Journal of Health and Nutrition Research
Vol. 4, No. 2, 2025, pg. 869-881, https://doi.org/10.56303/jhnresearch.v4i2.540
Journal homepage: https://journalmpci.com/index.php/jhnr/index

e-ISSN: **2829-9760**

Ambient Air Pollution Exposure and Social Health Outcomes in Communities Near the Kawatuna Landfill, Palu, Indonesia

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ORIGINAL ARTICLES

Submitted: 29 June 2025

Accepted: 27 July 2025

Keywords:
Ambient Air Pollution, Community Health, Stress, Respiratory Disorders, Social Behavior, Landfill, Anthropological Nursing

Access this article online

Quick Response Code

ABSTRACT

Communities living near landfill sites are often exposed to high levels of ambient air pollution, which may impact their physical and psychosocial health. This study aims to explore the relationship between ambient air pollution exposure, particularly carbon monoxide (CO) and nitrogen dioxide (NO_2), and the social health outcomes of communities residing near the Kawatuna Landfill in Palu, Indonesia. A cross-sectional study involving 143 respondents was conducted using structured interviews and environmental exposure assessments. Correlation analyses, Mann-Whitney U tests, and regression models were applied to examine the relationships between air pollution exposure and respiratory disorders, smoking behavior, stress levels, and social interaction. The findings revealed a significant positive correlation between CO and NO_2 exposure and stress levels ($r=0.217$, $p = 0.022$), although the relationship was weak. No significant associations were found between air pollution exposure and smoking behavior, social interaction, or respiratory disorders in multivariate analyses. The Mann-Whitney U test indicated that individuals with respiratory disorders were exposed to higher levels of CO and NO_2 ($p = 0.038$). Ambient air pollution exposure in this community is more closely related to psychosocial stress than to physical health behaviors or social interaction. Community-based health interventions should consider the cultural context and perceived environmental risks to effectively promote health in such vulnerable populations.

Key Messages:

- This study reveals that ambient air pollution, particularly CO and NO_2 exposure, is significantly associated with increased stress levels, indicating a psychosocial impact beyond physical health risks in landfill-adjacent communities.
- The findings emphasize the need for culturally sensitive, community-based public health interventions that integrate environmental and psychosocial factors to effectively support vulnerable populations.

GRAPHICAL ABSTRACT

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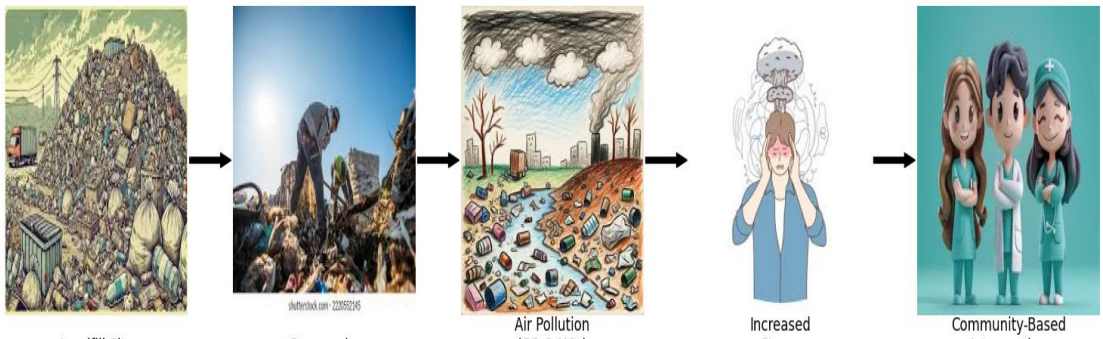

INTRODUCTION

Poor waste management has become a significant environmental issue with widespread impacts on public health, particularly for communities living near landfill sites (TPA) (1),(2). Exposure to ambient air contaminated by hazardous gases such as carbon monoxide (CO) and nitrogen dioxide (NO_2) from waste decomposition activities and open burning at landfill sites poses potential risks of both acute and chronic health problems (3). According to the World Health Organization (WHO), air pollution is responsible for approximately 4.2 million deaths annually due to long-term exposure to air pollutants, including CO and NO_2, which can trigger cardiovascular diseases, respiratory disorders, and psychosocial problems (4). This situation is especially concerning in developing countries like Indonesia, which continue to face challenges in waste management and air quality control (5).

