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RESEARCH **Open Access**

The Effect of Air Pollution on Malondialdehyde, Superoxide Dismutase, and Lung Function of Traffic Police in Banjarbaru City

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Abstract
Air pollution has a significant impact on lung health, especially for groups of workers who are directly exposed to pollution, such as traffic police. This study aims to evaluate the effect of air pollution on Malondialdehyde (MDA), Superoxide Dismutase (SOD), and lung function levels in traffic police in Banjarbaru City. The method used was observational analytic with a cross-sectional research design. This study involved two groups, namely traffic police and non-traffic police, with a purposive sampling technique. The subjects involved totaled 80 people, divided into 40 traffic police and 40 non-traffic police, with the criteria of traffic police who have worked for at least 5 years. Serum MDA and SOD levels and pulmonary function assessment using spirometry were performed in both groups. The results showed that MDA levels in traffic police were higher (184.75 ± 14.5 μM) compared to non-traffic police (178.4 ± 3.4 μM), while SOD levels in traffic police were lower (1.06 ± 0.384 units) compared to non-traffic police (1.22 ± 0.3 units). In addition, Forced Vital Capacity (FVC) and Forced Expiratory Volume in one second (FEV1) values in traffic police were lower, while the FEV1/FVC ratio showed no significant difference. Air pollution has a significant effect on increasing MDA, decreasing SOD, FVC, and FEV1 in traffic police. It is recommended to reduce air pollution exposure in this group through stricter pollution control policies and the use of respiratory protective equipment.

Keywords: Air Pollution, Malondialdehyde (MDA), Superoxide Dismutase (SOD), Lung Function, Traffic Police.

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1. INTRODUCTION

Occupational lung diseases are often the result of exposure to harmful substances in the workplace, including insect proteins, animal dander, dust, minerals, microbes, and chemicals. These diseases can be triggered by specific compounds such as asbestos, silica, and fungi, or nonspecific factors like dust and air pollution. Common air pollutants include carbon monoxide (CO), hydrocarbons (HC), ground-level ozone (O3), nitrogen dioxide (NO2), sulfur dioxide (SO2), and particulate matter (PM). The global air quality index primarily focuses on fine particles with a diameter of ≤2.5 µm (PM2.5). 1,2 These minuscule particles can infiltrate the bloodstream via the alveoli, leading to severe health complications such as respiratory disorders, blood abnormalities, metabolic disturbances, and cardiovascular diseases. The recommended PM2.5 levels are 15 µg/m³ for a 24-hour average or 5 µg/m³ annually (Doiron et al., 2019; Ramdhan et al., 2020; Xing et al., 2016). Air pollution is a pressing global issue, intensified by the rapid growth of industrial and transportation sectors. The World Health Organization (WHO) estimates that 90% of the global population is at risk of health issues due to inhaling air with pollution levels that exceed established standards. Developing countries, including Indonesia, are disproportionately affected by these adverse effects (World Health Organization, 2022). In 2019, Indonesia was ranked sixth among 98 countries with the highest pollution levels globally. Real-time measurements in 2022 revealed that Indonesia's air pollution index exceeded WHO standards by fivefold. Banjarbaru, a city in South Kalimantan Province, was among the ten cities with the worst air quality in Indonesia, with a PM2.5 index reaching 5.1 times the WHO standard. The primary sources of air pollution in this region include aerosols, vehicle emissions, forest fires, burning straw, fossil fuels, among others (IQair, 2021).

Individuals who spend considerable time outdoors, such as traffic police officers who spend extended periods on roadways, are particularly susceptible to developing lung disorders due to air pollution. Studies have shown that their lung function deteriorates due to factors like length of service, smoking history, and nutritional status (Abidin, & Hasibuan, 2019; Rosyidah, 2016; Zhang et al., 2016). For instance, a cross-sectional study in Semarang found that among traffic police officers, 16.2% exhibited mild restrictive lung disorders, 21.6% had moderate restrictions, and 5.4% experienced severe restrictions. Another study involving 100 traffic police officers and 100 controls in Mangalore demonstrated significant reductions in lung function parameters among traffic police officers exposed to air pollution ($p<0.05$). Additionally, the FEV1/FVC ratio was higher (84.57±4.33) compared to the control group with lower exposure (Paul et al., 2021). These declines in lung function among traffic police officers can be attributed to various factors, including length of service, smoking history, nutritional status, and other underlying health conditions. Pollutants act as pro-oxidants, triggering oxidative stress and inflammation (Amaliyah et al., 2018; Yadav et al., 2022; Sasikumar et al., 2020).

