000 children suffered from pneumonia globally, with the highest incidence occurred in Southern Asian countries, which was 2,500 cases per 100,000 children (5). Indonesia is among those countries with high number of ARI cases. According to Indonesia Basic Health Research 2018,the national prevalence of ARI in Indonesia reached 4.4% and the highest provincial prevalence was in East Nusa Tenggara Province, with a prevalence rate of 10% (6). In 2017, ARI was the highest case of hospital admission in East Nusa Tenggara with more than 530 thousand patients recorded (7). Furthermore, it was reported that 80-90% of under-5 mortality in East Nusa Tenggara Province was caused by ARI, which was often initiated by pneumonia and other acute diseases for which the management system was inadequate. Based on East Nusa Tenggara Province Health Profile Report, the number of pneumonia cases in children under five was reported to have doubled in three years, from 3,714 cases in 2014 to 6,059 cases at the end of 2017 (7).In addition, the under-5 mortality rate due to ARI was reported to be the highest, compared to other infectious diseases such as diarrhoea, malaria, cancer, HIV, and ischemic heart diseases (8–10).

There are three categories of risk factors for ARI to be experienced by children under five which are as

follows. The first one is the characteristics of parents and families (11),including the age, education, employment, marital status, tribe or ethnicity, and family size of the parents (11–19). The second category is related to the nutritional status of the children observed based on their age, gender, immunization status, and exclusive breastfeeding (20–27). Meanwhile, the last category is regarding the environmental factors such as the residence of the family and its quality, parental smoking status, and the type of cooking fuel used in the household (28–36). According to previous multivariate studies, of all the aforementioned categories, factors regarding the environment have a greater risk of transmitting the pathogens (9,11,16,23,30).

One of the environmental factors for the incidence of ARI is the indoor air quality, which is influenced by the quality of house components such as the types of material used for the floors, walls, and roofs. Regarding this factor, the 2018 East Nusa Tenggara Province Housing Statistics reported that the percentage of liveable houses in this region only reached 30.19% (37).

Another factor which affects the indoor air quality is the use of unclean/harmful cooking fuels, e.g. kerosene and coal that contain a variety of toxic materials, such as carbon monoxide, nitrogen dioxide, fluorine, arsenic, and mercury (38). The Indonesian National Socioeconomic Survey reported that nearly half the residents of East Nusa Tenggara still use solid fuels (charcoal and wood) and kerosene for cooking in 2017 (39). This means that almost 50% of the total population of this region have low quality of indoor air in their houses.

The smoking status of the parents is also one of the environmental factors for ARI which is closely related to the indoor air quality. Cigarettes are harmful to human health, particularly children, since the smoke releases toxic chemicals which can cause problems in the respiratory system (29,30,40,41). High smoking activity in a room with non-standard ventilation is extremely dangerous as the smoke lingers for hours and the toxic chemicals in it are likely to be inhaled by everyone entering the room. In East Nusa Tenggara, there is an increase in the number of smokers from 25.47% in 2015 to27.31% in 2017. This is a tremendously perturbing situation as it is presumably one of the main causes of the increasing incidence of ARI in children under five years old in this region (42).

Despite the fact that East Nusa Tenggara Province in Indonesia had the highest cases of ARI in children under five, there are insufficient studies on the association between the environmental factors and ARI in children under five in this region. Therefore, this study aims to identify the relationship between the incidence of acute respiratory infection among children under five years old in East Nusa Tenggara and the exposure of those children to the environmental risk factors for ARI.

MATERIALS AND METHODS

Study design

This cross-sectional study utilised secondary data sets obtained from The Demographic and Health Surveys (DHS) and authorised by DHS Program. The data was collected through direct interview and distribution of questionnaires during the survey program. Of the 2223 respondents from East Nusa Tenggara who were women aged 15-59, only 15% were examined due to the large amount of missing data.

The dependent variables in this study are the cases of ARI and severe ARI in children under five years old. Children are identified as suffering from ARI if they experienced coughing and shortness of breath for the last two weeks, while the acute respiratory infection is considered severe if the children had both aforementioned symptoms accompanied by fever. The variable data was adapted by questioning the respondents about the symptoms of ARI.

