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Original Article

Second-hand Smoke, Peak Expiratory Flow Rate (PEFR), And Pregnancy In The Second And Third Trimesters

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ABSTRACT

Background: Pregnant women exposed to Secondhand Smoke (SHS) face a high risk of impaired lung function, which is naturally reduced by advancing pregnancy. This study analyzed the effect of SHS exposure on Peak Expiratory Flow Rate (PEFR) and its relationship with gestational age and key physiological parameters.

Methods: This cross-sectional study involved 50 non-smoking pregnant women (Trimester II and III) exposed to SHS in Jambi City. PEFR was measured using a Peak Flow Meter. Statistical analysis used Pearson correlation and Chi-square tests ($p<0.05$).

Results: All respondents (100%) showed significantly lower actual PEFR than predicted values, confirming a universal decline in lung function. A significant association was found between gestational age and PEFR ($p<0.05$), with the third trimester group having the most pronounced decrease (<320 L/minute). PEFR was not significantly correlated with blood glucose ($r=0.089$), hemoglobin ($r=0.125$), or SpO2 ($r=0.153$).

Conclusion: Decreased PEFR in pregnant women exposed to SHS is primarily linked to mechanical limitations from late gestational age, not metabolic or oxygen-carrying disturbances. Prevention of SHS exposure is crucial for maternal respiratory health.

INTRODUCTION

Pregnancy brings significant physiological changes to almost all of a woman's body systems, including the respiratory system. These changes aim to accommodate the increased oxygen needs of the mother and the developing fetus.[1,2] In the second and third trimesters, the increasing size of the uterus will press on the diaphragm, which directly causes a decrease in lung capacities, such as Functional Residual

Capacity (FRC) and Expiratory Reserve Volume (ERV).[2,3] Peak Expiratory Flow Rate (PEFR) measurement, which is a non-invasive and straightforward measurement for assessing the maximum airflow rate during forced expiration, is often used as an indicator of lung function and to monitor respiratory conditions.[4,5]

In addition to the physiological changes of pregnancy, environmental factors such as exposure to secondhand smoke (SHS) can also worsen lung function.[6,7] Cigarette smoke contains various harmful substances such as carbon monoxide (CO) and nicotine, which can cause systemic inflammation and bronchoconstriction.[7,8] These substances not only interfere with the supply of oxygen and nutrients to the fetus, which increases the risk of Low Birth Weight (LBW) and other pregnancy complications, but also have a direct impact on the mother's respiratory health.[7-9] Research by Dharma (2020) and Ekambaram et al. (2022) shows that exposure to secondhand smoke (SHS) can also worsen lung function. Secondhand smoke can reduce PEFR values in non-pregnant women.[6,10] Other factors, such as Body Mass Index (BMI), are also known to influence PEFR values, which are relevant in population studies in Jambi.[4]

Previous research data, including those conducted in Jambi City, have identified an association between cigarette smoke exposure and decreased PEFR in pregnant women.[11] However, the relationship between decreased PEFR and other physiological parameters such as blood glucose levels (which are associated with the risk of Gestational Diabetes Mellitus/GDM due to cigarette exposure), hemoglobin (Hb) levels, and oxygen saturation (SpO2) still needs to be clarified, especially in the population of pregnant women exposed to secondhand smoke in Indonesia.[12-14]

This study was conducted to fill this knowledge gap by comprehensively analyzing the effect of secondhand smoke exposure on PEFR and examining its correlation with gestational age, as well as hematological and metabolic parameters in pregnant women.

METHOD

Research Design and Location

This research is an observational analytical study with a cross-sectional approach. The study was conducted at the Rawasari Community Health Center, Jambi City, in July 2024.

Population and Sample

The target population was pregnant women exposed to secondhand smoke and undergoing antenatal care (ANC) at the Rawasari Community Health Center. The sampling technique used was purposive sampling. The sample size that met the inclusion and exclusion criteria was 50 pregnant women.

Inclusion Criteria:

Pregnant women in their second and third trimesters, exposed to secondhand smoke, non-smokers, willing to participate in the study.

Exclusion Criteria:

History of heart disease, asthma, acute respiratory infections (ARI), or other respiratory disorders.

Variables and Measurements

The dependent variable was Peak Expiratory Flow Rate (PEFR) (L/minute), measured using a Peak Flow Meter. The independent variables were passive cigarette smoke exposure and gestational age (second and third trimesters). Control variables/cofactors included blood glucose levels (mg/dL), hemoglobin levels (mg/dL), and oxygen saturation (%).