In this study, Malondialdehyde (MDA) and Superoxide Dismutase (SOD) were chosen as the main parameters to evaluate the impact of air pollution due to their relevance and sensitivity in describing the balance between oxidants and antioxidants in the body. MDA is the end product of the lipid peroxidation process induced by reactive oxygen species (ROS). Elevated MDA levels indicate high oxidative stress, which is one of the main mechanisms of cell damage due to exposure to air pollutants, including PM2.5 and other toxic components. As a quantifiable biomarker, MDA provides a clear picture of the extent of oxidative damage experienced by individuals exposed to air pollution. SOD, on the other hand, is an antioxidant enzyme that plays an important role in reducing the impact of ROS by converting superoxide into hydrogen peroxide, which is then neutralized by other enzymes such as catalase or glutathione peroxidase. A decrease in SOD activity reflects the inability of the body's defense system to effectively fight oxidative stress, which can lead to chronic inflammation and tissue damage, including lung tissue. A cross-sectional study measuring hs-CRP, MDA, and TNF-α levels in street sweepers revealed significantly higher MDA levels in the exposed group (associated with higher PM2.5 exposure) (Morales & Munné-Bosch, 2019). Aydin et al. reported that nanoparticles can enhance ROS and MDA generation while reducing the activity of antioxidant enzymes like SOD, CAT, and GPx. Regular assessment of antioxidant and oxidant levels, along with lung function, can serve as an early detection modality for preventing occupational lung diseases caused by pollutants. These tests are readily available in many laboratories and are cost-effective (Wispriyono et al., 2021).

Based on the results of these previous studies, this study has specific differences compared to previous studies, including study subjects (traffic police) and research locations that have not been studied before. Therefore, there is a need for this study to explore the relationship between various types of pollutants and their impact on MDA, SOD, and other health parameters. Based on the above discussion, this study aims to investigate the impact of air pollution exposure as a work-related risk factor in traffic police officers, with a focus on MDA, SOD, and lung function.

The study will help elucidate how air pollution affects key biomarkers like Malondialdehyde (MDA) and Superoxide Dismutase (SOD), as well as lung function. This understanding is crucial for assessing the health risks faced by traffic police exposed to air pollution. The findings can guide policymakers and health authorities in developing targeted interventions and regulations to mitigate the adverse effects of air pollution on traffic police and other similarly exposed groups.

2. RESEARCH METHOD

This study employed an observational analytical method with a cross-sectional research design to investigate the impact of air pollution on various health parameters among Traffic police officers compared to non-traffic police officers in the city of Banjarbaru. The study population included Traffic police officers (traffic police) and police personnel who were not assigned to traffic units (non-Traffic police) in Banjarbaru. Subjects were categorized as follows: Traffic police Officers (the case group) and non-Traffic police Officers (the control group). Inclusion criteria required active working status for both groups, with Traffic police officers having a minimum of 5 years of service. Exclusion criteria applied to both groups included lung diseases (such as tuberculosis, asthma, chronic obstructive pulmonary disease), recent use of immunosuppressive drugs, and unwillingness to participate. The sample size calculation yielded a target of 40 subjects in each group after accounting for potential dropouts. The sampling in this study used the following formula:

$$n = Z^2 \, p \, (1-p) / d^2$$

Information:
n: Represents the minimum sample size needed
Z: For an alpha level of 0.05 is 1.96
p: Represents the proportion of traffic police in Banjarbaru city (0.1)
d: The limit of error or absolute precision, which is 0.01

The study examined the impact of air pollution on several key variables. The independent variable was air pollution, while the dependent variables included levels of malondialdehyde (MDA) (a marker for overall oxidative stress), superoxide dismutase (SOD) (an antioxidant enzyme mitigating inflammation), and lung function parameters (such as Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV1), and the FEV1/FVC ratio). Additionally, confounding variables such as age, body weight, smoking history, presence of chronic diseases, and vitamin consumption were considered. The study took place at the

Banjarbaru Police Resort (Polres Banjarbaru) and the Biochemistry Laboratory, Faculty of Medicine, University of Lambung Mangkurat (Laboratorium Biokimia FK ULM). Research occurred from June to July 2023.