Meanwhile, the independent variables in this study are the environmental factors for ARI, covering the types of residence (in rural and urban areas), wall material, roof material, and cooking fuel. The wall material variable is categorised into unimproved (cane/palm/trunks, dirt, bamboo with mud, stone with mud, uncovered adobe, plywood, and reused wood) and improved ones (bamboo with mud, stone with mud, uncovered adobe, plywood, cardboard, reused wood, trunks with mud, un-burnt bricks, un-burnt bricks with plaster, and un-burnt bricks with mud). As for the types of roof variable, the materials classified as unimproved ones include grass/thatch/palm leaf, sod, palm/bamboo, and wood planks, while the improved roof materials are metal, wood, calamine/cement fibre, cement, roofing shingles, and asbestos/slate roofing sheets. Furthermore, the cooking fuel variable is divided into two types, namely the unclean fuel (kerosene, charcoal, and wood) and the clean one(electric fuel and gas). Apart from those above-mentioned variables, another variable regarding the environmental factor for ARI is the status of the children as passive smokers, which is closely related to the presence of smokers in the house. There are also two categories for this variable, i.e. passive smokers and non-passive smokers.

Data analysis

IBM SPSS 25 software was utilised in this study to analyse the data, with the descriptive statistics to include univariate and bivariate analyses. Univariate analysis was carried out to obtain the frequency and percentage of each variable, while bivariate analysis with chi-square test calculated the value of the unadjusted odds ratio. In the multivariate analysis which performed multiple logistic regression linear tests, all variables with

p-value<0.25 were included. The output of this analysis is the adjusted odds ratio.

Ethical Clearance

The secondary data used in this study can be fully accessed in https://dhsprogram.com/Data/. The Demographic and Health Surveys (DHS) Program has authorised the data for research use with Authorization Letter Number 155593. Therefore, the ethics approval by any institution is not required.

RESULTS

Characteristics of the study subjects

The total number of subjects studied was 337, with the percentage of ARI and severe ARI cases of 9.04% and 6%, respectively. Of all the subjects, 49.3% (n=166) of the mothers were under 31 years old and 58.8% (n=198) of the fathers were under 36 years old at the time of the survey program. Most of the mothers (n=201), with a percentage of 59.6%, are highly educated.51.9% (n=175) of the children are male, with 57% (n=192) of them being less than 29 months old. The majority of these children came from families with less than six members (n=193; 57.3%) and from parents with fewer than three children (n=231; 68.5%). In addition, the respondents mostly resided in rural areas (n=270; 80.1%) and lived in houses with improved wall and roof materials, with a percentage of 65.3% (n=220) and 88.4% (n=298), respectively. As for the type of cooking fuel, unclean fuel (n=312; 92.6%) was most widely used by the respondents. Regarding the other environmental factor for ARI, which is the smoking status of the family members, the majority of the respondents were not passive smokers or did not live with smokers (n=317; 94.1%) (Table I).

Table I: Distribution of study subjects according to parent's characteristics, child's characteristic, family's characteristics environment factors and ARI status

	Frequency	
	N	(%)
Mother's age (years)		
< 31	166	49.3
>= 31	171	50.7
Father's age (years)		
< 36	198	58.8
>= 36	139	41.2
Mother's educational status		
Low	136	40.4
High	201	59.6
Child's age (months)		
< 29	192	57.0
>= 29	145	43.0
Sex of child		
Female	162	48.1
Male	175	51.9
Number of family member		
>= 6	144	42.7
< 6	193	57.3
Number of children		
>= 3	106	31.5
< 3	231	68.5
Type of residence		
Rural	270	80.1
Urban	67	19.9
Type of wall		
Unimproved	117	34.7
Improved	220	65.3
Type of roof		
Unimproved	39	11.6
Improved	298	88.4
Type of cooking fuel		
Unclean fuel	312	92.6
Clean fuel	25	7.4
Passive smoking		
Yes	20	5.9
No	317	94.1
ARI ***(acute respiratory infection)***		
Yes	91	27
No	246	73
Severe ARI		
Yes	60	17.8
No	277	82.2

Characteristics of the parents, children, and family

Table II shows the unadjusted odds ratio of ARI and severe ARI cases to all variables, including the age of the mother, father, and children, the educational status of the mother, the gender of the children, the number of the family members, and the number of children in the family.

Environmental factors

As seen in Table II, children under five years old who live together with smokers are 3.621 times at a greater risk of ARI (unadjusted OR: 3.621; CI 95% 1.448-9.005) than those who do not.

