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Factors Contributing to Rising Diabetes Cases in Indonesia: Insights from the 2023 Indonesian Health Survey

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ABSTRACT

Background: The 2023 Indonesian Health Survey (SKI) revealed an increase in diabetes mellitus (DM) prevalence among individuals aged ≥15 years from 2.0% in 2018 to 2.2% in 2023, potentially linked to post-COVID-19 lifestyle changes. This study explored factors contributing to the rising diabetes cases in Indonesia using 2023 SKI data.
Methods: This cross-sectional study utilized aggregate data from the 2023 SKI, collected between March and May 2025. The study selected 34,500 census blocks using proportional stratified sampling. Data collection involved interviews and physical examinations. Spearman's correlation and linear regression identified diabetes-related risk factors.
Result: Positive correlations were found between DM and daily smoking, former smoking, high-fat food consumption, body weight monitoring, telemedicine use, and obesity. Negative correlations were observed for occasional smoking exposure, tobacco use, sweet food consumption, and normal nutritional status. Physical activity showed no significant association. Multivariate analysis revealed that individuals with blood pressure checks less than once a year had an 8.63-fold higher DM risk. Telemedicine use, low-frequency starchy tuber intake, and BPJS PBI membership were associated with increased risk, while nut consumption (1–6 times/week) reduced the risk by 26%.
Conclusion : Behavioral and healthcare access factors significantly influenced diabetes risk. Smoking, unhealthy diet, and limited health monitoring increased this risk. Further research using individual-level data is recommended to better understand these associations and inform targeted interventions.

Keywords: Diabetes prevalence, Risk factors, Indonesian Health Survey 2023, Lifestyle Behaviors, Healthcare access.

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Introduction

Diabetes mellitus (DM) is no longer merely an individual chronic disease; it has evolved into a complex public health issue with widespread social and economic impacts. According to the International Diabetes Federation (IDF, 2021), more than 19.5 million people in Southeast Asia live with diabetes, and this number is projected to rise to 152 million by 2045.[1] Globally, the prevalence of DM increased from 7% in 1990 to 14% in 2022.[1] Ironically, although Southeast Asia accounts for approximately 16.8% of the world's diabetes cases, the region contributes only 1% of global health expenditure on diabetes management.[2]

Indonesia currently ranks fifth in the world in terms of the number of people living with diabetes. The IDF (2021) reported that approximately 28.6 million Indonesians aged 20–79 years are living with type 2 diabetes, with a prevalence rate of 10.6%. This marks a significant increase from the 2018 National Basic Health Survey (Riskesdas), which reported a prevalence of 2% based on physician diagnosis and 8.5% based on laboratory testing. The 2023 Indonesian Health Survey (SKI) also recorded an increase in DM prevalence among individuals aged ≥15 years from 2.0% (2018) to 2.2% (2023), reflecting a consistent upward trend.[3–5]

It is important to note that SKI 2023 is an integrated and enhanced version of two major prior surveys—Riskesdas and the Indonesian Nutrition Status Survey (SSGI). This integration strengthens data validity and broadens the scope of Indonesia's public health information. With more modern and representative methodologies, SKI 2023 provides essential data for mapping the prevalence of non-communicable diseases, including diabetes, and identifying associated risk factors.[4]

The rise in DM cases in Indonesia is also influenced by post-COVID-19 lifestyle transformations, including increased consumption of high-sugar foods, low physical activity, urban stress, and high smoking rates among adolescents.[6] Recent reports indicate a shifting disease burden toward younger age groups, with type 1 DM found in children aged 5–14 years (55.7%) and adolescents aged 15–24 years (29.3%) (Putra et al., 2023; *Journal of Diabetes Research*). Dietary habits rich in carbohydrates—such as consuming large portions of rice without sufficient fiber—and the growing intake of sugary packaged beverages have worsened the situation.[7]

In addition to its health consequences, diabetes imposes a significant economic burden through treatment costs and lost work productivity due to long-term complications. Therefore, this study aims to explore the determinants of the rising prevalence of diabetes in Indonesia in the post-COVID-19 era, using data from the 2023 Indonesian Health Survey (SKI) as the analytical foundation. The findings are expected to inform more contextual and effective health policy formulation.

