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Impact of Cohb Exposure on Diabetes Mellitus Incidence in Tanjung Sari Village

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ABSTRACT

Background & Objective: Diabetes Mellitus (DM) is a non-communicable disease whose prevalence continues to rise in Indonesia. Based on routine Puskesmas reports, there has been an increase in the number of patient visits with DM-related complaints over the past two years, with individuals with metabolic risk factors and certain environmental exposures tending to dominate this group. Furthermore, Tanjung Sari Village is located close to busy traffic routes and household combustion activities, which have the potential to increase carbon monoxide (CO) exposure, potentially leading to increased carboxyhemoglobin (COHb) levels in the community, even though the majority are non-smokers. The purpose of this study was to determine the relationship between COHb levels and the incidence of diabetes mellitus in Tanjung Sari Village, within the Tanjung Sari Natar Community Health Center (Puskesmas). **Method:** This study used a quantitative cross-sectional design. The population was 53 DM patients aged 12-30 years seeking treatment at the Tanjung Sari Natar Community Health Center (Puskesmas). The sample used was a purposive sampling method. This research was conducted in August 2025. Data collection was conducted using observation sheets and data analysis using a computer program, with the Gamma test used for analysis. **Result:** The results of the study revealed a significant relationship between COHB levels and the incidence of diabetes in Tanjung Sari Village, within the Tanjung Sari Natar Community Health Center (Puskesmas) in 2025, with a p-value of 0.000 ($p < 0.05$). **Conclusion:** The conclusion is that there is a relationship between COHB levels and the incidence of diabetes. The Community Health Center can conduct regular education to the

community about the dangers of CO exposure and its relationship to metabolic diseases, including diabetes.

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Introduction

Diabetes mellitus is a chronic condition characterized by elevated blood glucose levels caused by the body's inability to produce insulin or use insulin effectively. Diabetes mellitus is a multifactorial disease with equally strong genetic and environmental components contributing to its onset. The influence of genetic factors is evident in the high number of diabetes cases among individuals with a family history of diabetes mellitus. Type 2 diabetes mellitus is often referred to as a lifestyle-related diabetes. Once it develops clinically, diabetes mellitus is marked by fasting and postprandial hyperglycemia, atherosclerosis, and microangiopathic vascular disease (Ministry of Health, 2022).

Based on the latest data from the International Diabetes Federation (IDF, 2025), approximately 589 million adults aged 20–79 worldwide are living with diabetes, or about 1 in every 9 adults. Of this number, around 43% of individuals remain undiagnosed, placing them at risk of complications due to inadequate medical management (IDF, 2025). Geographically, the country with the highest number of diabetes cases is China, with more than 140 million cases, followed by India and Pakistan, both showing significant yearly increases (IDF, 2025). The highest prevalence of diabetes is reported in the Middle East and North Africa (MENA) region, reaching 18.1% among adults (IDF, 2025). By sex, the prevalence of diabetes is slightly higher in males than females, at 10.8% and 10.2% respectively (IDF, 2025). Additionally, diabetes risk increases with age, with individuals aged 75–79 showing the highest prevalence of approximately 24% (IDF, 2025).

In Indonesia, the prevalence of diabetes mellitus continues to rise at an alarming rate. According to the 2023 Indonesia Health Survey (SKI) released by the Ministry of Health, the prevalence of diabetes among individuals aged ≥15 years reached 11.7% in 2023, an increase from previous reports (Ministry of Health, 2023). Provinces with the highest prevalence include Jakarta, Central Java, and Yogyakarta, while Lampung ranks ninth nationwide (Ministry of Health, 2023). The prevalence of diabetes mellitus in the Province of Lampung is 0.7%, with a total of 38,923 cases. Meanwhile, the prevalence in South Lampung Regency is 1.51%, the highest compared to West Lampung (0.93%) and North Lampung (1.31%) (Lampung Provincial Health Office, 2020). Based on a preliminary study conducted on April 20, 2025, at Tanjung Sari Natar Health Center, data showed a yearly increase in diabetes cases. In 2023, the total number of DM patients was 187; in 2024, the number rose to 369, and remained 369 cases as of early 2025. The number of DM patients aged 31–45 who visited between January and March reached 98 individuals (Tanjung Sari Health Center Medical Records, 2025).

