



RISK FACTORS AFFECTING PULMONARY DISORDERS OF WORKERS IN INDONESIA: LITERATURE REVIEW 2017-2022

Dessy Widiyaristi¹, Elvi Sunarsih^{2*}, Rostika Flora³, Yuanita Windusari⁴, Mohammad Zulkarnain⁵, Suheryanto⁶

^{1,2,3,4}Fakultas Kesehatan Masyarakat, Universitas Sriwijaya, Jl. Palembang-Prabumulih KM 32 Ogan Ilir, 30662, Indonesia

⁵Fakultas Kedokteran, Universitas Sriwijaya, Jl. Sriwijaya Negara, Bukit Lama, Kec. Ilir Barat. I, Kota Palembang, South Sumatera, 30139, Indonesia

⁶Fakultas Ilmu Pengetahuan Alam, Universitas Sriwijaya, Jl. Palembang-Prabumulih KM 32 Ogan Ilir, 30662, Indonesia

*Correspondence Author: elvisunarsih@fkm.unsri.ac.id

ARTICLE INFO

Article History:

Received : March 03, 2023

Accepted : November 03 , 2023

Published: November 20, 2023

DOI:

<https://doi.org/10.26553/jikm.2023.14.3.263-280>

Available online at

<http://ejournal.fkm.unsri.ac.id/index.php/jikm>

ABSTRACT

Pulmonary disorders in 2018 entered the 5th rank as a disease that causes death. Dust and gas are air pollutants that have a high level of toxicity in the environment when entering and accumulating in human respiratory organs for a long time can cause lung function disorders. The purpose of this study was to determine the factors for impaired function in workers in Indonesia. This study used the literature review method with Google Scholar, PubMed, and BioMed Central databases. Search for articles according to topics published from 2017 to 2022 with a working population and research locations in Indonesia. The results of the study obtained a total of 4648 articles, after screening 30 articles were obtained for analysis. From the research it was found that dust exposure and gas exposure were the types of pollutants that caused lung function disorders. The factors that can be modified are setting the length of exposure so that it can affect the working period per year, nutritional status, exercise, smoking habits and the use of Personal Protective Equipment (PPE). Age and gender variables are risk factors that cannot be modified. The longer a person works, the greater the potential hazards that accumulate into the body, especially workers who are in a dusty environment. Therefore, efforts are needed to manage exposure to air pollution in the work environment and routinely conduct medical check-ups for workers, exercise regularly, use PPE, eliminate smoking habits to minimize the occurrence of lung function disorders.

Keywords: risk factors, pulmonary disorders, pollutant

Introduction

Indoor air quality is crucial for health. The body's respiratory and metabolic processes cannot be carried out without air. When breathing, the air inhaled by the lungs consists of 79.01% Nitrogen, 20.95% Oxygen and 0.04% Carbon dioxide and the air expelled from the lungs consists of 74.6% Nitrogen, 16.4% Oxygen and 4.0% Carbon dioxide.¹ WHO data showed that 99% of the world's population breathes air that exceeded WHO guideline limits and contains high levels of pollutants.² Air pollution occurred because there were pollutants, such as chemicals or other particles in large quantities, which disrupted the health of living creatures and the environment.

Pollutants were an important problem for workers' health. The data taken from the International Labor Organization (ILO) stated that 25.5% of work-related respiratory disorders occurred worldwide.³ In 2005, it was reported that 30% of lung diseases occurred out of a total of 250 million occupational diseases.⁴ In 2018, pulmonary disorders entered the 5th position as a disease that causes death. Lung disorders were estimated to increase to 4th place as a disease that causes death in the world by 2030. Dust and gas were air pollutants that had a high level of toxicity in the environment when they entered and accumulated in human respiratory organs, causing respiratory problems, one of which was pulmonary disorders.⁵

The most dominant pulmonary disorders originated from inhalation or the respiratory tract due to exposure to dust, gas, minerals, microbes and chemicals.⁶ Exposure to indoor dust and gas accumulated and had long-term impacts on workers.⁷ Previous research showed a relationship between air quality and health problems, such as lung cancer, respiratory disease, heart disease, reproductive disorders and blood pressure.⁸ Other previous research⁹ showed that there were differences in lung function between bus drivers and indoor workers. From the 65 people, 26.1% of indoor workers and 3.9% of bus drivers experienced pulmonary disorders. The decline in air quality occurred due to an increase in pollutants in the ambient air that exceeded quality standard values, thus having an impact on human health.¹⁰ Acute respiratory diseases in the form of allergies, mild irritation, inflammation of the respiratory tract, chronic bronchitis, emphysema, chronic pulmonary disorder up to total respiratory failure depending on how high the exposure to pollutants was.¹¹

Primary research examining the relationship between air pollution exposure and lung function in workers had been carried out by researchers in various locations using different methods. Several studies had outlined that the dominant factor in pulmonary disorders came from air contaminated with dust and gas through the inhalation route.¹ Dust and gas in the work environment had an impact on reducing health and work productivity.¹³ Therefore, the efforts were needed to manage air pollution in the work environment in order to minimize occupational diseases, pulmonary disorders of workers in Indonesia. Based on this description, researchers reviewed the risk factors that influenced pulmonary disorders of workers in Indonesia. The observed worker

population consisted of various work sectors both indoors: students in classrooms, workers in factories such as boiler areas, animal feed, palm oil, cigarette rolling, and offices, and as well as outdoors: parking attendants, gas stations, toll booths, traders, patchers tires, pedicab drivers, miners, drivers and others. The purpose of this study was to determine the factors for impaired function in workers in Indonesia.

Methods

A literature review method was used in this research, based on prisma guidelines. In this study, the review that were examined, was the exposure to air pollution Carbon monoxide (CO), Carbon Dioxide (CO₂), Volatile Organic Compounds (VOC) Ozon (O₃) Non-Methane Hydrocarbons (NMHC), Particulate Matter (PM₁₀) and dust in the workplace, worker characteristics and behavior (age, gender, Body Mass Index/nutritional status, smoking habits, exercise habits, and use of Personal Protective Equipment (PPE)), as well as exposure patterns (work period and length of exposure) on lung function of workers in Indonesia. Secondary data in the form of this research came from databases, such as Google Scholar, PubMed, and BioMed Central. The keywords that were used (Determinant OR "Risk Factor") AND ("CO Exposure" OR "CO₂ Exposure" OR "VOC Exposure" OR "O₃ Exposure" OR "NMHC Exposure" OR "PM₁₀ Exposure" OR "Dust Exposure") AND ("Lung Function" OR "Lung Capacity" OR "Pulmonary Function").

The inclusion criteria that had been determined are "The data collected was in the form of primary research published in journals within the last 6 years (2017 until 2022) to obtain relevance and up-to-date research results; method that used a cross sectional study approach; only involved quantitative studies in order to describe the prevalence, distribution and correlation between dependent and independent variables, articles that research air pollution exposure (CO, CO₂, VOC, O₃, NMHC, PM 10, and dust), worker characteristics and behavior (age, gender, BMI/nutritional status, smoking habits, exercise habits, and use of PPE) and exposure patterns (work period and length of exposure) on worker lung function; articles that were accessed in full text for free; articles in Indonesian and English; articles that had no duplicates detected".

