

# Nutritional status and diabetes knowledge as predictors of healthy lifestyle behaviors for prediabetes prevention in adolescents

Nur Indah Noviyanti<sup>1</sup>, Reza Bintangdari Johan<sup>1</sup>, Rusmiati<sup>1</sup>, Cici Ismuniar<sup>2</sup>, Ruqaiyah<sup>3</sup>,  
Hukmiyah Aspar<sup>3</sup>, Rahmi Padlillah<sup>1</sup>

<sup>1</sup>Department of Midwifery, University of Borneo Tarakan, Tarakan, Indonesia

<sup>2</sup>Department of Psychology, University of Borneo Tarakan, Tarakan, Indonesia

<sup>3</sup>Department of Midwifery, Pelamonia Institute of Health Sciences, Makassar, Indonesia

## Article Info

### Article history:

Received Mar 9, 2026

Revised May 2, 2026

Accepted May 22, 2026

### Keywords:

Adolescents  
Diabetes mellitus  
Knowledge  
Nutritional status  
Prediabetes  
Prevention behavior

## ABSTRACT

Prediabetes prevalence among adolescents has increased substantially worldwide, with estimates indicating that approximately 18-20% of adolescents in certain populations exhibit impaired glucose metabolism, paralleling the global rise in adolescent obesity. In Indonesia, the prevalence of diabetes mellitus continues to escalate, with North Kalimantan representing an underserved region where adolescent metabolic health remains poorly characterized. Identifying modifiable factors associated with prediabetes prevention behavior is essential for developing targeted interventions. To analyze factors associated with prediabetes prevention behavior in adolescents, focusing on nutritional status and knowledge about diabetes mellitus. A cross-sectional analytical design was employed among 316 adolescents aged 13-15 years in Tarakan City, North Kalimantan, Indonesia, selected through proportional stratified random sampling. Data were collected using a demographic questionnaire, an adapted diabetes knowledge questionnaire (DKQ-24), and a prediabetes prevention behavior questionnaire. Chi-square tests and binary logistic regression were performed. Most respondents (53.2%) demonstrated positive prevention behavior, and 70.9% had high knowledge. Nutritional status ( $p = 0.000$ ) and knowledge ( $p = 0.033$ ) were significantly associated with prevention behavior. Multivariate analysis confirmed nutritional status ( $\text{Exp}(B) = 1.320$ ; 95% CI: 1.017-1.714) and knowledge ( $\text{Exp}(B) = 0.583$ ; 95% CI: 0.352-0.965) as significant predictors (Nagelkerke  $R^2 = 0.052$ ). Nutritional status and diabetes knowledge significantly predict prediabetes prevention behavior, although their contributions remain relatively small.

*This is an open access article under the [CC BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license.*



## Corresponding Author:

Nur Indah Noviyanti  
Department of Midwifery, University of Borneo Tarakan  
Tarakan, North Kalimantan, Indonesia  
Email: nurindah@borneo.ac.id

## 1. INTRODUCTION

Diabetes mellitus is a non-communicable disease that is a public health priority worldwide because of its impact on mortality, morbidity, and quality of life [1], [2]. Global projections indicate that there will be 629 million individuals living with this lifelong chronic disease by 2045, with type 2 diabetes accounting for 90-95% of all diabetes cases [2]. The burden of type 2 diabetes has increased globally and continues to increase

in most countries [3]. In this context, prediabetes is one of the most widespread epidemics in the world, where individuals with prediabetes are the most vulnerable group to develop diabetes [4].

Prediabetes among adolescents represents a distinct and escalating public health concern. Approximately 18% of U.S. adolescents aged 12-18 years have prediabetes [5], with prevalence rising from 11.6% in 1999-2002 to 28.2% in 2015-2018 [6]. Similar trends have been documented in Korean adolescents, where prevalence increased from 5.14% to 10.46% between 2009 and 2018 [7]. Critically, youth-onset diabetes follows a more aggressive clinical course than adult-onset disease, characterized by rapid beta-cell decline and accelerated complications [8], underscoring the urgency of targeting prevention efforts specifically at this developmental stage.

Knowledge is an important foundation in developing health behaviors, including those that prevent prediabetes. Nutrition knowledge and positive attitudes toward healthy eating have been identified as important determinants of dietary intake in adolescents, with positive associations between nutrition knowledge and fruit and vegetable consumption and negative associations between nutrition knowledge and consumption of snacks and sugary drinks [9]. A previous study showed that interactive educational sessions led by pharmacy students significantly increased students' knowledge about type 2 diabetes prevention, from a mean score of  $7.0 \pm 1.6$  to  $9.7 \pm 1.4$  ( $p < 0.001$ ), and this knowledge remained significantly higher than baseline at follow-up 2-3 months later [10].

Although various studies have explored certain aspects of diabetes prevention, research specifically examining the relationship between nutritional status and knowledge about diabetes mellitus and prediabetes prevention behaviors in adolescents is still limited. Educational interventions based on the health behavior model have been shown to be effective in increasing awareness and changing the model's constructs, thereby promoting the adoption of preventive behaviors [11]. Providing health education can increase understanding of healthy eating behavior and optimize physical activity [12], and nutrition education interventions consistently improve knowledge, feeding behaviors, and self-monitoring practices [13]. Prevention and control of type 2 diabetes require a comprehensive approach, including strengthening health education and literacy [14].

The pathway from nutritional status and diabetes knowledge to prediabetes prevention behaviors requires systematic examination. BMI is a significant predictor of prediabetes prevalence among adolescents [15], yet risk awareness alone does not translate into behavioral change [16]. Parents also demonstrate critical knowledge gaps regarding healthy food preparation and prediabetes risk factors, directly impeding their ability to support adolescent prevention behaviors. Despite these recognized associations, research specifically examining the combined predictive role of nutritional status and diabetes knowledge on prediabetes prevention behaviors in adolescents remains scarce. Most existing studies have focused on adult populations or examined these variables in isolation, highlighting a clear gap that this study aims to address.