Epidemiological data in Indonesia indicate that air pollution is one of the major risk factors contributing to increased community morbidity, particularly in environments with high levels of pollution exposure (6). According to the 2022 report from the Ministry of Environment and Forestry (KLHK), air quality around landfill sites in several major cities, including Palu City, often exceeds the ambient air quality standards, especially for CO and NO_2 parameters, which originate from burning activities and the decomposition of organic waste (7). Local studies in Palu City have shown that ambient air exposure in the Kawatuna landfill area has higher concentrations of CO and NO_2 compared to residential areas and other locations (8). This condition has been linked to increased complaints of respiratory disorders, stress, and a decline in the quality of life among the surrounding communities (9).

The urgency of this study lies in the importance of understanding the relationship between ambient air pollution exposure and the social health impacts on communities living near landfill sites. To date, research on air pollution has predominantly focused on biological or clinical effects, while social impacts such as stress, changes in smoking behavior, disruptions in social interaction, and psychosocial burdens have not been comprehensively explored in the Indonesian literature, particularly from the perspective of community nursing (10). The novelty of this study lies in its integrated approach, combining environmental aspects with the psychosocial dimensions of affected communities areas that have often been treated separately in previous research. Recent studies have begun to highlight the broader psychosocial consequences of air pollution, including Cao et al. (2023), who demonstrated the impact of air pollution on stress and anxiety in urban populations(11); Qian et al. (2021), who found associations between nitrogen dioxide exposure and reduced community cohesion(12); and Anoqye et al. (2025), who documented diminished quality of life among residents near informal waste sites(13). However, there remains a gap in localized, community-based studies that integrate environmental exposure assessment

https://doi.org/10.56303/jhnresearch.v4i2.540

with social health outcomes in Indonesia. This study aims to fill that gap by providing empirical evidence on how air pollution, particularly from landfill emissions, affects not only physical but also psychosocial well-being in vulnerable urban communities.

As part of the field of community nursing, a deep understanding of the relationship between ambient air pollution exposure and social health impacts is crucial for planning effective, community-based health promotion interventions (14). Community nurses play a strategic role in identifying environmental health risks and providing appropriate education to enhance the community's capacity to reduce exposure, manage stress, and improve their quality of life (15),(16). Furthermore, the results of this study are expected to serve as a basis for policymakers in designing mitigation programs and environmental advocacy efforts that are more responsive to the health needs of populations living near landfill sites.

Based on the above explanation, the research question posed in this study is: "What is the relationship between ambient air pollution exposure, particularly the concentrations of carbon monoxide (CO) and nitrogen dioxide (NO_2), and the social health impacts on communities living near the Kawatuna Landfill in Palu, including respiratory disorders, smoking behavior, stress levels, and social interaction?" This question is expected to address the existing knowledge gap and provide a significant scientific contribution to the development of community nursing practices that are based on environmental risk management.

METHODS

Study Design and Setting

This study employed a quantitative cross-sectional design(17) to evaluate the relationship between ambient air pollution exposure, specifically carbon monoxide (CO) and nitrogen dioxide (NO_2) concentrations, and the social health impacts on communities living near the Kawatuna Landfill in Palu City, Central Sulawesi. The study was conducted from April to May 2025, with data collection carried out across three zones: the landfill waste disposal area (landfill zone), residential areas of scavenger communities, and the landfill administrative office zone. Air quality measurements and laboratory analyses were conducted at the Laboratory of Natural Resources and Environmental Analysis, Faculty of Agriculture, Tadulako University.

Population and Sampling

The study population consisted of individuals who were directly active in the landfill area, such as landfill management staff and scavengers, who are at high risk of air pollutant exposure. A total of 143 respondents were selected using a simple random sampling technique, with the sample size determined based on Slovin's formula. The sample size was estimated using Slovin's formula with an assumed population size of approximately 250 individuals based on preliminary data from local community records, as the exact total number of residents living near the landfill was not officially documented(18),. This assumption was made to allow for adequate sample representation while maintaining statistical validity for cross-sectional analysis (17).The inclusion criteria were: (1) actively working or residing near the landfill area, (2) providing informed consent to participate as respondents, and (3) willingness to undergo health examinations and complete the questionnaire in full. Demographic data collected included residential zone, age, gender, education level, and monthly income.

Tools and Materials

Ambient air pollution exposure was measured based on two main parameters: carbon monoxide (CO) and nitrogen dioxide (NO_2). CO was measured using a calibrated Non-Dispersive Infrared (NDIR) detector, while NO_2 was measured using a spectrophotometer after air sampling with an impinger following the grab sampling method. Supporting equipment included GPS, thermometers, hygrometers, anemometers, stopwatches, and air sampling and storage equipment. Health assessments included Body Mass Index (BMI) measurements using a microtoise and digital scales, as well as blood glucose levels using a Nesco Multicheck device.