To perform a multivariate analysis, variables with p-value <0.25, namely the type of residence, the type of roof, and passive smoking status, were selected. The result proved that the incidence of ARI was closely related to those variables. The type of residence got p-value: 0.030; adjusted OR: 2.154; 95% CI 1.076-4.311, whereas the passive smoking status achieved p-value: 0.002; adjusted OR: 4.663; 95% CI 1.751-12.417. Meanwhile, improved roof material showed indication as a protective factor with p-value: 0.016; adjusted OR: 3.317; 95% CI 1.252-8.787 (Table II).

The results of the chi-square test between the environmental factors and the incidence of severe ARI in children under five years old, on the other hand, did not indicate any relation between severe ARI and the types of residence, wall material, roof material, cooking fuel, and passive smoking status as none of those variables had p-value <0.05. Furthermore, a multivariate analysis was performed by including variables with p-value <0.25 and found a relation between the incidence of ARI and the passive smoking status variable. However, after conducting the multivariate analysis, this variable showed no correlation to the incidence of severe ARI, with p-value = 0.149 (Table III and Table IV).

Table II: Distribution of study subjects according to ARI status, parents and child characteristics, family's characteristics, and environmental factors

	ARI[a]				Severe ARI[b]			
	Yes *n (%)*	No *n (%)*	*Unadjusted* OR (95% CI)	p-value	Yes *n (%)*	No *n (%)*	*Unadjusted* OR (95% CI)	p-value
Parents, child, and family characteristics								
Mother's age (years)								
< 31	44 (48.4)	122 (49.6)	0.952	0.936	30 (50.0)	136 (49.1)	1.037	1.000
>= 31	47 (51.6)	124 (50.4)	(0.588-1.539)		30 (50.0)	141 (50.9)	(0.593-1.812)	
Father's age (years)								
< 36	54 (59.3)	144 (58.5)	1.034	0.993	33 (55.0)	165 (59.6)	0.830	0.612
>= 36	37 (40.7)	102 (41.5)	(0.634-1.686)		27 (45.0)	112 (40.4)	(0.473-1.456)	
Mother's educational status								
Low	38 (41.8)	98 (39.8)	1.083	0.846	25 (41.7)	111(40.1)	1.068	0.934
High	53 (58.2)	148 (60.2)	(0.664-1.765)		35 (58.3)	166 (59.9)	(0.606-1.883)	
Child's age (months)								
< 29	53 (58.2)	139 (56.5)	1.074	0.871	35 (58.3)	157 (56.7)	1.070	0.928
>= 29	38 (41.8)	107 (43.5)	(0.660-1.747)		25 (41.7)	120 (43.3)	(0.608-1.884)	
Sex of child								
Female	38 (41.8)	124 (50.4)	0.705	0.198*	27 (45.0)	135 (48.7)	0.861	0.702
Male	53 (58.2)	122 (49.6)	(0.434-1.147)		33 (55.0)	142 (51.3)	(0.491-1.507)	
Number of family member								
>= 6	36 (39.6)	108 (43.9)	0.836	0.554	21 (35.0)	123 (44.4)	0.674	0.234*
< 6	55 (60.4)	138 (56.1)	(0.512-1.365)		39 (65.0)	154 (55.6)	(0.377-1.205)	
Number of children								
>= 3	21 (23.1)	85 (34.6)	0.568	0.060*	15 (25.0)	91 (32.9)	0.681	0.301
< 3	70 (76.9)	161 (65.4)	(0.327-0.989)		45 (75.0)	186 (67.1)	(0.361-1.287)	
Environment factors								
Type of residence								
Rural	79 (86.8)	191 (77.6)	1.896	0.086*	51 (85.0)	219 (79.1)	1.501	0.386
Urban	12 (13.2)	55 (22.4)	(0.963-3.732)		9 (15.0)	58 (20.9)	(0.698-3.227)	
Type of wall								
Unimproved	33 (36.3)	84 (34.1)	1.097	0.815	24 (40.0)	93 (33.6)	1.319	0.425
Improved	58 (63.7)	162 (65.9)	(0.664-1.813)		36 (60.0)	184 (66.4)	(0.743-2.341)	
Type of roof								
Improved	85 (93.4)	213 (86.6)	2.195	0.122*	5 (8.3)	34 (12.3)	0.650	0.520
Unimproved	6 (6.6)	13 (13.4)	(0.887-5.428)		55 (91.7)	243 (87.7)	(0.243-1.737)	
Type of cooking fuel								
Unclean fuel	86 (94.5)	226 (91.9)	1.522	0.558	56 (93.3)	256 (92.4)	1.148	1.000
Clean fuel	5 (5.5)	20 (8.1)	(0.554-4.183)		4 (6.7)	21 (7.6)	(0.379-3.477)	
Passive smoking								
Yes	11 (12.1)	9 (3.7)	3.621	0.008*	6 (10.0)	14 (5.1)	2.087	0.141*
No	80 (87.9)	237 (96.3)	(1.448-9.005)		54 (90.0)	263 (94.9)	(0.768-5.675)	

