



Gender-Related Impact of Forest and Peatland Fires on Air Quality and Lung Function Analysis

Tumpal Simatupang^{1,2*}, Yetrie Ludang¹, Aswin Usup¹, Nawan¹, Bambang S. Lutt¹, Liswara Neneng¹

¹Postgraduate Program, Palangka Raya University, Indonesia

²Doris Sylvanus Hospital, Palangka Raya, Indonesia

*Corresponding Author, Email: simatupang_tumpal@yahoo.com

Article Info

Article history:

Received 14 January, 2024

Revised 15 March, 2024

Accepted 18 April, 2024

Keywords:

Lung Function;

Forest Fires;

PM2.5;

Spirometer

ABSTRACT

The issue of air quality continues to be a major concern for both the environment and human health on a global scale, especially in developing nations. In 2015, Indonesia garnered international recognition as a result of the extensive forest and land fires. Exposure to PM particles in the air presents a substantial health hazard to individuals participating in their everyday routines. Research on the effects of forest fires on respiratory health in Central Kalimantan is still lacking. The Chest Miyagi multipurpose HI-801 spirometer, which was calibrated, was used to do lung function measurements. The participants were assessed while standing indoors in an environment with consistent air movement. Prior to the test, the individual's height and weight were measured and recorded in the spirometer, which then used this data to automatically determine the expected lung function. A sample size of 215 respondents who fulfilled the research criteria was selected for the study. The examinations took place in 7 urban and rural locations that were considered to be most susceptible to forest and land fires, based on the researcher's subjective judgment. These locations were chosen to meet the required sample size and were in close proximity to the fire sources. The spirometry device measures lung function, including forced vital capacity (FVC), forced expiratory volume in one second (FEV1), the ratio of FEV1 to FVC, and Forced Expiratory Flow (FEF). This study aimed to assess the effect of recurrent forest fires on lung function, specifically in relation to gender, in Palangka Raya City, Pulang Pisau Regency, and Kapuas Regency, located in the Central Kalimantan Province. The analysis was conducted using spirometry tests. There were no notable disparities in lung function among the respondents based on their gender.

Corresponding Author:

Tumpal Simatupang

Postgraduate Program, Palangka Raya University, Indonesia

Doris Sylvanus Hospital Palangka Raya, Indonesia

*Email: simatupang_tumpal@yahoo.com

INTRODUCTION

Worldwide, particularly in developing nations, air quality continues to be a critical environmental and public health concern. Factories, transportation infrastructure, waste disposal through incineration, forest fires, and particulate matter comprise prevalent sources of pollutants (Hime NJ. et al., 2018). Schmeider SR and Jonathan P.D. Abbatt (2022); Hassan S.K and Mamdouh I.K (2017) identify forest fire smoke pollutants as PM, CO, CO₂, NO₂, CH₄, VOCs, and O₃. Khaniabadi et al. (2018) and Liu Jun et al. (2021) have identified the immediate and enduring consequences of air pollution exposure. The World Health Organization (2015) estimates that outdoor air pollution exposure indirectly causes around 4.3 million fatalities each year in developing nations. In Indonesia, particulate matter and ozone (O₃) air pollution caused an absolute increase in fatalities from 71,372 in 2010 to 80,650 in 2016 (Ritchie, 2021). Lung