The social health impacts were assessed using the Perceived Stress Scale (PSS) to measure stress levels and a social interaction questionnaire. Additional information such as smoking behavior, types of respiratory disorders, and other reported health symptoms were also recorded. The stress score in this

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study was measured using the Perceived Stress Scale (PSS-10), a widely used standardized instrument originally developed by Cohen, Kamarck, and Mermelstein (1983). The PSS-10 consists of 10 items designed to assess the degree to which individuals perceive their lives as stressful during the past month. Each item is rated on a 5-point Likert scale ranging from 0 (*never*) to 4 (*very often*), with total scores ranging from 0 to 40. Higher scores indicate higher perceived stress. The original PSS-10 has been shown to have good psychometric properties, with internal consistency reliability (Cronbach's alpha) typically ranging from 0.78 to 0.91 in various populations. In this study, we used a Bahasa Indonesia version of the PSS-10 that has been previously validated in the Indonesian context with acceptable reliability (Cronbach's alpha = 0.84)(19).

Data Collection Procedures

Air sampling was conducted at three observation points using purposive and grab sampling methods. CO was measured directly on-site using the NDIR detector connected to sterile air bags. For NO_2, air samples were collected using impingers containing absorbing solutions and were later analyzed spectrophotometrically in the laboratory. All results were digitally recorded and standardized.

Community health assessments were carried out through structured interviews and physical examinations conducted at the respondents' homes or workplaces. Measurements included height and weight for BMI calculation, capillary blood glucose testing, and completion of stress and social interaction questionnaires. Smoking behavior was assessed based on the number of cigarettes consumed per day, while respiratory disorders were classified according to reported symptoms (such as asthma, bronchitis, shortness of breath, etc.).

Data Analysis

Data were analyzed using Python programming language with statistical libraries such as pandas, numpy, scipy.stats, and seaborn for both statistical analysis and visualization. Descriptive statistics were employed to summarize demographic characteristics, CO and NO_2 exposure concentrations, as well as the distribution of health and social variables. Correlation tests (Pearson and Spearman) were used to examine the relationships between CO and NO_2 exposure with stress scores, smoking behavior, social interaction, and respiratory disorders. The Mann-Whitney U test was used to compare ambient air exposure levels between respondents with and without respiratory disorders, as the exposure data were categorized and did not meet the assumptions of parametric tests. Multivariate linear regression was applied to identify significant predictors of stress scores, while logistic regression was used to model the occurrence of respiratory disorders as a categorical variable. All analyses were conducted at a significance level of $\alpha = 0.05$ with a 95% confidence interval. Visualization of the results was performed using scatter plots, boxplots, and heatmaps to illustrate patterns and the strength of relationships between variables.

CODE OF HEALTH ETHICS

Ethical approval for the research protocol titled "Correlation between Ambient Air Exposure and the Social Health Impact on Communities around the Kawatuna Landfill in Palu" was granted by the Ethics Committee of the Faculty of Medicine, Tadulako University. The approval is documented under statement number 9809/UN28.10/KL/2025, issued on May 2, 2025.

RESULTS

This study aimed to explore the relationship between ambient air pollution exposure, particularly carbon monoxide (CO) and nitrogen dioxide (NO_2) concentrations, and the social and health impacts on communities living near the Kawatuna Landfill in Palu. Descriptive analysis was conducted to illustrate the characteristics of respondents, air pollution exposure levels, and the prevalence of health issues such as respiratory disorders, smoking behavior, stress levels, and social interaction. The findings provide an initial overview of the social, health, and environmental conditions of the affected community, which were then further analyzed to examine deeper relationships between variables.

Table 1 presents the descriptive characteristics of the numerical variables analyzed in this study. A total of 143 respondents participated, with a mean age of 46.57 years, ranging from 21 to 73 years. Respondents' income levels varied considerably, with an average of IDR 997,202.80 per month and a

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maximum income of IDR 4,700,000.00. The average body weight was 52.22 kg, and the average height was 153.24 cm, resulting in a mean Body Mass Index (BMI) of 22.27, which falls within the normal range. The average systolic and diastolic blood pressures were 124.83 mmHg and 81.53 mmHg, respectively, indicating that most respondents had blood pressure within the normal range, although considerable variation was observed. The average blood glucose level was recorded at 120.94 mg/dL, and the mean uric acid level was 6.18 mg/dL, both within physiological limits, although some respondents presented relatively high values. Smoking behavior varied, with an average consumption of 3.41 cigarettes per day, and the mean stress score was 18.24 on a scale with a maximum of 27, indicating a moderate level of stress. The mean social interaction score was 23.29, suggesting a reasonably good level of social connectedness. Ambient air pollution exposure showed an average carbon monoxide (CO) concentration of 180.51 $\mu g/m^3$ and a nitrogen dioxide (NO_2) concentration of 28.53 $\mu g/m^3$, reflecting a significant level of air pollution in the respondents' residential environment.

