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Distribution of Dust Exposure and Risk Factor Analysis of Symptoms of Respiratory Disorder Among Brick Industry Workers in Temanggung Regency, Central Java Province

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Abstract
The brick industry sector has the capacity to generate pollution in the form of harmful dust particles that can adversely affect the environment and workers health. The research uses a quantitative approach with an analytical observational design, cross sectional study. In addition, researchers conducted an analysis of risk factors related to respondent obiter total dust particulate levels, inhaled dust levels, working duration, exposure duration, and the utilization of personal protective equipment. The measurement results showed the average total dust level was 1748.47 µg/Nm^3 and the average respirable dust level of 75 respondents was 4.56 mg/m^3. This increases the risk of respiratory symptoms such as coughing, coughing up phlegm, and shortness of breath. Variables associated with respiratory symptoms were inhaled dust levels (p=0.023), working period (p=0.040), exposure duration (p=0.032), and use of personal protective equipment (p=0.015). The multivariate test resulted in four significant variables: inhaled dust level (p=0.022), working period (p=0.039), exposure duration (p=0.029), and use of personal protective equipment (p=0.023). In conclusion, the combination of inhaled dust levels, longer work periods, exposure duration, and inadequate use of PPE increased respiratory symptoms in workers by 99.5%.
Keywords: *dust exposure, symptoms of respiratory disorder, brick industry workers*

Abstrak
Sektor industri batu bata berpotensi menimbulkan pencemaran berupa partikel debu berbahaya yang dapat mengganggu lingkungan dan kesehatan pekerja. Penelitian ini menggunakan pendekatan kuantitatif dengan rancangan analitik observasional, studi *cross sectional*. Selain itu, peneliti melakukan analisis faktor risiko yang berhubungan dengan kadar debu total, kadar debu terhirup, masa bekerja, lama pajanan, dan penggunaan alat pelindung diri. Hasil pengukuran menunjukkan rata-rata kadar debu total sebesar 1748.47 µg/Nm^3 dan rata-rata kadar debu terhirup dari 75 responden sebesar 4.56 mg/m^3. Hasil pengukuran menunjukkan rata-rata kadar debu total adalah 1748.47 µg/Nm^3 dan rata-rata kadar debu terhirup dari 75 responden adalah 4.56 mg/m^3. Hal ini meningkatkan risiko terjadinya gejala gangguan pernapasan seperti batuk, batuk berdahak, dan sesak napas. Variabel yang terkait dengan gejala gangguan pernapasan adalah kadar debu terhirup (p=0.023), masa kerja (p=0.040), lama pajanan (p=0.032), dan penggunaan alat pelindung diri (p=0,015). Uji multivariat menghasilkan empat variabel yang signifikan yaitu kadar debu terhirup (p=0.022), durasi kerja (p=0.039), lama pajanan (p=0.029), dan penggunaan alat pelindung diri (p=0.023). Kesimpulannya, kombinasi kadar debu terhirup, masa kerja lebih lama, lama pajanan, dan penggunaan APD tidak memadai meningkatkan gejala gangguan pernapasan pada pekerja sebesar 99.5%.
Kata Kunci: *pajanan debu, gejala gangguan pernapasan, pekerja industri bata*

1. Introduction

The brick industry is classified as an informal sector under the employment industry. Informal sector workers need more precise data indicating the extent of danger they encounter and the frequency of injuries or accidents they experience.[1] However, this does not imply that brick industry workers do not encounter any risks. The brick-making process generates air pollution due to the combustion of diverse materials like husks and sawdust, resulting in significant dust emissions from the burning substances.[2]

The informal sector needs more accurate data regarding the quantity of workers, the hazards encountered, the prevalence of injuries or accidents, and other relevant information [3]. However, this does not imply that brick producers are not exposed to any hazards. The brick business is a significant contributor to air pollution. The red brick industry emits pollutants in the form of particulate matter and gasses during the process of brick combustion. These contaminants are found in the workplace, exposing workers to varying levels and sizes [4].

Kembangarum Village in Demak is a prominent hub for labor-intensive industries, particularly the brick-making industry. Nearly half of the village's population is engaged in brick-making, either as their primary occupation or as a part-time job [5]. Nganjuk Regency, specifically Ngronggot Subdistrict, is home to a traditional brick-making hub. The process involves using clay or loamy soil that has been washed, moistened, and shaped into a checkerboard pattern [6]. Following the molding process, the bricks are sun-dried until they reach a state of dryness, after which they are organized and subjected to burning. During the firing process, workers are required to remain at the site and regularly add fuel in the form of firewood, corncobs, husks, or sawdust [7].