This study aims to analyze factors associated with prediabetes prevention behavior in adolescents. Particular focus is given to the role of nutritional status and knowledge about diabetes mellitus. The results of this study are expected to provide a meaningful scientific contribution to the development of effective and targeted prediabetes prevention intervention strategies for adolescents, considering that early intervention in this age group is key to reducing the disease burden and economic burden associated with diabetes in adulthood.

## 2. METHOD

### 2.1. Research design

This study used an analytical cross-sectional design. The study location was Tarakan City. This study was conducted for six months in Tarakan City, North Kalimantan, Indonesia, from September 2025 to February 2026. The population in this study was all adolescents aged 13-15 years who were enrolled as active students in junior high schools in Tarakan City, North Kalimantan, Indonesia. The 13-15 age range was chosen because it is a critical period in the formation of health behavior patterns that can persist into adulthood. The study sample consisted of 316 respondents obtained through proportional stratified random sampling. This technique was chosen to ensure proportional representation of each age group (13, 14, and 15 years) in the target population. The sample size was determined using the Slovin formula with a 95% confidence level and a 5% margin of error. Inclusion criteria included adolescents aged 13-15 years, registered as active students at the selected junior high school, willing to be respondents by signing a consent form (informed consent), and present at the time of data collection. Exclusion criteria included: adolescents who were sick or hospitalized at the time of data collection, and adolescents who had been diagnosed with type 1 or type 2 diabetes mellitus.

### 2.2. Research variables

The dependent variable in this study was prediabetes prevention behavior in adolescents. The independent variables consist of five variables, such as gender, age, nutritional status, source of information about diabetes mellitus, and knowledge about diabetes mellitus. Nutritional status was categorized into four groups based on body mass index for age (BMI/Age) according to World Health Organization (WHO) standards: underweight, normal, overweight, and obesity. Knowledge about diabetes mellitus was categorized

into two groups, namely high knowledge and low knowledge, based on the median value as the cut-off point (cut-off point). The dependent variable (prediabetes prevention behavior) encompasses three domains: health control, diet, and exercise, dichotomized using a median split. Independent variables include gender (male/female), age (13–15 years), nutritional status (BMI/Age WHO classification), information sources (healthcare providers, internet, school, family), and knowledge level (high/low based on median cut-off).

### 2.3. Research instruments

The data collection instrument in this study consisted of three main parts. The first part was a demographic characteristics questionnaire covering gender, age, and sources of information about diabetes mellitus. The second part was a knowledge questionnaire about diabetes mellitus adapted from the Diabetes Knowledge Questionnaire (DKQ-24). This questionnaire consists of 24 items with true and false answers, covering aspects of etiology, pathophysiology, signs and symptoms, complications, and management of diabetes mellitus. The third part is a prediabetes prevention behavior questionnaire developed based on related literature and consists of 21 items with yes and no answer choices, covering three main domains: health control (4 items), diet (11 items), and exercise (6 items). Prediabetes prevention behaviors are categorized into positive and negative based on the median value as a cutoff point.

All instruments have gone through a cross-cultural adaptation process (cross-cultural adaptation), which includes translation into Indonesian, back-translation, and local context adjustments. Validity and reliability testing of the instrument was carried out through a trial (pilot study) on 30 respondents who had similar characteristics to the research sample but were not included in the final sample. Validity testing was conducted using correlation techniques. Pearson Product Moment with the calculated  $r$  value  $> r$  table (0.361) as the item validity criterion. The reliability test was carried out using the coefficient Cronbach's Alpha, with a value of  $\alpha > 0.60$  as the minimum acceptable limit of reliability. Measurement of nutritional status is carried out through anthropometric measurements, which include height using a stadiometer with an accuracy of 0.1 cm and body weight using a digital scale with an accuracy of 0.1 kg. Measurements were carried out by trained enumerators following WHO standard anthropometric measurement procedures.

Validity and reliability of the instrument showed that DKQ-24 knowledge questionnaire demonstrated item validity with Pearson Product Moment correlation coefficients ranging from 0.382 to 0.714 (all exceeding the critical  $r$ -table value of 0.361 at  $n = 30$ ) and achieved a Cronbach's Alpha reliability coefficient of 0.78. The prediabetes prevention behavior questionnaire yielded validity coefficients between 0.398 and 0.691, with a Cronbach's Alpha of 0.82.

### 2.4. Data collection procedures

Data collection ethics was carried out after obtaining research approval and administrative permission from the relevant agencies. The data collection process begins with coordination with the school to determine the implementation schedule. Before completing the questionnaire, the researcher provided an explanation of the research's purpose, benefits, procedures, and respondents' rights. Respondents who met the inclusion criteria and agreed to participate were asked to sign a consent form (informed consent). For respondents under 18 years of age, consent was also obtained from a parent or guardian through parental consent. Respondents completed the questionnaire independently, assisted by an enumerator to ensure understanding of each item. The average time to complete the questionnaire was between 20 and 30 minutes. Anthropometric measurements were taken after completion of the questionnaire.

### 2.5. Research flow

The first stage is preparation and licensing, which lasts for 4 weeks, including processing ethical permits, school administrative permits, as well as cross-cultural adaptation of instruments, including translation, back-translation, and local context adjustments. The second stage is instrument testing (pilot study) for 4 weeks, namely the implementation of validity and reliability tests on 30 respondents outside the main sample. The third stage is the collection of primary data, which takes 8 weeks. The fourth stage is data processing and analysis for 4 weeks, including editing, coding, entry, cleaning, and tabulating, as well as univariate and bivariate analysis (Chi-square), and multivariate (binary logistic regression). The final stage is writing a report over a four-week period. More details can be seen in Figure 1.