The risks of diabetes mellitus in the Indonesian population include various modifiable and structural factors that significantly contribute to the disease. Consistent with previous research, smoking behavior and frequent consumption of fatty or fried foods were positively correlated with diabetes risk.[8,9] These lifestyle factors contribute to chronic inflammation and insulin resistance, which are key mechanisms in the development of type 2 diabetes. Moreover, obesity and poor nutritional status were strongly linked to increased risk, highlighting the importance of energy balance and dietary quality in glycemic control, as also reported in regional studies.[10]

Healthcare-related variables, including the frequency of health check-ups and the use of online health services, showed a significant relationship with diabetes outcomes. Regular health monitoring has been associated with earlier detection and better disease management.[11] The use of telemedicine, which increased during the COVID-19 pandemic, may improve access to health information and services, particularly in underserved areas.[12] Additionally, the type of health insurance influenced diabetes risk, suggesting disparities in healthcare access and utilization depending on coverage schemes.

Dietary patterns and socioeconomic status also played crucial roles. Individuals from

lower socioeconomic backgrounds may face barriers to accessing healthy foods and quality healthcare, increasing their vulnerability to diabetes.[13] These findings underscore the need for targeted public health interventions that promote healthier lifestyles, improve access to preventive services, and address socioeconomic inequities in diabetes care. Integrating health promotion strategies with policy-level changes may contribute to reducing the burden of diabetes in Indonesia.

This study is urgently needed because of the rising incidence of diabetes in Indonesia, the heavy economic burden it causes, and the serious long-term health risks if left unmanaged. With limited local research on diabetes risk factors, this study fills a critical gap, especially as lifestyle changes and urbanization may increase risk. The COVID-19 pandemic has made this issue even more pressing, as people with diabetes are more vulnerable to severe illnesses and face challenges such as limited healthcare access, economic hardship, and changes in daily habits. This highlights the need to better understand diabetes risk factors in Indonesia to support prevention, guide health policies, and strengthen the healthcare system when facing both chronic diseases and health emergencies.

Methods

This cross-sectional observational study was conducted from March to May 2025 using secondary data from the 2023 Indonesian Health Survey (SKI). The study population comprised the entire Indonesian population, based on aggregate data from SKI 2023. The SKI 2023 sample size is 34,500 Census Blocks (345,000 ordinary households for the Riskesdas exercise and 345,000 under-five households for the SSGI exercise). Sample collection uses a stratification technique at the census block level and at the ordinary household level in selected census blocks according to urban/rural strata per district/city in a proportional to size (PPS) manner with the size of the number of families from SP2020. Data were collected based on interviews, measurements, and examinations based on household and individual instruments conducted by local enumerators with technical supervision by the District/City PJT and administrative supervision by the District/City PJO.[4] This study aimed to explore the risk factors for diabetes in Indonesia by examining lifestyle and healthcare-related variables. Key factors included smoking habits, consumption of fatty or fried foods, obesity, nutritional status, frequency of health check-ups, use of online health services, type of health insurance, dietary patterns, and socioeconomic status. Data were collected and analyzed to assess their association with the risk of developing diabetes. This quantitative study began with a descriptive analysis to outline the characteristics of the respondents. Subsequently, Spearman correlation analysis was employed to examine the associations between individual risk factors and diabetes. Finally, linear regression analysis was conducted to identify the most influential factors contributing to diabetes risk.

Result

A. Respondent characteristics

Table 1 Characteristics of Respondents with Diabetes based on SKI 2023

Variable	DM diagnosed by a doctor	
	%	95% CI
Ages		
15-24	0.0**	0.0-0.1
25-34	0.2	0.2-0.3
35-44	1.0	0.9-1.1
45-54	3.5	3.4-3.7
55-64	6.6	6.3-6.8
65-74	6.7	6.3-7.0
>75	4.8	4.2-5.4
Gender		
Male	1.8	1.7-1.8
Female	2.7	2.6-2.8
Education		
No/never attended school	2.5	2.3-2.8
Did not graduate from elementary school/Islamic elementary school	2.8	2.6-3.1

