

Prevalence and Risk Factors of Prediabetes in Indonesian Adults: A Cross-Sectional Study (2023)

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Abstract

Background: Prediabetes is an intermediate state of hyperglycemia which may elevate the risk of type 2 diabetes mellitus. Prediabetes is also associated with stroke, coronary heart disease, retinopathy, and all-cause mortality. This study aimed to determine the prevalence of prediabetes along with the risk factors among the adult population in Indonesia.

Materials and Methods: The study design was cross-sectional with secondary data from IHS 2023 interviews, measurements, and examinations. The study population consisted of adults (19-59 years). A total sample of 11,465 who had blood glucose test results was analyzed after weighted to the multivariate with Cox Regression.

Results: The prevalence of prediabetes among adults in Indonesia was 47.5% (95% CI 51.2%-53.7%). Multivariate analysis showed that age (aPR=1.191; 95% CI 1.133-1.252), educational level (aPR=1.081; 95% CI 1.030-1.135), physical activity (aPR=1.175; 95% CI 1.078-1.282), BMI (aPR=1.079; 95% CI 1.018- 1.144), central obesity (aPR=1.196; 95% CI 1.127-1.270), hypertension (aPR=1.092; 95% CI 1.029-1.159), LDL level (aPR=1.097; 95% CI 1.042-1.155), and triglyceride level (aPR=1.074; 95% CI 1.022-1.128) had a significant association with prediabetes across the adult population.

Conclusions: Central obesity was the predominant factor. It is recommended to strengthen education and prediabetes screening before adulthood to prevent the development of prediabetes in adults.

Keywords: Adults, Prediabetes, Risk Factors.

Introduction

Prediabetes and diabetes are significant global health concerns. Prediabetes is a risk factor for type 2 diabetes mellitus (T2DM). It also elevates the risk of macrovascular and microvascular disease [1]. Prediabetes, if untreated, can result in diabetes, carrying a risk of complications such as diabetic ketoacidosis (DKA) [2]. DKA is an acute metabolic disorder which can lead to life-threatening complications [3]. World Health Organization (WHO) has defined prediabetes as a condition of intermediate hyperglycemia [4]. Perkumpulan Endocrinology Indonesia (Perkeni) has adopted the same criteria for

prediabetes as the American Diabetes Association (ADA). These criteria are specified using the parameters of Impaired Fasting Glucose (IFG) and/or Impaired Glucose Tolerance (IGT), with additional criteria based on hemoglobin A1c (HbA1c) of 5.7% to 6.4% [5, 6]. Knowing the risk factors of prediabetes is key to developing effective prevention strategies. Individuals who recognize these factors can proactively initiate preventive measures to avert severe complications. The risk factors of prediabetes include advanced age, obesity (especially with excess fat in the abdomen), and hypertension. [7]. Furthermore, other studies have explored the relationship between dietary patterns and

physical inactivity, can augment the likelihood of prediabetes. [8]. Recognizing these risk factors is key to preventing progression from prediabetes to type 2 diabetes. Often referred to as a "golden period" for diabetes prevention, this time is a critical opportunity for individuals with prediabetes to make lifestyle changes that can significantly reduce the risk of developing diabetes [9].

Prediabetes is a serious condition that should not be overlooked. The prevalence of prediabetes has been reported to exceed that of diabetes mellitus. In 2021, the global prevalence of IGT was 10.6%, affecting 541 million, while the prevalence of IFG was 6.2%, affecting around 319 million. Recent data indicate that Indonesia has the fourth highest number of people with IGT worldwide, after China, India, and the USA. In 2021, there were 29.6 million cases in Indonesia. Projections reveal this will rise to 34.6 million by 2045 [10]. Concurrent with these findings, the Indonesian Health Survey (IHS) in 2023 found that the prevalence of IFG reached 13.4% and the prevalence of IGT rose to 18.6% in the population aged ≥ 15 years [11].

The Indonesian population often develops prediabetes in their adult years, typically around age 30 already at risk of prediabetes [12]. Adult age starts from 19 years old to 59 years old [13]. Prolonged poor lifestyle choices have been demonstrated to heighten the risk of developing chronic diseases, including obesity and diabetes mellitus. A meta-analysis by Glechner et al. indicated that following lifestyle interventions, such as regular diet and physical activity instruction for one year and three years, can lower the risk of diabetes mellitus by 36-54% in adults with prediabetes [14].