Sample processing and data collection starts with screening of research participants that was conducted using a form containing inclusion and exclusion criteria. Police officers who met the criteria filled out consent forms to participate in the study. The research utilized a data collection form to gather information on age, gender, body mass index (BMI), length of service, work duration, smoking status, medical history, vitamin consumption, and use of personal protective equipment (PPE). The form included open-ended questions, and participant responses were categorized based on trends. The measurements for Superoxide Dismutase (SOD) and Malondialdehyde (MDA) were performed using peripheral blood samples (3-5 ml) collected with syringes and stored in purple-capped EDTA tubes. The blood samples were promptly sent to the Biochemistry Laboratory for processing. After centrifugation at 2000 rpm for 10 minutes, the blood was transformed into serum. SOD enzyme activity was assessed by taking 500 µL of supernatant, placing it in a reaction tube, adding 800 µL of 100 mM carbonate buffer (pH 10.2), and 100 µL of 3 mM epinephrine. Absorbance at a wavelength of 480 nm was measured as A0. After 15 seconds, absorbance was measured again at the same wavelength (A1). One unit of SOD was defined as the amount of enzyme inhibiting 50% of epinephrine autooxidation. MDA measurement involved taking 100 µL of serum, placing it in a reaction tube, adding 550 µL of 100 µL TCA, 100 µL of 1 N HCL, and 100 µL of 1% NaThio, followed by homogenization. The sample was then centrifuged at 500 rpm for 10 minutes, heated in a water bath at 100°C for 30 minutes, and measured using a spectrophotometer at a maximum wavelength (λ max = 532 nm). The spirometry procedure is follows standardized protocols and meets criteria set by the American Thoracic Society (ATS) for reproducibility. Participants are instructed to refrain from smoking or using respiratory medications before testing. Key spirometry results include Forced Vital Capacity (FVC) and Forced Expiratory Volume in 1 second (FEV1). Proper positioning, patient instruction, and demonstration ensure accurate measurements.

Data analysis was conducted using SPSS (Statistical Package for the Social Sciences) version 21. Normality testing was performed due to the small sample size, utilizing the Shapiro-Wilk test for data distribution. Univariate analysis described data distribution through descriptive statistics, including mean, mode, and standard deviation. Key variables such as age, gender, body mass index (BMI), work history, smoking status, medical history, vitamin consumption, and Personal Protective Equipment (PPE) use were identified. Bivariate analysis involved parametric (unpaired T-tests) or non-parametric (Mann-Whitney) tests based on data distribution. This research has obtained Ethical Approval from the Health Research Ethics Commission of the Faculty of Medicine, Lambung Mangkurat University with number: 208/KEPK-FK ULM/EC/VIII/2023.

3. RESULTS AND DISCUSSION

The total number of research subjects in this study was 80 police officers, after excluding 4 samples based on exclusion criteria. Among the 80 research subjects, they were divided into two groups: 40 samples were Traffic police (traffic police), and 40 were non-Traffic police. Data were collected through survey forms distributed after obtaining consent from the subjects and before the blood collection process for MDA and SOD examinations, as well as spirometry tests. Body mass index (BMI) was determined from weight and height measurements during the study, and the results were interpreted based on the World Health Organization (WHO) BMI reference. Work duration, smoking history, medical history, and vitamin consumption were obtained through open-ended questions in the survey forms. The overall characteristics of the subjects, as well as those divided into groups, can be seen in Table 1.

Table 1. Characteristics of the subject.