Continued Table 2 Characteristics of Respondents with Diabetes based on SKI 2023

Variable	DM diagnosed by a doctor	
	%	95% CI
Education		
Did not graduate from elementary school/Islamic elementary school	2.7	2.6-2.9
Graduated from junior high school/Islamic junior high school	1.7	1.5-1.8
Graduated from senior high school/Islamic senior high school	1.8	1.7-1.9
Graduated from D1/D2/D2/PT	2.9	2.7-3.1
Occupation		
Unemployed	3.1	3.0-3.3
School	0.2	0.1-0.2
PNS/TNI/Polri/BUMN/BUMD	4.1	3.7-4.4
Private Employee	1.4	1.3-1.6
Self-Employed	2.5	2.4-2.7
Farmer/Farm Laborer	1.7	1.6-1.8
Fisherman	1.1	0.8-1.4
Laborer/Driver/Household Helper	1.5	1.4-1.7
Other	3.2	3-3.5
Residence		
Urban	2.7	2.6-2.8
Rural	1.5	1.5-1.6
Economic Status		
Bottom	1.2	1.1-1.3
Middle	1.7	1.6-1.8
Middle	1.9	1.8-2.0
Middle	2.6	2.4-2.7
Top	3.3	3.1-3.4

**Prevalence 0,05

Based on Table 1, the characteristics of respondents with diabetes in Indonesia based on SKI 2023, it was found that more respondents were aged 65-74 years (6.6%), female (2.7%), had jobs as civil servants / TNI / Polri / BUMN / BUMD (4.1%), urban (2.7%), and economic status was classified as top (3.3%).

Table 3 Types of DM in Indonesia

Province	DM type(%)			
	Type 1	Type 2	DM Gestational	Not Known
Aceh	19.9	54.8	1.7	23.6
North Sumatera	17.6	59.6	4.5	18.3
West Sumatera	22.9	58.5	0.9	17.7
Riau	25.5	53.3	0.6	20.6
Jambi	24.1	55.7	2.4	17.8
South Sumatera	27.2	44.3	0.3	28.2
Bengkulu	14.4	49.1	11.3	25.2
Lampung	23.8	44.4	0.9	30.9
Bangka Belitung	12.0	63.4	0.5	24.1
Kepulauan Riau	26.8	50.4	0.0	22.7
DKI Jakarta	18.1	47.9	5.6	28.4
West Java	15.3	50.0	2.3	32.5
Central Java	14.2	47.4	3.2	35.2
DI Yogyakarta	15.7	50.6	5.2	28.6
East Java	11.2	51.6	2.2	35.0
Banten	14.6	51.9	2.0	31.5
Bali	11.8	52.0	0.0	36.2
West Nusa Tenggara	27.7	57.2	2.3	12.8
East Nusa Tenggara	19.0	45.9	3.7	31.4
West Kalimantan	17.9	65.1	0.9	16.0
Central Kalimantan	24.5	56.4	0.3	18.8
South Kalimantan	24.0	52.6	4.5	19.0
East Kalimantan	15.2	50.4	1.8	32.6
North Kalimantan	23.7	49.4	0.6	26.3

Continued Table 4 Types of DM in Indonesia

Province	DM type(%)			
	Type 1	Type 2	DM Gestational	Not Known
North Sulawesi	31.9	42.4	1.9	23.8
Central Sulawesi	28.4	40.1	2.2	29.4
South Sulawesi	22.7	44.4	0.5	32.4
Sulawesi Tenggara	27.9	40.7	1.5	29.8
Sulawesi Gorontalo	21.4	46.1	7.5	25.0
West Sulawesi	35.3	23.9	5.6	35.2
Maluku	20.9	44.7	16.7	17.7
North Maluku	27.0	26.1	2.0	45.0
West Papua	35.3	31.3	3.0	30.4
Papua Barat Daya	25.6	25.3	3.4	45.7
Papua	20.0	45.3	2.1	32.5
South Papua	18.4	43.1	0.0	38.5
Central Papua	20.9	33.0	3.0	43.1
Papua Pegunungan	20.0	28.1	0.0	51.9
INDONESIA	**16.9**	**50.2**	**2.6**	**30.3**

Based on the table above, it was found that West Sulawesi (35.3%) and West Papua (35.3%) with the highest Type 1 DM sufferers, then West Kalimantan (65.1%) with the highest Type 2 DM, and Maluku (16.7%) with the highest Gestational DM, and Papua Mountains (51.9%) with unknown types of DM.

