



The Effect of Residence in Coastal Areas and Industrial Area on the Occurrence of Type 2 Diabetes Mellitus

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Abstract

In Kendal Regency, the prevalence of Diabetes mellitus reached 2.8% in 2021, higher than the average for Central Java province. An unhealthy lifestyle in coastal areas, including lack of physical activity and consumption of foods high in sugar, as well as exposure to air pollution, has the potential to increase the risk of type 2 diabetes mellitus. Previous studies have shown a relationship between environmental factors and the risk of type 2 diabetes mellitus, but the results have varied. This study aims to explore the effect of residence in coastal areas and industrial areas on the incidence of type 2 diabetes mellitus in Kendal Regency. With a deeper understanding of these factors, it is hoped that methods can be obtained to prevent and overcome type 2 diabetes mellitus in the area. This study was to analyze the effect of proximity to the beach and industrial areas on the incidence of type 2 diabetes mellitus in Kendal Regency. This study used observational analytics with a cross-sectional research design. The sampling technique used was purposive sampling. Univariate and bivariate analysis used the Chi-Square test. Significant results were obtained based on the Chi-Square test on the effect of residence in coastal areas and industrial areas on the occurrence of type 2 diabetes mellitus with a p-value of 0.000 (p -value < 0.05). This study shows the effect of proximity to the beach and industrial areas on the incidence of diabetes mellitus in Kendal Regency.

Introduction

Diabetes mellitus (DM) is a metabolic disorder characterized by hyperglycemia (high blood glucose levels) due to insulin deficiency, insulin resistance or both. Insulin is a hormone produced by pancreatic β cells to control blood glucose through the use and storage of glucose. Causes insulin deficiency due to damage to pancreatic β cells, cells that function to produce insulin. While the cause of insulin resistance is due to reduced insulin's ability to stimulate glucose use or decreased target cell response to physiological insulin levels (Hardianto, 2021; Rahman et al., 2021; Zhao et al., 2023).

In 2019, the International Diabetes Federation (IDF) estimated that there were 463 million people in the world with diabetes mellitus, or around 9.3% of the population aged 20-79 years. In Southeast Asia, Indonesia is ranked 3rd with a prevalence of diabetes mellitus of 11.3%. Globally, Indonesia is ranked 7th out of 10 countries with the largest number of diabetes sufferers, namely 10.7 million people (Widiasari et al., 2021).

Based on data from the Kendal Regency Health Office, in 2021 there were 19,020 people suffering from diabetes mellitus, with a prevalence rate of 2.8% of the total population. This

prevalence is higher than the average in Central Java province. Therefore, the problem of diabetes mellitus is a priority in efforts to overcome non-communicable diseases (PTM) in Kendal Regency (Sarifah & Siyam, 2023).

Coastal areas often have unhealthy lifestyles such as lack of physical activity, consumption of foods and drinks high in sugar, and processed seafood and vegetables that are often fried/stir-fried or cooked with excessive coconut milk, which are some of the risk factors for type 2 diabetes mellitus (Wulandari, 2023; Koneru et al., 2023; Pradhan et al., 2024).

Several pollutants such as nitrogen dioxide (NO₂) and particulate matter (PM_{2.5}) and particulate matter (PM₁₀) from air pollution have been shown to cause glucose metabolism disorders and increase HbA_{1c} levels (Yang et al., 2020; Liu et al., 2022; Tian et al., 2022). NO₂ and PM can damage lung and respiratory system function, as well as trigger inflammation and oxidative stress in the body. As a result, these pollutants can affect insulin resistance, disrupt glucose homeostasis, and increase the risk of diabetes mellitus. Increased HbA_{1c} levels are an indication of poor long-term blood glucose control, which is a risk factor for type 2 diabetes mellitus (Birman et al., 2023; Pranoto, 2012).

In contrast to research (Beulens et al., 2022) which found that several environmental factors that are considered to influence the risk of type 2 diabetes are lifestyle factors such as physical activity or diet, microbiome, inflammation, or chronic stress. In research (Noventi 2019) it was stated that people in mountainous areas have a higher prevalence of diabetes mellitus compared to urban and coastal areas (Noventi et al., 2019; Kouchaki et al., 2023).

Based on this background, there are differences in research results so that researchers are interested in conducting research on the influence of residence in coastal areas and industrial areas on diabetes mellitus in Kendal Regency.