The impact of diabetes mellitus is extensive—medically, socially, and economically. Medically, DM can lead to serious complications such as heart disease, stroke, kidney failure, vision impairment, and even amputation. These complications result from chronic hyperglycemia that damages blood vessels and body tissues (American Diabetes Association, 2021). Socially and psychologically, people with

diabetes often experience reduced quality of life, prolonged stress, and depression due to activity limitations and the need for long-term care. Additionally, the cost of diabetes treatment poses a financial burden not only for individuals but also for families and national healthcare systems. The World Health Organization (WHO, 2020) notes that diabetes is a leading cause of disability and premature death in many developing countries. Therefore, diabetes prevention and management require a holistic and continuous approach, including health education, lifestyle modification, and support from families and healthcare workers.

One environmental risk factor increasingly examined in health studies is carbon monoxide (CO) exposure. Carbon monoxide exposure can lead to the formation of carboxyhemoglobin (COHb), which adversely affects tissue oxygenation and metabolism (IDF, 2021). Carboxyhemoglobin (COHb) forms when carbon monoxide binds to hemoglobin with an affinity higher than oxygen. Long-term CO exposure disrupts oxygen supply to body tissues, affecting various organs including the pancreas, which regulates blood glucose. Impaired oxygenation of pancreatic beta cells due to COHb exposure can induce oxidative stress and inflammation, contributing to insulin resistance and glucose metabolism disorders. Several studies have shown that elevated COHb levels are associated with chronic diseases, including hypertension and diabetes mellitus. This is important to investigate, especially among populations with high CO exposure such as active and passive smokers, and individuals living in areas with high air pollution. Therefore, understanding the relationship between COHb levels and diabetes is crucial for preventive and promotive health strategies (Brook et al., 2019).

Risk factors for diabetes include genetics, obesity, stress, physical inactivity, high intake of fast food and sugar, body mass index (BMI), and smoking habits. There are also non-modifiable risk factors, such as genetic predisposition, particularly among individuals with diabetic parents. Lifestyle is one of the main contributing factors (Maulida et al., 2023). Smoking, a major risk factor in the development of DM, contributes not only to cardiovascular and pulmonary diseases but also disrupts glucose metabolism and insulin resistance, which are pathways leading to type 2 diabetes (American Diabetes Association, 2022). At the local level, carbon monoxide exposure is understudied, especially in rural areas where smoking prevalence is high and solid fuels are commonly used for cooking. The lifestyle in rural communities often overlooks CO exposure risks from daily activities such as smoking, burning household waste, and using firewood. These exposures may have systemic effects, including metabolic disorders like diabetes. Thus, it is important to explore the association between COHb levels and diabetes within local communities (Riskesdas, 2021).

Physiologically, nicotine and other toxic substances in cigarettes impair pancreatic beta-cell function, increase oxidative stress, and cause systemic inflammation. These processes lead to insulin resistance and eventually diabetes. According to the Centers for Disease Control and Prevention (CDC), smokers have a 30–40% higher risk of developing type 2 diabetes than nonsmokers (CDC, 2020). Smoking duration also plays a significant role in increasing diabetes risk. A study by Willi et al., published in the Journal of the American Medical Association, shows that the longer a person smokes, the higher their likelihood of developing diabetes. The study found that smoking for more than 10 years significantly increases DM risk, especially among individuals consuming more than 20 cigarettes per day. Even within

five years of active smoking, the risk of impaired glucose tolerance begins to rise (Willi et al., 2021). Conversely, individuals who quit smoking show reduced risk. A longitudinal study by Pan et al. in China found that former smokers who quit for more than 10 years had diabetes risk similar to that of never-smokers, demonstrating the long-term metabolic benefits of smoking cessation (Pan et al., 2015).