B. Bivariate Analysis

The following are the results of the correlation analysis of diabetes risk according to the *exposure* variables in this study.

Table 5 Diabetes Risk Factors in Indonesia based on SKI 2023 data

Variable	DM	
	r	p-value
Smoking Behaviors and Tobacco Use		
Smoking Behavior		
Daily smoker	0.337	0.039
Sometimes	-0.260	0.115

Continued Table 6 Diabetes Risk Factors in Indonesia based on SKI 2023 data

Variable	DM	
	r	p-value
Smoking Behaviors and Tobacco Use		
Smoking Behavior		
Former smoker	0.664	0.000
Non-smoker	-0.405	0.012
Age at First Smoking		
4-9 years	-0.003	0.985
10-14 years	0.125	0.453
15-19 years	0.042	0.803
20-24 years	-0.175	0.293
25-29 years	0.049	0.770
>30 years	0.061	0.716
Smoking Exposure		
Daily	0.228	0.168
Sometimes	-0.417	0.009
Never	0.092	0.579
Tobacco Use		
Daily	-0.606	0.000
Sometimes	-0.639	0.000
Former	-0.386	0.017

Variable	DM	
	r	p-value
Never	**-0.315**	**0.058**
Food and Beverage Consumtion		
Consumption of Sweet Foods		
>1 time per day	-0.231	0.162
1-6 times per week	0.432	0.007
<3 times per month	-0.009	0.966
Consumption of Sweet Drinks		
>1 time per day	-0.421	0.009
1-6 times per week	0.080	0.634
<3 times per month	0.131	0.434
Consumption of Salty Foods		
>1 time per day	0.103	0.540
1-6 times per week	0.237	0.153
<3 times per month	-0.231	0.164
Consumption of Fatty/Cholesterol/Fried Foods		
>1 time per day	0.416	0.009
1-6 times per week	-0.517	0.001
<3 times per month	0.015	0.928

Variable	DM	
	r	p-value
Never	**-0.315**	**0.058**
Consumption of Grilled Foods		
>1 time per day	>1 time per day	>1 time per day
1-6 times per week	1-6 times per week	1-6 times per week
<3 times per month	<3 times per month	<3 times per month
Consumption of Processed Meat/Chicken/Fish with Preservatives		
>1 time per day	-0.286	0.082
1-6 times per week	0.161	0.333
<3 times per month	-0.109	0.514
Consumption of Seasonings		
>1 time per day	0.423	0.008
1-6 times per week	-0.277	0.135
<3 times per month	-0.384	0.017
Consumption of Soft Drinks or Carbonated Drinks		
>1 time per day	-0.602	0.000
1-6 times per week	-0.277	0.092
<3 times per month	0.404	0.012
Consumption of Energy Drinks		
>1 time per day	-0.558	0.000
1-6 times per week	-0.532	0.001
<3 times per month	0.560	0.000
Consumption of Instant Noodles		
>1 time per day	-0.561	0.000
1-6 times per week	0.114	0.495
<3 times per month	0.263	0.110
Consumption of Fruits and Vegetables		
1-2 Servings	0.403	0.012
3-4 Servings	-0.122	0.465
>5 Servings	-0.299	0.068
Consumption of Cereals		
>1 time per day	-0.256	0.121
1-6 times per week	0.559	0.000
<3 times per month	-0.534	0.001
Consumption of Starchy Tubers and Their Processed Products		
>1 time per day	-0.567	0.001
1-6 times per week	-0.293	0.111
<3 times per month	0.682	0.000
Consumption of Nuts and Their Processed Products		
>1 time per day	0.149	0.372