As there is a lack of studies on prediabetes in Indonesia, particularly among adults, researchers will examine the risk factors for prediabetes across Indonesian adults using data from the Indonesian Health Survey (IHS) 2023.

Materials and Methods

The IHS 2023 data was employed in the study. The Ministry of Health of the Republic of Indonesia provided the data. The study utilized a cross-sectional design. The study population consisted of respondents aged 19-59 years who had never been diagnosed with diabetes mellitus in the IHS 2023. The sample was selected in cluster stages, starting with census blocks using the PPS method based on the number of families. This was followed by selecting households via systematic sampling with implicit stratification based on the education of the household head. The IHS 2023 data collection process entailed interviews, measurements, and examinations by trained officers.

The analysis was based on a sample of 11,645 respondents from IHS 2023 who fulfilled the following criteria: Fasting Blood Glucose (FBG) and/or Oral

Glucose Tolerance Test (OGTT) test results, age 19 to 59 years, and no previous diagnosis of diabetes mellitus or undiagnosed diabetes with $\text{FBG} \geq 126$ mg/dL and/or $\text{OGTT} \geq 200$ mg/dL. Weighting was applied during data analysis to account for the complex sampling design of the Indonesian Health Survey (IHS 2023) and to ensure that the estimates accurately represented the national adult population. The weighting procedure was conducted using sampling weights provided in the IHS dataset. The implementation of weighting was facilitated by SPSS Statistics version 25, culminating in generation of a weighted sample of 14,832.

The criteria for prediabetes, as outlined by PERKENI and ADA, are as follows: (1) FBG level of 100-125 mg/dL, and/or (2) OGTT level of 140-199 mg/dL. Normal status was defined as $\text{FBG} < 100$ mg/dL and $\text{OGTT} < 140$ mg/dL.

The independent variables in this study included age, gender, education level, employment status, hypertension, BMI, central obesity, smoking behavior, alcohol drinking status, LDL cholesterol levels, HDL cholesterol levels, triglycerides, physical activity, food and drink consumption patterns, and depression. Hypertension was defined according to physician diagnosis. BMI was categorized based on the national classification issued by the Indonesian Ministry of Health, where a $\text{BMI} \leq 25.0$ kg/m² was categorized as normal, and $\text{BMI} > 25.0$ kg/m² was categorized as overweight [11]. Central obesity was defined according to the criteria from the Indonesian Ministry of Health, with waist circumference ≥ 90 cm for men and ≥ 80 cm for women [11]. The analysis of smoking behavior variables was performed using the Brinkman index, calculated by the following formula: number of cigarettes smoked per day $\times$ length of smoking in years. The categorization of cholesterol levels followed established criteria: low HDL (< 40 mg/dL), high LDL (≥ 100 mg/dL), and high triglyceride (≥ 150 mg/dL). The quantity of individual physical activity was measured in MET-minutes per week, with the category of sufficient if the combination of moderate and vigorous physical activity was ≥ 600 MET-minutes per week. This study employed the Mini International Neuropsychiatric Interview (MINI) to assess depression.

Complex sample analysis was applied to the IHS 2023 data following the recommendations of the BKKP of the Indonesian Ministry of Health. The IHS 2023 data were analyzed using the Cox Regression test to identify factors linked to prediabetes among adults in Indonesia. Bivariate analysis chose the independent variables for the model, and those with a p-value < 0.25 were included in the multivariate model. The adjusted prevalence ratio was set at 0.05 with 95% CI. Weighting was implemented along the data analysis to ensure the representation of the population. All analyses were undertaken using SPSS software version 25.

Results

The final analytic sample consisted of 11,465 participants. The prevalence of prediabetes among adults in Indonesia was 47.5% (Table 1).

Among the total respondents with prediabetes, 15.6% had IFG, 21.8% had IGT, and 10.1% had a combination of IFG and IGT (Table 2).

Table 1. Prevalence of Prediabetes in Adults in Indonesia

Variables		n (11,465)	Percentage (%)	95% CI (%)
Prediabetes	No	5,829	52.5	51,2 – 53,7
	Yes	5,636	47.5	46,3 – 48,8

Table 2. Distribution of Prediabetes Determined Blood Glucose Measurement Results

Variabel	n (11,465)	Percentage	95% CI (%)
Normal	5,829	52.5	51,2 – 53,7
IFG	1,855	15.6	14,8 – 16,5
IGT	2,524	21.8	20,8 – 22,8
IFG + IGT	1,257	10.1	9,5 – 10,8