Data Analysis

Data were analyzed using statistical software. Descriptive analysis is presented in the form of a frequency distribution. Inferential analysis included: comparison of actual PEFR values with predicted values

(based on standard formulas) to classify lung function, testing the relationship between gestational age and PEFR values using appropriate statistical tests (p-value <0.05), pearson correlation test to assess the linear relationship between PEFR and blood glucose levels, hemoglobin levels, and oxygen saturation (p-value <0.05).

RESULT

Respondent Characteristics

A total of 50 pregnant women were sampled in this study, whose gestational age, blood glucose levels, and hemoglobin levels were assessed.

Table 1. Respondent Characteristic

Variables	Category	Frequency (n)	Percentage (%)
Gestational Age	Second trimester	22	44
	Third trimester	28	56
Blood Glucose Levels	< 80 mg/dL	9	18
	80–140 mg/dL (Normal)	38	76
	> 140 mg/dL	3	6
Hemoglobin Level	≥ 11 mg/dL (Normal)	27	54
	< 11 mg/dL (Anemia)	23	46

Based on gestational age, the majority of respondents were in the third trimester, comprising 56% (28 people), while the remaining 44% were in the second trimester. In the context of blood glucose levels, it was found that the majority of respondents (76% or 38 people) had blood glucose levels in the normal range (80–140 mg/dL). However, 18% of respondents had low blood glucose levels (<80 mg/dL), and 6% had high blood glucose levels (>140 mg/dL). The primary concern was the condition of the respondents' hemoglobin levels, where almost half (46% or 23 people) were identified as having anemia (<11 mg/dL). In comparison, slightly more than half (54% or 27 people) had normal hemoglobin levels (≥11 mg/dL). Overall, the results of this study highlight the high prevalence of anemia among the pregnant women studied, even though the majority of them had reasonable blood glucose control.

Distribution and Classification of Pulmonary Function (PEFR) Based on Gestational Age

Respondents were classified based on gestational age and actual Peak Expiratory Flow Rate (PEFR) (L/minute).

Table 2. Distribution and Classification of Pulmonary Function (PEFR) Based on Gestational Age

Gestational Age	Low PEFR (<320 L/min) (n) Normal	High PEFR (≥320 L/min) (n)	Total (n)	*p-value*
Second Trimester	22	0	22	<0,05
Third Trimester	27	1	28	
Total	49	1	50	

As many as 98% of pregnant women exposed to secondhand smoke have low lung function. This decrease in PEFR is significantly influenced by increasing gestational age, with women in their third trimester showing a higher incidence of low PEFR.

CORRELATION OF PEFR WITH OTHER PHYSIOLOGICAL PARAMETERS

The following are the results of the Pearson correlation test between PEFR values and the measured physiological parameters.

Table 3. Correlation of PEFR with Other Physiological Parameters

Physiological Parameters	Pearson Correlation Coefficient (r)	*p-value*
Oxygen Saturation (SpO2)	0,153	0,2944
Blood Glucose Levels	0,089	0,5396
Hemoglobin (Hb) Levels	0,125	0,389

No statistically significant linear correlation was found between impaired pulmonary function (PEFR) and SpO2, blood glucose, or Hb levels. This suggests that the decline in lung function is predominantly due to the mechanical factors of pregnancy and the irritating effects of cigarette smoke on the airways, rather than significant disturbances in metabolic parameters or oxygen-carrying capacity.

DISCUSSION

The results of this descriptive study of 50 pregnant women, the majority of whom were in their third trimester (56%), revealed two key interrelated health findings: reasonable blood glucose control in the majority (76% normal) and a high prevalence of anemia (46%). This high rate of anemia (Hb levels <11 mg/dL) is particularly relevant when associated with potential respiratory problems, such as decreased Peak Expiratory Flow Rate (PEFR) due to exposure to secondhand smoke. Anemia, characterized by low hemoglobin levels, reduces the blood's capacity to transport oxygen to all body tissues, including the lungs and respiratory muscles. Meanwhile, exposure to secondhand smoke, which contains Carbon Monoxide (CO) and other harmful substances, will exacerbate this condition. CO has a 200 to 300 times greater affinity for hemoglobin than oxygen, further reducing the amount of hemoglobin available to carry oxygen. This low oxygen supply (hypoxia), caused by anemia and exacerbated by CO2 binding from cigarette smoke, can cause respiratory muscle weakness, theoretically contributing to decreased lung function as measured by PEFR in pregnant women in the second and third trimesters.[15,16] Furthermore, exposure to secondhand smoke has been shown to increase the risk of anemia in pregnant women, further emphasizing the importance of research into how these two factors simultaneously affect respiratory health and fetal oxygenation.[17,18]