Workers in the brick industry engage in many stages of work, including excavating the soil, processing raw materials, shaping the bricks, drying them, firing them, sorting them, and ultimately selling them [8]. The essential equipment required for brick production comprises rectangular brick molds [9]. The brick-producing process occurs with a frequency of 8-12 times each month, and the duration of burning lasts for 1-2 days. Weather conditions and the amount of rainfall influence the specific length of time for burning. Brick burning necessitates a substantial amount of fuel, such as tree waste derived from husks, leaves, dried branches, and in some instances, coal [8]. Smoke and combustion residues, in the form of dust, can lead to respiratory tract irritation, inflammation, deposition in the alveoli, or reaction with fluids in the alveoli. The effects on the respiratory tract of workers depend on the chemical properties of these particulates and can interfere with normal respiratory function [10].

The symptoms of respiratory disorder develop gradually as a result of the steady buildup of exposure inhaled into the lungs [11]. In addition to environmental exposure, the symptoms of respiratory distress can be affected by various factors related to the workers themselves, including age, gender, history of pulmonary disease, duration of exposure, smoking habits, length of service, and the use of personal protective equipment such as masks or cloth [5].

2. Material and Methods

The research uses a quantitative approach with an analytical observational design, specifically a cross-sectional study. It examines several variables: total dust particulate levels, inhaled dust levels, working duration, exposure duration, and the utilization of personal protective equipment. The Haz-Duzt EPAM 5000 measuring instrument was utilized to assess total dust levels, and Personal Dust Sampler Aircheck Sampler Model 224 PCXR8 - SKC was used to evaluate respirable dust levels. The technique of collecting data directly from research subjects by conducting face-to-face sessions by providing questions sequentially following the Modified Medical Research Council (MMRC) questionnaire sheet which was created to obtain data that is in accordance with research needs. The population of interest for this study consists of 75 individuals who are employed in the brick industry in Tegowanuh Village, Temanggung Regency, Central Java Province.

The sampling strategy employed in this investigation utilized the total sampling methodology. This study data analysis involves several steps: univariate analysis to evaluate the characteristics of each variable, bivariate analysis to determine the association between independent and dependent variables using the Chi-Square test with a 0.05 significance level, and multivariate analysis to explore the more significant associations between the independent and dependent variables[12], [13]. The research was conducted in Kaloran District, Temanggung Regency, Central Java Province. The location points will be explained with the following map:

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Figure 1. Administrative Map of Temanggung Regency

3. Results and Discussion

Overview of Measurement Results of Total Dust Particulate Levels in Brick Industry Areas

Figure 2 is a map of total dust pollution conditions in the brick industry area. The average level of total particulate dust at thirteen points in the industry of Tegowanuh District, Temanggung Regency is 1748.47 µg/Nm^3. The highest particulate level was at point 11 with a level of 8008.89 µg/Nm^3 and the lowest particulate level was at point 3 with a level of 212.12 µg/Nm^3. The average air temperature at the thirteen points was 40.6ºC and the average humidity was 38.2%.