*Notes : [a]Child has symptoms of cough and shortness of breath for the last two weeks; [b] Child has symptoms of cough, shortness of breath, and fever for the last two weeks; *included to multivariate analysis*

Table III: Adjusted odds of ARI according to parents and child characteristics, family's characteristics, and environmental factors

Variable	*Adjusted* OR	95% CI	p-value
Type of residence (rural)	2.154	1.076 – 4.311	0.030
Type of roof (improved)	3.317	1.252 – 8.787	0.016
Passive smoking (yes)	4.663	1.751 – 12.417	0.002

Table IV: Adjusted odds of severe ARI according to parents and child characteristics, family's characteristics, and environmental factors

Variable	*Adjusted* OR	95% CI	p-value
Passive smoking (yes)	2.087	0.768 – 5.675	0.149

DISCUSSION

The incidence of ARI in children under five years old is closely related to the residential area, where children under five years old who live in rural areas are at higher risk of ARI. This finding is in accordance with a previous study conducted in Chennai City (India) which reported that 60% of the incidence of ARI in children under five years old occurred in respondents residing in rural areas (21). Other studies done in Ethiopia (AOR: 2.27; 95% CI 1.18-4.39) and Nigeria also showed similar results, characterised by odds ratio from the incidence of pneumonia, bronchiolitis, and AURI (acute upper respiratory infection), with OR: 2.77; 95% CI 2.17-3.54, OR: 2.17; 95% CI 0.13-.214, and OR: 0.31; 95% CI 0.21-0.47, respectively. This proves that ARI is more likely to be experienced by children under five years old who live in rural areas (15,20).

Rural area is located outside the metropolis and often characterised as an area with limited access to health care facilities, high population density, poor economy, and low level of concern. While those characteristics are often stated to have a close relation to the risk factors for acute respiratory infection (15,20,21), some studies reported contrasting results. These studies, which respondents mostly live in urban areas, discover that children under five years old residing in urban areas

have a higher risk of developing ARI with a value as follow: adjusted OR: 1.492; 95% CI 1.017-2.190. In addition, several other studies suggest that more people who suffer from ARI are those living in urban slums where the city functions do not run properly (12,43)

Regarding the roof material variable of this study, an improved roof material is seen as a protective factor. This is in line with prior studies done in Bangladesh and Indonesia which find that the use of unimproved roof materials is proven to be more risky in regards to the incidence of ARI, with risk values of RR= 0.782 and PR = 3.07; p = 0.02, respectively (12,29). Other related studies carried out in Ethiopia also reveal that children under five years old have a higher risk of ARI if they live in a house with thatched roof (adjusted OR: 2.51; 95% CI: 1.02-5.73)(16,24). This is because unimproved roof materials of a house can produce coarse fibres which, if accumulated in the human respiratory system, can have negative impacts on the health of the inhabitants, one of which is the incidence of ARI that mostly affects toddlers. Moreover, the use of the unimproved materials can also increase humidity and the proliferation of mould/fungi, thus triggering an extremely dangerous condition which can lead to the incidence of ARI (22,28,34). Several studies, however, show different results from this study, reporting no relation between ARI in children under five years old and the type of roof material (p-value= 1,000). This can happen when most of the respondents of those studies live in houses with improved roof materials and/or a good ventilation system (24,34).

According to the findings of this study, the incidence of ARI in children under five years old was shown to have a strong relation to the smoking activity of the family members. This is in accordance with the findings of several previous studies carried out in Indonesia, India, Ethiopia, and Cameroon, which risk values of each of them as follows: OR 5.09; 95 % CI= 1.06-24.34; p= 0.042, OR 1.6; 95% CI= 1.0–2.6; p= 0.038), adjusted OR= 0.638; 95% CI= 0.046–0.980; p= 0.042, and adjusted OR= 3.58; 95% CI= 1.45–8.84 (9,11,16,30).