function is comparable between prepubescent boys and girls; however, disparities in lung volume become more pronounced in boys subsequent to puberty due to thoracic growth that is significantly greater (Neidell, 2023). 58% of fatalities associated with outdoor air pollution in 2016 were attributed to ischemic heart disease and stroke, according to the World Health Organization. Acute lower respiratory tract infections and chronic obstructive pulmonary disease accounted for 18% of deaths, respectively, while lung cancer accounted for 6% of deaths. Certain fatalities may be simultaneously ascribed to multiple risk factors. As an illustration, lung cancer is influenced by smoking and ambient air pollution. By increasing ambient air quality or decreasing tobacco use, certain lung cancer mortality may be averted. Extreme forest and land flames in Indonesia in 2015 drew international attention to the country. The fact that the particulate matter (PM₁₀) concentration in Palangka Raya (Central Kalimantan) exceeded 2000 ug/m³ in 2015 is an indicator; in contrast, the concentration was less than 2000 ug/m³ in 2002 and 2006. According to the Kalteng Governor's Report (2015), significant numbers of acute respiratory infections (ARIs) affected Palangka Raya City, Pulang Pisau Regency, and Kapuas Regency in 2014 and 2015 were attributed to pollution and forest and peatland fires. Using spirometry, this study aims to determine whether in Palangka Raya City, Pulang Pisau Regency, and Kapuas Regency, Central Kalimantan Province, repeated forest and land fires have an effect on lung function according to gender. Due to the fact that these three regions are susceptible to and impacted by recurrent peatland and forest fires, the locations were selected using purposive sampling.

LITERATURE REVIEW

The total vital capacity of the lungs refers to the maximum amount of air that can be inhaled and exhaled during the process of breathing. Spirometry is a diagnostic technique used to evaluate lung vital capacity and examine the functioning of the organ. The American Thoracic Society (ATS) uses this measure of total lung capacity to categorize respiratory diseases, including both obstructive ventilation disorders and restrictive ventilation disorders. There exist three categories of lung function disorders: obstructive, restrictive, and mixed (WHO, 2021). External variables, such as the physical work environment, and internal issues within the patient's body, can both decrease lung capacity. Extrinsic factors encompass the characteristics of inhaled chemicals (such as gases, dust, and vapors), the length of time of exposure, smoking behaviors, the utilization of personal protective equipment (particularly those that safeguard the respiratory system), and exercise routines. It is important to take into account the inherent elements inside the human body, particularly those pertaining to the anatomical and physiological aspects of lung defense systems, gender, medical history, body mass index (BMI), and individual susceptibility. According to Schneider (2022), contaminants found in forest fire smoke, such as PM and O₃, have significant adverse effects on human health. Epidemiological studies have established a correlation between exposure to forest fire smoke and adverse respiratory outcomes such as asthma and chronic obstructive pulmonary disease. Additionally, there is a possibility of harmful effects on cardiovascular health. Preliminary evidence suggests that smoke particles from forest fires are more harmful than other types of carbon aerosols. The causes of this phenomenon are not thoroughly comprehended, however they may be partially attributed to the elevated levels of polycyclic aromatic hydrocarbons (PAH) and aromatic compounds present in particulate matter emitted during forest fires. Furthermore, the presence of aromatic chemicals, such as quinones, in smoke can effectively initiate redox reactions, leading to oxidative stress in the body when inhaled into the lungs (Schneider, 2022). Air pollutants can have a direct impact on human health at specific concentrations, causing either immediate or acute effects, as well as chronic or subclinical effects, which may manifest with nonspecific symptoms. The primary constituents of urban air pollution are nitrogen dioxide (NO₂), ozone (O₃), and particulate matter (PM). Environmental air pollution arises from a multitude of sources, including both natural phenomena and human activity. Air pollution arises from both natural sources, such as volcanic eruptions, and human activity, including emissions from transportation and industrial sectors (Choma, 2021). These pollutants can stimulate the development of reactive oxygen species (ROS), which can cause oxidative conditions. This, in turn, activates transcription factors NF-κB and AP-1, leading to the production of cytokines such as IL-1β, IL-6, IL-8, IL-13, and TNF-α (Loaiza-Ceballos, 2021).

METHODOLOGY

This study was conducted in the city of Palangka Raya, Pulang Pisau Regency, and Kapuas Regency. The selection of locations was done through purposive sampling, considering that these three areas are exposed to and affected by repeated forest and peatland fires. A total of 215 respondents who met the research criteria were recruited, with examinations conducted in 7 locations in urban and rural areas, chosen subjectively by the researcher to fulfill the sample size requirement, considering areas close to forest and peatland fire sources as depicted in Figure 1.