The total number of articles obtained was 4648 articles. In the screening stage, based on publication years below 2017, 424 articles were excluded. In addition, 1268 articles were excluded because duplication was detected. 2838 articles were found to be inconsistent with the research, resulting in 118 suitable articles based on research topic and abstract identification. The final result of articles that were appropriate to research and were accessed in full text for free is 30 articles. The prisma diagram of the stages of searching for scientific articles was seen in Figure 1.

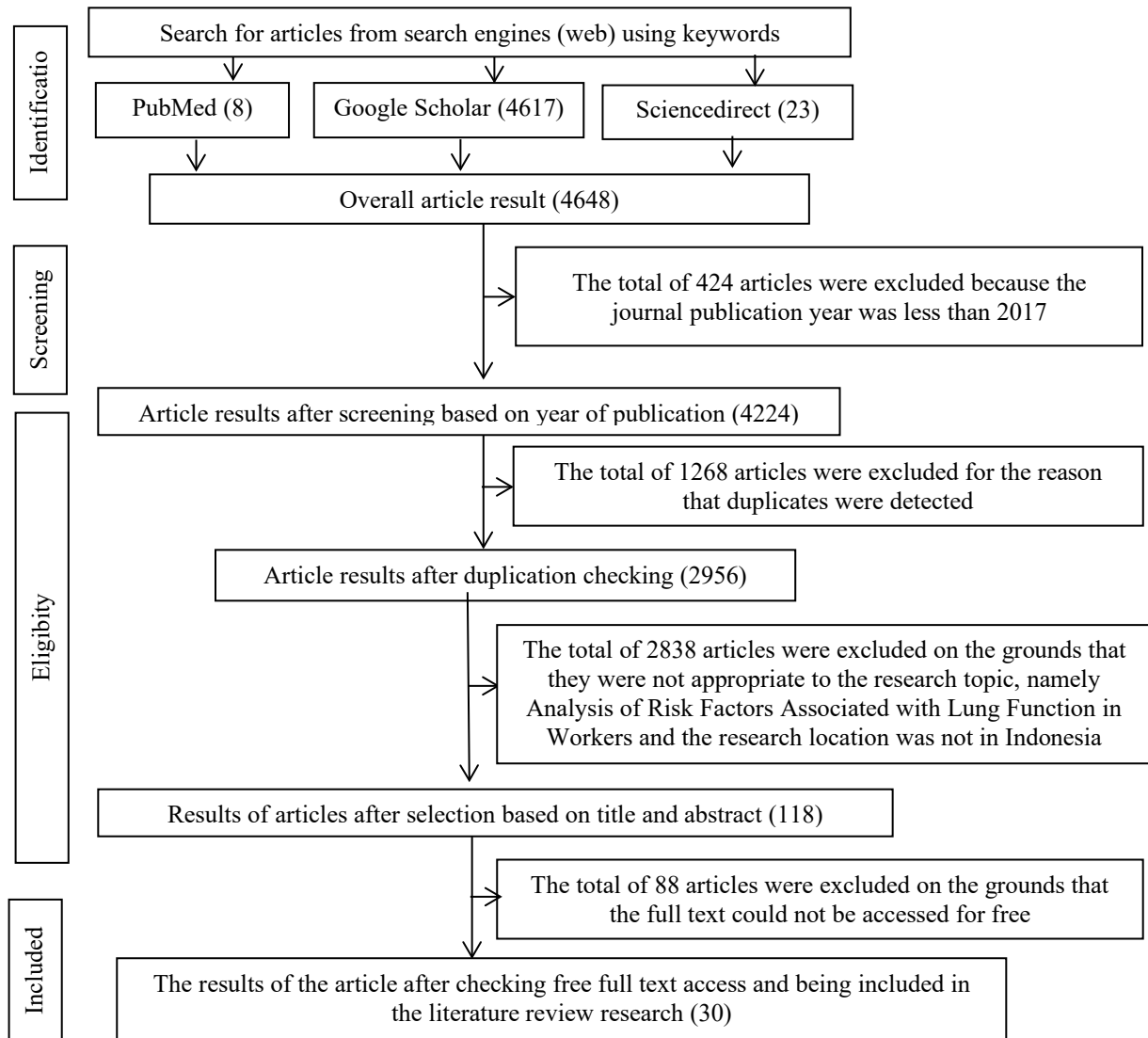


Figure 1. Prisma Diagram of Study Search and Selection

Table 1. Summary of studies on Pulmonary Disorders of Workers in Indonesia

| Researcher Name | Research Title | Year | Research sites | Number of Samples | Study Design | Key Findings |
|---|--|------|---|------------------------------------|-----------------------|---|
| Wispriyono B, Yulaeva E, Hartono B, Pratama S ⁶ | Indoor Air Pollution (Carbon Dioxide and Total Volatile Organic Compound) and Pulmonary Disorders in Junior High School Students in Depok, West Java | 2019 | Middle School in Depok | 139 junior high school students | Cross sectional study | This research showed that there was no effect of exposure to CO ₂ and VOC concentrations related to lung disorders in students because CO ₂ and VOC concentrations are still below the threshold. |
| Dana SHF, Esha I, Yunus F, Adrianison, Saad A, Restilla R ¹⁴ | Risk Factors Affecting Respiratory Symptoms and Impaired Lung Function of Palm Oil Mill Workers in the District of Kandis | 2021 | Palm Oil Factory in Kandis Area | 69 workers | Cross sectional study | The concentration of sulfur dioxide (SO ₂) outdoors was 25.7 µg/Nm ³ and indoors 20.6 µg/Nm ³ and 13% of workers had obstruction. Factors related to lung function were personal protective equipment (p=0.001), years of work (p=0.003), smoking habits (p=0.004). From multivariate analysis, personal protective equipment had a significant correlation with lung function (p=0.038). |
| Nazila Z, Sutomo AH ¹³ | Air Quality Results from Burning Avtur and Impaired Lung Function of Workers at Supadio Airport, Pontianak | 2017 | Pontianak Supadio International Airport | 36 <i>ground handling officers</i> | Cross sectional study | Based on bivariate analysis, the variables were NO ₂ (p = 0.04), SO ₂ (p = 0.15), dust (p = 0.25), age (p = 0.20), length of service (p = 0.09), and smoking habits (p = 0.03). There was a significant relationship between NO ₂ and smoking habits and lung function disorders in workers. |
| Novitasari DI, Wijayanti Y ¹⁵ | Individual Factors, Dust Exposure, and CO with the Description of Gas Station Attendant Lung Physiology | 2018 | Gas Station | 34 gas station officers | Cross sectional study | There was a relationship between gender (p=0.035), length of service (p=0.017), and smoking habits (p=0.023) with pulmonary function features. Meanwhile, the variables age, length of exposure, use of PPE, nutritional status, history of illness, dust exposure, and CO were not related. |
| Purba NH, Nurmaini, Marsaulina I ¹⁶ | Factors that Influence Lung Function Disorders in Parking Officers in Medan City | 2021 | Medan city | 30 parking attendants | Cross sectional study | 60% of workers experienced lung function disorders and there was a relationship between age (p= 0.001), length of service (p = 0.011) and use of PPE with lung function disorders (p = 0.010) and there was no relationship between length of work and lung function disorders (p=0.696). |
| Anggia RD ¹⁷ | Factors Related to Pulmonary Function Status of Animal Feed Industry Workers in Surabaya | 2020 | Animal Feed Industry in Surabaya | 34 admin areas and factory areas | Cross sectional study | Variables that have a relationship with lung function status are age (p = 0.000), length of service (p = 0.008), degree of smoking (p = 0.000), dust concentration (p = 0.000), bacteria concentration (p = 0.000), and concentration fungus (p = 0.000) while mask use has no relationship (p = 0.890). |
| Wahyuni A, Rahim MR, Arsyad DS, Selomo M ¹⁸ | Relationship between Dust Exposure and Lung Capacity in Workers in the PT Boiler Area. Makassar Tene | 2019 | Boiler Area PT. Makassar Tene | 57 production workers | Cross sectional study | 26 workers experienced abnormal lung disorders. Statistical tests showed that there was a relationship between dust exposure (p=0.001) and lung capacity (p=0.001) and there was no relationship with age, length of service, smoking habits and use of PPE among workers. |
| Sari JA, Astuti R, Prasetyo DB ¹⁹ | Vital Lung Capacity in Roadside Tire Repair Workers | 2020 | Tire repair on Mugas Raya Semarang road | 28 workers | Cross sectional study | Only 39.3% of workers had normal Vital Lung Capacity (VLC) and 60.7% had abnormal VLC. This is related to nutritional status (p=0.019), exercise habits (p=0.001), smoking habits (p=0.022), history of lung disease (p=0.041), length of work (p=0.019), and length of service (p=0.016). For multivariate analyze, VLC is determined by length of service. |
| Apsari L, Budiyo, Onny S ²⁰ | Relationship between Exposure to Inhaled Dust and Impaired Lung Function in Sand and Stone Mining Workers at X Rowsari Company, Semarang City | 2018 | Company X in Rowsari, Semarang City | 31 sand and stone mining workers | Cross sectional | 38.7% of workers had impaired lung function (25.8% restriction and 12.9% obstruction). Factors related to lung function disorders were length of exposure (p = 0.046), while the variables nutritional status (p = 1.00), years of work (p = 0.691) and exercise habits (p = 1.00) were not proven to be risk factors. . Protective factors included exposure to inhaled dust (p = 1.00), age (p = 1.00), smoking habits (p = 0.139) and use of PPE (p = 1.00). |