Variable (s)	**Total (n=80)**	**Traffic police officer (n=40)**	**Non-Traffic police officer (n=40)**
Age (mean±SD)	35.41±7.9	35.53±6.8	35.3±8.9
Gender			
Male	80 (100)	40 (100)	40 (100)
Body Mass Index (BMI)			
Underweight (<18.5)	0 (0)	0 (0)	0 (0)
Normal (18.5-24.9)	42 (52.5)	21 (52.5)	21 (52.5)
Overweight (25-29.9)	32 (40)	17 (42.5)	15 (37.5)
Obesity (>30)	6 (7.5)	2 (5)	4 (10)
Work Duration			
5-10 years	44 (55)	28 (70)	16 (40)
11-20 years	23 (28.8)	10 (5)	13 (32.5)
>20 years	13 (16.3)	2 (5)	11 (27.5)
Work Hours			
2-5 hours	29 (72,5)	29 (73.8)	0
6-9 hours	11 (27,5)	11 (27,5)	0
Smoking	78 (97.5)	38 (95.0)	40 (100)
Smoker	2 (2.5)	2 (5)	0 (0)
Non-smoker	47 (58.7)	23 (47.4)	24 (60)
Light smoker	31 (38.7)	15 (37.5)	16 (40)
Moderate smoker	0 (0)	0 (0)	0 (0)
Heavy smoker			
Medical History	2 (2.5)	2 (9.5)	0 (0)
Hypertension	1 (1.1)	1 (2.3)	0 (0)
Diabetes mellitus			
Vitamin Consumption	14 (17.5)	10 (25)	4 (10)
Vitamin C			
PPE Use (Mask)	0 (0)	0 (0)	0 (0)
Always	40 (50%)	40 (100%)	0 (0)
Sometimes	0 (0)	0 (0)	40 (100)
Never	35.41±7.9	35.53±6.8	35.3±8.9

From Table 1, it is evident that the age of both groups is relatively similar: 35.53±6.8 for the Traffic police and 35.3±8.9 for the non-traffic police. Overall, both groups predominantly consist of male participants. Most subjects (52.5%) have a normal Body Mass Index (BMI). Among Traffic police officers, 70% have a work duration between 5-10 years and spend an average of 2-5 hours per day outdoors for work purposes. Almost all subjects are active smokers, with a small percentage (17.5%) reporting regular vitamin C consumption. Additionally, three Traffic police officers have chronic diseases (2 with hypertension and 1 with diabetes mellitus). All Traffic police subjects acknowledge not always use Personal Protective Equipment (PPE) masks while working in traffic management.

Table 2. MDA Levels, SOD Levels, and Pulmonary Function (FVC%, FEV1%, and FEV1/FVC) in Traffic police and Non-traffic police Groups.

Variable (s)	Total	Traffic police officer	Non-Traffic police officer	p-value
MDA$^{\alpha}$				
mean±SD	181.57±10.97	184.75±14.5	178.4±3.4	0.004*
median (min-max)	180 (174.0-233.0)	180.00 (175-233)	179 (174-185)	
SOD$^{\beta}$				
mean±SD	1.14±0.35	1.06±0.384	1.22±0.3	0.046*
median (min-max)	1.22 (0.481-1.817)	1.11 (0.481-1.817)	1.23 (0.482-1.743)	
FVC%$^{\beta}$				
mean±SD	85.62±17.12	80.86±15.51	90.37±17.51	0.012*
median (min-max)	83.58 (41.47-130)	82.01 (41.47-108)	88.01 (54.96-130)	
FEV1%$^{\beta}$				
mean±SD	90.36±19.19	83.78±19.06	96.931±17.15	0.002*
median (min-max)	90.51(27.85–145)	86.74 (27.85-114)	96.55 (53.92-145)	
FEV1/FVC$^{\alpha}$				
mean±SD	87.76±10.01	86.89±12	89.62±7.22	0.322
median (min-max)	89.41 (40.1-100.0)	88.99 (40.1-100)	90.01(59.39-100)	

Note:
α: Difference test using Mann-Whitney.
β: Difference test using the Independent T Test.
**Significant at the 0.05 level (p<0.05).*

Table 2 shows that the mean comparison of MDA, SOD levels, and pulmonary function between Traffic police (traffic police) and non-Traffic police groups is presented in 3. The data for MDA (Malondialdehyde) and FEV1/FVC ratio did not follow a normal distribution. The Mann-Whitney test revealed a significant difference in MDA levels between the two groups (p=0.004). However, no significant difference was observed in FEV1/FVC ratio (p>0.05). On the other hand, SOD, FVC%, and FEV1% data had normal distributions. Independent T Test showed significant differences in SOD, FVC%, and FEV1% levels (p<0.05). In this study, the mean±SD MDA level was 181.57±10.97 µM. The Traffic police group exhibited a higher mean MDA level (184.75±14.5 µM) compared to the non-Traffic police group (178.4±3.4 µM). Conversely, the mean SOD level was lower in the Traffic police group (1.06±0.384 units) than in the non-Traffic police group (1.22±0.3 units). Regarding pulmonary function, the mean FVC% was lower in the Traffic police group (80.86±15.51) compared to the non-Traffic police group (90.37±17.51). Similarly, the mean FEV1% in the Traffic police group (83.78±19.06) was lower than in the non-Traffic police group (96.931±17.15). However, the mean FEV1/FVC ratio was similar between both groups (86.89±12 for Traffic police and 89.62±7.22 for non-Traffic police). Overall, Table 2 suggests that Traffic police officers have higher MDA levels and lower SOD levels, FVC%, and FEV1%, indicating a tendency toward restrictive lung function.