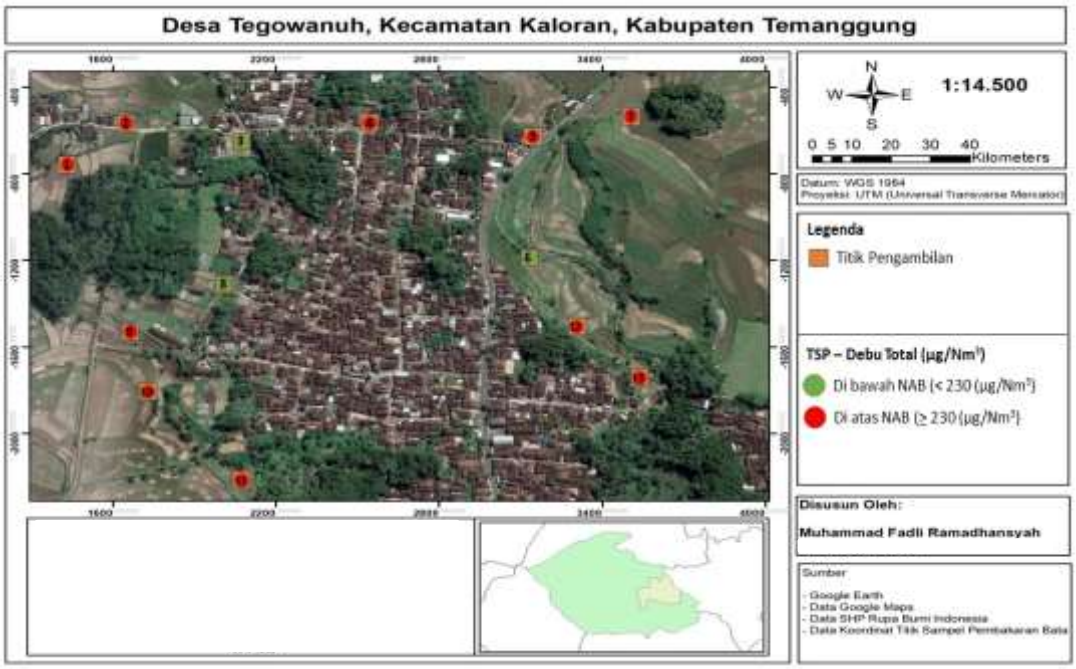

Figure 2. Total Dust Levels Distribution Map

Respondents in this study totaled 75 brick industry workers in Tegowanuh Sub-District, Kaloran District, Temanggung Regency. Based on the results of measurements on respondents, it shows that workers who have symptoms of respiratory problems based on the MMRC questionnaire with a cutoff are 37 people (50.7%), while workers who are declared asymptomatic are 38 people with a percentage (49.3%). The results of the study can be seen in the following table.

Table 1. Distribution Frequency of Symptoms of Respiratory Disorders of Respondents in Tegowanuh Sub-District, Kaloran District, Temanggung Regency 2022

Symptoms of Respiratory Disorder Category	Frequency	Percentage (%)
Symptomatic	37	49,3
Not Symptomatic	38	50,7
Total	75	100

Various factors, such as the utilization of personal protection equipment, can impact the occurrence of respiratory disorder in workers in dusty environments. Symptoms of respiratory disorder are influenced by circumstances that are beyond our control, such as age and a pre-existing respiratory ailment. Self-restraint can avoid respiratory symptoms [14].

Risk Factor Analysis of Dust Exposure with Symptoms of Respiratory Disorder

The independent variables, which include total dust levels, inhaled dust levels, working period, exposure duration, and use of personal protective equipment, will be tested against the dependent variable, which is respiratory symptoms. In the data analysis, a Chi-Square test with a p-value of less than 0.05 will indicate a significant association.

Table 2. Association Between Risk Factors and Symptoms of Respiratory Disorders in Brick Industry Workers in Tegowanuh Sub-District in 2022

No	Variable	Symptoms of Respiratory Disorder n= 75		*p-value*	95 % CI	
					Lower	Upper
	Total Dust Particulate Levels					
1	≥ 230 µg/Nm^3	31 (53,4%)	27(46,6%)	0,298	0,762	3,010
	< 230 µg/Nm^3	6 (35,3%)	11 (64,7%)			
	Inhaled Dust Levels					
2	≥ 3mg/m^3)	32 (58,2%)	23 (41,8%)	0,023*	1,055	5,135
	< 3mg/m^3)	5 (25,0%)	15 (75,0%)			
	Working Period					
3	≥ 10 Years	32 (57,1%)	24(42,9%)	0,040*	0,990	4,765
	< 10 Years	5 (26,3%)	14 (73,7%)			
	Exposure Duration					
4	≥ 7 hours/day	30 (58,8%)	21 (41,2%)	0,032*	1,038	3,919
	< 7 hours/day	7 (29,2%)	17 (70,8%)			
	Usage of Personal Protective Equipment					
5	Not Obey	24 (64,9%)	13 (35,1%)	0,015*	1,149	3,128
	Obey	13 (34,2%)	25 (65,8%)			

The research revealed that 31 (53.4%) of the 58 respondents exposed to total dust levels exceeding the quality limit of 230 µg/Nm^3 reported experiencing respiratory symptoms. Among the responders exposed to total dust levels below the quality threshold of 230 µg/Nm^3, 6 respondents (35.3%) reported experiencing symptoms of respiratory disorder.

The study results of the variable inhalation dust levels indicated that out of the 55 respondents exposed to inhalation dust levels exceeding the quality requirement of 3 mg/m^3, 32 respondents (58.2%) reported experiencing symptoms of respiratory disorder. Among the respondents who were exposed to inhaled dust below the quality threshold, 5 individuals (25.0%) reported experiencing symptoms of respiratory disorder.

