Factors associated decrease of forced vital capacity on gas station employees exposed to sulfur dioxide (SO₂)

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Abstract. Sulfur dioxide is particulate matter which primarily from the combustion emissions of motor vehicles. If inhaled into lungs, sulfur dioxide (SO₂) is deposited at alveoli and inflammation occurs. A long-term exposure to SO₂ can cause impaired lung function with increased morbidity and mortality. The research is a cross-sectional study done to 59 employees at gas stations with sulfur dioxide exposure in the working environment. Data has been analysed by regression logistic test using SPSS software. Of the 59 research subjects, there are 38 people (64.4%) whose Forced Vital Capacity value decreased (restrictive lung disease), with 36 people (61%) are categorized into mild restriction and 2 others (3.4%) are in moderate restriction. In this study, there are no significant correlations between FVC decrease and age, gender or working duration. There was not found employees exposed with SO₂ above 126.7 ppm in whom the decreased of FVC value occurred. In other words, employees exposed with a great level of SO₂ will undergo decrease of FVC value. This study showed that there was only a weak correlation between sulfur dioxide exposure level and FVC value. The contribution of SO₂ exposure to influence FVC value was only 9.4%.

Keywords: sulfur dioxide (SO₂), forced vital capacity (FVC), gas station employees, lung function, air pollution

1. Introduction

Air pollution is known as the main cause of health problems. According to World Health Organization (WHO), air pollution has led to 800,000 mortality per year [1]. Epidemiology study explained that concentration of ambient particles in air affects health level, especially to cardiovascular and respiratory system [2]. In Asia, air pollution is often attributed to the economy and social growth [3].

Exposure to 100 parts of sulfur dioxide per 1 part of air (ppm) is very dangerous to health and lives. Several studies showed the changes in the lung functions after an exposure to 0.4 - 3.0 ppm of SO₂. Research done to guinea pigs which were exposed to sulfur dioxide under 1 ppm suffered from impaired respiration with occurrence of inflammation or respiratory tract infection and the lung destruction [4,5,6]. Sulfur dioxide, one of the components that cause pollution, is particulate matter with diameter of < 2.5 μm (PM₂.₅) which comes from combustion emissions of motor vehicles. If inhaled, SO₂ reaches into the lungs and is deposited in alveoli [7]. Sulfur dioxide is a strong irritant which causes local inflammation.
and able to bind organic particulate matter. As a result, there are increases in vascular distension, mucosal oedema, smooth muscle contraction and respiratory tract secretion [8].

Operators at gas stations is one of the jobs with high risk of long-term exposure to motor vehicle emission which lead to respiratory disorders and decreased of the lung functions. The lung function in a healthy individual can relatively stand high sulfur dioxide dosage (5 ppm), while people with asthma for example, will have acute bronchoconstriction after an exposure to a lower dosage (<1 ppm) [8]. The same case was found in Kanchipuram, India with decreased in the lung function (forced vital capacity (FVC) and forced expiratory volume in one second (FEV1)) [9]. Therefore the researchers would like to observe the factors affect FVC decrease in employees at gas station who are exposed to sulfur dioxide in Medan City, Indonesia.

2. Materials and Methods

Fifty nine operators in gas stations at Medan Amplas sub-district who are willing to join the study and approved by Health Care Ethic Commissary Medical Faculty, Universitas Sumatera Utara. The inclusion criterias for the subjects are working duration of minimum 1 year, work hours of minimum 8 hours per day and aged between 18 and 40 years old. Whereas the exclusion criterias are smokers, suffering from lung or respiratory disorder (COPD or TB), obese, pregnant and liver disease.

The lung function (Forced Vital Capacity) examination was done with Spirometry vitalograph Alpha model series 6000, Ireland. Sulfur dioxide was examined using 0.04M tetrachloromercurate (TCM) absorbing reagent Impringer based on SNI 19-7119-7-2005 by Environmental Agency Laboratory team, North Sumatera.

Logistic regression was used to analyse the relationship between gender, age or working duration and forced vital capacity while Spearman correlation was used to determine the relationship between FVC and the level of sulfur dioxide exposure.

3. Results and Discussion

Sulfur dioxide is one of group of highly reactive gas and at the toxic level could cause upper and lower respiratory tract diseases. At the beginning, sulfur dioxide will contact mucosa wall at the tract where respiration is going to happen. It the activate macrophage alveolar and causes cell damages directly [8].