Table 1. Descriptive Statistics of Numerical Variables

Variable	n	Mean	Standard Deviation	Minimum	Maximum
Respondent	143	72.00	41.42	1.00	143.00
Age (years)	143	46.57	10.27	21.00	73.00
Income (IDR)	143	997,202.80	834,970.19	200,000.00	4,700,000.00
Body Weight (kg)	143	52.22	11.38	32.00	84.00
Height (cm)	143	153.24	8.94	130.00	170.00
Body Mass Index (BMI)	143	22.27	4.29	12.00	36.00
Systolic Blood Pressure (mmHg)	143	124.83	21.07	90.00	192.00
Diastolic Blood Pressure (mmHg)	143	81.53	13.04	53.00	120.00
Blood Glucose Level (mg/dL)	143	120.94	29.68	78.00	216.00
Uric Acid Level (mg/dL)	143	6.18	1.62	4.00	12.00
Smoking Behavior (number of cigarettes)	143	3.41	6.52	0.00	36.00
Stress Score	143	18.24	4.43	5.00	27.00
Social Interaction Score	143	23.29	3.53	13.00	32.00
Ambient CO Exposure ($\mu g/m^3$)	143	180.51	7.44	160.33	183.23
Ambient NO_2 Exposure ($\mu g/m^3$)	143	28.53	0.81	26.34	28.82

Table 2. Frequency Distribution of Categorical Variables

Variable	Category	n	%
Gender	Female	105	73.43
	Male	38	26.57
Ethnicity	Kaili	129	90.21
	Javanese	4	2.80
	Kulawi	2	1.40
	Poso	2	1.40
	Makassar	2	1.40
	Bali	2	1.40
	Bugis	2	1.40
Education	Primary	72	50.35
	Junior High	30	20.98
	Senior High	36	25.17
	Diploma	3	2.10
	Bachelor	2	1.40
Occupation	Scavenger	119	83.22
	Staff	24	16.78
Residence	Near TPA	126	88.11
	Outside TPA	17	11.89
Respiratory Disorders	No	124	86.71
	Yes	19	13.29

Table 2 shows that the majority of respondents in this study were female (73.4%), while male respondents accounted for 26.6%. In terms of ethnicity, most respondents were of Kaili descent (90.2%), with other ethnic groups such as Javanese, Kulawi, Poso, Makassar, Balinese, and Bugis each comprising a very small proportion, approximately 1.4–2.8%. The respondents' education level was predominantly elementary school graduates (50.3%), followed by high school graduates (25.2%) and junior high school

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graduates (21.0%), with very few having diploma or university-level education. Most respondents worked as waste sorters or scavengers (83.2%), with only a small proportion employed as landfill site staff (16.8%). Regarding their place of residence, the majority of respondents (88.1%) lived within the landfill area, while the remainder resided outside the landfill zone. Additionally, around 13.3% of respondents were reported to have respiratory disorders, while most (86.7%) did not experience such health issues. This distribution pattern provides a strong social overview of the demographic and environmental characteristics of the respondents, which is essential in understanding the context of ambient air pollution exposure and its health impacts.

Correlation Between Ambient Air Exposure and Social Health Indicators

The correlation analysis results presented in Figure 1 show a varying relationship between ambient air pollution exposure and community social health indicators. Based on the Pearson correlation matrix, carbon monoxide (CO) and nitrogen dioxide (NO_2) exposure showed a weak positive correlation with stress levels (r = 0.192), indicating that higher exposure to CO and NO_2 tends to be associated with increased stress levels, although the strength of this relationship is low. On the other hand, air pollution exposure showed a weak negative correlation with social interaction (r = -0.124), suggesting that individuals with higher CO and NO_2 exposure tend to have slightly lower levels of social interaction. The correlation with smoking behavior was very weak and almost negligible. The Spearman correlation results showed a consistent pattern, with a positive relationship between air pollution exposure and stress levels, as well as a negative relationship with social interaction, although the strengths remained weak. Interestingly, in the Spearman correlation, the negative relationship between stress and social interaction became stronger (r = -0.259) compared to the Pearson correlation, indicating that higher stress levels are associated with lower reported social interaction. These findings provide preliminary indications that ambient air pollution exposure may influence the psychosocial dimensions of communities living near the Kawatuna Landfill in Palu; however, this relationship needs to be further investigated using more complex approaches to strengthen the evidence.

