
THE IMPACT OF COAL COMBUSTION ON THE RESPIRATORY HEALTH OF COMMUNITIES RESIDING IN THE SURROUNDING AREA OF PT. LL IN ACEH BESAR REGENCY

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ABSTRACT

Burning coal produces dangerous air pollutants such as fine particles (PM10 and PM2.5), sulfur dioxide (SO₂), nitrogen dioxide (NO₂), and carbon monoxide (CO) that can cause respiratory disorders, increase the risk of respiratory diseases, and contribute to the rise in morbidity and mortality rates due to respiratory illnesses. In the vicinity of PT LL in Aceh Besar Regency, where coal burning takes place, residents living in the area are potentially exposed to detrimental health effects. The aim of this research is to determine the relationship between air quality and respiratory health in the vicinity of PT LL in Aceh Besar Regency. This study is a descriptive analytical study with a cross-sectional design. The population of this study consisted of 5,220 individuals, and the sample size was 132 respondents who met the inclusion criteria. Data analysis was conducted using univariate, bivariate, and logistic regression tests for the bivariate stage. The results of the study indicate that several environmental factors such as the use of mosquito coils, residential location, and house ventilation significantly influence the occurrence of Acute Respiratory Tract Infections (ARTIs) among the residents in the vicinity of PT LL in Aceh Besar Regency. The use of mosquito coils increases the likelihood of ARTIs by 2.7 times. Residing in Lhoknga area increases the likelihood of ARTIs by 2.1 times compared to residing in Simpang Tiga area. Respondents who have inadequate house ventilation have a 2.3 times higher likelihood of experiencing ARTIs compared to those with sufficient ventilation. However, there is no significant influence between bedroom occupancy density, indoor lighting, roof/ceiling condition, indoor humidity, indoor temperature, and the occurrence of ARTIs among the residents.

Keyword: Aceh Besar Regency; Air quality; Coal burning; Respiratory health

INTRODUCTION

According to the World Health Organization (WHO), Upper Respiratory Tract Infection (URTI) is a general term that encompasses a group of diseases that affect the upper respiratory tract, including the nose,

sinuses, throat, and small airways (Pusat Pengobatan Infeksi Saluran Pernapasan Akut Berat, 2022). Acute Respiratory Tract Infections (ARTIs) can be caused by various infectious agents, including viruses, bacteria, and fungi. ARTIs are common diseases that

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occur worldwide and can affect individuals of all ages. However, infants, children, and the elderly are usually more vulnerable to ARTIs and may experience serious complications. According to the World Health Organization (WHO), the number of deaths due to ARTIs reaches 4.25 million annually. In 2020, WHO reported a total of 1,988 cases of ARTIs in toddlers aged 1-5 years, with a prevalence rate of 42.91%. Toddlers are the most vulnerable group to ARTIs (Kemenkes, 2022). Approximately 20-40% of patients treated in hospitals and health centers are children suffering from ARTIs. Data indicates that each year there are approximately 1.6 million deaths due to pneumonia in children under the age of five (Gheissari et al., 2022; Qin et al., 2021).

Pneumonia emerges as one of the serious complications that can occur due to ARI in children (Merera, 2021; Santri et al., 2023). The air pollution resulting from coal burning activities in the vicinity of industrial areas makes residents vulnerable to Upper Respiratory Tract Infections (URTI). (Maryuningsih & Maryuningsih, 2015). The proportion of Acute Respiratory Tract Infections (ARTIs) in Indonesia in 2018 was 56.51%, while in Aceh Province, the proportion of ARTIs was only 12.59% (Ministry of Health, Republic of Indonesia, 2018). Based on the health profile data from the Aceh Besar District Health Office in 2019, Lhoknga Sub-District is one of the areas with the highest percentage of Acute Respiratory Tract Infection (ARTI) cases, reaching 22%, compared to Simpang Tiga Sub-District with 4.7%, Kuta Malaka Sub-District with 12.63% cases, Kuta Baro Sub-District with 2.4% cases, and Krueng Barona Jaya Sub-District with 4.2% cases. Acute respiratory tract infections ranked first among the top 10 diseases in Aceh Besar District in 2019 (Aceh Besar District Health Office, 2019).

Lhoknga Sub-District is one of the areas where industries engage in coal burning processes. Research conducted on the impact of coal burning on respiratory health in Indonesia has yielded significant results. There is a correlation between environmental air pollution due to coal burning and increased hospitalizations and mortality rates due to chronic obstructive pulmonary disease (Laden et al., 2000; Liburd et al., 2019). Air pollution generated by coal-fired power plants in coastal areas has negative effects on human health (Dunn, 2019; Hendryx et al., 2020). Communities residing near open coal mining areas experience impaired lung function and respiratory symptoms (Odo et al., 2022, 2023b).