| Researcher Name | Research Title | Year | Research sites | Number of Samples | Study Design | Key Findings |
|---|---|------|--|-------------------------|-----------------------|---|
| Amerta PWP, Wirawan IMA ¹² | Relationship between Dust Exposure and Lung Function Capacity of Paras Stone Craftsmen in Ketewei Village, Sukawati, Gianyar | 2020 | Ketewei Village, Sukawati, Gianyar | 60 sandstone craftsmen | Cross sectional | 56.67% of sandstone craftsmen experienced impaired lung function capacity. Variables that have a significant relationship with lung function capacity are dust exposure (p = 0.04), age (p = 0.006), nutritional status (p = 0.003), work period (p = 0.003) and work duration (p = 0.017) while the variables that did not have a significant relationship were the use of PPE (p = 0.432) and smoking habits (p = 0.846) |
| Susilaningtyas M, Suwondo A, Ekawati ² | Relationship between Benzene Exposure and Lung Function in Fuel Tank Car Crews at PT. X Semarang | 2018 | PT. X Semarang | 16 fuel tanker car crew | Cross sectional study | The average urine phenol level in tank car crews is relatively high, namely >25 ppm. Variables that have a relationship to lung function disorders are age (0.015), smoking habits (p = 0.038), and exercise habits (0.045). Meanwhile, variables that did not have a relationship were phenol levels (p = 0.411), nutritional status (p = 0.552), length of service (p = 0.870), |
| Pramesti IGAV, Sutiari NK ²¹ | Determinants of Impaired Lung Function Capacity in Red Brick Craftsmen in Badung Regency | 2021 | Badung regency | 42 red stone craftsmen | Cross sectional study | 92.86% of craftsmen experienced impaired lung function capacity. Variables that have a significant relationship to impaired lung function capacity are use of PPE (p = 0.04) and exposure to dust (p = 0.007). Variables that did not have a relationship were age (p = 0.421), nutritional status (p = 0.793), years of work (p = 0.687), duration of work (p = 0.667) and smoking habits (p = 0.929). |
| Anggraeni A ²² | The Relationship Between Particulate Matter-10 (PM10) Levels and Lung Function in Pedicab Drivers in the Muhammadiyah University Surakarta Area | 2018 | muhammadiyah Surakarta university | 25 Pedicab Drivers | Cross sectional study | The results of statistical tests show that there is a significant relationship between PM10 levels (p = 0.000) and the lung function of pedicab drivers in the Muhammadiyah University area of Surakarta. |
| Fithri NK ²³ | Analysis of Factors that Influence Lung Function Disorders in Tangerang Karawaci Toll Gate Guard Workers | 2017 | Tangerang-Karawaci Toll Road | 55 Toll Gate Officers | Cross sectional study | The results of bivariate analysis showed that there was a significant relationship between working years (p-value = 0.046), smoking habits (p-value = 0.009), and exercise habits (p-value = 0.030) with lung function disorders. And there was no significant relationship between age (p-value = 0.103) and lung function disorders. |
| Sari DPP, Budiono, D NAY ²⁴ | Factors related to Lung Function Disorders in Female Workers at the Praoe Lajar Cigarette Factory, Semarang, Central Java | 2017 | Praoe Lajar Cigarette Factory Semarang | 36 female workers | Cross sectional study | 20 workers (55.5%) experienced lung function disorders in the categories of restriction, obstruction, and mixed restriction-obstruction. The results of statistical tests show that there is a significant relationship between dust exposure (p = 0.001) and years of work (p = 0.024) on lung function disorders, while the variables age (p = 0.229) and nutritional status (p = 0.793) do not have a significant relationship. significant impact on lung function disorders. |
| Pradesi R, Suwondo A, Jayanti S ²⁵ | Analysis of the Relationship between Cement Dust Exposure and Vital Lung Capacity in Production Department Workers at PT. X Central Java | 2018 | PT. X Central Java | 51 production workers | Cross sectional study | The results of statistical tests show that the variables smoking habits (p = 0.035), years of work (p = 0.041), and exercise habits (p = 0.048) have a significant relationship with vital lung capacity. Meanwhile, the variables age (p = 0.575), nutritional status (p = 0.692), history of lung disease (p = 0.611), and dust exposure (p = 0.139) did not have a significant relationship. |
| Nazira, Wuni C, Parman ²⁶ | Factors Associated with Lung Capacity in Brick Workers in Talang Belido Village in 2022 | 2022 | Talang Belido Village | 38 brick workers | Cross sectional study | Variables that were significantly related to lung function capacity were dust levels (p = 0.034), smoking habits (p = 0.025), and use of masks (p = 0.001). Meanwhile, the variable that was not significantly related to lung function capacity was working period (0.692). |
| Putri FN, NAY Dewanti, Sulistiyani ²⁷ | Factors Associated with Vital Lung Capacity in Home Batik Industry Workers in Pekalongan City | 2020 | Home Batik Industry X Pekalongan | 49 workers | Cross sectional study | 49 batik workers working in 5 industries found that 57.1% had abnormal vital lung capacity. The results of statistical tests show that the variables length of service (p = 0.047) and length of work (0.025) have a significant relationship with vital lung capacity in workers at the Batik X Pekalongan Industry. |