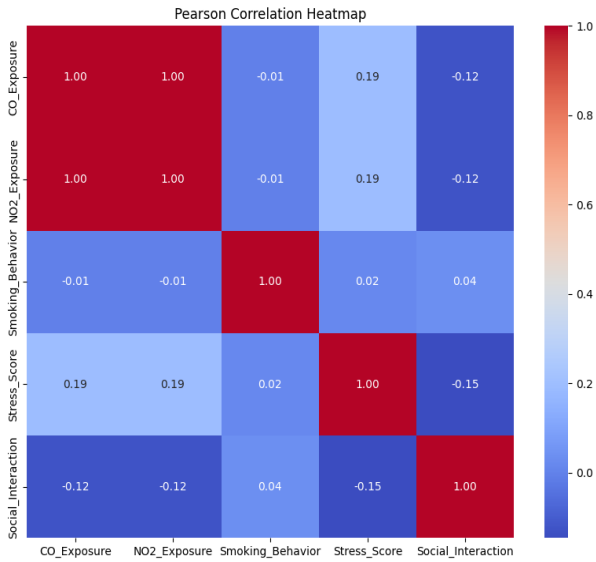

Figure 1. Pearson Correlation Matrix and Between Air Exposure and Social Health Indicators

Table 3. Bivariate Correlation Between Ambient Air Exposure and Social-Health Variables

Air Pollution Exposure	Social-Health Variable	Pearson Correlation	p-value
CO Exposure	Smoking Behavior	-0.007	0.938
NO_2 Exposure	Smoking Behavior	-0.007	0.938
CO Exposure	Stress Score	0.192	0.022
NO_2 Exposure	Stress Score	0.192	0.022
CO Exposure	Social Interaction	-0.124	0.141
NO_2 Exposure	Social Interaction	-0.124	0.141

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The results of the Pearson correlation analysis show that exposure to carbon monoxide (CO) and nitrogen dioxide (NO_2) has a very weak and non-significant relationship with smoking behavior, with a correlation coefficient of -0.007 and a p-value of 0.938. This indicates that the level of ambient air pollution exposure is not associated with smoking frequency in the studied population. Conversely, there is a significant positive relationship between CO and NO_2 exposure and stress scores, with a correlation coefficient of 0.192 and a p-value of 0.022. This suggests that higher ambient air pollution exposure is associated with higher stress levels experienced by respondents, although the strength of this relationship is considered weak. Meanwhile, the correlation between CO and NO_2 exposure and social interaction shows a negative but non-significant relationship, with a coefficient of -0.124 and a p-value of 0.141 (Table 3), indicating that air pollution exposure does not have a noticeable impact on the level of social interaction within the community. Overall, these results suggest that ambient air pollution exposure around the Kawatuna landfill tends to be more associated with psychological aspects such as stress rather than with smoking behavior or social interaction in the community.