Table 3. Interpretation of Pulmonary Function Test Results (FVC%, FEV1%, and FEV1/FVC) in Traffic police and Non-Traffic police Groups.

Interpretation of spirometry	Total (n=80)	Traffic police (n=40)	Non-traffic police (n=40)
Normal	52	21	31
Mild restriction	19	13	6
Moderate restriction	4	2	2

Interpretation of spirometry	Total (n=80)	Traffic police (n=40)	Non-traffic police (n=40)
Mild obstruction	1	1	0
Moderate obstruction	1	1	0
Mixed pattern	3	2	1

Table 3 shows that in the traffic police group, there were more individuals with mild restriction cases and mixed patterns compared to the non-traffic police group. In contrast, the non-traffic police group had a higher proportion of individuals with normal lung function. In the traffic police group, 13 people showed mild restriction, while only 6 people in the non-traffic police group. In addition, the traffic police group also showed a higher number of individuals with mixed patterns, namely 2 individuals, compared to only 1 individual in the non-traffic group. In other categories, such as moderate restriction, mild obstruction and moderate obstruction, both groups showed relatively similar numbers. Overall, these data suggest that traffic police are more susceptible to lung function impairment, with mild restriction and mixed pattern impairment being more common compared to the non-traffic police group.

DISCUSSION

All subjects in this study were male, with an average age of 35.41±7.9 years. The age distribution was similar between the Traffic police and non-traffic police groups. Age significantly influences lung function, antioxidant levels (SOD), and oxidative stress markers (MDA). Aging can weaken the diaphragm muscles, reducing lung tissue elasticity and chest muscle function involved in respiration. Pulmonary function typically peaks around 20-25 years of age and gradually declines after approximately 35 years (Hasan et al., 2017). The majority of subjects had a normal Body Mass Index (BMI), but a significant proportion were overweight or obese. Among the Traffic police group, 17 (42.5%) individuals were overweight, while the non-traffic police group had a higher proportion of 4 (10%) individuals with obesity. Obesity can impact lung function by accumulating fat around the abdominal wall and organs, hindering diaphragm movement, and reducing lung expansion during inspiration, thus decreasing lung capacity (Svartengren et al., 2020). There were differences in the distribution of work experience between the traffic police groups and the control group. Among the Traffic police group, the majority of subjects (70%) had work experience ranging from 5 to 10 years. Conversely, only 25% of subjects had work experience between 11 and 20 years, and 5% had more than 20 years of experience. In contrast, the non-Traffic police group had a more evenly distributed work experience.

Traffic police officers working in densely populated metropolitan areas manage traffic for hours on end over many years. Their habits, including smoking and inconsistent mask usage, make them vulnerable to respiratory morbidity. This vulnerability arises due to exposure to air pollution and cigarette smoke, both of which are toxic, particularly for the respiratory system (Aguscik et al., 2017; Jaggi & Yadav, 2015; Li et al., 2020). Prolonged exposure to air pollution leads to inflammation and damage in the respiratory tract, affecting lung function and resulting in decreased lung capacity. In this study, most individuals in both groups exhibited normal lung function. However, some individuals in both groups showed various forms of lung function impairment, including mild and moderate restrictions, mild and moderate obstructions, as well as mixed patterns. Interestingly, traffic police officers had a higher prevalence of mild restriction and mixed patterns compared to non-traffic police officers. This suggests that Traffic police officers are more susceptible to certain conditions that can affect their lung function, possibly due to exposure to air pollution on the roads or other environmental factors, consistent with the research hypothesis. Air pollution can lead to either or both restrictive and obstructive patterns through mechanisms involving inflammation, increased oxidative stress, and lung tissue damage. (Bălă et al., n.d.; Doiron et al., 2019; R. R. Patil et al., 2014)

The Impact of Air Pollution on MDA Levels in the Traffic Police and Non-Traffic Police Groups