| Researcher Name | Research Title | Year | Research sites | Number of Samples | Study Design | Key Findings |
|--|--|------|-----------------------------------|----------------------------|-----------------------|--|
| Stevent A, Kurniawati E, Hapis AA ²⁸ | Study of Lung Function of Sawmill Processed Wood Workers in Pasir Panjang Village | 2021 | Pasir Panjang Village | 40 workers | Cross sectional study | 85.0% of respondents had abnormal lung function. The results of bivariate analysis showed that there was a relationship between length of service ($p = 0.010$) and age ($p = 0.029$) with lung function in Processed Wood Sawmill workers in Pasir Panjang Village, Jambi City. There is no relationship between smoking habits and lung function in Processed Wood Sawmill workers in Pasir Panjang Village, Jambi City ($p = 0.073$). |
| Helmy R ⁵ | Relationship between Dust Exposure and Individual Characteristics with the Lung Physiology Status of Traders Around the Gresik Industrial Area | 2019 | Gresik Industrial Area | 24 traders | Cross sectional study | Based on statistical tests, the variables were dust exposure ($p < 0.05$), age ($p = 0.038$) and length of exposure ($p = 0.013$). Meanwhile, the variables of length of service ($p > 0.05$), smoking habits ($p = 1,000$), nutritional status ($p = 0.767$), and history of illness ($p = 0.266$) had no relationship with traders' pulmonary function status. |
| Ganggut MCN, Manafe DRT, Sasputra IN ²⁹ | Correlation between Exposure to Motor Vehicle Dust and Vital Lung Capacity in Gas Station Operators in Kupang City | 2018 | Gas station in Kupang City | 50 Gas Station Operators | Cross sectional | The results of statistical analysis using chi square showed that there was a relationship between the length of exposure to motor vehicle dust and the vital lung capacity of gas station operators in the city of Kupang ($p = 0.002$). |
| Suryadi I, Widjarnarti MP, Nugraha AP ³⁰ | Working Environment Dust to Disorders of Lung Function of Workers Textile Industry Spinning | 2020 | PT | 35 textile workers | Cross sectional | The results of this study show that the measured result of dust exposure in the work area is $0.395\text{mg}/\text{m}^3$. The results of statistical tests show that there is a significant relationship between dust exposure variables in work areas and lung function ($p = 0.016$). |
| Esha I, Afandi D, Amrifo V ³¹ | Analysis of Exposure to Carbon Monoxide Pollutant Gas on Lung Function of Parking Attendants in the Basement of Mall X, Pekanbaru City | 2017 | Basement of Mall X Pekanbaru City | 45 Parking Attendants | Cross sectional | The results of statistical tests showed that there was a significant relationship between length of work ($p = 0.035$), smoking habits ($p = 0.007$), use of PPE ($p = 0.005$) and history of respiratory disease ($p = 0.001$) on workers' lung function. A significant correlation was obtained ($-1 \leq r \leq 1$) where $r = -0.795$, where the higher the concentration of carbon monoxide pollutant gas, the lower the lung function value of the underground parking attendant at Mall X Pekanbaru. |
| Sunarsieh, Repelita F, Akhmadi Z ³² | Factors Related to Cafe Worker's Lung Capacity in Pontianak, Indonesia | 2022 | Pontianak | 74 cafe employees | Cross sectional | Statistically there is a significant relationship between the variable age ($p = 0.006$) and exposure to cigarette smoke (0.028) on workers' lung function. Meanwhile, the variables length of service ($p = 0.630$) and length of work ($p = 1.000$) do not have a significant relationship with workers' lung function. |
| Alamsyah PR, Nurcandra F, Arbitera C, Hardy FR ³³ | Factors Related to Complaints of Lung Function Disorders in UPN Veteran Jakarta Employees | 2022 | UPN Veteran Jakarta | 102 employees | Cross sectional | Factors that influence abnormal lung function are the BMI/BMI variable ($p = 0.003$) which has a relationship with impaired lung function in workers. Meanwhile, the variables age ($p = 0.824$), smoking ($p = 0.64$), physical activity ($p = 1.00$) and history of lung disease ($p = 0.061$) did not have a significant relationship to impaired worker lung function. |
| Supriyanto, helmy, Raharjo M ³⁴ | Disorders of Lung Function in Mattress Making Workers at Wonoyoso Village, Pringapus District, Semarang Regency | 2019 | Wonoyoso Village, Semarang | 30 mattress making workers | Cross sectional | Statistically, the variables exposure to inhaled cotton dust ($p = 0.001$), length of service ($p = 0.000$), age ($p = 0.034$), and smoking habits ($p = 0.018$) have a significant relationship with impaired lung function in workers. |
| Tanzila RA, Gunawan EP, Khairani A ³⁵ | Factors Related to Vital Lung Capacity of Workers at Fertilizer X Factory in Indonesia | 2021 | X Fertilizer Factory | 78 ammonia operators | Cross sectional | The lung vital capacity of most respondents was included in the normal classification (55.1%), there was a significant relationship between lung vital capacity and the risk factors of age ($p = 0.001$), length of work ($p = 0.009$), use of PPE ($p = 0.012$), and smoking habits ($p = 0.020$) |

| Researcher Name | Research Title | Year | Research sites | Number of Samples | Study Design | Key Findings |
|--|--|------|-----------------------------------|----------------------------------|-----------------|--|
| Sutanti L, Rahman ZF, Masruroh NL, Tualeka AR ³⁶ | Relations Exposure to Dust Inhalation Against Impaired Lung Function in Worker Unloading at the Port of Manado, North Sulawesi | 2020 | Manado Port, North Sulawesi | 60 loading and unloading workers | Cross sectional | There is no relationship between using a mask ($p = 0.195$), smoking habits ($p = 0.766$), years of work ($p = 0.143$), length of work ($p = 0.838$), and exposure to inhaled dust (100% below the limit value) on functional impairment. lungs in workers at the Port of Manado. |
| Suryadi, Widjanarti MP, Wardani TL, Fajariani R, Rachmawati S. ³⁷ | Lung Capacity Determinant Tirtonadi Bus Station Workers in Surakarta | 2020 | Tirtonadi Bus Terminal, Surakarta | 36 bus terminal workers | Cross sectional | The variables dust exposure ($p = 0.003$), work area ($p = 0.005$), and use of masks ($p = 0.001$) have a significant relationship with lung function disorders in workers at bus terminals. Meanwhile, the variables smoking habits ($p = 0.131$) and age ($p = 0.433$) did not have a significant relationship with lung function disorders. |
| Novziransyah N, Dania IA, Veronica S, Maimunah R ⁴ | Factors Associated with Vital Lung Capacity on Road Sweeper Workers | 2022 | Medan Denai District | 27 street sweepers | Cross sectional | Statistically, the variables of work experience ($p = 0.005$) and use of masks ($p = 0.008$) have a significant relationship with workers' vital lung capacity. |