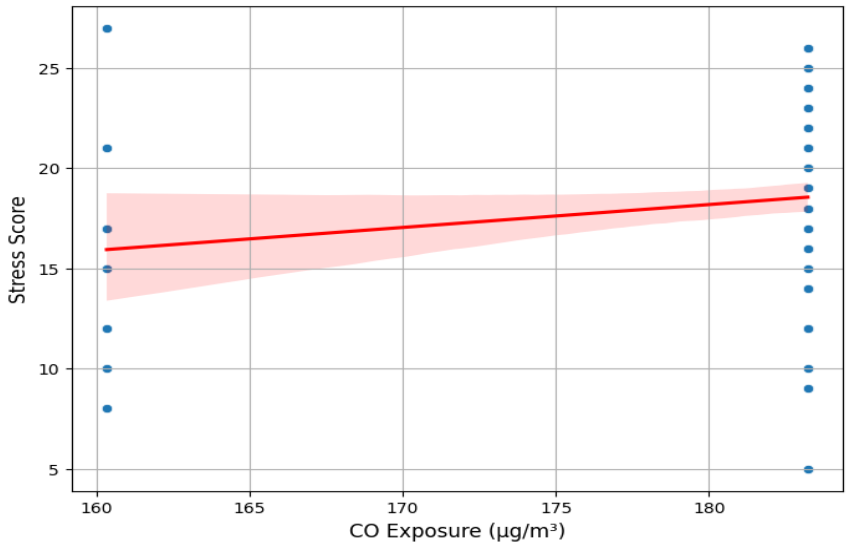

Figure 2. Scatterplot of CO Exposure and Stress Score

Figure 2 presents a scatterplot illustrating the relationship between carbon monoxide (CO) exposure and stress scores among respondents living near the Kawatuna landfill site. The observed pattern shows a tendency for increased CO concentrations in the environment to correlate with higher stress scores in individuals. Although the relationship identified in this study is weak, the scatterplot provides a visual representation indicating that as CO exposure rises, the stress levels reported by respondents also tend to increase. This pattern supports the statistical findings that demonstrate a significant association between air pollution and the community's psychosocial burden, further emphasizing the importance of community-based health interventions that take the surrounding environmental conditions into account.

Comparative Analysis of Ambient Air Exposure Based on Respiratory Health Status

The results of the Mann-Whitney test (Table 4) indicate a statistically significant difference between respondents who experienced respiratory disorders and those who did not, in terms of exposure levels to both carbon monoxide (CO) and nitrogen dioxide (NO_2). Respondents with respiratory disorders had an average CO exposure of 183.23 µg/m^3 and NO_2 exposure of 28.82 µg/m^3, while respondents without respiratory disorders had an average CO exposure of 180.51 µg/m^3 and NO_2 exposure of 28.53 µg/m^3. Before conducting the comparative analysis, the normality of the CO and NO_2 exposure data was assessed using the Shapiro-Wilk test. The results indicated that the data were not normally distributed ($p < 0.05$), thus the Mann-Whitney test was employed to compare exposure levels between groups. Although the differences in mean values appear small, the Mann-Whitney test yielded a p-value of 0.038 for both variables, indicating that this difference is statistically significant at the 95% confidence level. It is important to note that the identical test results for both variables occur because the CO and NO_2 exposure

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levels in this dataset are perfectly correlated, as they are entirely determined by the respondents' residential locations. These findings confirm that higher ambient air pollution exposure levels are more commonly experienced by those with respiratory disorders, although the specific influence of each pollutant cannot be independently separated within this dataset.

Table 4. Mann-Whitney Test Results for CO and NO_2 Exposure Based on Respiratory Disorders

Variable	Group	Mean Exposure	Mann-Whitney U	p-value
CO Exposure ($\mu g/m^3$)	With Respiratory Disorders	183.23	1374.000	0.038
	Without Respiratory Disorders	180.51		
NO_2 Exposure ($\mu g/m^3$)	With Respiratory Disorders	28.82	1374.000	0.038
	Without Respiratory Disorders	28.53		

Regression Analysis of the Impact of Ambient Air Exposure on Community Health and Behavior

To further explore the relationship between ambient air exposure and various health and behavioral outcomes in the community living near the Kawatuna landfill, several regression analyses were conducted. Logistic regression was used to assess the association between exposure to carbon monoxide (CO) and nitrogen dioxide (NO_2) with the occurrence of respiratory disorders, while linear regression was employed to examine the potential effects of air pollution exposure on smoking behavior and stress levels.

Prior to conducting the regression analyses, key statistical assumptions were tested. For linear regression, the assumption of normality was assessed using the Shapiro-Wilk test ($p > 0.05$ for residuals of smoking and stress models), indicating normal distribution of residuals. Linearity and homoscedasticity were visually evaluated using residual plots and found to be acceptable. Multicollinearity was assessed using the Variance Inflation Factor (VIF), with all predictors showing VIF values below 2.0, indicating no multicollinearity concerns. For logistic regression, multicollinearity was also checked and found to be within acceptable limits (VIF < 2.1). However, given the relatively small sample size and potential measurement error in exposure estimates, some assumptions may only be partially met, which could weaken the statistical power and predictive capacity of the models.

The regression analyses revealed that ambient air exposure, particularly CO and NO_2 concentrations, was not significantly associated with the likelihood of respiratory disorders in the community, as indicated by the non-significant logistic regression model ($p > 0.05$). Additionally, linear regression analysis showed that CO and NO_2 exposure had no significant effect on smoking behavior ($p > 0.05$), with the model explaining none of the variance in smoking habits (Adjusted $R^2 = 0\%$). Although the linear regression model for stress score reached statistical significance ($p = 0.0218$), the overall explanatory power was very low (Adjusted $R^2 = 3\%$), suggesting that CO and NO_2 exposure only had a minimal effect on stress levels in this population.