The analysis of the working period variable revealed that out of the 56 respondents who were exposed to inhaled dust for more than 10 years, 32 respondents (57.1%) reported experiencing symptoms of

respiratory disorders. Among responders with a work term of less than 10 years, 5 respondents (26.3%) reported experiencing symptoms of respiratory disorder.

The study results for the exposure duration revealed that out of the 51 respondents who were exposed to more than 7 hours per day, 30 respondents (58.8%) reported experiencing signs of respiratory distress. Among the responders who were exposed to less than 7 hours per day, 7 respondents (29.2%) reported experiencing signs of symptoms of respiratory disorder.

The research results on the variable usage of Personal Protective Equipment indicate that out of the 37 respondents who did not wear personal protective equipment, 24 of them (64.9%) reported experiencing symptoms of respiratory disorder. Out of the responders who used Personal Protective Equipment, 13 respondents (34.2%) reported experiencing symptoms of respiratory disorder.

Association Between Total Dust Levels and Symptoms of Respiratory Disorder

The statistical analysis revealed that there was no significant correlation between the amounts of total dust particulates and the occurrence of respiratory symptoms (p-value = 0.298; RP = 1.514; 95% CI = 0.762 - 3.010). This indicates that respiratory symptoms are not caused by brick industry workers who are exposed to total dust levels over the Threshold Value.

Combustion dust, which consists of organic components like wood, husks, and leaves, can be visually observed by researchers during the combustion process. This can elicit physiological responses, particularly in the eyes, nose, and throat. The physiological responses experienced by researchers while measuring dust concentrations include irritated and watery eyes, an itchy nose, and general discomfort. This is followed by a bit of soreness in the throat due to continual exposure during the measurement process. Nevertheless, an increased amount of overall dust particles can pose a threat to the workers themselves. As workers are more exposed to dust particulates, the accumulation of dust will also increase with time [15].

The findings of this study contradict the research conducted by Fatimah et al. in 2018, which established a correlation between high levels of total dust particulates and impaired respiratory function (p = 0.020; RP = 2.280; 95% CI = 1.078 - 4.821). The dust level of 290 µg / Nm^3 observed in this study exceeded the threshold value of 230 µg / Nm3. The health condition of workers can lead to variances in the clinical abnormalities observed in individuals exposed to the same dose of dust [16].

Combustion activities in the brick industry in Tegowanuh Sub-District create a highly dusty working environment. The combustion smoke present in stacks of incinerated bricks generates a significant amount of particulate matter. Workers can breathe these dust particles, which may cause respiratory symptoms such as coughing, mucus production, and difficulty breathing. This is because dust is hot and irritating to human respiratory organs [17].

Efforts to prevent and mitigate the health effects of total dust on workers require controlling variables that trigger respiratory symptoms and implementing the Trae System dust capture devices. This system involves gradually introducing dust into a room filled with water, allowing it to settle from top to bottom. The furnace owner can fabricate this equipment, and it is an affordable system. Nevertheless, the utilization of the trae system does not eliminate the potential for inefficient operation, as it is contingent upon additional variables such as wind speed and wind direction. Therefore, there is a requirement for a novel and uncomplicated technology that can effectively mitigate the dust levels produced during the brick-burning process and can be easily manufactured or acquired by industry proprietors.

Association Between Inhaled Dust Levels and Symptoms of Respiratory Disorder

Statistical tests have shown a significant link between exposure to inhaled dust and respiratory symptoms among brick industry workers in Tegowanuh Sub-District, Kaloran District, Temanggung Regency. The findings reveal that workers exposed to inhaled dust levels above the threshold of 3 mg/m^3 are 2.373 times more likely to experience respiratory symptoms compared to those exposed to lower levels. The relative risk (RP) value is 2.373 (RP>1) with a 95% Confidence Interval (CI) of 1.055 - 5.135, indicating that exposure to respirable dust significantly increases the risk of respiratory disorders.

The findings from field observations revealed that workers in the brick industry in Tegowanuh Sub-District, Kaloran Subdistrict, Temanggung Regency, are exposed to dust inhalation during the production process. Furthermore, employees are also exposed to the inhalation of particulate matter originating from the work environment. During the combustion process, workers who do not wear masks are often in close proximity to the furnace. Regarding workers who wear masks, the masks they use are unsuitable as they are constructed from discarded clothing or cloth that can be washed. Consequently, these masks fail to effectively filter out dust, thereby increasing the workers' risk of dust exposure. Inhaled dust particles that

enter the respiratory system can accumulate in the lungs, posing a risk for workers to develop symptoms of respiratory disorder.