Table 2. Results of Literature Review of Risk Factors Associated with Lung Function of Workers in Indonesia

| Variables studied | Number of Researched Articles | Literature Review Results |
|-------------------------------------|-------------------------------|--|
| Air Pollution Exposure | | |
| CO | 2 | 1 article (50%) showed that there was a significant relationship between CO exposure and lung function in workers and 1 article (50%) showed that there was no significant relationship between CO exposure and lung function in workers. |
| CO ₂ | 1 | 1 article (100%) showed that there was no significant relationship between CO ₂ exposure and workers' lung function. |
| VOC | 2 | 2 articles (100%) showed that there was no significant relationship between VOC exposure and workers' lung function |
| O ₃ | 0 | - |
| NMHC | 0 | - |
| PM 10 | 1 | 1 article (100%) showed that there was a significant relationship between PM 10 exposure and workers' lung function |
| Dust | 15 | 10 articles (66.66%) showed results that there was a significant relationship between dust exposure to workers' lung function and 5 articles (33.33%) showed results that there was no significant relationship between dust exposure to workers' lung function. |
| Worker Characteristics and Behavior | | |
| Age | 20 | 9 articles (45%) showed that there was a significant relationship between age and workers' lung function and 11 articles (55%) showed that there was no significant relationship between age and workers' lung function. |
| Gender | 4 | 1 article (25%) showed statistical results that there was a relationship between gender and workers' lung function and 3 articles (75%) showed statistical results that there was no relationship between gender and workers' lung function |
| BMI/Nutritional Status | 14 | 3 articles (21.42%) showed that there was a significant relationship between BMI/nutritional status and workers' lung function and 11 articles (78.57%) showed that there was no significant relationship between BMI/nutritional status and workers' lung function. |
| Smoking habit | 23 | 13 articles (56.62%) showed results that there was a significant relationship between smoking habits and workers' lung function and 10 articles (43.47%) showed results that there was no significant relationship between smoking habits and workers' lung function. |
| Exercise Habits | 8 | 4 articles (50%) showed that there was a significant relationship between exercise habits and workers' lung function and 4 articles (50%) showed that there was no significant relationship between exercise habits and workers' lung function. |
| Use of PPE | 16 | 8 articles (50%) showed the results that there was a significant relationship between the use of PPE and the lung function of workers and 8 articles (50%) showed the results that there was no significant relationship between the use of PPE and the lung function of workers |
| Exposure Patterns | | |
| Years of service | 25 | 16 articles (64%) showed results that there was a significant relationship between length of service and lung function of workers and 9 articles (36%) showed results that there was no significant relationship between length of service and lung function of workers |
| Exposure Time | 11 | 5 articles (45.45%) showed results that there was a significant relationship between length of exposure to worker lung function and 6 articles (54.54%) showed results that there was no significant relationship between length of exposure to worker lung function |

Discussion

Risk factors for pulmonary disease that cannot be modified based on a literature review were the variables age and gender. From the 20 articles that examined the age variable, 9 articles showed that statistically there was a significant relationship between age and workers' lung

function. The 9 articles explained that respondents who had pulmonary disease were respondents aged older than 40 years so that the age variable could be a factor that caused a decrease in lung function in respondents. Age has an important role in respiratory disorders in a person. From the 20 articles that examined the age variable, 9 articles showed that there was a significant relationship between age and lung function. Age factors were influence a person's respiratory frequency and lung capacity.¹² Cells that experienced the aging process cause a decrease in lung muscle strength in respiration, the bronchioles thicken, the alveoli became less elastic and decrease lung capacity. Optimum lung function was in the range of 22 to 40 years and decreases by 20% after age older than 40 years. Age and poor environmental conditions characterized by excessive pollutants could trigger an accelerated decline in lung function.¹³ Increasing age had a negative effect on the function of body organs. Someone aged 40 years and over was at risk of experiencing a decrease in lung capacity as indicated by the Forced Expiratory Volume in 1 second (FEV1) being 1-1.5L with an average normal limit of 3.5L.

From the 4 articles that examined the gender variable, 1 article showed that statistically there was a significant relationship between age and workers' lung function. Women's respiratory capacity was up to 25% smaller than men's. The maximum lung capacity in men was 4.5 L and in women it was 3.1 L. Therefore, men's oxygen needs were greater than women's because men's energy needs were greater. From the 4 articles obtained, there was 1 article that had a statistical relationship between gender and lung function. This showed that both women and men were equally at risk of decreased lung function. Another factor that worsens lung quality was that men had a smoking habit and women did not smoke.¹⁵

Risk factors for pulmonary disorders that were modified based on a literature review were management of pollutants in the form of dust and gas below the limit value, regulation of length of exposure, so it influenced a decrease in the annual working period, nutritional status, physical activity or sports, smoking habits and use of Personal Protective Equipment (PPE). From the research, it was found that exposure to dust as many as 16 articles and exposure to gas as many as 5 articles were types of pollutants that caused pulmonary disorders.

Exposure to air pollution that exceeded the normal threshold caused problems with lung function. Based on the Ministry of Health Regulations RI Number 1405/MENKES/SK/XI/2002 concerning Health Requirements for Office and Industrial Work Environments, it was stated that the maximum concentration for dust is 10mg/m³, CO is 115mg/m³, and CO₂ is 9000mg/m³. Based on the Ministry of Health Regulations RI Number 48 of 2016 concerning Office Occupational Safety and Health Standards, it was stated that the quality standard for O₃ was 0.5ppm, VOC was 3ppm, and PM 10 was 0.15mg/m³. And based on Government Regulation Number 22 of 2021 concerning the Implementation of Environmental Protection and Management, it was stated that the ambient air quality standard for NMHC was 160mg/m³. The size of

particulates influences how far pollutants penetrated the body and determined toxic effects based on where the dust was deposited.³⁸ The smaller the particulate size, the further the particulates settled in the respiratory tract. Particles that more than equal to 100 microns were called inhalable dust and settle up to the nose, particles 4-10 microns were called thoracic dust and settle up to the bronchioles and particles less than 4 microns were called respirable dust and settle up to the alveoli. When pollutants entered deeper organs in the body, they caused irritation to the respiratory organs and caused responses such as coughing, sore throat and fever.³⁹ The effects of pollutants on health depended on the size, solubility, concentration, reactivity and composition of the pollutant.⁴⁰

Dust exposure^{12,21} and continuous gas reduced lung function. This was explained in the table above, from the 15 articles that examined dust variables, 10 articles showed that there was a relationship between dust levels and workers' lung function. The higher the level of dust inhaled, the more lung function decreases.¹³ Pollutants in the form of dust and gas in the air entered the body through several routes: inhalation, skin, swallowing and mucous membranes. Over a certain period of time, the accumulation of dust and gas resulted in a buildup of pollutants in the respiratory tract, so the alveolar walls harden and damage to lung function occurs in the process of inspiration (breathing in oxygen) and expiration (exhaling carbon dioxide).⁴¹ The buildup of pollutants in the airways caused airway obstruction, which lead to decreased lung function.⁴² Workers who had pulmonary disorders experienced difficulties when working, and this lead to a decline in the quality of a person's work due to decreased lung function. Therefore, it was hoped that company owners made management efforts to minimize the concentration of air pollution exposure in the work environment. Based on the literature review, the most dominant variable showing statistical results that there was a relationship in the length of service. From the 25 articles that examined the working period variable, 16 articles showed that statistically there was a relationship between working years and workers' lung function. There are 16 articles explained that more respondents had worked more than 10 years and had abnormal lung function. The factor of work experience or the length of time a person had worked in years were a risk factor for decreased lung function.⁴³ The longer a person worked, the more exposure to hazards in the work environment that entered the body, especially workers who worked in dusty environments.¹⁵ Work environments that produced dust, such as industrial work environments, caused workers to experience respiratory problems.²⁷