The findings of this research provide a deeper understanding of the negative impacts of coal combustion on the health of the Indonesian population. Based on initial observations, the proportion of ISPA cases in Lhoknga District is higher at 22% compared to Simpang Tiga District at 4.7%. This disparity has sparked the interest of researchers to investigate the influence of coal combustion on the occurrence of ISPA, especially in Lhoknga District, where coal burning industries are present.

RESEARCH METHODS

The method used in this study was a quantitative analytical survey with a cross-sectional design, which means the research was conducted at a specific point in time using a questionnaire as the data collection instrument. The variables, including independent and dependent factors, were observed simultaneously. The aim of this study was to determine the factors influencing the impact of coal combustion on respiratory health in communities residing near industrial areas and Simpang Tiga Subdistrict, Aceh Besar Regency, which is far from the Lhoknga Subdistrict.

The study was conducted among the residents living in the vicinity of the Lhoknga industrial area, which consists of four villages: Naga Uambang, Lambaro Kueh, Monikeun, and Lamkruet, and in the Simpang Tiga Subdistrict, which is distant from the industrial area and consists of four villages: Ateuk Lam Ura, Ateuk Mon Panah, Lambunot, and Lamjamee Dayah. The population of this study included all individuals residing near the Lhoknga industrial area in Aceh Besar Regency, covering both Simpang Tiga and Lhoknga subdistricts. The sample size was determined using the Stanley Lemeshow formula (2000), resulting in a total sample of 132 respondents. The cross-sectional design included 66 respondents from the Lhoknga subdistrict and 66 respondents from the Simpang Tiga subdistrict.

Data collection methods included observation, questionnaires, interviews, and the involvement of data collectors in the

research area. The data analysis comprised univariate and bivariate analyses using logistic regression, as well as multivariate analysis with two models involving significant independent variables. This study underwent an ethical review process with the reference number No. 026/KEP-UNISM/IX/2021.

RESULTS

Univariate Analysis

The data in this study were subjected to univariate analysis, which included the disease status, air quality, respondent characteristics (gender, age, education, and occupation), behavioral factors (smoking, burning garbage, and burning mosquito repellents), and environmental factors (residential area, air ventilation, house lighting, humidity, indoor temperature, roof/ceiling type, and bedroom occupancy density). The details of each variable can be seen in the following Table 1.

Tabel 1. Frequency Distribution of the Disease Status and Air Quality of Communities Living in the Vicinity of PT LL, Aceh Besar regency

Variable	n	%
ISPA		
ISPA (Acute Respiratory Infection)	72	54,55
Non-ISPA (Non-Acute Respiratory Infection)	60	45,45
Air Quality		
Unhealthy	19	14,39
Healthy	113	85,61

In Table 1, it can be seen that the distribution of respiratory health frequency shows higher levels in the occurrence of Acute Respiratory Tract Infections (ARTIs) with 72 cases (54.55%), while the distribution of air quality frequencies classified as healthy reaches 113 cases (85.61%).

Looking at the characteristics of the respondents in Table 2, the majority of respondents were females, totaling 91 individuals (68.94%), and respondents under

the age of 21 reached 73 individuals (55.30%). Furthermore, about 40.91% of respondents have a secondary level of education, and a total of 113 respondents (85.61%) are unemployed. When examining behavioral factors in Table 3, it was found that respondents who smoke have a higher frequency, totaling 75 individuals (56.82%). Additionally, 99 respondents (75%) reported the practice of burning waste around their



Tabel 2. Frequency Distribution of the Respondents Characteristics of Communities Living in the Vicinity of PT LL, Aceh Besar regency

Respondent Characteristics	n	%
Gender		
Male	41	31,06
Female	91	68,94
Age		
<21 years	73	55,30
≥21 years	59	68,94
Education		
No Schooling	9	6,82
Elementary	51	38,64
Middle School	54	40,91
High School	18	13,64
Occupation		
Unemployed	113	85,61
Employed	19	14,39

homes, and 106 respondents (80.3%) use mosquito repellents. Meanwhile, the distribution of environmental factors shows

several findings (Table 4). It was found that 66 respondents (50%) live in the Lhoknga area, which may have a higher risk of ARTIs.