In 2018, a study revealed revealed that 35 (97.22%) respondents experienced symptoms of respiratory disorder due to dust levels beyond the threshold value of 3 mg/m^3. This was observed among workers who were exposed to high dust levels in their settings. Meanwhile that 4 respondents (66.7%) reported experienced symptoms of respiratory disorder that were below the threshold value of 3mg/m^3[15].

The brick industrial region in Tegowanuh Sub-District, Kaloran District, Temanggung Regency, is believed to have high levels of total dust particles, resulting in a significant risk of inhaling dust. Thirteen measurements of total dust levels were conducted at different places to assess the variable levels of inhalable dust exposure produced by each point and combustion furnace. The primary cause of dust generation is the combustion process, which involves the use of fuel such as wood, husks, twigs, and leaves. This process emits significant quantities of smoke and dust particles, which disperse in industrial areas.

The concentration of dust inhaled by workers is directly influenced by the physical environmental circumstances in which they do their tasks. High levels of dust in the environment are indicative of a correspondingly high level of dust exposure for workers. In addition, the duration of labor, duration of exposure, and the worker's utilization of personal protective equipment are all factors associated with the inhalation of dust. As the duration of a person's exposure in an area increases, so does the concentration of dust that the worker can breathe in. Similarly, personal protection equipment (PPE) serves as a safeguarding device that aims to avoid and reduce worker's contact with dust particles.

Association Between Working Period and Symptoms of Respiratory Disorder

The statistical tests confirm a strong correlation between the length of service and the occurrence of respiratory problems among brick industry workers in Tegowanuh Sub-District, Kaloran District, Temanggung Regency. The p-value is 0.040, the relative risk (RP) is 2.171, and the 95% confidence interval (CI) is from 0.990 to 4.765. The value RP = 2.171 indicates that brick industry workers who have worked for more than 10 years are 2.171 times more likely to experience symptoms of respiratory difficulties compared to workers who have worked for less than 10 years. The RP value is 2.171, indicating that exposure to inhaled dust is a risk factor for symptoms of respiratory disorder.

The working periode is one of the causes can have either a beneficial or detrimental impact on performance. The longer the working period, the more expertise you will acquire, resulting in a beneficial impact on your performance. Conversely, an extended duration of employment may have detrimental effects on workers' health, particularly if they are exposed to a dusty environment for prolonged periods [18], [19].

Working period refers to the duration or frequency of a person's contact with dust. The longer the duration of exposure, particularly at high concentrations, the greater the likelihood of respiratory issues arising.[20] Exposure to high quantities of dust in work locations for extended periods can have harmful effects. Inhaled dust can lead to respiratory irritation, resulting in symptoms such as coughing, shortness of breath, and sneezing [21].

The same findings of this study demonstrates a significant correlation (p=0.002) between working period and respiratory illnesses [22]. In a study conducted in Tehran Province in 2020, it was discovered that the duration of work does not have a direct impact on respiratory disorders. This is because the pollutants that enter the respiratory tract do not trigger immediately a reaction but instead require a prolonged period. Therefore, individuals who work in hazardous environments over an extended period are more likely to develop health problems [23].

Action to mitigate the risks associated with dust exposure include providing industrial combustion workers with sufficient rest and flexible working hours, mainly if they have been working for more than 10 years. This ensures that they do not spend excessive time in the industrial environment once their tasks are completed. Colleagues in the industrial sector can coordinate the work schedules of individual workers who perform their tasks in a single location in order to minimize the likelihood of respiratory problems among workers. In addition, other measures to mitigate the likelihood of respiratory symptoms in workers with a work history of > 10 years include conducting periodic health examinations, utilizing personal protective equipment, and embracing a healthy lifestyle encompassing physical exercise and sufficient rest [24],[25].

Association Between Exposure Duration and Symptoms of Respiratory Disorder

Statistical tests confirm a significant correlation between exposure duration and respiratory symptoms among brick workers in Tegowanuh Sub-District, Kaloran District, Temanggung Regency. The p-value of 0.032 indicates a strong level of statistical significance. The Prevalence Ratio (PR) is 2.017,

meaning that workers with longer exposure times are more than twice as likely to experience respiratory symptoms. The 95% Confidence Interval (CI) ranges from 1.038 to 3.919, showing the likely range of the actual prevalence ratio. An RP value of 2.017 (RP > 1) indicates that brick industry workers who work more than 7 hours per day are 2.017 times more likely to experience respiratory disorders compared to those who work less than 7 hours per day.