Working time regulations were based on Law No. 13 of 2003, normal working hours in the range of 7-8 hours. Working more than equal to eight hours caused fatigue, lack of concentration, decreased productivity, work-related illnesses and work accidents.¹⁵ The longer the work period, the higher the accumulative exposure time. Workers with more than five years of service had a 5.4 times greater risk of decreased lung function than workers with less than equal five years of service.⁴⁴ Therefore, workers who had worked more than equal to five years should pay attention to

their working hours, so not to work more than 8 hours/day to reduce the decline in lung function due to exposure to particles inhaled during work. Working time regulations were based on Law No. 13 of 2003, normal working hours in the range of 7-8 hours. Working more than eight hours caused fatigue, lack of concentration, decreased productivity, work-related illnesses and work accidents.¹⁵

Based on the results of the literature review, the dominant characteristic variables showed statistically there was a relationship were nutritional status, physical activity or exercise, smoking habits and the use of PPE. From the 23 articles that examined smoking habit variables, 13 articles showed that there was a relationship which explained that respondents who had excessive smoking habits (more than 3 cigarettes/day) could cause changes in respiratory tract function. 16 articles that examined the use of PPE, 8 articles showed that there was a relationship between the use of PPE and the lung function of workers. There were more respondents who did not use PPE when working compared to respondents who used PPE when working. It was explained that respondents only wore PPE/masks when their superiors were present, and it was also explained that respondents felt uncomfortable wearing masks while working, because it felt hot and interfered with communication between workers.¹⁰

Smoking was modifiable risk factor for decreased lung function.¹⁷ Cigarettes were synonymous with men's habits. A person who consumed cigarettes at the age of more than equal to twenty-five years has a 2 to 5 times risk of decreased lung function. Cigarette smoke was a dangerous pollutant consisting of main smoke, smoke inhaled by active smokers, as much as 25% and side smoke, smoke inhaled by other people or passive smokers, as much as 75%.¹⁸ In a non-smoker, the decrease in Forced Expiratory Volume (FEV) per year was 28.7ml, while in an active smoker, the decrease in Forced Expiratory Volume (FEV) per year was 41.7ml.⁴⁵ When smoking, a combustion process occurred which produces gas residue and solid particles.⁴⁵ The dangerous substances contained in cigarette smoke, namely CO₂, nicotine, balangkin and combustion residue gas, accumulated over a long period of time and the remaining particulates and gas stick to the walls of the alveoli, resulting in a decrease in elasticity resulting in the lungs not being able to carry out their function optimally, obstructed breathing air circulation.¹⁵ The longer you smoke, the higher the accumulation of harmful substances would be and were retained in the respiratory tract. If this condition was left for a long period of time and continuously, it would cause problems with lung function.⁴⁶

One of the indicators that showed nutritional status was calculating the Body Mass Index (BMI). Obesity or being overweight carried a greater risk of decreased lung function compared to normal weight.⁴⁷ When breathing, someone who had a lot of fat deposits, experienced additional burden on the thorax, characterized by limited movement of the diaphragm resulting in the lungs becoming stiff and the ability to expand and deflate decreased.¹⁵ Malnutrition inhibited the development and function of body organs, resulting in a decrease in the body's ability to cleanse

toxins (detoxification) due to inhaled pollutants or body metabolic residues. A low immune system and body resistance made a person vulnerable to infection with diseases such as coughing up phlegm due to the body's inability to detoxify foreign objects such as dust and gas.¹³ A person's level of health affects lung function. A history of previous illnesses caused the strength of the respiratory muscles to decrease, so that there was less air exchange resulting in a decrease in oxygen in the blood.²⁴ Based on this, the more diseases you have suffered, the more accelerated the decline in lung function. Physical activity had a positive influence on lung function. Someone who frequently exercised accompanied by good nutritional intake increased their body's endurance. When doing routine physical activity, the airway cleared, so the respiration process run smoothly. A healthy lifestyle, good nutritional status and exercise skills minimized lung function disorders.¹³

The PPE factor was one of the factors that were modified and influenced the occurrence of disease in workers. Personal protective equipment (PPE) was a very important tool for workers to use with the aim of protecting themselves from sources of danger, especially workers in the industrial sector. One of the PPE that was often used by workers was a mask. Masks were used to filter dust or other particles that enter the breath and were made of cloth of a certain size. The use of PPE reduced the severity of disease that occurred. Workers who worked in dusty work environments and regularly wore masks while working, could minimize the amount of exposure to particles that were inhaled.⁴⁸

Conclusion

There was a dominant variable that influenced the lung function of workers in Indonesia, dust levels that exceeded the limit value. The factors that were modified, were setting the length of exposure, so it affected the annual work period. Dust content and working period were the dominant variables related to the decline in workers' lung function. The variables age and gender were risk factors that could not be modified. The worker behavioral factors most often found to be related to pulmonary disorders were smoking habits, exercise and use of PPE.

Acknowledgement

Not applicable.

Funding

This research did not have funding from other parties.

Conflict of Interest

The author declared that the author had no conflict of interest.

References

1. Talarosha B. Jendela dan Dampaknya terhadap Konsentrasi CO₂ di dalam Ruang Kelas, Kajian Literatur. *J Lingkung Binaan Indones* [Internet]. 2018;7(1):46–53. Available from: <https://doi.org/10.32315/jlbi.7.1.46>
2. Susilaningtyas M, Suwondo A, Ekawati. Hubungan Paparan Benzene Dengan Fungsi Paru Pada Awak Mobil Tangki BBM di PT. X Semarang. *J Kesehat Masy* [Internet]. 2018;6(5):579–86. Available from: <https://doi.org/10.14710/jkm.v6i5.22097>
3. Sunaryo M, Rhomadhoni MN. Analisis Kadar Debu Respirabel Terhadap Keluhan Kesehatan Pada Pekerja. *J Kesmas (Kesehatan Masyarakat) Khatulistiwa* [Internet]. 2021;8(2):63. Available from: <https://doi.org/10.29406/jkkm.v8i2.2480>
4. Novziransyah N, Dania IA, Veronica S, R M. Factors Associated with Lung Capacity on Road Sweeper Workers. *J Asian Multicult Res Med Heal Sci Study* [Internet]. 2022;3(3):47–55. Available from: <https://doi.org/10.47616/jammhss.v3i3.315>
5. Helmy R. Hubungan Paparan Debu dan Karakteristik Individu dengan Status Faal Paru Pedagang di Sekitar Kawasan Industri Gresik. *J Kesehat Lingkung* [Internet]. 2019;11(2):132–40. Available from: <https://doi.org/10.20473/jkl.v11i2.2019.150-157>
6. Wispriyono B, Yulaeva E, Hartono B, Pratama S. Indoor Air Pollution (Carbon Dioxide and Total Volatile Organic Compound) and Pulmonary Disorders in Junior High School Students in Depok , West Java. *Glob J Health Sci*. 2019;11(12):45–54. Available from: <https://doi.org/10.5539/gjhs.v11n12p45>
7. Sudaryanto S, Prasetyawati ND, Sinaga E, Muslikah. Socialization of the Impact of Air Pollution on Health Disorders Comfort and the Environment. *Sess Social Impact Air Pollut Heal Disord Comf Environ* [Internet]. 2020;10. Available from: <https://doi.org/10.31603/ce.7058>
8. Şengören Dikiş Ö, Yıldız T, Us Dulger S, Yuksel Kacan C, Haberal MA, Cetin T. Does occupational air pollution threaten the lung health of indoor workers more than those of bus drivers?: a cross-sectional study. *Aging Male* [Internet]. 2021;23(5):934–40. Available from: <https://doi.org/10.1080/13685538.2019.1635579>
9. Maulianti S, As ZA, Junaidi J. Kecukupan Udara Mempengaruhi Kenyamanan Pada Ruang Kamar. *J dan Apl Tek Kesehat Lingkung* [Internet]. 2021;18(1):19–26. Available from: <https://doi.org/10.31964/jkl.v18i1.272>
10. Muhith A, Hannan M, Mawaddah N, Aqnata CA. Penggunaan Alat Pelindung Diri (APD) Masker dengan Gangguan Saluran Pernapasan Pada Pekerja di PT BOKORMAS Kota Mojokerto. *J Ilmu Kesehat*. 2018;3(1):20–33. Available from: <https://doi.org/10.24929/jik.v3i1.628>
11. Fuadi MF, Setiani O, Darundiati YH. Paparan Partikulat Debu Kapur dan Faktor Risiko