### 2.6. Data analysis

The collected data is processed through stages of editing, coding, entry, cleaning, and tabulating using statistical software. Data analysis was conducted in three stages. First, univariate analysis was conducted to describe the frequency distribution and proportion of each research variable, which is presented in the form of a frequency distribution table along with the mean and standard deviation. Second, bivariate analysis was conducted to test the relationship between each independent variable and the dependent variable using the  $t$ -test. Chi-square at a significance level of  $\alpha = 0.05$ . Third, multivariate analysis was conducted using a binary

logistic regression test (binary logistic regression) to identify independent variables that simultaneously act as significant predictors of prediabetes prevention behavior. Variables included in the multivariate model were those with a p-value < 0.05 in the bivariate analysis. The results of the multivariate analysis are presented in the form of an odds ratio (Exp(B)) along with a 95% confidence interval (CI).

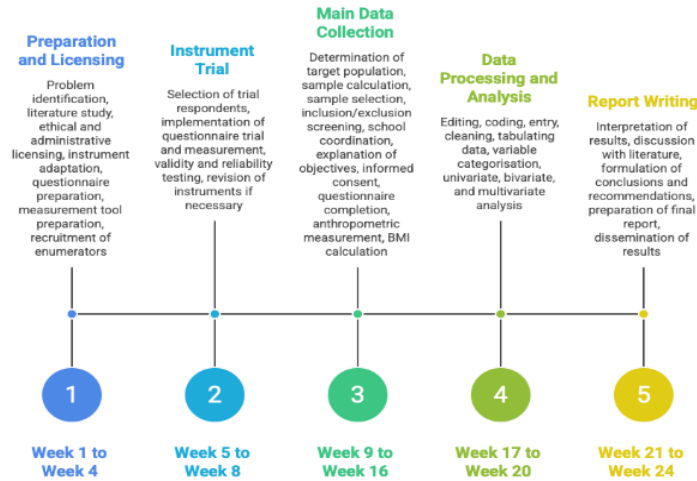


Figure 1. Research FLOW

3. RESULTS

Based on Figure 2, the majority of respondents were male (181 people) (57.3%), and female (135 people) (42.7%). The age distribution was relatively even, with the largest proportion at age 13 (34.8%), followed by age 15 (32.9%) and age 14 (32.3%). In terms of nutritional status, almost half of the respondents had normal nutritional status (47.8%), while 27.5% were classified as underweight. 17.1% overweight and 7.6% obese. The primary sources of information about diabetes mellitus most frequently accessed by adolescents were social media and the internet (56.3%), followed by health workers (16.8%), family (13.9%), and peers (13.0%). Most respondents had high knowledge about diabetes mellitus (70.9%), and more than half of the respondents demonstrated positive prediabetes prevention behaviors (53.2%).

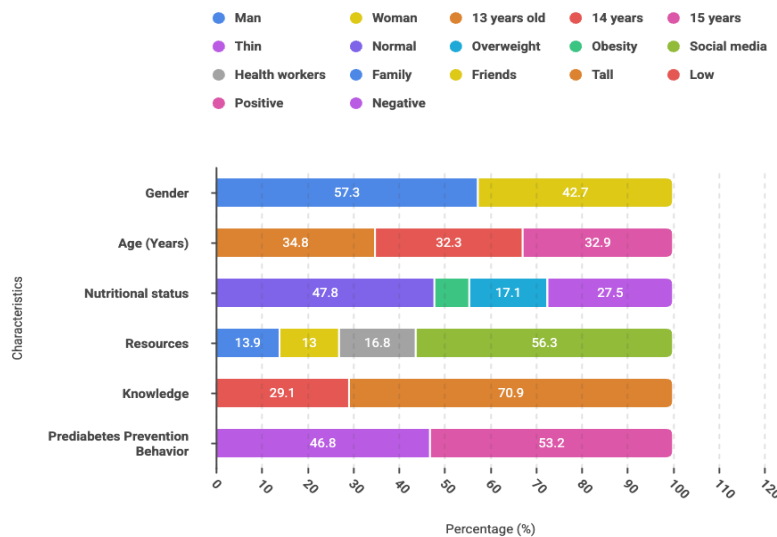


Figure 2. Frequency distribution of characteristics of teenage respondents

Table 1 showed that adolescents demonstrated suboptimal prediabetes prevention behaviors across multiple domains. In health control, most did not actively seek diabetes information (86%) or monitor blood sugar during weight changes (76%). Dietary behaviors were poor, with many not avoiding high-cholesterol foods (70%), preferring frying over boiling (65%), and frequently consuming fast food (66%). Despite 67%

reporting regular exercise, 72% remained sedentary, watching television. Diabetes knowledge was notably low; 86% misidentified shaking and sweating as hyperglycemia signs, while 72% confused frequent urination and thirst as hypoglycemia symptoms. Management knowledge was also inadequate regarding dietary requirements (68%) and cooking methods (66%).