Thus, smoking—especially long-term and heavy smoking—significantly increases the risk of developing diabetes mellitus. The duration of smoking is a key determinant of its metabolic impact. Therefore, preventive efforts should not only include diet and exercise management but also early control of smoking behavior (WHO, 2021). A study by Wicaksono (2021) found that smokers have three times the risk of developing type 2 diabetes compared to nonsmokers. However, research by Ainur Rafiq (2022) suggested that smoking modifies the protective effect of physical activity against type 2 diabetes. Smoking behavior significantly increases the risk of diabetes mellitus. Nicotine disrupts insulin sensitivity and accelerates inflammation, contributing to insulin resistance (Choirunnisa et al., 2022). Smoking increases free radicals in the body, damaging endothelial cells and pancreatic beta cells. This impairs insulin production, preventing glucose from entering cells, causing elevated blood glucose levels, and ultimately diabetes mellitus (Fitriyah & Herdiani, 2022).

Nicotine affects insulin by reducing its secretion due to catecholamine activation, negatively impacting insulin function and causing beta-cell dysfunction. Smokers tend to have lower insulin receptor sensitivity than non-smokers. Even individuals who quit smoking for 1–2 weeks may not immediately regain normal insulin sensitivity (Chairunnisa, 2020). Previous studies show that active smokers tend to have higher COHb levels than non-smokers, and elevated COHb is linked to vascular and metabolic disturbances. High COHb levels can trigger systemic inflammation, disrupt endothelial function, and impair insulin sensitivity, increasing diabetes risk. Therefore, populations with high smoking prevalence, such as those in Tanjung Sari, are at significant risk (Kusuma et al., 2020). Passive smokers and people exposed to household pollution are also affected. Many individuals are unaware that environmental CO exposure increases their COHb levels. Epidemiological studies show that populations living in high-pollution areas have higher diabetes prevalence. This highlights the need to study CO exposure in rural settings like Tanjung Sari (Lee et al., 2021). The relationship between CO exposure and diabetes is also influenced by exposure duration and individual susceptibility. Individuals with family history, unhealthy lifestyle, or obesity are more vulnerable to metabolic impacts. By combining COHb measurements with health and lifestyle data, this research can provide comprehensive and applicable insights to inform community-based public health interventions (Wijaya & Prasetyo, 2022).

A pre-survey conducted on April 25, 2025, at Tanjung Sari Natar Health Center showed an increase in the number of diabetes patients. Interviews with five DM patients revealed that three were active smokers, smoking for 5–10 years at 12–24 cigarettes per day, with COHb levels ranging from 2.6% to 3.7% and blood glucose levels of 200–302 mg/dL. The two non-smokers had been diagnosed for 2–3 years with COHb levels of 2.0%. Based on these findings, the researcher intends to examine the relationship between COHb levels and the incidence of diabetes mellitus in the working area of Tanjung Sari Natar Health Center in 2025.

Objective

The purpose of this study was to determine the relationship between COHb levels and the incidence of diabetes mellitus in Tanjung Sari Village, within the Tanjung.

Method

The research method used was a quantitative study with a cross-sectional approach involving a total sample of 53 respondent selected through purposive sampling. This study was conducted in August 2025. Data collection was conducted using observation sheets and data analysis using a computer program, with the Gamma test used for analysis.

Results

TABLE 1. Respondent Characteristics

Characteristics	Frequency	%
Age		
11-15 Years Old	25	47,2
15-20 Years Old	15	28,3
21-25 Years Old	8	15,1
26-30 Years Old	5	9,4
Gender		
Male	29	54,7
Female	24	45,3
Total	**53**	**100,0**

Based on the respondents' characteristics by age, it is known that most respondents were in the age range of 11–15 years, totaling 25 respondents (47.2%). Furthermore, respondents aged 15–20 years numbered 15 individuals (28.3%), followed by those aged 21–25 years with 8 respondents (15.1%). The smallest proportion was found in the 26–30-year age group, with 5 respondents (9.4%).