Exposure duration refers to the duration that an individual spends in a particular occupational setting. Workers in the brick sector often work for a minimum of 3 hours and a maximum of 18-24 hours every day, depending on the nature of their tasks. Extending working hours can lead to significant inefficiencies and potentially contribute to the development of health issues resulting from prolonged exposure in the work environment [26].

According to Law No. 11 of 2020 on Job Employment, the maximum working hours are 7 hours per day or 40 hours per week for those working 6 days a week [27]. He longer workers are on the job, the more they are exposed to dust, increasing the likelihood of lung function disorders. However, this risk also depends on factors such as the dust concentration, each individual's clearance mechanism, the chemical nature of the dust, dust particle size and content, and individual susceptibility [28].

In 2017, the same research revealed a significant association between the duration of daily employment and respiratory illnesses (p = 0.003, OR 5.304) [29]. Another research in 2019 revealed that those who engaged in employment for more than 7 hours each day had symptoms. The individual experiences respiratory issues as a consequence of neglecting to utilize personal protective equipment and engaging in smoking while at work. This leads to the buildup of chemicals and dust in the body, which cannot be eliminated from the respiratory organs [30].

Other studies have demonstrated that the utilization of personal protective equipment, such as masks, effectively filters dust particles of different sizes, thereby reducing the inhalation of dust and preventing the buildup of dust in the lungs and respiratory tract [31]. Consequently, this reduces the likelihood of experiencing respiratory symptoms [32],[33].

Furthermore, in order to mitigate the respiratory problems among workers who work either more than 7 hours or less than 7 hours per day, it is recommended to implement preventive measures such as utilizing personal protection equipment, namely wearing a mask. This practice can effectively minimize the workers' exposure and inhalation of dust particles. It is reduced in order to lessen the chance of acquiring an acute respiratory infection [32],[34].

Association Between the Usage of Personal Protective Equipment and Symptoms of Respiratory Disorder

Workers utilization of personal protective equipment is intricately linked to safeguarding themselves from potential exposure to entering dust particles, based on their respective sizes. The personal protection equipment associated with this study includes masks, long-sleeved shirts, long pants, gloves, glasses, caps, and boots. Cloth masks are less effective as they allow dust and smoke from combustion to enter the respiratory system [35].

The statistical analysis confirms a significant correlation between using personal protective equipment (PPE) and respiratory symptoms among brick industry workers in Tegowanuh Sub-District, Kaloran District, Temanggung Regency. The p-value is 0.015, the RP (Relative Proportion) is 1.896, and the 95% Confidence Interval ranges from 1.149 to 3.128. The RP value of 1.896 indicates that red brick industry workers who wear improper personal protective equipment are 1.896 times more likely to get respiratory symptoms than workers who wear masks while working.

The respondents primarily wear long sleeves, pants, and gloves for their work. However, they choose not to wear masks due to discomfort, such as tightness and heat. Additionally, 38 participants reported using complete personal protective equipment (PPE) throughout their employment. The primary focus when using PPE is the utilization of masks to minimize the potential for direct exposure to sources of pollution.[36] However, the masks employed include medical masks, discarded garments, or cloth masks that may be laundered for reuse. Using personal protective equipment (PPE) in the form of masks does not guarantee protection against exposure to dust and smoke from combustion, as the PPE may not effectively filter out the dust. Protective equipment is crucial to reduce the entry of potentially harmful substances into the body during work, mainly through inhalation and skin contact.

Minister of Health Regulation No. 48 of 2016 includes occupational health standards to enhance occupational health by increasing knowledge in this field. The aim is for health workers, including those

from community health centers, to provide information and education on the appropriate use of masks and the potential health consequences of working in dusty environments [37].

Respiratory symptoms may occur because workers either neglect to use or do not properly use personal protective equipment (PPE), such as masks, while working [38]. Another research study in 2018 found that using PPE can be an effective early measure to prevent workplace accidents and diseases. It is recommended to implement basic occupational safety and health policies to reduce the incidence of work-related diseases, especially those caused by dust [32].

Multivariate Analysis

The study utilized multivariate analysis, specifically logistic regression, to assess the influence of several independent variables (such as total dust particulate levels, respirable dust levels, work duration, exposure length, and use of personal protective equipment) on the dependent variable, which is the presence of symptoms of respiratory disorder. The bivariate analysis results indicated that four independent variables met the criteria for inclusion in the multivariate modeling, with a p-value of less than 0.25. These variables are the level of inhaled dust (p-value = 0.023), the duration of the working period (p-value = 0.040), the length of exposure (p-value = 0.032), and the use of personal protective equipment (PPE) (p-value = 0.015).