Variable	DM	
	r	p-value
Never	**-0.315**	**0.058**
Consumption of Nuts and Their Processed Products		
1-6 times per week	-0.082	0.624
<3 times per month	-0.423	0.008
Meat, Poultry, and Processed Products		
>1 time per day	0.136	0.417
1-6 times per week	0.468	0.003
<3 times per month	-0.496	0.002
Fish and Nuts Group		
>1 time per day	-0.151	0.366
1-6 times per week	0.254	0.123
<3 times per month	-0.053	0.754
Eggs and Nuts Consumption		
>1 time per day	0.380	0.018
1-6 times per week	0.248	0.133
<3 times per month	-0.529	0.001
Milk and Nuts Consumption		
>1 time per day	0.380	0.018
1-6 times per week	0.248	0.133
<3 times per month	-0.529	0.001
Fat and Oil Group Consumption		
>1 time per day	0.425	0.008
1-6 times per week	-0.240	0.147
<3 times per month	-0.387	0.016
Sugar. Syrup. and Confectionery Group Consumption		
>1 time per day	-0.068	0.684
1-6 times per week	-0.046	0.783
<3 times per month	0.069	0.679
Alcoholic Beverage Consumption		
Yes	-0.146	0.79
No	0.146	0.79
Physical Activity		
Sufficient	0.236	0.153
Insufficient	-0.236	0.153
Routine Health Screening Indicators		
Blood Pressure Measurement		
At least once a year	0.281	0.087
More than 1 year	0.118	0.482
Never	-0.315	0.058
Weight Measurement		
At least once a year	0.498	0.001
More than 1 year	-0.050	0.767
Never	0.384	0.019

Variable	DM	
	r	p-value
Never	**-0.315**	**0.058**
Height Measurement		
At least once a year	0.156	0.349
More than 1 year	0.188	0.259
Never	0.268	0.104
Waist Circumference Measurement		
At least once a year	0.103	0.539
More than 1 year	-0.040	0.813
Never	0.142	0.396
Cholesterol Measurement		
At least once a year	0.200	0.229
More than 1 year	0.250	0.129
Never	-0.259	0.116
Blood sugar Measurement		
At least once a year	0.209	0.209
More than 1 year	0.293	0.074
Never	-0.287	0.081
Health Service Utilization		
Health insurance		
BPJS PBI	0.234	0.157
BPJS non PBI	0.572	0.000
Jamkesmas	-0.369	0.023
Private insurance	0.409	0.011
Others	-0.086	0.607
BPJS non PBI & Private insurance	0.561	0.000
Not used	0.067	0.691
Use of Online Health Services		
Ever	0.738	0.000
Never	-0.738	0.000
Nutritional Status BMI		
Wasting	0.072	0.666
Normal	-0.592	0.000
Overweight	0.218	0.189
Obesity	0.524	0.001

Based on the bivariate table of diabetes risk factors above, the following results were obtained:

1. Smoking Behaviors and Tobacco Use

Daily smokers showed a positive and significant association with diabetes in Indonesia (r=0.337; p=0.039), indicating that daily smoking increases the risk of diabetes. Furthermore, former smokers had a stronger correlation (r=0.664; p=0.000), indicating that the risk of diabetes remains high even after quitting smoking. Non-smokers had a negative and significant association with diabetes (r=-0.405; p=0.012), indicating that not smoking is associated with a lower risk of diabetes. Those with occasional cigarette exposure showed a negative and significant association with diabetes (r=-0.417; p=0.009). Daily and occasional tobacco use showed a strong and significant negative association with diabetes (r ≈ -0.6), but this result is contrary to existing evidence. Overall, these findings emphasize the importance of interventions to reduce smoking as part of population-level diabetes prevention efforts, whether through education, health promotion, or tobacco control policies.

2. Food and Beverage Consumption

The results of the analysis showed that consumption of fatty or fried foods more than once per day had a positive and significant association with the incidence of diabetes mellitus (r=0.416; p=0.009). In contrast, consumption of sugary foods or beverages more than once per day showed a negative and significant association with diabetes (r = -0.421; p = 0.009), which is contrary to previous studies.

3. Physical Activity

The results of this study showed no significant association between physical activity and diabetes mellitus (DM) (p > 0.05).

4. Health Service Utilization

The results showed that weight checks at least once a year had a positive and significant association with diabetes (r=0.498; p=0.001). The group of respondents who had
strong positive association with DM (r=0.738; p=0.000), reflecting that individuals with DM are more likely to use digital health services.