TABLE 2. Incidence of Diabetes Millitus

Incidence of Diabetes Millitus	Total	GDS Frequency	Percentage
DM	35	≥ 200	66,0
No DM	18	≤ 200	34,0
Total	**53**		**100,0**

Based on Table 2 regarding the incidence of Diabetes Mellitus (DM), the results showed that out of 53 respondents, 35 respondents (66.0%) had DM, while 18 respondents (34.0%) did not have DM.

TABLE 3. Carboxyhemoglobin (COHb) levels

Category	Total	Frequency	Percentage
Non-smoker	21	≤ 1,5%	39,6
Light smoker	5	1,6-2,5%	9,4
Moderate smoker	12	2,6%-3,5%	22,6
Heavy smoker	9	3,6%-5,0%	17,0
Very heavy smoker	6	≥ 5,0%	11,3
Total	**53**		**100,0**

According to Table 3 on the distribution of respondents based on Carboxyhemoglobin (COHb) levels, it is known that most respondents were categorized as non-smokers, totaling 21 respondents (39.6%). This was followed by

moderate smokers with 12 respondents (22.6%), heavy smokers with 9 respondents (17.0%), very heavy smokers with 6 respondents (11.3%), and the smallest proportion was found in the light smoker category, totaling 5 respondents (9.4%).

TABLE 4. Relationship Between Cohb Levels and the Incidence of Diabetes Mellitus Among The Respondents

COH2 Levels	DM Incidence				Total		*P-Value*
	DM		No DM				
	n	%	n	%	n	%	
Non-smoker	5	9,4	16	30,2	21	39,6	**0,000**
Light smoker	5	9,4	0	0,0	5	9,4	
Moderate smoker	11	20,8	1	1,9	12	22,6	
Heavy smoker	8	15,1	1	1,9	9	17,0	
Very heavy smoker	6	11,3	0	0,0	6	11,3	
Total	**35**	**66,0**	**18**	**34,0**	**53**	**100,0**	

Based on Table 4.4 regarding the relationship between Carboxyhemoglobin (COHb) levels and the incidence of Diabetes Mellitus (DM), the results show that out of 35 respondents (66.0%) who had DM, most were in the moderate smoker category, totaling 11 respondents (20.8%). This was followed by heavy smokers with 8 respondents (15.1%), very heavy smokers with 6 respondents (11.1%), and light smokers with 5 respondents (9.4%). Meanwhile, respondents who had DM but were categorized as non-smokers amounted to 5 respondents (9.4%). On the other hand, among the 18 respondents (34.0%) who did not have DM, the highest proportion was found in the non-smoker category, totaling 16 respondents (30.2%). Furthermore, there was 1 respondent (1.9%) in both the moderate smoker and heavy smoker categories, while no respondents in the light smoker or very heavy smoker categories were found to be free of DM. These findings indicate that the higher the COHb category (from moderate, heavy, to very heavy smokers), the greater the proportion of respondents who experienced DM compared with those who did not. The statistical test using the gamma test showed a p-value of 0.000 ($p < 0.05$), indicating a significant relationship between COHb levels and the incidence of Diabetes Mellitus among the respondents.

Discussion

Incidence of Diabetes Mellitus (DM)

The results of the study show that out of a total of 53 respondents, the majority experienced Diabetes Mellitus (DM), namely 35 respondents (66.0%), while 18 respondents (34.0%) did not have DM. This finding indicates that the prevalence of DM in this study is considerably high, as more than half of the respondents were affected. This condition aligns with the International Diabetes Federation (IDF, 2021), which reported that globally more than 537 million adults are living with DM, and the number is projected to continue increasing each year. These data emphasize that DM remains a serious public health problem worldwide, including in Indonesia (IDF, 2021).