Table 1. Frequency distribution of prediabetes prevention behavior and knowledge about diabetes mellitus in adolescents

Variables and items	Positive/correct response (%)	Negative/wrong responses (%)
<b>A. Prediabetes prevention behavior</b>		
Domain 1: Health control		
– Participate in health education activities about DM	56	44
– Looking for information about DM disease	14	86
– Checking blood sugar levels when weight changes drastically	24	76
– Check your blood sugar levels when you often feel weak	37	63
Domain 2: Diet		
– Like eating sweet foods	45	55
– Consume more than 4 tablespoons of sugar per day	73	27
– Eat regularly at the same time every day	42	58
– Delay eating when you have activities	51	49
– Avoid foods high in cholesterol	30	70
– Avoid high-fat foods	65	35
– Changing the cooking method from frying to boiling	35	65
– Prefer to consume soda and packaged drinks rather than water	50	50
– Like eating fast food	34	66
– Prefer to eat low-calorie foods (vegetables and fruit)	48	52
– Prefer eating snacks (chips) rather than fruit	54	46
Domain 3: Sports		
– Exercise regularly at least 3–4 times a week	67	33
– Warm up for ± 15 minutes before exercising	58	42
– Exercise for 30 minutes per session	44	56
– Cool down for ± 15 minutes after exercising	49	51
– Spend time doing housework to maintain health	52	48
– Often stay at home watching television	72	28
<b>B. Knowledge about diabetes mellitus</b>		
Etiology and pathophysiology		
– Excessive sugar consumption as a cause of diabetes	94	6
– Lack of effective insulin as a cause of diabetes	53	47
– Diabetes is caused by kidney failure, preventing sugar from entering the urine	55	45
– The kidneys produce insulin	44	56
– Blood sugar levels increase in untreated diabetes	40	60
– Hereditary factors in diabetes	51	49
– Diabetes mellitus can be cured	58	42
Diagnosis and classification		
– A fasting blood sugar level of 210 is too high	47	53
– The best way to detect diabetes is with a urine test.	57	43
– There are two main types of diabetes (Type 1 and Type 2)	70	30
Management		
– Regular exercise increases insulin requirements	41	59
– Insulin works because of eating too much	43	57
– Treatment is more important than diet and exercise	46	54
– How you cook is as important as what you eat.	34	66
– The diet of diabetes consists of special foods	32	68
Signs, symptoms, and complications		
– Diabetes causes blood circulation disorders	48	52
– Diabetic wounds take a long time to heal.	39	61
– Diabetes can damage the kidneys	41	59
– Diabetes causes numbness in the hands, fingers, and feet	38	62
– Shaking and sweating as a sign of high blood sugar	14	86
– Frequent urination and thirst as a sign of low blood sugar	28	72
Foot and wound care		
– People with diabetes should be careful when cutting their toenails.	82	18
– Cleaning the wound with iodine and alcohol	47	53
– Tight socks are allowed for diabetics	19	81

Information: In section A (prediabetes prevention behavior), a positive response refers to a "Yes" answer and a negative response refers to a "No" answer. In section B (Knowledge of Diabetes Mellitus), a positive response refers to a "True" answer and a negative response refers to a "False" answer. Knowledge items are grouped by subdomain for ease of interpretation. The knowledge instrument was adapted from the Diabetes Knowledge Questionnaire (DKQ-24).

Table 2 showed that two of five independent variables were significantly associated with prediabetes prevention behavior among adolescents. Nutritional status showed a significant relationship ( $p = 0.000$ ), with obese adolescents demonstrating the highest positive behavior proportion (83.3%), followed by normal nutritional status (59.6%), while overweight (38.9%) and thin (42.5%) adolescents showed lower proportions. Knowledge was also significant ( $p = 0.033$ ), though paradoxically, adolescents with low knowledge exhibited higher positive behavior (63.0%) than those with high knowledge (49.1%). Gender ( $p = 0.605$ ), age ( $p = 0.125$ ), and resources ( $p = 0.189$ ) were not statistically significant ( $p > 0.05$ ).

Table 3 showed that Model 2 (full multivariate) revealed that nutritional status ( $p = 0.037$ ,  $\text{Exp}(B) = 1.320$ ) and knowledge ( $p = 0.036$ ,  $\text{Exp}(B) = 0.583$ ) were significant predictors of prediabetes prevention behavior, while gender, age, and information source were not. The parsimonious Model 3, retaining only these two variables, yielded a Nagelkerke  $R^2$  of 0.052, explaining merely 5.2% of behavioral variation, suggesting that unmeasured factors such as family support, self-efficacy, and socioeconomic conditions substantially influence adolescent prevention behavior. Table 4 showed that both models demonstrated adequate fit (Hosmer-Lemeshow  $p > 0.05$ ), with classification accuracy ranging from 57.6–58.9%, marginally exceeding the chance level.

Table 2. Relationship between gender, age, nutritional status, information source, and knowledge of diabetes mellitus on prediabetes prevention behavior in adolescents

Variables	Positive behavior n (%)	Negative behavior n (%)	p-value
Gender			0.605
Man	99 (54.7)	82 (45.3)	
Woman	69 (51.1)	66 (48.9)	
Age (years)			0.125
13 years old	61 (55.5)	49 (44.5)	
14 years	46 (45.1)	56 (54.9)	
15 years	61 (58.7)	43 (41.3)	
Nutritional status			0.000*
Thin	37 (42.5)	50 (57.5)	
Normal	90 (59.6)	61 (40.4)	
Overweight	21 (38.9)	33 (61.1)	
Obesity	20 (83.3)	4 (16.7)	
Resources			0.189
Social media and the internet	93 (52.2)	85 (47.8)	
Health workers	25 (47.2)	28 (52.8)	
Family	22 (50.0)	22 (50.0)	
Friends of the same age	28 (68.3)	13 (31.7)	
Knowledge			0.033*
Tall	110 (49.1)	114 (50.9)	
Low	58 (63.0)	34 (37.0)	

Information: \*Significant at  $\alpha < 0.05$

Table 3. Complete multivariate analysis with a stepwise logistic regression model