In this logistic regression analysis, the enter method assesses the probability of each variable causing respiratory symptoms. Variables are entered one by one to determine their impact. Then, all variables are entered together to evaluate the combined probability of causing respiratory symptoms. Variables with a p-value greater than 0.05 are sequentially excluded, starting with the variable with the most significant p-value.

Table 3. Results of Multivariate Analysis of Inhaled Dust Level Variables

Variable	B	Sig.	Exp(B)	95 % CI
Inhaled Dust Level	1,429	0,014	4,174	(1,328 – 13,119)

The **Table 3** shows that the inhaled dust level variable has a p-value of 0.014, an Exp (B) value of 4.174, and a 95% Confidence Interval (CI) of 1.328 – 13.119. This indicates that inhalable dust levels above the threshold increase the risk of respiratory symptoms by 4.174 times. The probability of brick industry workers experiencing respiratory symptoms can be calculated using the following formula:

$$P = \frac{1}{1+e^{-(\alpha+\beta 1x1+\beta 2x2+\cdots+\beta pxp)}}$$

$$P = \frac{1}{1+2{,}718^{-(1{,}429)}}$$

$$P = \frac{1}{1+0{,}239583}$$

$$P = \frac{1}{1{,}239583}$$

$$P = 0{,}806$$

Workers with inhaled dust levels exceeding the Threshold Value (>3 mg/m^3) have an 80.6% probability of experiencing respiratory symptoms compared to workers exposed to inhalable dust levels below the Threshold Value (< 3 mg/m^3).

Table 4. Result of Multivariate Analysis of Working Period Variables

Variable	B	Sig.	Exp(B)	95 % CI
Working Period	1,317	0,025	3,733	(1,182 – 11,792)

The results in **Table 4** show that the work period variable has a p-value of 0.025 with an Exp (B) value of 3.733 and a 95% Confidence Interval (CI) = 1.182 – 11.792, which indicates that work experience more than 10 years has a 3.733 times greater risk of experiencing symptoms of respiratory disorders. The probability of brick industry workers experiencing symptoms of respiratory disorders can be calculated using the following formula:

$$P = \frac{1}{1+e^{-(\alpha+\beta 1x1+\beta 2x2+\cdots+\beta pxp)}}$$

$$P = \frac{1}{1+2{,}718^{-(1{,}317)}}$$

$$P = \frac{1}{1+0{,}267974}$$

$$P = \frac{1}{1{,}267974}$$

$$P = 0{,}788$$

Workers with > 10 working period have a 78.8% probability of experiencing symptoms of respiratory disorder compared to workers with < 10 working period.

Table 5. Result of Multivariate Analysis of Exposure Duration Variables

Variable	B	Sig.	Exp(B)	95 % CI
Exposure Duration	1,244	0,019	3,469	(1,224 – 9,835)

The results in **Table 5** show that the length of the exposure variable has a p-value of 0.019 with an Exp (B) value of 3.469 and a 95% Confidence Interval (CI) = 1.224 – 9.835 which indicates that exposure time more than 7 hours/day has a risk of 3.469 times greater to experience symptoms of respiratory disorders. The probability of brick industry workers experiencing symptoms of respiratory disorders can be calculated using the following formula:

$$P = \frac{1}{1+e^{-(\alpha+\beta 1x1+\beta 2x2+\cdots+\beta pxp)}}$$

$$P = \frac{1}{1+2{,}718^{-(1{,}244)}}$$

$$P = \frac{1}{1+0{,}288266}$$

$$P = \frac{1}{1{,}288266}$$

$$P = 0{,}776$$

Workers with exposure duration more than 7 hours/day have a 77.6% probability of experiencing respiratory symptoms compared to workers who work less than 7 hours/day.