This finding is consistent with a study by Munawaroh et al. (2020), which reported a DM prevalence of 64.3% among adults in rural areas, showing that DM is no longer concentrated in urban populations but is also increasing in rural communities. Another study by Rahmawati & Yusuf (2021) found that 60.2% of individuals with metabolic risk factors were diagnosed with DM, strengthening the

notion that the rise in DM cases is closely related to lifestyle changes and unhealthy dietary patterns. Furthermore, research by Handayani (2019) found that 67.5% of respondents in rural areas with a family history of DM also developed the condition, suggesting that genetic factors contribute significantly to DM incidence. Therefore, the 66.0% prevalence found in this study falls within the range reported in prior studies.

According to Smeltzer & Bare (2010) in *Brunner and Suddarth's Textbook of Medical-Surgical Nursing*, DM is a chronic metabolic disorder characterized by hyperglycemia resulting from abnormalities in insulin secretion, insulin action, or both. Prolonged hyperglycemia may lead to serious microvascular and macrovascular complications. In the context of this study, the high proportion of respondents experiencing DM indicates possible lifestyle issues and environmental exposures that trigger the disease. Consistent with this theory, research by Putri et al. (2020) in the *Indonesian Nursing Journal* demonstrated that DM prevalence continues to rise, particularly among productive-age adults, which is associated with high consumption of fast food, simple sugars, and low levels of physical activity. These findings support the assumption that participants in this study may be exposed to similar risk factors.

Based on the author's assumption, the high proportion of respondents experiencing DM (66.0%) suggests that the community in the study area still has low awareness regarding healthy lifestyle practices. Factors such as age, family history, and smoking habits which were also examined in this study are likely to contribute to the incidence of DM. These findings reinforce the importance of health promotion focusing on DM prevention through nutrition education, increased physical activity, and routine blood glucose monitoring. Thus, this study is expected to serve as a foundation for strengthening preventive and promotive health interventions in the community.

COHb Levels

The study results indicate that the distribution of respondents based on Carboxyhemoglobin (COHb) levels was dominated by the non-smoker category, totaling 21 respondents (39.6%). However, when combined, respondents categorized as light, moderate, heavy, and very heavy smokers reached 32 respondents (60.4%), suggesting that more than half were exposed to carbon monoxide due to smoking habits. This finding is consistent with Putra & Lestari (2020), who reported that 41.2% of non-smokers showed low to moderate COHb levels caused by environmental air pollution. Similarly, Hidayat (2019) noted that 38.7% of non-smokers demonstrated elevated COHb levels despite not smoking, particularly in areas with high traffic density. A study by Widyaningsih et al. (2021) also reported that environmental CO exposure could increase COHb levels by 36–40% among non-smokers. These findings support the notion that COHb levels are influenced not only by smoking habits but also by air quality, household combustion activities, and proximity to pollution sources.

Research by Prabandari et al. (2019) in the *Journal of Public Health* found that smokers had significantly higher COHb levels than non-smokers, and the more cigarettes smoked per day, the higher the COHb levels. This supports the current study, in which, despite the presence of non-smokers, the majority of respondents were smokers of varying intensity, indicating smoking behavior that may increase health risks. According to Guyton & Hall (2021) in *Textbook of Medical Physiology*, carbon monoxide has a much higher affinity for hemoglobin than oxygen, forming

COHb and reducing the blood's oxygen-carrying capacity. This may cause tissue hypoxia, organ dysfunction, and—in the long term—various chronic diseases. The 2021 PERKENI guidelines state that smoking is a major risk factor for non-communicable diseases, including diabetes mellitus, hypertension, and cardiovascular disease. Smoking not only elevates COHb levels but also contributes to insulin resistance and accelerates atherosclerosis. Thus, the high proportion of smokers found in this study illustrates that carbon monoxide exposure is a serious concern that may worsen health conditions.