Methods

The method used is observational analytic with a *cross-sectional approach*. This study was conducted at the Cepiring Health Center (Coastal Area), Brangsong Health Center (Industrial Area), and Patebon Health Center (Area far from the coast and industrial areas). The sample was participants of the Integrated Development Post (Posbindu) in May to July 2024 who lived in coastal areas (Cepiring Health Center), industrial areas (Brangsong Health Center), and not both (Patebon Health Center). The sample size was calculated using the lemeshow formula and a minimum of 96 samples were obtained in each health center. Sampling was carried out using a *purposive sampling type* where the samples were taken based on certain criteria. The inclusion criteria for this study were all posbindu participants in coastal areas (Cepiring Health Center), industrial areas (Brangsong Health Center), and not both areas (Patebon Health Center), all posbindu participants aged ≥ 40 years, and have complete health records (address and random blood sugar data). The type of data used in this study is secondary data. The variables studied were coastal area residence with the criteria of near the beach and far from the beach, as well as industrial area residence with the criteria of near industry and far from industry which will be measured using Google Earth, and blood sugar level variables with normal criteria $< 200\text{mg/dL}$ and diabetes mellitus $\geq 200\text{mg/dL}$. Data analysis was performed univariately and bivariately. The statistical test used was the *Chi-Square test* with a confidence level of 95% (0.05). The researcher has obtained a research permit from the Faculty of Medicine, Muhammadiyah University of Surakarta No.4377./C.4-III/FK/VIII/2024 and research approval from the Head of the National Unity and Politics Agency of Kendal Regency No. 000.9/1537/VIII/2024.

Result and Discussion

Secondary data in this study are age, gender, place of residence, and blood sugar levels. The research data were analyzed using *SPSS 25.0 for Windows software* consisting of univariate

analysis to determine the frequency distribution and bivariate analysis using the *Chi-Square test*. The following are the results of the data analysis:

Respondent Characteristics

The following univariate analysis shows that the characteristics of respondents based on their place of residence can be seen in the following table :

Table 1. Characteristics of Respondents' Residential Areas

Region Category	Frequency	Percentage
Near the Beach	110	26.6%
Industrial area	110	26.6%
Far from the beach and industrial areas	194	46.9%
Total	414	100

Source: Primary Data (2024)

Based on univariate analysis using SPSS version 26 on the category of area, it is known that there are 110 people with a percentage of 26.6% who live near the coast, there are 110 people with a percentage of 26.6% who live near the industrial area, and there are 194 people with a percentage of 46.9% who live far from the coast and industrial area. The following univariate analysis shows that the characteristics of respondents based on gender can be seen in the following table:

Table 2. Respondents' Gender

Gender	Frequency	Percentage
Man	69	16.7%
Woman	345	83.3%
Total	414	100

Source: Primary Data (2024)

Based on univariate analysis using SPSS version 26 on gender, it is known that there are 69 people with a percentage of 16.7% who are male and there are 345 people with a percentage of 83.3% who are female . The following univariate analysis on blood sugar variables can be seen in the table . The following univariate analysis shows that the characteristics of respondents based on blood sugar can be seen in the following table:

Table 3. Respondents' Blood Sugar Characteristics

Blood sugar	Frequency	Percentage
Normal	321	77.5%
Diabetes	93	22.5%
Total	414	100

Source: Primary Data (2024)

Based on univariate analysis using SPSS version 26 on gender, it is known that there are 321 people with a percentage of 77.5 % who are male and there are 93 people with a percentage of 22.5 % who are female. The following univariate analysis shows that the characteristics of respondents based on the age of respondents can be seen in the following table:

Table 4. Respondents' Age Distribution Characteristics

Age	Frequency	Percentage
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Pre-elderly and below	309	74.6%
Elderly	105	25.4%
Total	414	100

Source: Primary Data (2024)

Based on univariate analysis using SPSS version 26 regarding age, it is known that there are 309 people with a percentage of 74.6% who are pre-elderly and below and there are 105 people with a percentage of 25.4% who are elderly from all the total samples available.

Bivariate Analysis

The influence of proximity of residence to the beach and industrial areas on the incidence of hypertension.

Table 5. Distribution of Diabetes Mellitus Cases Based on Regional Category

Region category	Diabetes mellitus		total	X ²	P
	Normal (n/%)	Diabetes mellitus (n/%)			
Area Beach	62 (56.4)	48 (43.6)	110	101,388	0,000
Industrial area	66 (60)	44 (40)	110		
Control areas (not highlands and industrial areas)	193 (99.5)	1 (0.5)	194		

Source: Secondary Data (2024)

Significant results were obtained based on the *Chi-Square test* on the effect of coastal residence and industrial areas on the occurrence of diabetes mellitus with a p-value of 0.000 (*p-value* <0.05). In the bivariate analysis above, respondents with coastal residences were more likely to have diabetes mellitus, as many as 48 samples (43.6%). While respondents with residences in industrial areas were more likely to not have diabetes mellitus, as many as 44 samples (40%).

The Effect of Proximity of Residence to the Beach on the Incidence of Diabetes Mellitus

The results of this study found that there was an influence of the proximity of residence to the beach on the incidence of Diabetes Mellitus. This is evidenced by the large *p-value* obtained of 0.000 (0.000 <0.05). So it can be concluded that there is an influence of the proximity of residence to the beach on the incidence of Diabetes Mellitus in Kendal Regency. Diabetes mellitus is a chronic disease in the form of a metabolic disorder characterized by an increase in blood sugar levels that exceed normal limits (Musdalifah et al., 2020).