These findings collectively indicate that while some bivariate correlations appeared statistically significant, the predictive strength of ambient air exposure on health and social outcomes in this community remains limited when tested in multivariable models. These analyses provide an important overview of potential trends and highlight the need for further research with larger sample sizes, improved exposure assessment, and more robust model designs.

DISCUSSION

Air Pollution and Psychosocial Health (A Medical Anthropology Perspective)

The results of this study indicate a significant positive relationship between ambient air pollution exposure, particularly carbon monoxide (CO) and nitrogen dioxide (NO_2), and stress levels among communities living near the Kawatuna Landfill in Palu. Although the strength of the correlation is weak, this finding is important as it suggests potential psychosocial impacts experienced by the community due to the polluted environment. In the context of communities like those around the Kawatuna Landfill, air pollution is not only a physical health issue but can also lead to prolonged mental and emotional stress. This situation is further exacerbated by the community's inability to relocate due to economic constraints, leaving them continuously exposed to environmental risks that may increase their psychological burden.

Exposure to poor environmental conditions, such as living near a landfill site characterized by foul

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odors, smoke from open waste burning, and low air quality, can become a source of chronic stress for individuals in the community (20),(21). Continuous exposure to environmental stressors can significantly impact mental health and individual well-being, especially within communities that have limited adaptive resources (22). In the context of the community living around the Kawatuna landfill, daily exposure to air pollution is not only a visible health issue but also a social pressure that lowers their quality of life. Anxiety about long-term health effects, persistent discomfort, and social stigma as "landfill residents" further exacerbate their psychosocial condition. However, for many people living near the landfill, working in such dirty and high-risk environments is still considered the fastest and easiest way to earn money, despite being aware of the health hazards, foul odors, and social humiliation they may face. For them, the most important thing is to secure an income to meet their daily food needs. This harsh economic reality creates a difficult dilemma, strengthening their attachment to unhealthy environments and prolonging continuous exposure to health risks.

From the perspective of medical anthropology, community perceptions of risk and health do not always align with the biological risks measured scientifically (23),(24). Community perceptions and responses to disease are strongly influenced by cultural meanings and everyday life experiences (25). In the community around the Kawatuna landfill, air pollution has likely become part of an “accepted daily reality,” leading to its normalization. They may not prioritize exposure to pollution as a primary threat compared to their economic needs and work as waste pickers. However, even though the perceived threat is low, the psychosocial impacts—such as increased stress—remain evident, as demonstrated by the findings of this study.

In community nursing practice, it is essential to understand that health interventions in communities like this are not sufficient if limited to providing education about the dangers of air pollution. A culturally and contextually sensitive approach is needed to deliver relevant education and psychosocial support (26). This aligns with the community-based nursing approach, which emphasizes the importance of social, cultural, and environmental understanding as the foundation for planning and implementing public health programs (27). Community nurses need to act as facilitators who build trust with the community, explore their perceptions of pollution and health, and offer solutions that are socially and culturally acceptable (28).

Furthermore, it is important to emphasize that in communities such as those near the Kawatuna landfill, air pollution should be viewed as a multidimensional issue that affects physical, mental, and social health. Within the framework of the *ecological model of health behavior*, physical environments such as air pollution interact with social factors and individual behaviors in shaping health status (29),(30). In this case, effective interventions should include environmental improvements, enhanced social support, and the strengthening of mental health. Through an understanding of health anthropology and the application of community-based nursing that focuses on community empowerment, it is hoped that the psychosocial burden caused by air pollution exposure can be minimized.

Healthy Behavior and Risk Perception in TPA Community

The results showed that ambient air exposure, especially carbon monoxide (CO) and nitrogen dioxide (NO_2), did not have a significant relationship with smoking behavior and social interaction in the community around the Kawatuna landfill, Palu. This finding indicates that although the level of air pollution exposure is quite high, it does not automatically affect changes in health behavior such as reducing smoking habits or increasing or decreasing social interaction. In this context, public health behavior seems to be more influenced by deep-rooted social and cultural factors, compared to perceptions of external environmental threats.

From a health anthropology perspective, this phenomenon can be explained through the concept of risk normalization, where communities that have long coexisted with pollution sources tend to no longer perceive such exposure as a serious threat (31),(32). According to J. McEvoy et al. (2017) in the cultural theory of risk perception, risk perception is heavily influenced by the value systems, collective experiences, and social structures that prevail within a community (33). In this context, the community around the Kawatuna landfill may have internalized air pollution as an ordinary part of daily life that does not need to be avoided or controlled, thus failing to encourage changes in health behaviors such as smoking cessation.