Tabel 3. Frequency Distribution of the Behaviour Factors of Communities Living in the Vicinity of PT LL, Aceh Besar regency

Behaviour Factors	n	%
Smoking Behavior		
Poor	57	43,18
Good	75	56,82
Burning Trash around the House		
Present	99	75
Absent	33	25
Use of Mosquito Coil		
Present	26	19,7
Absent	106	80,3

Furthermore, 88 respondents (66.67%) have well-ventilated homes. However, a total of 112 respondents (84.85%) reported inadequate lighting inside their homes. Moreover, 90 respondents (68.18%) have roofs or ceilings that meet the requirements, while 87 respondents (65.91%) have inadequate humidity levels inside their homes. Additionally, 78 respondents (59.91%) reported inadequate temperatures

inside their homes, and 101 respondents (76.52%) have overcrowded bedrooms.

Bivariate Analysis

Bivariate analysis was conducted to determine the relationship between the dependent variable and independent variables. This analysis involved statistical



Tabel 4. Frequency Distribution of the Enviromental Factors of Communities Living in the Vicinity of PT LL, Aceh Besar regency

Enviromental Factors	n	f
Residential Area		
Lhoknga	66	50
Simpang Tiga	66	50
Home Ventilation		
Does Not Meet Criteria	44	33,33
Meets Criteria	88	66,67
Home Lighting		
Does Not Meet Criteria	112	84,85
Meets Criteria	20	15,15
Roof/Ceiling of the House		
Does Not Meet Criteria	42	31,82
Meets Criteria	90	68,18
Humidity in the House		
Does Not Meet Criteria	87	65,91
Meets Criteria	45	34,09
Temperature in the House		
Does Not Meet Criteria	78	59,09
Meets Criteria	54	40,91
Bedroom Occupancy Density		
Does Not Meet Criteria	31	23,48
Meets Criteria	101	76,52
Total	132	100

testing using logistic regression, and the significance level was set at a P-value < 0.05. The table 5 shows that the occurrence of Acute Respiratory Tract Infections (ARTIs) is higher in unhealthy air quality conditions (78.95%) compared to healthy air (50.44%). The analysis indicates a significant influence between air quality and the occurrence of ARTIs (p-value=0.028).

Respondents exposed to unhealthy air have a 3.7 times higher chance of experiencing ARTIs compared to those exposed to healthy air (OR=3.7, 95% CI: 1.15-11.7). Additionally, the occurrence of ARTIs is higher in male respondents (82.93%) compared to females (41.76%). The analysis shows a significant influence between gender and the occurrence of ARTIs (p-value=0.0001). Males have a 6.7 times

higher chance of experiencing ARTIs compared to females (OR=6.7, 95% CI: 2.7-16.8). The occurrence of ARTIs is also higher in respondents under the age of 21 (78.08%) compared to those aged 21 or older (25.42%). There is a significant influence between age and the occurrence of ARTIs (p-value=0.0001). Respondents under the age of 21 have a 10.4 times higher chance of experiencing ARTIs compared to those aged 21 or older (OR=10.4, 95% CI: 4.6-23.4). There is no significant influence between educational level and the occurrence of ARTIs.

However, smoking behavior (66.67%) and burning garbage around the house (59.6%) have a significant influence on the occurrence of ARTIs (p-value=0.016 and



Tabel 5. The Impact of Air Quality and Respondent Characteristics on Respiratory Health of Communities Living Around PT. LL Aceh Besar Regency

Independent Variable	Respiratory Health				Total		OR (95% CI)	P-value
	ARI		Non ARI		n	%		
	N	%	N	%				
Air Quality								
Unhealthy	15	78,95	4	21,05	19	100	3,7 (1,15-11,7)	0,028
Healthy	57	50,44	56	49,56	113	100		
Gender								
Male	34	82,93	7	17,07	41	100	6,7 (2,7-16,8)	0,0001
Female	38	41,76	53	58,24	91	100		
Age								
<21 years	57	78,08	16	21,92	73	100	10,4 (4,6-23,4)	0,0001
≥21 years	15	25,42	44	74,58	59	100		
Education								
No Schooling	6	66,67	3	33,33	9	100	2 (0,4-9,2)	0,336
Primary	25	49,02	26	50,98	51	100		
Secondary	28	51,85	26	48,15	54	100	1,8 (0,4-8,2)	0,414
Tertiary	13	72,22	5	27,78	18	100	0,7 (0,1-4,3)	0,766
Occupation								
Unemployed	64	56,64	49	43,36	113	100	1,8 (0,6-4,8)	0,243
Employed	8	42,11	11	57,89	19	100		