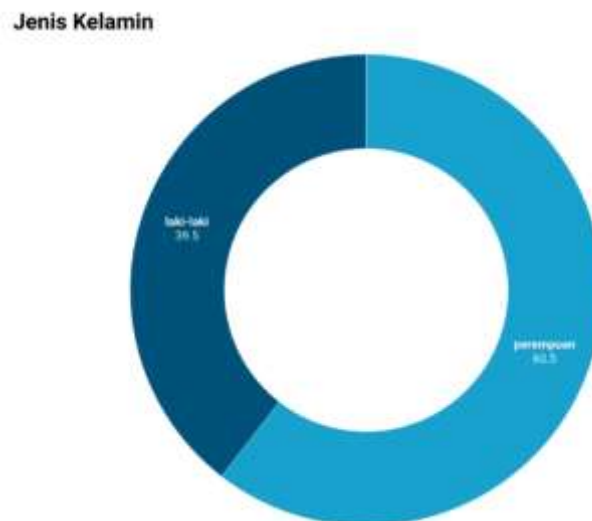


Figure 1. Distribution of Respondents

This study employed a cross-sectional approach using data obtained from samples of affected communities in Palangka Raya City, Pulang Pisau Regency, and Kapuas Regency. The study population consisted of adults aged 20 years or older. Participants in this study were selected using non-probability purposive sampling, where respondents were selected based on specific considerations by the researcher or sample determination for specific purposes, and data collection was conducted from September to December 2023.

RESULTS

Figure 2 illustrates the distribution of lung function disorders in accordance with lung function impairment as measured by vital lung capacity via spirometry. A significant proportion of the participants (34.9%) had vital lung capacities despite acute obstruction (< 50%). Subsequently, the normal range (>80%) was observed at 28.8%, whereas mild obstruction (60-80%) was reported by 18.6% and moderate obstruction (50-59%) by 17.7%.

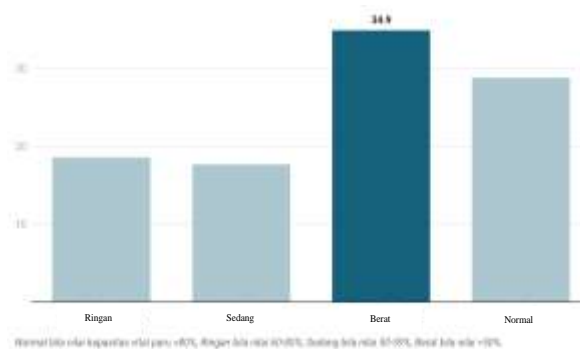


Figure 2. Distribution of Lung Function Disorders

Based on the average PM2.5 intake calculations above, the results obtained are (a) for adult women and (b) for adult men.

$$I_{nk} = \frac{57,4 \frac{\mu g}{m^3} \times 0,83 \frac{m^3}{jam} \times 24 \frac{jam}{hari} \times 112 \frac{hari}{tahun} \times 30 tahun}{52,4 kg \times 10,500 hari}$$

.....(a)

$$I_{nk} = \frac{3,841,850,9}{550,200} = 6,9 \frac{\mu g}{kg, hari}$$

$$I_{nk} = \frac{57,4 \frac{\mu g}{m^3} \times 0,83 \frac{m^3}{jam} \times 24 \frac{jam}{hari} \times 112 \frac{hari}{tahun} \times 30 tahun}{69,1 kg \times 10,500 hari} \dots\dots\dots (b)$$

$$I_{nk} = \frac{3,841,850,9}{725,550} = 5,3 \frac{\mu g}{kg, hari}$$

Based on the calculations above, it may be concluded that the daily intake of PM2.5 with non-carcinogenic effects on individuals exposed to forest and land fires is approximately 6.9 $\mu\text{g}/\text{kg}\cdot\text{day}$ in adult women and 5.3 $\mu\text{g}/\text{kg}\cdot\text{day}$ in adult men. The function of the lungs based on gender can be observed in Table 1, which presents data on the average values of lung capacity parameters in males and females. It is evident that there is no significant difference in the values of lung capacity parameters between males and females.