Model	Variables	B	SE	Wald	df	p-value	Exp(B)	95% CI
Model 1 (Univariate)								
	Gender	-0.147	0.228	0.416	1	0.519	0.863	0.552–1.350
	Age	0.073	0.131	0.311	1	0.577	1.076	0.832–1.391
	Nutritional status	0.312	0.127	6.035	1	0.014*	1.366	1.065–1.752
	Resources	0.082	0.094	0.761	1	0.383	1.085	0.903–1.305
	Knowledge	-0.571	0.253	5.091	1	0.024*	0.565	0.344–0.928
Model 2 (Full multivariate)								
	Gender	-0.098	0.236	0.172	1	0.678	0.907	0.571–1.440
	Age	0.105	0.135	0.605	1	0.437	1.111	0.853–1.447
	Nutritional status	0.278	0.133	4.370	1	0.037*	1.320	1.017–1.714
	Resources	0.109	0.097	1.263	1	0.261	1.115	0.922–1.349
	Knowledge	-0.540	0.258	4.381	1	0.036*	0.583	0.352–0.965
	Constant	0.624	0.578	1.165	1	0.281	1.866	–
Model 3 (Final/parsimony)								
	Nutritional status	0.264	0.134	3.841	1	0.050	1.303	1.000–1.697
	Knowledge	-0.546	0.256	4.553	1	0.033*	0.579	0.351–0.956
	Constant	0.782	0.412	3.603	1	0.058	2.186	–

Information: \*Significant at  $\alpha < 0.05$ . Dependent variable: prediabetes prevention behavior (0 = Negative, 1 = Positive). Model 3 is the final model that only includes variables with  $p < 0.25$  in the bivariate analysis.

Table 4. Model fit statistics of logistic regression

Model statistics	Model 1	Model 2	Model 3
-2 log likelihood	–	421,538	425,672
Nagelkerke R <sup>2</sup>	–	0.068	0.052
Hosmer-Lemeshow test (p)	–	0.412	0.538
Overall classification (%)	–	58.9	57.6

#### 4. DISCUSSION

Nutritional status was significantly associated with prediabetes prevention behaviors ( $p = 0.000$ ), with obese adolescents demonstrating the highest positive behaviors (83.3%), followed by normal weight (59.6%), underweight (42.5%), and overweight (38.9%). Multivariate analysis confirmed nutritional status as a significant predictor ( $p = 0.037$ ,  $\text{Exp}(B) = 1.320$ ). Obese adolescents exhibited more positive preventive behaviors, likely because they received greater health education and risk warnings from healthcare providers regarding diabetes, increasing their motivation for behavioral change. This aligns with Spurr *et al.* [17] findings that clear communication of health risks and diagnoses can effectively trigger preventive behavioral modifications among at-risk populations. Overweight adolescents showed a low proportion of positive health behaviors (38.9%), possibly due to insufficient awareness or clinical attention before reaching visible obesity. Given that class 3 obesity significantly increases prediabetes odds (OR 2.7, 95% CI 2.3–3.1), early intervention at the overweight stage is critical [18]. Prediabetes increased with the severity of obesity (20.1%, 25.2%, 33.2% for obesity grades 1, 2, 3), which suggests that overweight adolescents should have started adopting better preventive behaviors [19].

Prabawati and Natalia [20] also reported that health education on preventing prediabetes was effective in increasing dietary awareness in adolescents ( $p = 0.04$ ), although it was not significant for sedentary lifestyles ( $p = 0.636$ ). This indicates that educational interventions need to be designed comprehensively and not focus solely on one aspect of behavior. Waist-to-height ratio (WHtR) is the strongest determinant of diabetes and prediabetes in children and adolescents in India, with an optimal cutoff of 0.62, sensitivity of 0.93, and AUC of 0.79 [21]. These findings strengthen the argument that anthropometric measurements and nutritional status are critical components in screening and preventing prediabetes in adolescents. Obesity is one of the most important environmental risk factors for the development of T2DM in children and adolescents, and screening for abnormal blood glucose in high-risk children and adolescents is an effective population intervention method [22].

The most counterintuitive finding in this study was the inverse relationship between knowledge and prediabetes prevention behaviors. Although this relationship was statistically significant ( $p = 0.033$ ), adolescents with low knowledge actually demonstrated a higher proportion of positive behaviors (63.0%) than adolescents with high knowledge (49.1%). In multivariate analysis, knowledge remained a significant predictor ( $p = 0.036$ ,  $\text{Exp}(B) = 0.583$ ), with an  $\text{Exp}(B)$  value  $< 1$  confirming the direction of this negative relationship. Analysis of the frequency distribution of knowledge (Table 2) revealed significant knowledge gaps in several subdomains.

In the management subdomain, 68% of adolescents did not know that a diabetes diet does not have to consist of special foods, and 66% did not understand the importance of cooking methods. These findings are relevant to Leak *et al.* [23], who found that adolescents with prediabetes had significantly lower whole grain component scores and lower intakes of vitamin D, phosphorus, and potassium than adolescents without prediabetes. They concluded that diabetes prevention interventions for adolescents are needed and should promote healthy diet targets and encourage physical activity [23].

The finding that social media and the internet are the primary sources of information about diabetes mellitus for adolescents (56.3%) has important implications for health communication strategies. Although information sources did not show a significant association with prediabetes prevention behaviors ( $p = 0.189$ ), the dominance of digital media as a source of health information for adolescents cannot be ignored. Alpin *et al.* [24], in a focus group study to inform a community-based adolescent diabetes prevention program, found that adolescents preferred text messaging for monitoring behavior, tracking goals, and receiving personalized guidance. This finding strengthens the argument that although the source of information was not statistically significant in this study, the quality and delivery of information through digital platforms need to be optimized to increase their effectiveness in changing behavior.