One of the factors that influences the incidence of Diabetes Mellitus in coastal communities living in coastal areas is lifestyle. Most coastal communities like to consume *seafood* such as skipjack tuna, tuna, snapper, sardines, anchovies, shrimp, squid, crab, shellfish, and other ingredients, because the food ingredients are abundant and easy to obtain (Wulandari, 2023). These basic ingredients are mostly processed by frying, salting, making crackers, and cooking in coconut milk (Musdalifah et al., 2020). This habit can affect the increase in lipid fractions which results in an increase in fatty acids or free fatty acids (FFA) in cells which has an impact on decreasing the translocation of glucose transporters to the plasma membrane, which can cause insulin resistance (Kaffah et al., 2024). Insulin resistance causes a lack of ability of cells to respond properly to insulin, making it difficult for glucose to enter the cells. As a result, glucose that should enter the cells will remain trapped in the blood vessels, causing increased blood sugar levels (Astuti et al., 2021; Putri et al., 2024).

The results of this study are in line with the results of research conducted by (Wulandari, 2023) which found that unhealthy lifestyles of coastal communities such as lack of physical activity,

consumption of foods and drinks high in sugar, and processed seafood and vegetables that are often fried/stir-fried or cooked with coconut milk excessively are

some of the risk factors for disease. The results of another study conducted by (Ermawati, 2019) also found that there is a significant relationship between diet and blood glucose levels of patients living in coastal areas. The worse the diet experienced, the blood sugar levels will increase over time. In contrast to the two research results, the results of research conducted by (Noventi et al., 2019) found that people in mountainous areas have a higher prevalence of prediabetes compared to urban and coastal areas, this is influenced by hypertension and obesity.

The Influence of Proximity of Residence to Industrial Areas on the Incidence of Diabetes Mellitus

The results of this study also found that there was an influence of proximity to the place of residence . Industrial areas on the incidence of Diabetes Mellitus. This is proven by the large *p-value* obtained of 0.000 ($0.000 < 0.05$). So it can be concluded that there is an influence of the proximity of the residence to Industrial areas on the incidence of Diabetes Mellitus in Kendal Regency. The incidence of diabetes mellitus is generally more common in developing countries compared to developed countries (Astutisari et al., 2022). One of the factors that influences the high prevalence of diabetes mellitus in developing countries is air pollution from industrial areas (Fauzi Rachman et al., 2024).

Meta-analysis studies in Europe and North America have shown an association between long-term exposure to air pollution and an increased risk of type 2 diabetes mellitus (type 2 DM). This correlation has been found in several studies, and although not fully understood, there are several mechanisms that may be involved in the relationship. The proposed mechanism is that long-term exposure to air pollution can cause systemic inflammation and oxidative stress in the body, which affects insulin resistance and pancreatic beta cell function is a risk factor for type 2 DM. In addition, exposure to air pollution can also affect the composition of the gut microbiota, which has been associated with the development of type 2 DM (Siregar & Fitrianti, 2022) . Several pollutants such as *nitrogen dioxide* (NO₂) and *particulate matter* (PM_{2.5}) and *particulate matter* (PM₁₀) from air pollution have been shown to cause glucose metabolism disorders and increase HbA_{1c} levels. NO₂ and PM can damage lung and respiratory system function, as well as trigger inflammation and oxidative stress in the body. As a result, these pollutants can affect insulin resistance, disrupt glucose homeostasis, and increase the risk of diabetes mellitus. Elevated HbA_{1c} levels are an indication of poor long-term blood glucose control, which is a risk factor for diabetic complications (Soiza et al., 2018).

The results of this study are in line with the results of a study conducted by (Meng et al., 2023) which found that several air pollutants including O₃, NO₂, PM₁₀, and PM_{2.5} were associated with an increased risk of diabetes and diabetes severity among Californians, especially among Native Americans and Alaskans. The results of another study conducted by (Meo & Suraya, 2015) which found that exposure to air pollutants was significantly associated with an increased risk of type 2 diabetes mellitus. In contrast to the two results of the study, the results of the study conducted by (Beulens et al., 2022) found that several environmental factors that are thought to influence the risk of type 2 diabetes are lifestyle factors such as physical activity or diet, microbiome, inflammation, or chronic stress.

Research Limitations

This research is not free from several weaknesses which are limitations of the research, the limitations in this research are: 1) Not all risk factors for diabetes mellitus can be found in this study, because the analysis conducted was only based on the data found; 2) This study uses a *cross-sectional research design* , so that the data collection process is carried out at one time . As a result, researchers cannot analyze other factors that may be related to the incidence of diabetes mellitus.

Conclusion

Based on the results of the study and discussion on respondents at the Cepiring Health Center, Brangsong Health Center, and Patebon Health Center, it can be concluded that there is a significant relationship between the proximity of residence to the beach and the incidence of diabetes mellitus in Kendal Regency with a *p-value* of 0.000 (<0.05 means very significant), and there is a significant relationship between the proximity of residence to the industrial area and the incidence of diabetes mellitus in Kendal Regency with a *p-value* of 0.000 (<0.05 means very significant), and the number of respondents who experience diabetes mellitus is greater in coastal areas than in industrial areas. The implications of this study indicate that the proximity of residence to the beach and industrial areas are risk factors for diabetes mellitus in Kendal Regency.

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