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Moreover, culture and social habits play a crucial role in shaping the health behaviors of communities (34). In scavenger communities such as those in Kawatuna, smoking behavior may not only be viewed as a personal habit but also as part of social interaction and a coping mechanism to deal with heavy workloads and the stressful environmental conditions they face. This presents a significant challenge in community-based health promotion because interventions that focus solely on medical messages, without considering the cultural and social values of the community, are unlikely to be well accepted (35). As Kwame (2016) emphasized, health behaviors cannot be separated from the symbolic meanings, social relationships, and cultural beliefs that are deeply embedded within the community (36).

Therefore, in community nursing practice, the approach used must go beyond simply providing education about the dangers of pollution or prohibiting smoking. A culturally sensitive approach is required one that understands and respects how the community interprets air pollution, smoking behavior, and healthy lifestyles within the context of their daily lives (37). Community nurses must be able to bridge communication between modern health science and the local perspectives of the community, and encourage behavior change through trusted community leaders, culturally appropriate social activities, and interventions that actively involve the community (38).

Furthermore, the results of this study highlight the importance of developing health promotion strategies that are realistic and adaptive, taking into account the social and cultural context. In communities like those near the Kawatuna landfill, the success of health programs is not solely measured by how many individuals reduce smoking habits or avoid pollution, but also by how well the community collectively understands health risks and engages in efforts to improve their living environment. An approach based on health anthropology allows nurses and health professionals not only to "change behaviors" but also to strengthen the community's capacity to manage health risks in a sustainable manner.

This study has several limitations that must be acknowledged. First, the cross-sectional design limits the ability to establish causal relationships between air pollution exposure and psychosocial outcomes. Additionally, stress levels were measured using self-report instruments, which may be influenced by subjective biases and social desirability. The sample size and specific setting near the Kawatuna landfill also limit the generalizability of the findings to other communities facing different environmental and socio-economic conditions. Despite these limitations, the study provides important insights into the overlooked psychosocial consequences of environmental pollution, particularly in vulnerable communities. For future research, longitudinal studies are recommended to explore the long-term mental health impacts of chronic pollution exposure. It would also be beneficial to incorporate qualitative methods to capture the lived experiences, coping mechanisms, and cultural interpretations of risk among community members. Such approaches would enrich the understanding of how environmental, social, and cultural dimensions intersect to shape health outcomes and could inform more effective, community-centered public health interventions.

CONCLUSION

This study highlights the complex relationship between ambient air pollution exposure and the social health impacts experienced by communities living near the Kawatuna landfill in Palu, Indonesia. The findings indicate that exposure to carbon monoxide (CO) and nitrogen dioxide (NO_2) is significantly associated with increased stress levels, suggesting that prolonged exposure to poor environmental conditions contributes to psychosocial burdens within the community. Although no significant relationships were found between air pollution exposure and smoking behavior or social interaction, this may reflect a normalization of environmental risks and deeply rooted cultural practices that shape health behaviors independent of pollution exposure. Additionally, individuals with respiratory disorders were found to have significantly higher exposure levels to both CO and NO_2, reinforcing the health risks associated with living in close proximity to the landfill. These results underscore the importance of incorporating culturally sensitive community health interventions that address not only the physical health consequences of pollution but also the psychological and social dimensions. Future public health strategies must consider the environmental, cultural, and socioeconomic contexts to effectively mitigate the health impacts of air pollution in marginalized communities.

https://doi.org/10.56303/jhnresearch.v4i2.540

FUNDING

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

ACKNOWLEDGMENTS

The author would like to sincerely thank all respondents from the communities living near the Kawatuna landfill site in Palu for their valuable time, trust, and willingness to participate in this study. The success of this research would not have been possible without the support and assistance of the field enumerators, local health workers, and community leaders who greatly facilitated the data collection process. The author also extends appreciation to the academic supervisors, research colleagues, and the Faculty of Public Health at Tadulako University for their insightful feedback and continuous encouragement throughout the research period. Special thanks are also directed to Tadulako University for providing institutional support and to the Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia for funding this research through the 2024 DIPA BLU grant.

CONFLICTS OF INTEREST

The author declares no conflicts of interest related to the design, execution, analysis, or publication of this study. All research activities were conducted independently and objectively, without any influence from third parties or funding sources that could potentially bias the results.

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