In this study, 59 respondents are operators at gas station in Medan Amplas sub-district, Medan. There are 29 males and 12 females. From all the respondents, 38 are found to have restriction while the other 21 do not. Association of gender, age, and working duration showed in the table below.

| Variable       | Restriction | No Restriction | p-value | OR    | 95% CI      |
|----------------|-------------|----------------|---------|-------|-------------|
| Gender         | Female      | 12             | 10      | 0.22  | 1.00 - 1.00 |
|                | Male        | 26             | 11      | 1.97  | 0.65 - 5.89 |
| Age            | < 30 years old | 26             | 16      | 0.45  | 1.00 - 1.00 |
|                | 30 - 39 years old | 6             | 1      | 0.22  | 0.10 - 3.78 |
|                | ≥ 40 years old | 6              | 4      | 3.7   | 0.4 - 33.5  |
| Working duration | < 5 years | 19             | 11     | 0.86  | 1.00 - 1.00 |
|                | ≥ 5 years   | 19             | 10     | 1.00  | 0.4 - 33.5  |
| Total          | 38          | 100            | 21      | 1.00  | 0.37 - 3.19 |

Logistic Regression test

Table 1 shows that male employees are 1.97 times more likely to decrease FVC (p-value = 0.22). Employees who aged more than 40 years old are 3.7 times higher at risk of FVC decrease (p-value = 0.45) and those who have been working for more than 5 years are 1.1 times more prone to decrease
Forced Vital Capacity ($p$-value = 0.86). Nonetheless, these three variables do not show a significant correlation.

Bhide et al.[10] in his study compared spirometry test of employees who have worked for more than 5 years and less than 5 years with control group. In his study, Bhide found significant differences in FEV1/FVC and FEF 25-75%. Whereas in FEV1 and FVC parameters have no significant difference. However in this study, employees who have worked for 5 years and above are found to be 1.1 more likely to be at risk in FVC decrease yet there is no significant difference ($p$-value = 0.86). Meanwhile, research done by Chawla and Lavania show spirometry test for employees in gas stations based on work hours and exposure to smoking. FEV1 and FEF 25-75% decreased significantly[11]. The results are align with this study in which all employees with working duration of 5 years more show restrictive respiratory tract.

This study is different from the result of Begum and Rathna study who found significant decreased in FVC and FEV1 parameters but not in FEV1/FVC values whereas a research done by Choudari et al.[12] found a significant decreased in FVC and FEV1 values.

The study conducted to gas stations operators in Bhopal showed significant to decrease FEV1 (forced expiratory volume in 1 second) and FVC (forced vital capacity) in employees who had worked for more than 5 years and so did FEF (forced expiratory flow) 25 - 75%, PEFR and PIFR in employees who have been exposed to SO2 for more than 10 years [13]. Chawla and Lavania also found that employees whose working duration is more than 11 years had FEF 25-75% decreased to below 70%. This shows that a long-term exposure to sulfur dioxide can cause to decrease FEF 25-75% parameter [11].

| Table 2. Association of Sulfur dioxide exposure level to FVC value |
|---------------------------------------------------------------|
| SO2 Level (ppm) (5 hours) | SO2 Level (ppm) (10 hours) | FVC Value (%) |
|--------------------------|-----------------------------|---------------|
| 108.3                    | 216.6                       | 64.4 ± 12.96 |
| 115.2                    | 230.4                       | 72.7 ± 11.5  |
| 117.6                    | 235.2                       | 82.3 ± 33.3  |
| 120.7                    | 241.4                       | 89.1 ± 20.9  |
| 126.7                    | 253.4                       | 73.3 ± 15.9  |

Spearman Correlation test

$p = 0.011$
$r = 0.307$
$r^2 = 0.094$

The table above showed that the higher SO2 exposure level, the higher the FVC value. However, this association was not found on employees exposed with SO2 above 126.7 ppm in whom the decrease of FVC value occurred. In other words, employees exposed with a great level of SO2 will undergo decrease of FVC value.

Statistical analysis showed that there was only weak correlation between SO2 exposure level and FVC value ($r = 0.307$). The contribution of SO2 exposure to influence FVC value was only 9.4%.

4. Conclusion

In this study showed that the higher SO2 exposure level to the higher the FVC value. However, this association was not found on employees exposed with SO2 above 126.7 in whom the decrease of FVC value occurred. In other words, employees exposed with a great level of SO2 will undergo decrease of FVC value. Statistical analysis showed that there was only weak correlation between SO2 exposure level to FVC value. The contribution of SO2 exposure to influence FVC value was only 9.4%.
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