The respondents were predominantly comprised of individuals aged <45 years (65.1%) and female (61.7%), with a low level of education (53.9%), and employed (60.5%). The majority of respondents had a BMI of ≤25 (57.5%), did not have central obesity (55.2%), were not depressed (98.6%), nor did they have hypertension (93.6%). Considering risk behaviors, the majority of

respondents did not smoke (72.3%), engaged in sufficient physical activity (80.4%), consumed sweet foods 1-6 times per week (57.4%), consumed sweet drinks ≥1 time per day (47.1%), and did not use alcohol (97.5%). The majority of respondents revealed normal HDL levels (55.3%), high LDL levels (65.0%), and normal triglyceride levels (67.1%) (Table 3).

Table 3. Distribution of Prediabetes Risk Factors among Adults

Variable		n (11,465)	Percentage (%)
Age	<45 Years	7,103	65.1
	≥45 Years	4,362	34.9
Gender	Male	4,008	38.3
	Female	7,457	61.7
Level of education	High	5,235	46.1
	Low	6,230	53.9
Job	Working	6,873	60.5
	Not working	4,592	39.5
Smoking behavior	Not smoking	8,659	72.3
	Light smokers	1,170	13.0
	Moderate smokers	910	8.2
	Heavy smokers	153	1.3
	Don't know/forget	573	5.2
Physical activity	Enough	9,080	80.4
	Less	2,385	19.6
BMI	BMI≤25,0	6,466	57.5
	BMI>25,0	4,999	42.5
Central obesity	No	6,077	55.2
	Yes	5,388	44.8
Hypertension	No	10,690	93.6
	Yes	775	6.4
Depression	No	11,341	98.6
	Yes	124	1.4
Consumption of Sweet Food	Never	259	2.2
	≤3 times the monthly	940	8.4
	1 – 6 times per week	6,557	57.4
	≥1 time per day	3,709	32.0
Consumption of Sweet Drinks	Never	397	3.4
	≤3 times the monthly	801	7.0
	1 – 6 times per week	4,906	42.4
	≥1 time per day	5,361	47.1
Consumption of Alcohol	No	11,200	97.5
	Yes	265	2.5
HDL	Normal (>40 mg/dL)	6,409	55.3
	Low (≤40 mg/dL)	5,056	44.7

LDL	Normal (<100mg/dL)	3,832	35.0
	High (≥100 mg/dL)	7,633	65.0
Triglyceride	Normal (<150 mg/dL)	7,689	67.1
	High (≥150 mg/dL)	3,776	32.9

Bivariate analysis was performed using the Cox Regression test, with the majority of variables deemed eligible for multivariate analysis. Four variables had P-value>0.25 and were not included in the multivariate analysis: depression (P-value = 0.64), consumption of sweet foods (P-value = 0.45), consumption of sweet drinks (P-value = 0.71), and HDL (P-value = 0.44).

Multivariate analysis was carried out using the Cox

Regression test. Eligible candidate variables were inputted into the model and subsequently removed if P-value>0.05 from the largest. The final results (fit model) of the multivariable analysis indicated that the risks linked tp prediabetes were age, education level, physical activity, BMI, central obesity, hypertension, LDL, and triglyceride levels. The final model of the multivariable analysis is reported in Table 4.