5. Nutritional Status

The finding that the obesity group has a positive and significant association with diabetes (r=0.524; p=0.001) further strengthens the evidence that obesity is one of the major risk factors for the development of type 2 diabetes mellitus (type 2 DM). In contrast, normal nutritional status showed a negative and significant association with diabetes (r=-0.592;

p=0.000), indicating that individuals with ideal weight or in the normal nutritional category have a lower risk of developing type 2 DM.

To discuss further, multivariate analysis is required, as follows.

C. Multivariate Analysis

Tabel 4 Dominant Risk Factors

Variabel	B	p-value	OR (exp (B))
Blood pressure checked > once a year	2.155	0.000	8.63
Ever used online health services	0.563	0.001	1.76
Consumption of starch tubers <3 times/month	0.461	0.022	1.59
BPJS PBI	0.104	0.020	1.11
Consumption of nuts 1–6x/week	-0.302	0.014	0.74

Multivariate analysis showed that several factors significantly influenced the risk of developing diabetes mellitus (DM) in the Indonesian adult population. One of the most dominant factors was the frequency of blood pressure checks. Individuals who checked their blood pressure more than once a year had an 8.63 times higher risk of developing DM than those who regularly checked.

Discussion

A. Smoking, cigarette exposure, and tobacco

Daily smokers showed a positive and significant association with diabetes in Indonesia, indicating that daily smoking increases the risk of diabetes. Furthermore, former smokers had a stronger correlation, indicating that the risk of diabetes remains high even after quitting smoking.[14] Non-smokers had a negative and significant association with diabetes, indicating that not smoking is associated with a lower risk of diabetes. Those with occasional cigarette exposure showed a negative and significant association with diabetes. The results of this study show that smoking is associated with an increased risk of diabetes mellitus (DM). Individuals who smoke daily as well as former smokers have a positive and significant correlation with the incidence of DM. This finding is consistent with the meta-analysis by Pan et al. (2015), which concluded that current smokers have a 37% higher risk of developing type 2 diabetes compared to nonsmokers, while former smokers have a 14% higher risk. Possible biological mechanisms underlying this include insulin resistance, oxidative stress and chronic inflammation induced by toxic compounds in cigarettes [7,15].

The high correlation in ex-smokers suggests that the impact of smoking on glucose metabolism may persist even after individuals have quit smoking, especially when the smoking history is long-term. Therefore, smoking cessation remains important, but needs to be accompanied by diabetes risk management through a healthy diet and regular physical activity. Meanwhile, the results showing a negative and significant association between occasional cigarette exposure and diabetes contradict most of the literature. The study by Qin et al. (2023) actually showed that exposure to secondhand smoke increases the risk of type 2 diabetes.[8] This discrepancy could be due to reporting bias, misclassification of smoking status, or confounding variables that have not been controlled for in the analysis, such as physical activity and diet.[14]

Daily and occasional tobacco use showed a strong and significant negative association with diabetes ($r \approx -0.6$), but this result is contrary to existing evidence. The study by Pan et al. (2015) showed that tobacco use, including smoking, increases the risk of type 2 diabetes. These conflicting results warrant further research to identify possible confounding factors. Biologically and epidemiologically, tobacco use-both in smoking and non-smoking forms-has been shown to be an important risk factor for type 2 diabetes mellitus.[16] A meta-analysis by Pan et al. (2015) showed that active smokers have a 37% higher risk of developing type 2 diabetes compared to non-smokers. Similar findings were also reported by Willi et

al. (2007) and CDC (2020), who explained that toxic substances in tobacco can cause pancreatic beta cell dysfunction, reduce insulin sensitivity, and increase insulin resistance through oxidative stress and chronic inflammation.[14] Overall, these findings emphasize the importance of interventions to reduce smoking as part of population-level diabetes prevention efforts, whether through education, health promotion, or tobacco control policies.