The average total MDA of the subjects was 181.57±10.97, for the Traffic police it was 184.75±14.5, and for the non-Traffic police it was 178.4±3.4 (Table 2). This difference is statistically significant, with a p-value <0.05, indicating that the Traffic police have higher MDA levels than the non-traffic police. This can be explained by the fact that MDA is a product of lipid peroxidation and cell damage mediated by reactive oxygen species (ROS). Conditions such as oxidative stress, injury, inflammatory diseases, and chronic infections usually increase MDA levels. Increased MDA levels have been associated with various diseases, especially chronic ones such as atopic dermatitis, psoriasis, diabetes mellitus, coronary heart disease, and cancer (Ayuningati et al., 2018; Hartley et al., 2021; Karadsheh et al., 2021; Lorente et al., 2015). In the context of this study, the increase in MDA occurred due to chronic exposure to air pollution experienced by the Traffic police. Air pollutants such as hydrocarbons, NO2, SO2, and particulates can enter the body through the respiratory system, reach and accumulate in the alveoli. This accumulation of pollutants can damage lung cells and trigger the production of ROS.

Traffic police officers are at higher risk of oxidative stress and related health problems due to continuous exposure to hazardous pollutants. This can manifest in a variety of chronic conditions such as cardiovascular diseases, respiratory problems, and other chronic inflammatory conditions. The association between high MDA levels and air pollution highlights the need for targeted interventions to reduce these risks, such as better protective measures, better air quality control, and regular health monitoring for traffic police officers (Haro Girón et al., 2023; Jaggi & Yadav, 2015). ROS will break down polyunsaturated fatty acids in cell membranes, triggering a chain reaction known as lipid peroxidation and causing an increase in MDA. In addition, smoking habits, overweight, and obesity also contribute to increased MDA levels. Smoking and obesity can exacerbate oxidative stress, which in turn increases MDA production (Aguscik et al., 2017; Morales & Munné-Bosch, 2019)

This study is consistent with the research of Prasad et al., which analyzed the relationship between air pollution exposure, specifically in traffic police, and MDA levels. Th e study was conducted in India, involving 173 traffic police and 179 control subjects, and found similar results, namely increased MDA and significant gradual decrease in SOD in traffic police (Prasad et al., 2013). A cross-sectional analytical observational study by Kahar involving 12 terminal workers an d 12 administrative workers showed that there was a very significant difference in serum MDA levels between bus terminal workers and administrative workers, where there was an increase in MDA levels in operational bus terminal workers compared to administrative workers (Kahar & Sulistyorini, 2016). A study by Ding et al., which evaluated the effect of air pollution on MDA levels and lung function in wild-type rats, found that PM 2.5 exposure was associated with increased inflammatory factors and malondialdehyde in rats (Ding et al., 2021; Wirjatmadi & Suryadinata, 2020). A study by Romieu et al., conducted on 43 children with asthma aged 5-13 years, found that an increase in the interquartile range (IQR) in the 24-hour average exposure of PM2.5 (22.2-33.5 μg/m^3), with an increase in nasal MDA concentration of 38. 6-54.9%. Increased nasal MDA levels also correlated with a decrease in FVC and FEV1 (He et al., 2020; Romieu et al., 2008).

The Impact of Air Pollution on SOD Levels in the Traffic Police and Non-Traffic Police Groups

This study shows that the average SOD level is lower in the Traffic police group, which is 1.06±0.384 units, compared to the non-Traffic police group, which is 1.22±0.3 units (Table 2). This difference is statistically significant (p=0.046), indicating that the Traffic police are more susceptible to oxidative stress than the non-traffic police. This can be explained by the theory that SOD is an antioxidant enzyme that protects cells from oxidative damage by converting superoxide anion into more stable oxygen and hydrogen peroxide. However, in conditions such as immunocompromise, chronic diseases, and chronic inflammation, SOD production usually decreases. Some disease conditions that can decrease SOD are like multiple sclerosis, leprosy, cardiovascular disease, and cancer (Sheilaadji et al., 2019; Simanjuntak & Zulham, 2020). In the context of this study, the decrease in SOD occurred due to chronic exposure to air pollution, especially by PM2.5, because out of 5 air pollution parameters in the city of Banjarbaru, PM2.5 is the parameter that increases its levels above normal values. Air pollutants such as PM2.5 can damage lung cells and stimulate the production of ROS. ROS will then attack various cell components, including fatty acids in cell membranes, proteins, and DNA, triggering various oxidative reactions, disrupting normal cell function, and triggering an inflammatory chain, thereby decreasing SOD production. In addition, some air pollutants such as lead (Pb) and CO can also directly inhibit the SOD enzyme. Therefore, exposure to air pollution can cause a decrease in SOD levels in the body, and increase oxidative stress and cell damage (Ma et al., 2015; Wispriyono et al., 2021).