Simamora *et al.* [25], in a phenomenological study in Padangsidempuan City, found that family support, particularly in the Batak Angkola socio-cultural context through the Dalihan Na Tolu system, is crucial in raising awareness among prediabetes sufferers. Family involvement in prediabetes care can prevent the progression of prediabetes to diabetes mellitus. These findings indicate that although families were not the primary source of information in this study, their role in supporting behavior change remains crucial and needs to be strengthened. Evidence is still insufficient to assess the balance of benefits and harms of type 2

diabetes screening in children and adolescents, which may contribute to low awareness of screening among adolescents [26].

Abnormal blood glucose screening in high-risk children and adolescents serves as an effective population intervention for early diagnosis and management of prediabetes and T2DM. The low self-screening behavior observed highlights the necessity for more intensive educational programs emphasizing regular health monitoring, particularly for at-risk adolescents. Regarding dietary behaviors, significant suboptimal practices were identified, including failure to avoid high-cholesterol foods (70%), not shifting cooking methods from frying to boiling (65%), and fast-food preference (66%). These findings align with existing literature indicating that adolescent dietary quality, regardless of prediabetes status, remains far from optimal, with inadequate intake of essential nutrients and low whole grain consumption [27], [28].

Miyamura *et al.* [29] found that skipping breakfast in Japanese adolescents was significantly associated with prediabetes (OR 1.95, 95% CI 1.03–3.69), with a stronger association in overweight adolescents (OR 4.31, 95% CI 1.06–17.58). These findings reinforce the importance of regular eating patterns, as in this study, only 42% of adolescents ate regularly at the same time each day. Medina *et al.* [30] also reported that consumption of total dairy products and full-fat dairy products was associated with a lower combined prevalence of prediabetes and T2DM in Brazilian adolescents, suggesting that the type of food consumed has a significant impact on the risk of prediabetes.

Despite the significant associations identified, several research gaps remain. The inverse knowledge-behavior relationship ( $\text{Exp}(B) = 0.583$ ) challenges conventional KAP frameworks, yet mediating variables such as self-efficacy and perceived susceptibility were not examined. Overweight adolescents exhibited the lowest positive behaviors (38.9%), indicating a critical intervention blind spot before obesity onset. Although digital media dominated as the primary information source (56.3%), its association with preventive behaviors was non-significant ( $p = 0.189$ ), revealing a disconnect between information access and behavioral impact.

## 5. CONCLUSION

This study found that nutritional status and diabetes mellitus knowledge were the only significant predictors of prediabetes prevention behavior among adolescents ( $p = 0.037$  and  $p = 0.036$ , respectively), while gender, age, and information sources were not significant. A paradoxical inverse relationship emerged: adolescents with lower knowledge demonstrated superior preventive behaviors (63.0%) compared to those with higher knowledge (49.1%). Obese adolescents showed the highest positive behaviors (83.3%), whereas overweight adolescents exhibited the lowest (38.9%). However, the model explained only 5.2% of behavioral variance, suggesting substantial unmeasured influences. These findings challenge the conventional knowledge-attitude-practice paradigm, indicating that knowledge alone does not linearly improve behavior among Indonesian adolescents. Practically, interventions should target overweight adolescents, address suboptimal dietary practices through school-based programs, and leverage digital platforms for behaviorally oriented content. Future research should employ longitudinal and mixed-methods designs incorporating mediating variables such as self-efficacy, perceived susceptibility, and family support.

## ACKNOWLEDGMENTS

The authors would like to express their sincere gratitude to the Rector of Borneo Tarakan University and the Institute for Research and Community Service of Borneo Tarakan University for their financial support and support in advancing this research. We also express our appreciation to the Tarakan City Education Office for granting research permits and to the principals, teachers, and students of the participating junior high schools for their cooperation during data collection.

## FUNDING INFORMATION

This research received funding from the Institute for Research and Community Service of Borneo Tarakan University.

## AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Nur Indah Noviyanti	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Reza Bintangdari Johan	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Rusmiati	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓
Cici Ismuniar	✓	✓	✓	✓	✓	✓			✓	✓			✓	✓
Ruqaiyah	✓	✓	✓	✓	✓	✓		✓	✓	✓			✓	✓
Hukmiyah Aspar	✓	✓	✓	✓	✓	✓	✓		✓	✓			✓	✓
Rahmi Padlillah	✓	✓	✓	✓	✓	✓			✓				✓	✓

C : Conceptualization

M : Methodology

So : Software

Va : Validation

Fo : Formal analysis

I : Investigation

R : Resources

D : Data Curation

O : Writing - Original Draft

E : Writing - Review & Editing

Vi : Visualization

Su : Supervision

P : Project administration

Fu : Funding acquisition

## CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

## DATA AVAILABILITY

The data that supports the findings of this study are available from the corresponding author upon reasonable request.