Table 4. Risk Factors for Prediabetes in Adults in Indonesia

Variable	Prediabetes		Crude PR (95% CI)	P-value	Adjusted PR (95% CI)	P-value
	No (%)	Yes (%)				
Age	<45 Years	5,458 (56.5)	4,203 (43.5)	Ref	Ref	Ref
	≥45 Years	2,322 (44.9)	2,849 (55.1)	1.27 (1.21–1.33)	0.001	1.19 (1.13–1.25)
Gender	Male	3,258 (57.3)	2,427 (42.7)	Ref	Ref	
	Female	4,522 (49.4)	4,625 (50.6)	1.18 (1.13–1.24)	0.001	
Level of education	High	3,786 (55.4)	3,053 (44.6)	Ref	Ref	Ref
	Low	3,994 (50.0)	3,999 (50.0)	1.12 (1.07–1.18)	0.001	1.08 (1.03–1.14)
Job	Working	4,793 (53.4)	4,177 (46.6)	Ref	Ref	
	Not working	2,987 (51.0)	2,875 (49.0)	1.05 (1.00–1.10)	0.032	
Smoking behavior	Not smoking	5,294 (49.3)	5,434 (50.7)	Ref	Ref	
	Light smokers	1,221 (63.3)	709 (36.7)	0.73 (0.67–0.78)	0.001	
	Moderate smokers	753 (61.7)	467 (38.3)	0.76 (0.69–0.83)	0.001	
	Heavy smokers	109 (57.4)	81 (42.6)	0.84 (0.68–1.05)	0.124	
	Don't know/forget	403 (52.7)	361 (47.3)	0.93 (0.84–1.04)	0.201	
Physical activity	Enough	6,327 (53.0)	5,602 (47.0)	Ref	Ref	Ref
	Less	1,453 (50.1)	1,45 (49.9)	1.06 (1.00–1.13)	0.036	1.18 (1.08–1.28)
BMI	BMI≤25,0	4,941 (57.9)	3,589 (42.1)	Ref	Ref	Ref
	BMI>25,0	2,839 (45.0)	3,463 (55.0)	1.31 (1.25–1.37)	0.001	1.08 (1.02–1.14)
Central obesity	No	4,715 (57.6)	3,473 (42.4)	Ref	Ref	Ref
	Yes	3,065 (46.1)	3,579 (53.9)	1.27 (1.21–1.33)	0.001	1.20 (1.13–1.27)
Hypertension	No	7,439 (53.6)	6,451 (46.4)	Ref	Ref	Ref
	Yes	341 (36.2)	601 (63.8)	1.37 (1.26–1.49)	0.001	1.09 (1.03–1.16)
Depression	No	5,761 (50.8)	5,580 (49.2)	Ref	Ref	
	Yes	68 (54.8)	56 (45.2)	0.95 (0.77–1.17)	0.638	
Consumption of sweet food	Never	174 (54.2)	147 (45.8)	Ref	Ref	
	≤3 times the monthly	636 (50.9)	613 (49.1)	1.07 (0.90–1.28)	0.451	
	1 – 6 times per week	4,479 (52.6)	4,035 (47.4)	1.04 (0.88–1.22)	0.683	
	≥1 time per day	2,491 (52.5)	2,257 (47.5)	1.04 (0.88–1.23)	0.661	
Consumption of sweet drinks	Never	266 (52.1)	245 (47.9)	Ref	Ref	
	≤3 times the monthly	528 (50.7)	514 (49.3)	1.03 (0.88–1.20)	0.714	
	1 – 6 times per week	3,268 (51.9)	3,023 (48.1)	1.00 (0.88–1.14)	0.973	
	≥1 time per day	3,718 (53.2)	3,27 (46.8)	0.98 (0.86–1.11)	0.714	
Consumption of alcohol	No	7,562 (52.3)	6,904 (47.7)	Ref	Ref	
	Yes	218 (59.6)	148 (40.4)	0.85 (0.72–1.00)	0.046	
HDL	Normal	4,27 (52.1)	3,932 (47.9)	Ref	Ref	
	Low	3,51 (52.9)	3,12 (47.1)	0.98 (0.94–1.03)	0.439	
LDL	Normal	2,968 (57.3)	2,216 (42.7)	Ref	Ref	Ref
	High	4,812 (49.9)	4,836 (50.1)	1.17 (1.12–1.23)	0.001	1.10 (1.04–1.16)
Triglyceride	Normal	5,439 (54.7)	4,508 (45.3)	Ref	Ref	Ref
	High	2,341 (47.9)	2,544 (52.1)	1.15 (1.10–1.21)	0.001	1.07 (1.02–1.13)

Discussion

The objective of this study was to explore the prevalence and risk factors of prediabetes among

Indonesian adults using nationally representative data. The findings offered important insights regarding the modifiable and non-modifiable factors contributing to

prediabetes. They can serve as a knowledge base for future community as well as public health policies and interventions.

The results of univariate analysis demonstrated that the prevalence of prediabetes among Indonesian adults was 47.5%, with a further breakdown indicating that 15.6% of individuals had Impaired Fasting Glucose (IFG), 21.8% had Impaired Glucose Tolerance (IGT), and 10.1% had prediabetes based on IFG and IGT. According to data from the IHS 2023, the prevalence of prediabetes in the population aged ≥ 15 years based on IFG was 13.4%, and based on IGT was 18.6% [11]. The discrepancy in prevalence is accounted for by the high prevalence of prediabetes in certain age groups [15]. This high prevalence among adults is also thought to be closely linked to lifestyle changes and the growing prevalence of obesity among adults [16]. Further, a study using data from the Bogor Cohort found that the prevalence of prediabetes following a decade of observation was 50.3% [17]. The high prevalence of prediabetes can be assigned to changes in diet, especially the consumption of foods and beverages with elevated sugar levels, often accompanied by scant physical activity [18].