The results of this study are consistent with the research of Ma et al., (2015) in Shenyang in August 2013. The study showed that the Traffic police have lower SOD levels (1.11 ± 0.21 U/mL) compared to the control group (1.28 ± 0.18 U/mL) ($p < 0.01$) (Ma et al., 2015). The study also found that SOD levels are inversely proportional to the concentration of PM2.5 ($r = -0.41$, $p < 0.01$). This study shows that PM2.5 exposure can decrease SOD activity and increase oxidative stress in Traffic police. Another study that is also in line with the results of this study is a study by Wispriyono et al., in 2021, which examined the impact of indoor air pollution exposure on oxidative stress biomarkers in junior high school students. The study showed that the average concentration of PM2.5 indoors caused by cigarette smoke and burning smoke from mosquito coils affects the level of oxidative stress biomarkers in students, which potentially poses health risks. These studies reinforce the hypothesis that air pollution can decrease SOD activity and increase oxidative stress (Wispriyono et al., 2021).

The Impact of Air Pollution on FVC% in Traffic Police and Non-Traffic Police Groups

This study shows that the mean±SD FVC% in the Traffic Police group, which is 80.86±15.51, is significantly lower compared to the non-Traffic Police group, which is 90.37±17.51 (Table 2). This difference indicates that the Traffic Police have restrictive lung function disorders, as their FVC% values are below the normal value (80%). FVC% is a measure of the maximum volume of air that can be forcefully exhaled after a full inhalation. This can be explained by the fact that the chronic exposure to air pollution experienced by the Traffic Police can cause oxidative stress, which is supported by the increase in MDA levels and the decrease in SOD levels in the Traffic Police in this study. Oxidative stress conditions will damage lung cells and create scar tissue, thereby reducing FVC%. In addition, air pollution can also trigger mutations and direct lung cell damage, causing a decrease in lung volume capacity (Husaini, 2016; Patil et al., 2014; Prasad et al., 2013; Wang et al., 2018)

A study by Paul et al., which evaluated lung function in Traffic Police personnel serving at various traffic intersections in the city of Mangalore, India, is in line with this research. This study shows that the lung function parameters of the exposed Traffic Police have significantly lower FVC (3.27±0.55), FEV1 (2.76±0.47) and PEFR (7.77±1.69) ($p < 0.05$) and higher

FEV1/FVC (84.57±4.33) compared to the control group. It was found that as the years of experience increased, lung function parameters such as FVC and FEV1 significantly decreased in Traffic Police personnel (Paul et al., 2021).

The Impact of Air Pollution on FEV1% in Traffic Police and Non-Traffic Police Groups.

The mean±SD FEV1% in the Traffic Police group is 83.78±19.06, and in the non-Traffic Police group is 96.93±17.15 (Table 2). The difference in the mean of these two groups is statistically significant with a p-value of 0.002. Forced Expiratory Volume in the first second (FEV1) is the amount of maximum air that can be forcefully exhaled in the first second after maximum inspiration. FEV1 values are used to assess obstructive conditions and assist in the diagnosis of obstructive lung diseases such as asthma or bronchitis. The results of this study show that the Traffic Police are affected by their FEV1% values, and may experience obstructive respiratory disorders. Theoretically, air pollution can cause obstructive or restrictive respiratory disorders, but this is influenced by many factors such as the type of exposure, the initial condition of the traffic police, body mass index and others. A study by Patil, which shows similar results, is a study that also compares Traffic Police and police with general duties (non-traffic) in Dhule, Maharashtra. This study involved 50 Traffic Police and 60 general duty police. The results of the study showed that the Traffic Police have significantly lower levels of FVC, FEV1, PEFR, MMV ($p<0.01$) compared to their predictive values. However, in a study by Makwana et al., about police in Gujarat, India involving 100 Traffic Police personnel, compared to a control group consisting of 100 less exposed men, it showed that Traffic Police personnel have a significant decrease in FVC, Slow Vital Capacity (SVC), and Maximum Voluntary Ventilation (MVV) compared to the expected normal value. However, the decrease is not significant in FEV1 and SVC in cases compared to controls, this is because the measurement results of FEV1 are not lower than FVC, so it leads to restrictive abnormalities (Patil et al., 2013).