B. Food and Beverage Consumption

The results of the analysis showed that consumption of fatty or fried foods more than once per day had a positive and significant association with the incidence of diabetes mellitus. This indicates that the more often a person consumes high-fat foods, especially fried foods, the higher the risk of developing type 2 diabetes mellitus. The biological mechanism underlying this finding relates to the effects of saturated fat and trans fat in increasing insulin resistance and triggering chronic inflammation in the body, two major factors in the pathogenesis of type.[17,18] Saturated fat is known to increase LDL cholesterol levels and interfere with glucose metabolism, while the process of frying with repeated oils (used cooking oil) can produce toxic compounds such as free radicals that damage pancreatic β-cells.[19]

In terms of diet, low consumption of starchy tubers (<3 times/month) was correlated with a 59% increased risk of DM. Although root vegetables are a source of carbohydrates, they contain a variable glycemic index and are relatively more natural compared to processed foods. The low consumption pattern of starchy tubers likely reflects a shift towards consumption of refined carbohydrates and ultra-processed foods that have been associated with increased DM risk.[20]

In contrast, consumption of sugary foods or beverages more than once per day showed a negative and significant association with diabetes, which is contrary to previous studies. In general, high consumption of added sugars, especially in the form of sugar-sweetened beverages, has been associated with an increased risk of type 2 diabetes. The large study by Imamura et al. (2015), which was a meta-analysis of 17 prospective studies, concluded that regular consumption of sugary drinks increased the risk of diabetes by 26%. (8)

The difference in the direction of the association in these studies is most likely due to reporting bias, where individuals with diabetes may have reduced or stopped consuming sugary foods/beverages after diagnosis so the results look as if low sugar consumption is associated with diabetes incidence. In addition, reverse causality and other confounding factors such as socioeconomic status, physical activity and overall diet may affect the findings. Therefore, these results need to be interpreted with caution and further assessed through longitudinal studies.[2,16]

C. Physical Activity

The results of this study showed no significant association between physical activity and diabetes mellitus (DM) ($p > 0.05$), which contradicts the findings from the meta-analysis by Aune et al. (2015), which showed that physical activity significantly reduces the risk of type 2 diabetes. Physical activity can increase insulin sensitivity, reduce body fat, and improve glucose metabolism, thereby reducing the risk of developing DM.[21] However, the results of this study show that not all physically active individuals are spared from the risk of diabetes, indicating that other factors besides physical activity also play an important role in the development of this disease.[16,22,23]

Some possible causes of the difference in results between this study and previous findings are the physical activity measurement methods used. In this study, the measurement of physical activity may have been done in an inappropriate way, such as using questionnaires or self-reports, which may result in reporting bias or inaccurate portrayal of actual physical activity levels. In addition, confounding factors such as age, nutritional status, genetics and socio-economic factors may also affect the relationship between physical activity and diabetes. For example, individuals who are more physically active may also pay more

attention to their diet, or may have genetic factors that protect them from diabetes. Therefore, further research that can control for these confounding factors is essential to gain a clearer understanding of the relationship between physical activity and diabetes.[21]

D. Health Service Utilization

The results showed that weight checks at least once a year had a positive and significant association with diabetes. This finding suggests that individuals at risk of diabetes are more likely to have regular check-ups, which allows for early detection and more effective management of risk factors. Regular weight checks can help detect obesity or significant weight changes, which are major risk factors for type 2 diabetes. As such, regular check-ups can serve as a preventive measure by providing an opportunity for early intervention (e.g., dietary changes or increased physical activity) before diabetes develops further.[124]

Non-PBI BPJS and Private Insurance users showed a positive and significant relationship with DM, while Jamkesmas showed a negative and significant relationship. This is in line with research by Zhang et al. (2021) which shows that the type of health insurance can affect the health outcomes of patients with diabetes mellitus. [23] Private insurance is usually better able to provide access to better and faster care, as well as provide a more comprehensive range of services, which in turn can support more effective diabetes management. In contrast, Jamkesmas (Jaminan Kesehatan Masyarakat) enrollees may have limited access to quality healthcare or limited chronic disease management, which may lead to poorer health outcomes for DM patients than those with private insurance or BPJS Non-PBI.

The group of respondents who had used online health services showed a very strong positive association with DM, reflecting that individuals with DM are more likely to use digital health services. The use of telemedicine or online health services is increasingly popular and provides convenience for patients to access medical services, consultations, and monitoring of their conditions without having to go to a hospital or clinic in person.[25] The study by Wang et al. (2022) supports these findings, showing that the use of telemedicine can assist in the management of DM risk factors, provide disease management support and reminders, and facilitate consultation with medical personnel without the barriers of distance and time. [26] This allows patients to receive more consistent and monitored care, and improves adherence to medication and treatment.