Based on the author's assumption, although the proportion of non-smokers is relatively large (39.6%), the presence of moderate to very heavy smokers—amounting to 50.9%—indicates a worrying smoking pattern within the study population. This has the potential to significantly increase chronic disease morbidity in the future. The author assumes that environmental factors, cultural norms, and low awareness of smoking risks contribute to the high prevalence of smoking. Therefore, this study underscores the need for health promotion interventions, including education and early smoking-prevention programs.

Relationship Between COHb Levels and DM Incidence

The results indicate a significant relationship between Carboxyhemoglobin (COHb) levels and the incidence of Diabetes Mellitus (DM), with a p-value of 0.000 ($p < 0.05$). This means that the higher the COHb level resulting from smoking, the greater the risk of developing DM. Thus, COHb levels can serve as an important indicator in assessing exposure to cigarette smoke that affects glucose metabolism. This finding aligns with Kurniawan et al. (2021), who also found a significant relationship between COHb levels and metabolic disorders ($p = 0.001$), showing that higher CO exposure contributes to increased insulin resistance. Rahmadani & Putro (2020) reported a similar relationship between exposure to air pollutants—including CO—and DM incidence ($p = 0.004$), supporting the idea that CO exposure triggers oxidative stress and chronic inflammation that disrupt glucose regulation. Sutrisno et al. (2022) also found a significant relationship between COHb levels and hyperglycemia in industrial areas ($p = 0.002$), indicating that environmental CO exposure may impair glucose metabolism.

Biological mechanisms proposed by previous studies suggest that increased COHb reduces hemoglobin's oxygen-binding capacity, causing tissue hypoxia that contributes to insulin resistance and β-cell dysfunction. The findings of this study are therefore consistent with earlier research indicating that COHb levels have a significant association with DM incidence. According to Guyton & Hall (2019), cigarette smoke contains carbon monoxide, which binds to hemoglobin and disrupts oxygen transport, including to the pancreas—the organ responsible for insulin secretion. Chronic tissue hypoxia due to prolonged CO exposure can trigger oxidative stress that damages pancreatic β-cells, reducing insulin production and affecting receptor sensitivity. Al-Delaimy et al. (2022) reported that elevated COHb levels in smokers were associated with insulin resistance and higher fasting blood glucose levels, supporting that smoking affects physiological mechanisms related to glucose metabolism.

Furthermore, toxic substances in cigarettes—such as nicotine and tar—can increase systemic inflammation and endothelial dysfunction, both of which play a role in reducing insulin sensitivity. In a meta-analysis by Willi et al. (2022), active smokers

were found to have a 44% higher risk of developing DM than non-smokers. This suggests that smoking affects not only respiratory and cardiovascular health but is also closely related to metabolic diseases like DM. In this study, the high proportion of moderate to very heavy smokers who also experienced DM illustrates a direct link between COHb levels and glucose metabolic disorders. According to Suyono (2021), long-term smoking can reduce insulin effectiveness, causing chronic hyperglycemia that may develop into DM if not controlled. Based on the author's assumption, the significant relationship found in this study is due to a combination of tissue hypoxia, oxidative stress, and insulin resistance caused by carbon monoxide exposure from smoking. Therefore, smoking cessation should be considered a key strategy in preventing and managing DM within the community.

Conclusion

The characteristics of respondents based on age show that most respondents were in the 11–15-year age group, totaling 25 respondents (47.2%). The COHb levels in Tanjung Sari Village, the working area of Tanjung Sari Natar Public Health Center in 2025, indicate that the majority of respondents were non-smokers, totaling 21 respondents (39.6%). The incidence of Diabetes Mellitus (DM) in Tanjung Sari Village, the working area of Tanjung Sari Natar Public Health Center in 2025, shows that most respondents experienced DM, totaling 35 respondents (66.0%). There is a significant relationship between COHb levels and the incidence of Diabetes Mellitus in Tanjung Sari Village, the working area of Tanjung Sari Natar Public Health Center in 2025.

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