Table 1. Mean values of lung function parameters by gender

Variable	Gender (x \pm SD)		Total	p-Value
	Male	Female		
FVC	64.65 \pm 24.7	67.23 \pm 18.4	66.21 \pm 21.1	0.594
FEV ₁	56.89 \pm 25.6	58.19 \pm 24.4	57.68 \pm 22.5	0.692
FEV ₁ /FVC	89.77 \pm 19.9	93.50 \pm 92.1	92.02 \pm 72.6	0.130
FEF	79.63 \pm 98.9	68.89 \pm 33.6	73.13 \pm 67.5	0.848

Women in this study exhibited a higher susceptibility to ambient PM2.5 in comparison to men, although no statistically significant disparity was identified. The study revealed a detrimental correlation between the PM2.5 pollutant and expiratory flow characteristics, such as FVC, FEV₁, FEV₁/FVC, and FEF, particularly among women.

Table 2 Lung Function Disorders by Gender

Variable	Lung Function Disorders		Total	p-Value	OR (95% CI)
	With	Without			
Jenis kelamin					
Laki-laki	60 (70,6%)	25 (29,4%)	85 (100%)	0,880	1,1
Perempuan	93 (71,5%)	37 (28,5%)	130 (100%)		(0,6 - 1,9)

In Table 2, it is shown that gender does not appear to be associated with lung function disorders. This is evident in the small difference in proportions between those with lung function disorders in males (70.6%) and females (71.5%).

DISCUSSION

The issue of air pollution has garnered significant attention in numerous major cities in Indonesia, mostly due to the consistent deterioration of air quality in these urban areas. Despite the existence of current

programs aimed at managing it, this study reveals that air quality in certain areas falls below the established requirements in Indonesia, particularly in terms of average PM_{2.5} levels (Santoso, M. 2020). The variations in the effects of gender-pollutant interactions observed in different regions can be attributed to disparities in hormonal and physiological parameters related to lung development across genders (de Marco et al., 2000; Voraphani et al., 2022). Gender disparities exist in the correlation between lung volume and flow (Schwartz et al., 1988), potentially leading to gender-specific reactions to air contaminants. An extensive longitudinal study conducted in the United States examined the correlation between air quality standards implemented during the 1990s and the functioning of the lungs. The tenuous correlation corroborates the results of the present study, in which researchers deliberately selected some characteristics as potential confounding factors (such as home region and work status), and discovered that both FVC and FEV₁ lung function scores in the entire population were lower than 80%. In a study conducted by Zakaria (2019), it was shown that female patients had lower average values for all metrics in comparison to male patients. All patients had an estimated Forced Vital Capacity (FVC) that was below 80%. Additionally, the ratio of Forced Expiratory Volume in one second (FEV₁) to FVC rose as Body Mass Index (BMI) increased. The body mass index (BMI) showed a significant correlation with peak expiratory flow in all patients. Additionally, it was found to be favorably connected with the FEV₁/FVC ratio in males, but not in women (Zakaria, 2019).

There is an inverse correlation between pollutants and expiratory flow measures, including as FVC, FEV₁, FEV/FVC, and FEF, particularly among women. Gender disparities in the impact of pollutants in different places may be attributed to variations in gender-specific hormonal and physiological variables that influence lung development (de Marco et al., 2000; Voraphani et al., 2022). Gender disparities exist in the correlation between lung volume and flow (Schwartz et al., 1988), potentially leading to gender-specific reactions to air contaminants.

CONCLUSION

The conclusion of this research is that the lung function of the respondents based on gender does not show any significant difference.