## REFERENCES

- [1] M. Alimehr, S. Malayan, Z. Karimipour, K. Doostifar, F. S. Vafa, and M. Nikbina, "Pre-diabetic women's understanding of the role of diet in preventing diabetes using the PEN-3 cultural model," *Clinical Diabetology*, vol. 10, no. 3, pp. 261–269, 2021, doi: 10.5603/DK.a2021.0023.
- [2] X. Cao *et al.*, "An overview of environmental risk factors for type 2 diabetes research using network science tools," *Digital Health*, vol. 10, 2024, doi: 10.1177/20552076241271722.
- [3] L. Liang, Y. Lin, Z. Liu, Y. Jiang, W. Cheng, and L. Zhao, "The global burden of early-onset type 2 diabetes mellitus caused by high body-mass index from 1990 to 2021 and projection to 2050," *Diabetes Research and Clinical Practice*, vol. 226, no. 8, pp. 1–11, Aug. 2025, doi: 10.1016/j.diabres.2025.112368.
- [4] J. B. Echouffo-Tcheugui and E. Selvin, "Prediabetes and what it means: The epidemiological evidence," *Annual Review of Public Health*, vol. 42, no. 1, pp. 59–77, Apr. 2020, doi: 10.1146/annurev-publhealth-090419-102644.
- [5] S. Jain, "'Prediabetes' as a practical distinctive window for workable fruitful wonders: Prevention and progression alert as advanced professionalism," *World Journal of Clinical Pediatrics*, vol. 13, no. 1, 2024, doi: 10.5409/wjcp.v13.i1.89201.
- [6] H. Y. Ng and L. T. W. Chan, "Prediabetes in children and adolescents: An updated review," *World Journal of Clinical Pediatrics*, vol. 12, no. 5, pp. 263–272, 2023, doi: 10.5409/wjcp.v12.i5.263.
- [7] N. O. A. Usman, F. A. Okanlawon, and S. O. Usman, "Prevalence of pre-diabetes and risk factors among secondary school adolescents in Osogbo Local Government Area, Osun State, Nigeria," *African Health Sciences*, vol. 21, no. 3, pp. 1301–1309, 2021, doi: 10.4314/ahs.v21i3.41.
- [8] P. Kumar, S. Srivastava, and P. S. Mishra, "Understanding the linkage between different measure of obesity/overweight and Pre-diabetes/diabetes Prevalence among Adolescents (10-19 years) in India," 2020, doi: 10.21203/rs.3.rs-47939/v1.
- [9] M. Huitink, M. P. Poelman, J. C. Seidell, and S. C. Dijkstra, "The healthy supermarket coach: Effects of a nutrition peer-education intervention in dutch supermarkets involving adolescents with a lower education level," *Health Education and Behavior*, vol. 48, no. 2, pp. 150–159, 2021, doi: 10.1177/1090198120957953.
- [10] D. Hagen, F. Sayed, L. Cale, D. A. Vega, and A. J. Dirks-Naylor, "Pharmacist-student-led health outreach improves knowledge and behavior change motivation for prevention of type 2 diabetes among a college community," *Advances in Physiology Education*, vol. 49, no. 3, pp. 729–737, 2025, doi: 10.1152/advan.00088.2025.
- [11] R. Panahi, F. S. Siboni, M. Kheiri, K. J. Ghoozlu, M. Shafaei, and L. Dehghankar, "Promoting the adoption of behaviors to prevent osteoporosis using the health belief model integrated with health literacy: quasi-experimental intervention study," *BMC Public Health*, vol. 21, no. 1, pp. 1–11, 2021, doi: 10.1186/s12889-021-12300-8.
- [12] T. J. Walker *et al.*, "Physical activity and healthy eating programming in schools to support student's health-related fitness: An observational study," *International Journal of Environmental Research and Public Health*, vol. 18, no. 21, pp. 1–14, Oct. 2021, doi: 10.3390/ijerph182111069.
- [13] L. Lindawati, H. Susanto, S. Wahyuni, and N. N. Khasanah, "The impact of nutritional education interventions on maternal knowledge, self-monitoring, and stunting prevention among children under five: A literature review," *Indonesian Journal of Global Health Research*, vol. 8, no. 1, pp. 323–332, 2025, doi: 10.37287/ijghr.v8i1.670.
- [14] J. Butayeva, Z. A. Ratan, S. Downie, and H. Hosseinzadeh, "The impact of health literacy interventions on glycemic control and self-management outcomes among type 2 diabetes mellitus: A systematic review," *Journal of Diabetes*, vol. 15, no. 9, pp. 724–735, Sep. 2023, doi: 10.1111/1753-0407.13436.
- [15] S. Koohmanae, S. Pourkazem, A. H. Rad, and S. Nikpour, "Preventing childhood obesity in diabetes: A critical imperative," *Journal of Comprehensive Pediatrics*, vol. 15, no. 3, 2024, doi: 10.5812/jcp-147829.