The Impact of Air Pollution on FEV1/FVC in Traffic Police and Non-Traffic Police Groups

This study shows that the average FEV1/FVC in the Traffic Police group, which is 86.89±12, is lower compared to the non-Traffic Police group, which is 89.62±7.22 (Table 2). However, this difference is not statistically significant ($p=0.322$), so it cannot be concluded that the Traffic Police have obstructive lung disorders. The FEV1/FVC ratio can help determine the lung disease suffered. Obstructive lung disease if the FEV/FVC ratio is less than 70%, and in restrictive lung disease, an FVC value of ≤ 80% will be obtained. If both FVC% and FEV1/FVC% are low, it indicates mixed lung disease (Milanzi & Gehring, 2019). Statistically insignificant results can be caused because lung function abnormalities are more often found to be restrictive abnormalities in both groups, with FEV1 values decreasing less than FVC. The FEV1/FVC data in the Traffic Police group is lower than the non-Traffic Police value, but is still interpreted as a normal ratio and the difference is also not significant. This can be explained by the fact that in this study the Traffic Police are more likely to experience restrictive lung disorders, which is supported by the lower FVC% value in the Traffic Police. In addition, in this study obesity was found more in the non-Traffic Police group than in the Traffic Police group, in accordance with the theory that obesity can affect lung function. (Huang et al., 2015; Svartengren et al., 2020)

The results of this study are in line with the research of Patil who also compared Traffic Police and police with general duties (non-traffic) in Dhule, Maharashtra. This study involved 50 Traffic Police and 60 general duty police. The study showed that the Traffic Police have significantly lower levels of FVC, FEV1, PEFR, MMV ($p<0.01$) compared to their predictive values. Traffic Police have lower FVC and higher FEV1/FVC ratio compared to the control group ($p<0.01$), this is because the Traffic Police sample population suffers more from restrictive lung disease (Patil et al., 2013). Another study in line is a study by Makwana et al., about police in Gujarat, India involving 100 Traffic Police personnel, compared to a control group consisting of 100 less exposed men, showing that Traffic Police personnel have an increased FEV1/FVC ratio compared to controls and a decrease not significant in FEV1 and SVC in cases compared to controls. This is because the measurement results of FEV1 are not lower than FVC, so it increases the FEV1/FVC ratio which leads to restrictive abnormalities. (Makwana et al., 2015)

The limitations of this study are that it cannot definitively determine the pollutant components that cause lung abnormalities in traffic police. This study also cannot control confounding variables such as smoking and mask usage, as almost all of the samples are smokers and do not regularly use masks, which can certainly affect the results of the study. Given these limitations, future studies should be more in-depth in analyzing the pollutant components that have the most impact on lung health, using more specific pollutant detection tools. In addition, it is recommended to involve tighter control of confounding variables such as smoking habits and mask use. In addition, longitudinal studies conducted over a longer period of time can provide a clearer picture of the impact of air pollution exposure on lung health over a longer period of time, as well as provide a more comprehensive understanding of the relationship between air pollution and impaired lung function in traffic police.

4. CONCLUSION

The study concludes that air pollution has a significant impact on traffic police officers in Banjarbaru City compared to non-Traffic police. Specifically, it increases the level of malondialdehyde (MDA) and decreases the level of superoxide dismutase (SOD), both significantly. Furthermore, air pollution significantly reduces the forced vital capacity (FVC) and forced expiratory volume (FEV1) values in Traffic police. While air pollution also reduces the FEV1/FVC ratio in Traffic police compared to non-Traffic police, this reduction is not statistically significant. Based on the conclusions of this study, several recommendations can be made, especially to the traffic police. First, it is important to enhance the improvement of air quality monitoring systems in areas with high pollution levels to support timely protective measures. In addition, regular medical check-ups for traffic police officers, including monitoring of biomarkers such as MDA and SOD as well as lung function indicators, are important for early detection and prompt medical intervention. Educational campaigns are also needed to raise awareness among officers and the public about the health risks of air pollution, emphasizing the need for protective measures such as mask use and healthy living habits.

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