The results showed that almost all pregnant women (98%) sampled and exposed to secondhand smoke (SHS) had low actual Peak Expiratory Flow Rate (PEFR) values (<320 L/min) [Table 2]. This finding indicates significant obstructive pulmonary function impairment in this population. Sharma's (2022) research consistently shows that exposure to secondhand smoke generally reduces lung function in non-smoking women and has even been identified as a risk factor for respiratory disorders in adults and the elderly.[6,19] Toxic substances such as carbon monoxide (CO) and nicotine in cigarette smoke systemically affect the body's physiology. They cause chronic irritation and inflammation of the airways, leading to bronchoconstriction and increased airway resistance, thereby reducing forced expiratory capacity.[20,21]

In addition to external factors (SHS), the analysis revealed a significant association ($p<0.05$) between decreased PEFR and increasing gestational age. Pregnant women in the third trimester showed a higher prevalence of low PEFR (27 out of 28 women) compared to those in the second trimester [Table 2]. Studies of pregnancy physiology strongly support this finding. Eke et al. (2023) explained that increased uterine volume and pressure in the final trimester cause diaphragm elevation.[1] This mechanical limitation directly reduces lung volumes such as Expiratory Reserve Volume (ERV), which contributes to a decrease in PEFR values.[2] A study by Kumar (2020) also confirmed

significant changes in pulmonary function tests, including a decrease in PEFR, with increasing gestational age.[2] Therefore, the low PEFR in this group is a result of a combination of the irritating effects of SHS and mechanical compression due to advanced gestational age.[22] Research in Jambi itself has also highlighted anthropometric factors such as Body Mass Index (BMI) as factors that contribute to PEFR values, which emphasizes the need for comprehensive lung function measurements.[4,5]

Although maternal lung function is impaired, Pearson's correlation test results showed no significant linear correlation between PEFR and blood glucose levels (r=0.089; p=0.5396), hemoglobin (Hb) levels (r=0.125; p=0.389), or oxygen saturation (SpO2) (r=0.153; p=0.2944) [Table 3]. This absence of correlation warrants further analysis by comparing it with existing literature.

PEFR and Blood Glucose: Exposure to SHS is an identified risk factor for increasing the risk of Gestational Diabetes Mellitus (GDM).[23,24] Prospective studies by Na et al. (2022) and Morales-Suárez-Varela et al. (2022) confirmed the association between secondhand smoke exposure and an increased risk of GDM.[23,24] However, the lack of a significant correlation between PEFR and blood glucose in this sample (where the majority, 76%, had normal glucose levels) suggests that acute/mechanical lung function impairment (measured by PEFR) may not be directly correlated with impaired glucose metabolism, which is a multifactorial and chronic condition.

PEFR and Hemoglobin (Hb) / Oxygen Saturation (SpO2): Low PEFR did not correlate significantly with Hb or SpO2 levels. Although exposure to CO from cigarette smoke can cause carboxyhemoglobin formation and anemia, nearly half of the respondents (46%) experienced anemia. However, the physiological compensatory ability of the pregnant woman's body tends to maintain oxygen saturation (SpO2) within stable limits.[18,25] This is supported by the findings of Jain and Bhat (2022) regarding physiological adaptations to pregnancy.[26] This lack of correlation strengthens the conclusion that the decrease in PEFR in this case is predominantly due to obstructive and mechanical mechanisms in the airways, rather than a significant failure in gas exchange efficiency or oxygen carrying capacity. Interventions to increase Hb levels, such as taking iron tablets, have been shown to correlate more with nutritional status, highlighting the complexity of hematological parameters not directly linked to PEFR function.[27]

Overall, these findings underscore that the dangers of secondhand smoke exposure in pregnant women not only impact the fetus (risk of low birth weight and stunting) but also universally impair maternal respiratory mechanical function.[28,29] Public health interventions, including educational programs to reduce SHS exposure and accurate monitoring of health statistics, are essential to protect pregnant women from these risks.[30,31]

CONCLUSION

Lung function, measured by Peak Expiratory Flow Rate (PEFR), in all non-smoking pregnant women exposed to secondhand smoke at the Rawasari Community Health Center, Jambi City, was very low compared to the normative predicted value. This decline in lung function was significantly associated with increasing gestational age (the third trimester had the lowest PEFR), but was not significantly correlated with blood glucose levels, hemoglobin levels, or oxygen saturation. These findings highlight the need for stronger public health interventions to protect pregnant women from exposure to secondhand smoke.

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