The findings of the multivariate analysis revealed that central obesity was the predominant factor in the incidence of prediabetes among adults in Indonesia. Those with central obesity had a risk of 1.2 times to experience prediabetes (95% CI: 1.13-1.27) compared to individuals without central obesity. These findings are in line with the research by Alkandari et al., who found that a high waist circumference ratio (≥ 0.9 for men and ≥ 0.85 for women) had a risk of prediabetes 1.29 times (95% CI: 1.00-1.65) compared to those with a normal waist circumference ratio [19]. Increased visceral adiposity has been identified as a precursor to the development of prediabetes and diabetes mellitus. A study indicated that visceral adiposity exerts an independent impact on the development of diabetes, independent of fasting insulin, insulin secretion, glycemia, total and regional adiposity, and family history of diabetes [20].

Adults aged ≥ 45 years had a risk of 1.2 times (95% CI: 1.13-1.25) of having prediabetes compared to those aged < 45 years. This finding aligns with the results of a study by Brož et al., which reported that the 45-54 years age group had a risk of 3.489 times (95% CI: 2.435-4.999) compared to the 24-44 years age group [21]. As the CDC has explained, age ≥ 45 years are a primary risk factor for prediabetes [22]. However, studies demonstrate a growing prevalence of prediabetes among young adults. A study noted a higher prevalence of prediabetes in the 25-44 age group [23,24]. This is partly due to biological differences between the sexes, as well as behavioral risk factors including smoking, alcohol consumption, and lack of physical activity. Younger demographics tend to have less health

awareness. This results in poor lifestyle choices and less medical care among the young [23,25].

The findings of the present study indicated that individuals with low educational levels had 1.1 times elevated risk of prediabetes (95% CI: 1.03-1.14) compared to those with high educational levels. A parallel finding emerged from research performed by Li et al., demonstrating that individuals with low education levels revealed a risk of 1.08 times higher (95% CI: 0.96-1.21) compared to those with high education levels (high school and above) [25]. Research suggests that the more educated, the more likely they are to seek and use health checkups. This results in better access to medical care and earlier detection of health conditions. Educational initiatives and other preventative measures can ameliorate health behaviors and health literacy [26]. Those with less physical activity had 1.18 times (95% CI: 1.08-1.28) the risk of developing prediabetes compared to individuals with sufficient physical activity. This finding aligns with the conclusions of previous studies conducted in adult populations, reporting that light physical activity augmented the risk of prediabetes in men by 1.55 times (95% CI: 1.17-2.05) compared to those engaging in moderate to vigorous physical activity [27]. Moderate to vigorous physical activity positively correlates with enhanced insulin sensitivity and improved β -cell function. Research indicates that aerobic and resistance training promotes insulin sensitivity in skeletal muscles and optimizes glucose transport, ensuring effective blood glucose level regulation. Thus, the maintenance of regular physical activity emerges as a critical component in the management of blood glucose levels as well as the enhancement of overall health [28, 29].

A Body Mass Index (BMI) > 25 or overweight has been identified as a significant risk factor for prediabetes. Individuals with BMI > 25.0 presented a risk of 1.1 times (95% CI: 1.02-1.14) to develop prediabetes compared to those with BMI ≤ 25.0 . This association has been identified in other studies, which found BMI is a risk factor for prediabetes with an aOR of 1.07 (95% CI: 1.04-1.1) [30].

A parallel set of findings was noted in Kuwait, people with a BMI > 25 (overweight) have a 1.41 times greater risk (95% CI: 1.03-1.92) of developing prediabetes, compared to a normal BMI. The risk was 1.6 times higher (95% CI: 1.17-2.19) for obese individuals (BMI > 27) (95% CI: 1.17-2.19) [19]. Obesity, a condition that can be modified through lifestyle changes, has been linked to augmented insulin demand and increased insulin resistance. This can result in prediabetes or hyperinsulinemia, and eventually T2DM. The underlying pathophysiology of this condition involves heightened insulin resistance from the accumulation of excess fat, leading to elevated plasma Free Fatty Acid (FFA) levels, which causes more insulin resistance in muscle tissues. The condition is

further exacerbated by chronic physical and psychological stress, which cumulatively elevates the risk of developing prediabetes and T2DM [20].