Table 6. Results of Multivariate Analysis of Personal Protective Equipment Use Variables

Variabel	B	Sig.	Exp(B)	95 % CI
Usage of PPE	1,267	0,009	3,550	(1,371 – 9,191)

The results in **Table 6** show that the use of PPE has a p-value of 0.009 with an Exp (B) value of 3.550 and a 95% Confidence Interval (CI) = 1.371 – 9.191 which indicates that incomplete use of PPE has a 3.550 times greater risk of experiencing symptoms of respiratory disorders. The probability of brick industry workers experiencing respiratory symptoms can be calculated using the following formula:

$$P = \frac{1}{1+e^{-(\alpha+\beta 1x1+\beta 2x2+\cdots+\beta pxp)}}$$

$$P = \frac{1}{1+2{,}718^{-(1{,}267)}}$$

$$P = \frac{1}{1+0{,}281712}$$

$$P = \frac{1}{1{,}281712}$$

$$P = 0{,}780$$

Workers who use incomplete PPE have a 78% probability of experiencing respiratory symptoms compared to workers who use complete PPE.

Table 7. Results of First Model Multivariate Data Analysis

No	Variable	B	Sig.	Exp(B)	95 % CI
1.	Inhaled Dust Levels	1,518	0,022	4,561	(1,241 – 16,761)
2.	Working Periode	1,399	0,039	4,051	(1,076 – 15,254)
3.	Exposure Duration	1,320	0,029	3,744	(1,144 – 12,255)
4.	Usage of PPE	1,263	0,023	3,535	(1,194 – 10,465)
	Constant	-2,468	0,006	0,085	

The final model of multivariate data analysis revealed that four variables significantly influence respiratory symptoms in brick industry workers in Tegowanuh Sub-District, Kaloran District, Temanggung Regency. These variables include inhaled dust levels (p-value = 0.022), working period (p-value = 0.039), exposure duration (p-value = 0.029), and use of personal protective equipment (p-value = 0.023).

The likelihood of respiratory symptoms occurring in brick industry workers can be determined by applying the following mathematical equation:

$$P = \frac{1}{1+e^{-(\alpha+\beta 1x1+\beta 2x2+\cdots+\beta pxp)}}$$

$$P = \frac{1}{1+2{,}718^{-(1{,}518+1{,}399+1{,}320+1{,}263)}}$$

$$P = \frac{1}{1+2{,}718^{-(5{,}505)}}$$

$$P = \frac{1}{1{,}0040687103}$$

$$P = 0{,}995$$

Brick industry workers in Tegowanuh Sub-District, located in Kaloran Subdistrict of Temanggung Regency, face a significantly elevated risk of respiratory issues. This risk, a staggering 99.5% increase in the likelihood of experiencing symptoms of respiratory disorder, is associated with several factors. These include exposure to dust levels that exceed safety thresholds, working in the industry for more than ten years, daily dust exposure lasting over seven hours, and inadequate use of personal protective equipment. The combination of these conditions creates a hazardous work environment that substantially impacts the respiratory health of these workers.

After conducting multiple rounds of multivariate modeling and removing variables with a significance value greater than 0.025, we obtained the final multivariate analysis model. In this model, the primary variable is the level of respirable dust, which has an Exp (B) value of 4.561. Workers exposed to respirable dust concentrations exceeding the established Threshold Value of 3 mg/m^3 face a significantly higher health risk. Specifically, these individuals are 4.561 times more likely to develop symptoms of respiratory disorder than their counterparts who work in environments where dust levels remain below this critical threshold. This stark difference in risk underscores the importance of maintaining dust levels within safe limits to protect workers respiratory health in such industrial settings.

If brick industry workers are exposed to respirable dust levels surpassing the quality standard (> 3 mg/m^3), work for more than ten years, have daily exposure over 7 hours, and do not utilize complete personal protective equipment, there is a 99.5% chance that they will experience symptoms of respiratory disorder. The study yielded a significant value, indicating that there is no correlation between respiratory symptoms and total dust levels, smoking behaviors, and age, as determined by the findings of the multivariate analysis. This study demonstrates that inhalation of dust by workers in the brick sector can indirectly lead to the development of respiratory problems in workers from Tegowanuh Sub-District, Kaloran District, Temanggung Regency.

4. Conclusion

The findings revealed that several elements significantly contribute to respiratory issues, including inhaled dust levels, working period, the exposure duration, and the use of personal protective equipment. Interestingly, total dust particulate levels were not found to be associated with respiratory disorder symptoms. Four variables were specifically identified as triggers for respiratory symptoms in brick industry workers in Tegowanuh Sub-District, Kaloran District, Temanggung Regency: inhaled dust levels ($p = 0.022$), length of work ($p = 0.039$), exposure duration ($p = 0.029$), and personal protective equipment usage ($p = 0.023$). Among these, inhaled dust level emerged as the most significant factor, with an Exp (B) value of 4.561. When considering these four variables collectively, the risk of symptoms of respiratory disorder may increase by up to 99.5%.

5. References

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