REFERENCES

- Aiken CE. Respiratory disease in pregnancy. *Obstetrics, Gynaecology & Reproductive Medicine*. 2024;34(Uda et al, 2019):6-10. doi: 10.1016/j.ogrm.2023.10.002.
- Ardiyani V. The impact of 2018/2019 wildfire exposure on BaP-DNA adducts and birth weight in Indonesia. London: King's College London; 2022.
- Azizah, I. T. N. (2019). Analysis The Level of PM_{2,5} And Lung Function of Organic Fertilizer Industry Workers In Nganjuk. *Jurnal Kesehatan Lingkungan*, 11(2), 141. <https://doi.org/10.20473/jkl.v11i2.2019.141-149>
- Brown, D. M., Donaldson, K., Borm, P. J., Schins, R. P., Dehnhardt, M., Gilmour, P., Jimenez, L. A., & Stone, V. (2015). Calcium and ROS-mediated activation of transcription factors and TNF- α cytokine gene expression in macrophages exposed to ultrafine particles. *American Journal of Physiology - Lung Cellular and Molecular Physiology*, 286(2 30-2), 344–353. <https://doi.org/10.1152/ajplung.00139.2003>
- Gade EJ, Thomsen SF, Lindenberg S, Kyvik KO, Lieberoth S, Backer V. Asthma affects time to pregnancy and fertility: a register-based twin study. *Eur Respir J*. 2014;43(Wooster et al, 2018):1077-85. doi: 10.1183/09031936.00148713.
- Hime, N. J., Marks, G. B. and Cowie, C. T. (2018) 'A comparison of the health effects of ambient particulate matter air pollution from five emission sources', *International Journal of Environmental Research and Public Health*, 15(6), pp. 1–24. doi: 10.3390/ijerph15061206.
- Laporan Gubernur Kalimantan Tengah pada Acara Kunjungan Presiden Terkait Penanganan Kabut Asap di Kalimantan Tengah, 2015.
- Loaiza-Ceballos, M.C, et al. Viral respiratory infections and air pollutants. *Air Quality, Atmosphere & Health* (2022) 15:105–114
- Marpaung, Y. M. (2012). Pengaruh Pajanan Debu Respirable PM_{2.5} Terhadap Kejadian Gangguan Fungsi Paru Pedagang Tetap di Terminal Terpadu Kota Depok Tahun 2012. 70.
- Mirabelli MC, Preisser JS, Loehr LR, Agarwal SK, Barr RG, Couper DJ, et al. Lung function decline over 25 years of follow-up among black and white adults in the ARIC study cohort. *Respir Med*. 2016;113:57-64. doi: <https://doi.org/10.1016/j.rmed.2016.02.003>.
- Ritchie, H., dan Roser, M. 2021. Air Pollution. <https://ourworldindata.org/air-pollution#:~:text=Air%20pollution%20is%20attributed%20to,in%20rates%20across%20the%20wor> Id. Diakses pada 08 April 2022 pukul 21.38.
- Schneider, S. R. et al. (2020) 'Reactive Uptake of Ozone to Simulated Seawater: Evidence for Iodide

- Depletion', *Journal of Physical Chemistry A*, 124(47), pp. 9844–9853. doi: 10.1021/acs.jpca.0
- Xander Bertels, James C. Ross, Rosa Faner, Michael H. Cho, M. Arfan Ikram, Guy G. Brusselle, Lies Lahousse. Clinical relevance of lung function trajectory clusters in middle-aged and older adults *ERJ Open Research* Jan 2024, 10 (1) 00793-2023; DOI: 10.1183/23120541.00793-2023
- Yulianti N. *Pengenalan Kebakaran dan Kabut Asap Lintas Batas: Studi kasus eks proyek lahan gambut sejuta hektar*. Bogor: IPB Press; 2018.
- Zakaria R, Harif N, Al-Rahbi B, Aziz CBA, Ahmad AH. Gender Differences and Obesity Influence on Pulmonary Function Parameters. *Oman Med J*. 2019 Jan;34(1):44-48. doi: 10.5001/omj.2019.07. PMID: 30671183; PMCID: PMC6330191.