Cigarette smoke contains more than 4000 toxic substances which can damage the function of cilia and supervisory epithelial cells, thereby lowering the immune of human body (34). Those toxic substances belong to the HAP (Household Air Pollution) group and can disrupt the balance of Th1 and Th2 in the rudimentary respiratory system of children under five years old, thus triggering the emergence of secondary infections (12,15,32,44,45). The risk factors of ARI which are closely related to cigarette exposure include the poor quality of the house, high population density of the residential area, and low economic status of the family (15). However, several prior studies reveal no correlation between cigarette exposure and the incidence of ARI in children under five years old. This may occur due to the incomplete questionnaire (for example, there is no question on the number of cigarettes consumed) or because the family members do not smoke near the children (31,34,44).

As regards to the cooking fuel variable, this study finds no correlation between the incidence of ARI in children under five years old and the use of unclean cooking fuels. This finding contradicts the results of previous studies stating that children under five are at a higher risk of ARI if they live in a household in which unclean materials such as wood, kerosene, charcoal, and others are used for cooking (9,11,13,23,44). This is because the use of unclean fuels, especially coal and kerosene, can increase the risk of children under five being exposed to particulates and other carcinogenic substances (38). In addition, imperfect wood burning can release pollutants proven to increase the prevalence of pneumonia, bronchitis, asthma, and other respiratory system-related diseases (13,28).

Although the studies mentioned previously above show different results as this study, there are at least two related studies with similar results to this study, both reporting no relation between the use of clean cooking fuel and the incidence of ARI in children under five years old, with p-values of p= 0.358 and p= 1,000 respectively (16,34). This is presumably due to the possibilities that the respondents are not with their toddlers while cooking, the respondents apply outdoor cooking at home, and the good ventilation of their houses that the finding of this study is not in line with previous studies (16,31,33).

In contrast to urban communities, people living in rural areas often have lower economic capability, education, and health literacy level. Therefore, the government should address the gap by providing equal support for both rural and urban residents. One of the actions to be taken is to organize a mass education on basic health information, such as personal hygiene and prevention of infectious diseases in children (46,47). To overcome the problem of smoking habit of the residents, previous studies conducted in Indonesia analysed two approaches for smoking cessation therapy, i.e. the Spiritual Emotional Freedom Technique (SEFT) and the Transtheoretical Model (TTM),both of which have been proven to increase the desire to quit smoking (48,49). Regarding for the implementation of the healthy-housing criteria, many of the residents face various obstacles and end up using unsafe/unimproved materials to build their home, especially for the roofs. Therefore, technical assistance from the government for the residents to build their houses is highly recommended to make sure they can implement the guidelines and policies regarding healthy housing.

One of the limitations of this study is the data regarding the incidence of ARI and severe ARI, which are only self-diagnoses by the mothers with no confirmation

from clinicians, leading to the possibility of causing a bias in the data reporting. Besides, due to the limited data obtained, this study did not include the calculation of the number of cigarettes consumed by the family members. In addition, this study did not investigate the data related to the chemical substances released by the cigarette smoke as well as particulate matter, dust, and any pathogenic substances from the use of unimproved house materials.

CONCLUSION

According to the findings of this study, the percentage of ARI cases in children under five years old in East Nusa Tenggara Province was 9.04%. The environmental risk factors for ARI cases in children under five include the residential area (rural) and the passive smoker status of the children due to the existence of smoker in the house, while the type of roof becomes the protective factor. However, this study found no relation between those environmental factors and the incidence of severe ARI among children under five years old in East Nusa Tenggara. In addition, it was discovered that the diagnoses of ARI and severe ARI in this region were limited to self-reporting based on the symptoms experienced by the children. A clinical diagnosis of acute respiratory infection is highly recommended so that more accurate outcome can be obtained for future studies.

ACKNOWLEDGEMENTS

The authors would like to express my special gratitude to Mrs. Laila Fitria for her suggestions, support, comments, and input during the writing of this article. We are also grateful for the assistance provided by Ms. Sarah Nabila in the arrangement of the research concept and data analysis. Finally, we would like to thank the Demographic and Health Surveys (DHS) Program for providing the data for this study.

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