p-value=0.046) in Table 6. Respondents with smoking behavior have a 2.4 times higher chance of experiencing ARTIs compared to non-smokers (OR=2.4, 95% CI: 1.1-4.9), while respondents with a behavior of burning garbage around the house have a 2.3 times higher chance of experiencing ARTIs compared to those without this behavior (OR=2.3, 95% CI: 1.01-5.07). The use of mosquito repellents also has a significant influence on the occurrence of ARTIs. Respondents who use mosquito repellents have a 2.7 times higher chance of experiencing ARTIs compared to those who do not use them (OR=2.7, 95% CI: 1.05-6.9).

The residential area also has a significant influence on the occurrence of ARTIs. Respondents living in the Lhoknga area have a 2.1 times higher chance of experiencing ARTIs compared to those living in the Simpang Tiga area (OR=2.1, 95% CI: 1.04-4.2). House ventilation also affects the occurrence of ARTIs. Respondents with inadequate house ventilation have a 2.3 times higher chance of experiencing ARTIs compared to those with proper ventilation (OR=2.3, 95% CI: 1.09-5.01). However, there is no significant influence between bedroom occupancy density and the occurrence of ARTIs.



Tabel 6. The Impact of Behaviour and Enviromental Factors on Respiratory Health of Communities Living Around PT. LL Aceh Besar Regency

Variable	Respiratory Health				Total		OR (95% CI)	P-value
	ARI		Non ARI		n	%		
	N	%	N	%				
Smoking Behavior								
Poor	38	66,67	19	33,33	57	100	2,4 (1,1-4,9)	0,016
Good	34	45,33	41	54,67	75	100		
Burning Trash Around the House Behavior								
Exists	59	59,6	40	40,4	99	100	2,3 (1,01-5,07)	0,046
Does Not Exist	13	39,39	20	60,61	33	100		
Use of Mosquito Repellent								
Exists	19	73,08	7	26,92	26	100	2,7 (1,05-6,9)	0,039
Does Not Exist	53	50	53	50	106	100		
Residential Area								
Lhoknga	42	63,64	24	36,36	66	100	2,1 (1,04-4,2)	0,037
Simpang Tiga	30	45,45	36	54,55	66	100		
House Ventilation								
Does Not Meet Criteria	30	68,18	14	31,82	44	100	2,3 (1,09-5,01)	0,028
Meets Criteria	42	47,73	46	52,27	88	100		
House Lighting								
Does Not Meet Criteria	61	54,46	51	45,54	112	100	0,97 (0,3-2,5)	0,965
Meets Criteria	11	55	9	45	20	100		
House Roof/Ceiling								
Does Not Meet Criteria	30	71,43	12	28,57	42	100	2,8 (1,3-6,2)	0,009
Meets Criteria	42	46,67	48	53,33	90	100		
House Humidity								
Does Not Meet Criteria	54	62,07	33	37,93	87	100	2,4 (1,1-5,1)	0,017
Meets Criteria	18	40	27	60	45	100		
House Temperature								
Does Not Meet Criteria	49	62,82	29	37,18	78	100	2,2 (1,1-4,6)	0,023
Meets Criteria	23	42,59	31	57,41	54	100		
Bedroom Occupant Density								
Does Not Meet Criteria	15	48,39	16	51,61	31	100	0,72 (0,3-1,6)	0,432
Meets Criteria	57	56,44	44	43,56	101	100		

DISCUSSION

Interesting findings regarding factors influencing the occurrence of Acute Respiratory Tract Infections (ARTIs) in communities around PT. LL, Aceh Besar Regency. Firstly, unhealthy air quality has a significant relationship with the occurrence of

ARTIs. Respondents exposed to unhealthy air have a higher chance of experiencing ARTIs compared to those exposed to healthy air. This factor emphasizes the importance of maintaining air quality in our surroundings to prevent ARTIs. Furthermore, gender also plays a significant role in the occurrence of



ARTIs. Males have a higher risk of experiencing ARTIs compared to females. This directs attention to specific factors that may influence the occurrence of ARTIs in the male population, such as different behaviors or environmental exposures. Additionally, age is also a significant factor in the occurrence of ARTIs.

Respondents under the age of 21 have a much higher risk of experiencing ARTIs compared to those aged 21 or older. This factor highlights the need for specific prevention efforts and better care for vulnerable populations such as children and adolescents. Interestingly, this study did not find a significant influence of educational level on the occurrence of ARTIs. However, unhealthy smoking behavior and burning garbage around the house have a significant influence on the occurrence of ARTIs. This suggests that daily habits such as smoking or burning trash can increase the risk of contracting ARTIs.