E. Nutritional Status

The finding that the obesity group has a positive and significant association with diabetes further strengthens the evidence that obesity is one of the major risk factors for the development of type 2 diabetes mellitus (type 2 DM). Obesity, particularly the accumulation of visceral fat, can lead to insulin resistance, where the body is unable to use insulin effectively. This leads to elevated blood glucose levels, which in turn can trigger the onset of type 2 DM. In addition, obesity also increases systemic inflammation and disturbances in lipid metabolism, further worsening glucose management in the body.[9]

In contrast, normal nutritional status showed a negative and significant association with diabetes, indicating that individuals with ideal weight or in the normal nutritional category have a lower risk of developing type 2 DM.[27] Good nutritional status, as reflected by weight maintained within the normal range, is associated with a healthier lifestyle, including a balanced diet and higher levels of physical activity.[28] Individuals with normal body weight tend to have better insulin sensitivity, which may reduce the risk of developing type 2 DM.[29]

These findings are consistent with the existing literature, which states that obesity is a strong risk factor for type 2 diabetes. Several large studies, such as those conducted by Donnelly et al. (2004) and Chan et al. (2009), show that being overweight and obese significantly increases one's risk of developing type 2 diabetes. Meanwhile, individuals with normal or slightly lower body weight have a much lower risk of developing this condition, given that they tend to have a more efficient metabolism in managing glucose.[2,24]

Multivariate analysis showed that several factors significantly influenced the risk of

developing diabetes mellitus (DM) in the Indonesian adult population. One of the most dominant factors was the frequency of blood pressure checks. Individuals who checked their blood pressure more than once a year had an 8.63 times higher risk of developing DM than those who regularly checked. This finding emphasizes the importance of early detection in DM prevention and control efforts.[30] Infrequent blood pressure checks reflect low health awareness and delays in identifying cardiometabolic risk factors associated with DM.[17]

In addition, the use of online health services (telemedicine) was also found to increase the risk of DM by 76%. This could be due to the tendency of individuals with chronic or symptomatic conditions to seek alternative health services online.[31] This finding is in line with previous studies showing that DM patients tend to utilize online services to monitor their chronic conditions, especially during the COVID-19.[32] Therefore, online health services need to be optimally integrated in the chronic disease management system.[26]

Aspects of health insurance also contribute to DM susceptibility. BPJS beneficiaries, who represent a group with low socioeconomic status, have an 11% higher risk of DM compared to the non-PBI group. Low economic status is often associated with limited access to healthy food, exercise facilities, and delays in seeking treatment.[33] Therefore, DM prevention strategies in Indonesia need to pay attention to aspects of social inequality.[23]

Interestingly, moderate consumption of nuts (1-6 times per week) reduced the risk of DM by 26%. Nuts contain fiber, monounsaturated fat, and bioactive compounds that are known to have anti-inflammatory and low glycemic effects.[34] Prospective studies have shown that regular nut consumption is associated with a reduced risk of type 2 DM and improved insulin sensitivity.[219]

The use of aggregated data from the 2023 SKI provides useful insights, but also has a number of limitations, especially in terms of individual variability, potential ecological error, and control for confounding factors. Therefore, to gain a deeper understanding and stronger conclusions about the factors influencing diabetes, studies using more detailed individual data and longitudinal analyses that consider contextual factors and changes in time are needed.

Conclusions

This study reveals significant associations between various risk factors and diabetes mellitus (DM) incidence in Indonesia based on SKI 2023 data. Behavioral factors like smoking, dietary habits, and healthcare utilization patterns showed notable correlations with DM risk. Obesity emerged as a significant risk factor, while normal nutritional status and legume consumption demonstrated protective effects.

These findings underscore the importance of early detection, lifestyle management, and targeted interventions in DM prevention. Future research should focus on longitudinal studies using individual-level data to establish causality and minimize bias. Additionally, investigating the effectiveness of tailored education programs, exploring the impact of local food consumption patterns, and evaluating the long-term outcomes of integrated health check-up and nutrition access policies could provide valuable insights for refining DM prevention strategies in Indonesia.

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