- [16] S. Cheema *et al.*, "Assessment of overweight, obesity, central obesity, and type 2 diabetes among adolescents in Qatar: A cross-sectional study," *International Journal of Environmental Research and Public Health*, vol. 19, no. 21, p. 14601, 2022, doi: 10.3390/ijerph192114601.
- [17] S. Spurr, J. Bally, and N. Nalwooga, "Honoring the voices of families: An interpretive description of parents' understandings of, and insights into preventing type 2 diabetes in adolescents," *BMC Pediatrics*, vol. 22, 16, 2022. doi: 10.1186/s12887-022-03487-9.
- [18] L. A. Rodriguez, A. Gopalan, M. Chandra, J. A. Darbinian, L. Greenspan, and J. C. Lo, "998-P: Association between modifiable lifestyle behaviors and prediabetes among Latino adolescents with obesity," in *Diabetes*, 2022 doi: 10.2337/db22-998-p.
- [19] C. Chu, L. A. Rodriguez, M. Chandra, L. Greenspan, A. M. Bacong, and J. C. Lo, "1103-P: prediabetes and associated characteristics among asian/pacific islander adolescents with obesity," in *Diabetes*, 2023 doi: 10.2337/db23-1103-p.
- [20] D. Prabawati and L. Natalia, "Preventing prediabetes through adolescent health education: Pathways to achieving good health and well-being (SDG 3)," *Journal of Lifestyle and SDGs Review*, vol. 5, no. 8, 2025, doi: 10.47172/2965-730x.sdgsreview.v5.n08.pe07377.
- [21] K. Chauhan, T. Sathyapalan, U. Malabu, S. R. Joshi, S. K. Singh, and H. Deshmukh, "Machine learning identifies waist-height ratio (WHtR) as the strongest determinant of diabetes and prediabetes in children and adolescents: A comprehensive national nutrition survey," *International Journal of Diabetes in Developing Countries*, 2025, doi: 10.1007/s13410-025-01531-9.
- [22] N. Soliman, A. H. Zosel, and A. Soliman, "Epidemiological criteria and risk factors for type two diabetes mellitus (T2DM) in children and adolescents: Can we modify them?," *World Journal of Advanced Research and Reviews*, vol. 16, no. 1, pp. 174–186, 2022, doi: 10.30574/wjarr.2022.16.1.1010.
- [23] T. M. Leak, F. Overcash, M. Reicks, C. W. Leung, D. J. Barr-Anderson, and M. Censani, "Diet and physical activity by prediabetes status among U.S. adolescents: national health and nutrition examination survey, 2007-2018," *Childhood Obesity*, vol. 20, no. 7, pp. 543–548, 2024, doi: 10.1089/chi.2023.0110.
- [24] N. M. Alpin, C. R. Elaiho, F. Khan, C. Cruceta, C. Goytia, and N. Vangeepuram, "Use of focus groups to inform a new community-based youth diabetes prevention program," *International Journal of Environmental Research and Public Health*, vol. 19, no. 15, p. 9655, 2022, doi: 10.3390/ijerph19159655.
- [25] F. A. Simamora *et al.*, "Socio-cultural perspective of dalihan na tolu in pre-diabetes care in Padangsidempuan City: A phenomenological study," *Health Leadership and Quality of Life*, vol. 4, p. 723, 2025, doi: 10.56294/hl2025723.
- [26] C. M. Mangione *et al.*, "Screening for prediabetes and type 2 diabetes in children and adolescents US preventive services task force recommendation statement," *Jama*, vol. 328, no. 10, pp. 963–967, 2022, doi: 10.1001/jama.2022.14543.
- [27] R. Poličnik *et al.*, "Dietary intake of adolescents and alignment with recommendations for healthy and sustainable diets: Results of the SI. menu study," *Nutrients*, vol. 16, no. 12, pp. 1–26, Jun. 2024, doi: 10.3390/nu16121912.
- [28] K. Mueller *et al.*, "Determinants of diet quality in adolescents: results from the prospective population-based EVA-tyrol and EVA4YOU cohorts," *Nutrients*, vol. 15, no. 24, pp. 1–17, Dec. 2023, doi: 10.3390/nu15245140.
- [29] K. Miyamura, N. Nawa, A. Isumi, S. Doi, M. Ochi, and T. Fujiwara, "Association between skipping breakfast and prediabetes among adolescence in Japan: Results from A-CHILD study," *Frontiers in Endocrinology*, vol. 14, 2023, doi: 10.3389/fendo.2023.1051592.
- [30] M. Medina *et al.*, "Association between dairy products consumption and the prevalences of combined prediabetes and type 2 diabetes mellitus in Brazilian adolescents: a cross-sectional study," *British Journal of Nutrition*, vol. 130, no. 12, pp. 2162–2173, 2023, doi: 10.1017/S0007114523001356.

## BIOGRAPHIES OF AUTHORS






**Nur Indah Noviyanti**     is the is a lecturer in the Midwifery Department, Midwife Profession Study Program, Faculty of Health Sciences, University of Borneo Tarakan. She received a Master's Degree in Midwifery from Hasanuddin University, Makassar, in 2017. She has an interest in reproductive health, adolescents, gender equality, and lactation. She can be contacted at email: nurindah@borneo.ac.id.






**Reza Bintangdari Johan**     is a lecturer in the Department of Midwifery, Faculty of Health Sciences, University of Borneo Tarakan. She received a Master's Degree in Midwifery from Universitas Aisyiyah Yogyakarta in 2019. She has an interest in the reproductive health of pregnant women. She can be contacted at email: bintangjohan@borneo.ac.id.






**Rusmiati**    is a lecturer in the Department of Midwifery at the University of Borneo Tarakan, located in Tarakan City, North Kalimantan, Indonesia. She specializes in midwifery and contributes to the development of education and research in maternal and child health. As an academic at a university in Indonesia's border region, she plays a role in advancing the quality of midwifery services in North Kalimantan. She can be contacted at email: [bidan.rusmiati84@gmail.com](mailto:bidan.rusmiati84@gmail.com).






**Cici Ismuniar**    is an academic affiliated with the Department of Psychology at Borneo Tarakan University, located in Tarakan City, North Kalimantan, Indonesia. She is active in the field of psychology and contributes to academic development in the North Kalimantan region. She can be contacted at email: [ciciismuniarubt@gmail.com](mailto:ciciismuniarubt@gmail.com).






**Ruqaiyah**    is a lecturer in the Bachelor of Midwifery study program, Pelamonia Institute of Health Sciences, Makassar. She received a Master's Degree in Midwifery from Hasanuddin University, Makassar, in 2020. She has an interest in adolescent reproductive health and infant and toddler health. She can be contacted at email: [aikruqaiyah71@gmail.com](mailto:aikruqaiyah71@gmail.com).



**Hukmiyah Aspar**    is a lecturer in the Bachelor of Midwifery study program, Pelamonia Institute of Health Sciences, Makassar. She received a master's degree in midwifery from Hasanuddin University Makassar in 2017. She has an interest in pregnant women's health, reproductive health, infant and toddler health. She can be contacted at email: [hukmiyahaspar@gmail.com](mailto:hukmiyahaspar@gmail.com).



**Rahmi Padlillah**    is an academic affiliated with the Department of Midwifery, University of Borneo Tarakan, located in the City of Tarakan, North Kalimantan, Indonesia. She is engaged in teaching and research within the field of midwifery, contributing to the advancement of maternal and reproductive health sciences in the region. Her scholarly work contributes to the body of knowledge in midwifery and public health, addressing issues pertinent to the healthcare needs of communities in North Kalimantan and Indonesia more broadly. She can be contacted at email: [rahmipadlillah@gmail.com](mailto:rahmipadlillah@gmail.com).