- Pekerja dengan Kejadian ISPA: Sebuah Literature Review. *J Kesehat Lingkung* [Internet]. 2021;11(1):8–15. Available from: <https://doi.org/10.47718/jkl.v11i1.1338>
12. Amerta PWP, Wirawan IMA. Hubungan Paparan Debu Dengan Kapasitas Fungsi Paru Perajin Batu Paras Di Desa Ketewel, Sukawati, Gianyar. *Arch Community Heal* [Internet]. 2020;7(1):87. Available from: <https://doi.org/10.24843/ach.2020.v07.i01.p09>
 13. Nazila Z, Sutomo AH. Hubungan Kualitas Udara Hasil Pembakaran Avtur Dengan Gangguan Fungsi Paru Pekerja di Bandara Supadio Pontianak. *Ber Kedokt Masy* [Internet]. 2017;33(6):277. Available from: <https://doi.org/10.22146/bkm.23904>
 14. Dana SHF, Esha I, Yunus F, Adrianison, Saad A, Restilla R. Risk Factors Affecting Respiratory Symptoms and Impaired Lung Function of Palm Oil Mill Workers in The District of Kandis. *J Respirologi Indones*. 2021;41(3):180–6. Available from: <https://doi.org/10.36497/jri.v41i3.194>
 15. Novtasari DI, Wijayanti Y. Faktor Individu, Paparan Debu, dan CO dengan Gambaran Faal Paru Petugas SPBU. *HIGEIA (Journal Public Heal Res Dev* [Internet]. 2018;2(4):553–63. Available from: <https://doi.org/10.15294/higeia.v2i4.23617>
 16. Purba NH, Nurmaini, Marsaulina I. Faktor-Faktor Yang Mempengaruhi Gangguan Fungsi Paru Pada Petugas Parkir di Kota Medan. *J Heal Sains*. 2021;2(3):343–9. Available from: <http://doi.org/10.46799/jhs.v2i3.134>
 17. Anggia RD. Factors Related to Pulmonary Function Status of Animal Feed Industry Workers in Surabaya Faktor yang Berhubungan dengan Status Faal Paru Pekerja Industri Pakan Ternak di Surabaya. *Indones J Occup Saf Heal* [Internet]. 2020;9(2):183–95. Available from: <https://doi.org/10.20473/ijosh.v9i2.2020.183-195>
 18. Wahyuni A, Rahim MR, Arsyad DS, Selomo M, Keselamatan D, Kesehatan F, et al. Hubungan Pajanan Debu Dengan Kapasitas Paru Pada Pekerja di Area Boiler PT. Makassar Tene. *J Kesehat Masy Marit*. 2019;2(1):18–24. Available from: <https://doi.org/10.30597/jkmm.v2i1.10702>
 19. Sari JA, Astuti R, Prasetio DB. Kapasitas Vital Paru pada Pekerja Tambal Ban Pinggir Jalan. *HIGEIA (Journal Public Heal Res Dev*. 2020;4(2):223–32. Available from: <https://doi.org/10.15294/higeia.v4i2.32604>
 20. Apsari L, Budiyono, Onny S. Hubungan Paparan Debu Terhirup Dengan Gangguan Fungsi Paru Pada Pekerja Pertambangan Pasir dan Batu Perusahaan X Rowosari Kota Semarang. *J Kesehat Masy* [Internet]. 2018;6(4):463–76. Available from: <https://doi.org/10.14710/jkm.v6i4.21455>
 21. Pramesti IGA AV, Sutiari NK. Determinan Gangguan Kapasitas Fungsi Paru-Paru Pada Pengrajin Batu Bata Merah di Kabupaten Badung. *ArcCom Heal*. 2021;8(1):16–28. Available from: <https://doi.org/10.24843/ACH.2021.v08.i01.p02>

22. Anggraeni A. Hubungan Antara Kadar Particulate Matter-10 (PM10) Dengan Fungsi Paru Pada Tukang Becak di Area Universitas Muhammdyah Surakarta. Universitas Muhammadiyah Surakarta; 2018. Available from: <https://doi.org/10.36590/jika.v2i2.45>
23. Fithri NK. Analisis faktor yang mempengaruhi gangguan fungsi paru pada pekerja penjaga pintu tol tangerang karawaci. 2017;5. Available from: <https://doi.org/10.47007/inohim.v5i2.129>
24. Sari DPP, Budiono, Yunita DNA. Faktor Terkait Gangguan Fungsi Paru Pada Pekerja Wanita di Pabrik Rokok Praoe Lajar Semarang, Jawa Tengah. *J Kesehat Masy* [Internet]. 2017;5(5):581–591. Available from: <https://doi.org/10.14710/jkm.v5i5.19180>
25. Pradesi R, Suwondo A, Jayanti S. Analisis Hubungan Paparan Debu Semen Dengan Kapasitas Vital Paru Pada Pekerja Dpeartemen Produksi di PT. X Jawa Tengah. *J Kesehat Masy* [Internet]. 2018;6(2):103–112. Available from: <https://doi.org/10.14710/jkm.v6i2.20805>
26. Nazira, Wuni C, Parman. Faktor-Faktor yang Berhubungan dengan Kapasitas Paru Pada Pekerja Batu Bata di Desa Talang Belido Tahun 2022. *J Cakrawala Ilm.* 2022;2(4):1321–1338. Available from: <https://doi.org/10.53625/jcijurnalcakrawalailmiah.v2i4.4320>
27. Putri FN, Dewanti NAY, Sulistiyani. Faktor Yang Berhubungan Dengan Kapasitas Vital Paru Pada Pekerja Industri Batik Rumahan di Kota Pekalongan. *Media Kesehat Masy Indones.* 2020;19(3):206–212. Available from: <https://doi.org/10.14710/mkmi.19.3.206-212>
28. Stevent A, Kurniawati E, Hapis AA. Study of Lung Function of Sawmill Processed Wood Workers in Pasir Panjang Village. *Community Res Epidemiol.* 2021;2(1). Available from: <https://doi.org/10.24252/corejournal.v2i1.25363>
29. Ganggut M, Manafe D, Sasputra IN. Hubungan Lama Paparan Debu Asap Kendaraan Bermotor Dengan Kapasitas Vital Paru Pada Operator Spbu Kota Kupang. *Cendana Med J.* 2018;15(3):3–7. Available from: <https://doi.org/10.35508/cmj.v6i3.671>
30. Suryadi I, Widjarnarti MP, Nugraha AP. Working Environment Dust to Disorders of Lung Function of Workers Textile Industry Spinning. 2020;11(03):2517–2521. Available from: <https://doi.org/10.15294/kemas.v17i4.25069>
31. Esha I. Analisis Paparan Gas Polutan Karbon Monoksida Terhadap Fungsi Paru Petugas Parkir Di Ruang Bawah Tanah Mal X Kota Pekanbaru. Tesis. 2017; Available from: http://lib.pps.unri.ac.id/index.php?p=show_detail&id=3292
32. Sunarsieh, Repelita F, Akhmadi Z. Factors Related to Cafe Worker ' s Lung Capacity in Pontianak , Indonesia. *J Kesehat Masy Nas* [Internet]. 2022;17(1):48–53. Available from: <https://doi.org/10.21109/kesmas.v17i1.5344>
33. Alamsyah PR, Nurchandra F, Arbitera C. Original Article Factors Related to Complaints of Lung Function Disorders In UPN Veteran Jakarta Employees. *Respir Sci.* 2022; 3(1): 14-24.