Furthermore, environmental factors such as the use of mosquito repellents, residential area, and house ventilation also influence the occurrence of ARTIs. The use of mosquito repellents, living in specific areas, and inadequate ventilation can increase the risk of ARTIs in exposed populations. However, it should be noted that other environmental factors such as indoor lighting, roof/ceiling conditions, indoor humidity, and indoor temperature were not found to have a significant influence on the occurrence of ARTIs in this study. Overall, this research provides important insights into the factors influencing the occurrence of ARTIs in communities around PT. LL, Aceh Besar Regency.

Several studies have been conducted to investigate the impact of coal combustion on respiratory health in Indonesian communities. The findings of these studies provide a deeper understanding of the negative consequences

of air pollution resulting from coal combustion on respiratory health of individuals. The study conducted by Hafsari et al., (2015). The study focuses on indoor air pollution caused by the use of biomass fuel in rural areas of Indonesia. This research found that indoor air pollution contributes to respiratory health issues such as coughing, shortness of breath, and other symptoms. These findings highlight the need for better mitigation measures to reduce exposure to indoor air pollution in communities using biomass as an energy source.

Furthermore, research conducted by Abidin et al., (2019) The study evaluated the health risks associated with air particles originating from power plants in Indonesia. The research findings indicate that exposure to air particles generated by coal combustion potentially leads to respiratory disorders and other health issues among communities living near these power plants. This study provides further understanding of the contribution of air pollution from energy sources to the respiratory disease burden in Indonesia, particularly in areas with significant mining activities. The research results suggest a correlation between mining activities and respiratory symptoms in the local population (Suryani, 2012).

Therefore, this research indicates that the negative impact of coal combustion is not only limited to air pollution generated by power plants but can also stem from the mining activities themselves. Similarly, the study conducted by Khasanah et al., (2023) The research examined the impact of combustion on the respiratory health of children in coal mining areas. The study found that children living in these areas have a higher risk of experiencing respiratory problems, such as coughing and shortness of breath, due to exposure to air pollution generated by coal mining activities. The findings emphasize the importance of

protecting vulnerable groups such as children from the negative effects of combustion on respiratory health.

The research by Gheissari et al., (2022) involving communities exposed to mining activities. The findings of this study indicate respiratory health issues among the exposed population, with more frequent respiratory symptoms reported. This study underscores the importance of protecting the health of communities living around coal mining areas. Additionally, Odo et al., (2023a) The research conducted in Jepara involving exposure to air particulates from power plants revealed a correlation between this exposure and respiratory health issues such as coughing, shortness of breath, and respiratory tract irritation. There is a need for more effective air pollution control efforts to protect the health of communities exposed to coal-fired power plant activities.

This study emphasizes the necessity of effective mitigation measures to reduce the adverse effects of coal combustion on respiratory health. These findings can serve as a basis for developing more effective prevention strategies and interventions to reduce the burden of acute respiratory infections (ARI) in the region.

CONCLUSION

Based on this study, there are several important conclusions regarding factors influencing the occurrence of Acute Respiratory Tract Infections (ARTIs) in communities residing in the vicinity of PT. LL, Aceh Besar Regency. Firstly, unhealthy air quality significantly increases the risk of ARTIs. Respondents exposed to unhealthy air have a 3.7 times higher likelihood of experiencing ARTIs compared to those exposed to healthy air. Secondly, gender also plays a significant role, with males having a 6.7 times higher likelihood of experiencing ARTIs compared to females. Thirdly, age is

also a risk factor, with respondents under the age of 21 having a 10.4 times higher likelihood of experiencing ARTIs compared to those aged 21 or older. Additionally, unhealthy smoking behavior and the practice of burning garbage around the house are also significantly associated with the occurrence of ARTIs. The use of mosquito repellents, residential area, and house ventilation also have a significant influence on ARTIs. However, there is no significant influence observed between bedroom occupancy density, indoor lighting, roof/ceiling conditions, indoor humidity, and indoor temperature on the occurrence of ARTIs. Overall, this study indicates that factors such as air quality, gender, age, smoking behavior, burning garbage, use of mosquito repellents, residential area, and house ventilation play significant roles in the occurrence of ARTIs in communities around PT. LL, Aceh Besar Regency. These findings emphasize the importance of taking appropriate measures to mitigate the identified risk factors and prevent ARTIs.

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