Individuals diagnosed with hypertension reveal a 1.1 times higher risk (95% CI: 1.03-1.16) of developing prediabetes compared to those not diagnosed with hypertension. This finding is in line with the findings of a study conducted on a population of adults aged 25-64 years, which demonstrated that individuals with hypertension had 1.43 times (95% CI: 1.05-1.94) risk of developing prediabetes compared to those without hypertension [21]. Hypertension has been identified as a risk factor for glucose intolerance, given its association with reduced insulin sensitivity and impaired glucose absorption. High insulin levels promote sodium retention in renal tubules, potentially triggering hypertension. This finding highlights the notion that diabetes and hypertension are interconnected and reciprocally affect each other [31, 32].

The LDL cholesterol level variable revealed an adjusted PR value of 1.1 (95% CI: 1.04-1.16), suggesting that those with high LDL (≥ 100 mg/dL) had a 1.1 times greater risk of prediabetes compared to those with normal LDL (< 100 mg/dL). A study by Li et al. also indicated that high LDL levels had a risk of 1.16 times (95% CI: 1.06-1.27) to experience prediabetes compared to individuals with normal LDL levels [25]. The acceleration of the development of prediabetes by elevated LDL levels can be attributed to the decline of maximum glucose-stimulated insulin secretion and the inhibition of human β -islet cell proliferation [33].

The analysis exhibited that those with elevated triglyceride levels (≥ 150 mg/dL) had 1.1 times (95% CI: 1.02-1.13) the risk of developing prediabetes compared to those with normal triglyceride levels (< 150 mg/dL). The study by Gong et al. is in accordance with these findings, where triglycerides were identified as a risk factor for prediabetes and diabetes with an adjusted odds ratio (aOR) of 1.09 (95% CI: 1.02-1.16) [30]. The study also noted that elevated triglyceride levels have been shown to raise Free Fatty Acid (FFA) levels, which lower insulin sensitivity. This results in impaired glucose tolerance, speeding prediabetes, and T2DM development [34].

This study confirms a high prevalence of prediabetes among Indonesian adults, with central obesity, older age, low education, physical inactivity, high BMI, hypertension, and dyslipidemia identified as significant associated factors. Since many of these are modifiable, public health strategies should prioritize lifestyle interventions, health promotion, and early screening, especially targeting high-risk groups. Strengthening preventive measures could help mitigate the progression of prediabetes and lower the burden of type 2 diabetes mellitus (T2DM) in Indonesia.

This study had several limitations. The cross-sectional design of the study did not allow for determining cause-and-effect relationships between variables. The presence of missing data was observed on several variables, including waist circumference measurement, BMI, lipid profiles, and depression. The proportion of missing data for each variable was lower than 10%, these missing values could still result in selection bias and compromise the study's internal validity. Information bias may also occur owing to recall bias and respondents giving answers in accordance with the enumerator's expectations (Clever Hans Effect). Future studies should consider a longitudinal design to better ascertain causal relationships. It is imperative to explore further variables that may be implicated in this relationship, such as the family history of diabetes mellitus.

Conclusion

The prevalence of prediabetes among adults in Indonesia was found to be 47.5% (95% CI: 51.2% - 53.7%), with central obesity identified as the main risk factor, with an adjusted PR value of 1.196 (95% CI: 1.127 - 1.270). This study aimed to raise awareness about prediabetes prevention through lifestyle modifications, including dietary and regular physical activity. The rise in prediabetes can guide intervention program development, such as screening initiatives for young adults, digital tools for education and screening reminders, as well as collaborative efforts with the food industry to lower sugar content and promote healthy eating.

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Conflict of interest

None declared.

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Ethical Considerations

The analysis was conducted using secondary data from the 2023 Indonesian Health Survey (SKI 2023), accessed with permission from the Ministry of Health of the Republic of Indonesia. All data were anonymized prior to analysis to ensure the confidentiality and privacy of participants.

Code of Ethics

Ethical approval was obtained from the Health Research Ethics Commission (KEPK) UPN Veteran Jakarta, on November 21, 2024, under letter number 450/XI/2024/KEP.

Authors' Contributions

Asti Elysia Rahmatul Fitri: Conceptualization, Methodology, Software, Formal analysis, Resources, Data curation, Writing - Original Draft, Visualization, Project administration; Chandrayani Simanjorang: Conceptualization, Methodology, Validation, Data curation, Writing - Review & Editing, Supervision; Laily Hanifah: Methodology, Validation, Writing - Review & Editing, Supervision.

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