- Available from: <https://doi.org/10.36497/respirsci.v3i1.36>
34. Nurjazuli SMR. Disorders of Lung Function in Mattress Making Workers at Wonoyoso Village, Pringapus District, Semarang Regency. *Int J Res Inf Sci Appl Tech* [Internet]. 2019 Mar 15;3(3):22–34. Available from: <https://doi.org/10.46828/ijrisat.v3i3.68>
 35. Tanzila RA, Gunawan EP, Khairani A. Factors Related to Vital Lung Capacity of Workers at Fertilizer X Factory in Indonesia Analisis Faktor-faktor yang Berhubungan dengan Kapasitas Vital Paru pada Pekerja Pabrik Pupuk X di Indonesia. *Maj Kedokt Bandung* [Internet]. 2021;53(1):22–6. Available from: <https://doi.org/10.15395/mkb.v53n1.2219>
 36. Sutanti L, Rahman ZF, Masrurroh N, Tualeka AR. Relations Exposure to Dust Inhalation Against Impaired Lung Function in Worker Unloading at the Port of Manado , North Sulawesi. *Indian J Forensic Med Toxicol*. 2020;14(2):1310–4. Available from: <https://doi.org/10.37506/ijfmt.v14i2.3090>
 37. Suryadi, Widjanarti MP, Wardani TL, Fajariani R, Rachmawati S. Lung Capacity Determinant Tirtonadi Bus Station Workers in Surakarta Lung Capacity Determinant Tirtonadi Bus Station Workers in Surakarta. *IOP Conf Ser Earth Environ Sci*. 2020;448(012014). Available from: <https://doi.org/10.15294/kemas.v17i4.25069>
 38. Francová A, Chrástný V, Vítková M, Šillerová H, Komárek M. Health Risk Assessment of Metal(loid)s in Soil and Particulate Matter From Industrialized Regions: A Multidisciplinary Approach. *Environ Pollut* [Internet]. 2020;260(114057):1–10. Available from: <https://doi.org/10.1016/j.envpol.2020.114057>
 39. Sunarsih E, Suheryanto, Septiawati D, Andarini D, Garmini R. Risk Model of Exposure To Air Pollution (No₂, So₂, TSP and dust) on Pulmon Function in Traffic Police in Palembang city. *Int J Recent Technol Eng* [Internet]. 2019;8(2 Special Issue 9):51–6. Available from: <https://doi.org/10.35940/ijrte.B1012.0982S919>
 40. Husaini H. Koreksi Terhadap Pengukuran Polutan Di Udara Dan Dampaknya Terhadap Kesehatan. *J Berk Kesehat*. 2016;1(1):5–12. Available from: <http://doi.org/10.20527/jbk.v1i1.588>
 41. Rahman A, Nukman A, Setyadi S, Akib CR, Sofwan S, Jarot J. Analisis Risiko Kesehatan Lingkungan Pertambangan Kapur Di Sukabumi, Cirebon, Tegal, Jepara Dan Tulung Agung. 2019; Available from: <https://doi.org/10.22435/jek.v7i1>
 42. Sentosa EA, Riviwanto M, Seno BA. Analisis Risiko Gangguan Fungsi Paru Akibat Paparan Debu PM₁₀ Pada Pekerja Mebel Kayu. *J Sanitasi Lingkung* [Internet]. 2022;2(1):30–7. Available from: <https://doi.org/10.36086/jsl.v2i1.1239>
 43. Ganggut MCN, Manafe DRTM, Sasputra IN. Hubungan Lama Paparan Debu Asap Kendaraan Bermotor Dengan Kapasitas Vital Paru Pada Operator SPBU Kota Kupang. *Cendana Med J*. 2018;15(3):390–4. Available from: <https://doi.org/10.35508/cmj.v6i3.671>

44. Suryani M, Setiani O, Nurjazuli. Analisis Faktor Risiko Paparan Debu Kayu Terhadap Gangguan Fungsi Paru Pada Pekerja Industri Pengolahan Kayu PT . Surya Sindoro Sumbing Wood Industry Wonosobo. *J Kesehat Lingkung Indones* [Internet]. 2017;4(1):17–22. Available from: [https://doi.org/10.14710/jkli.4.1.17 - 22](https://doi.org/10.14710/jkli.4.1.17-22)
45. Muhammad Arifin B. Faktor-Faktor yang Berhubungan dengan Perilaku Merokok pada Siswa SMP N 1 Pangkatan Kabupaten Labuhanbatu Tahun 2017. Institut Kesehatan Helvetia; Tesis. 2018.
46. Tipa EW, Kawatu PA, Kalesaran AFC. Hubungan Kebiasaan Merokok Dengan Kapasitas Vital Paru Pada Penambang Emas Di Desa Tatelu Kabupaten Minahasa Utara. *J KESMAS*. 2021;10(3):140–6. Available from: <https://ejournal.unsrat.ac.id/index.php/kesmas/article/view/33666>
47. Haznawati ND, Probosari E, Fitranti DY. Hubungan Indikator Obesitas Dengan Kapasitas Vital Paru Pada Remaja Akhir. *J Nutr Coll* [Internet]. 2019;8(2):95. Available from: <https://doi.org/10.14710/jnc.v8i2.23820>
48. Pinugroho BS. Hubungan Usia, Lama Paparan Debu, Penggunaan APD, Kebiasaan Merokok Dengan Gangguan Fungsi Paru Tenaga Kerja Mebel di Kec. Kalijambe Sragen. *Jurnal Kesehatan*. 2016. 10(2): 37. Available from: <https://doi.org/10.23917/jurkes.v10i2.5529>