

# Overview of risk factors for the incidence of diabetes mellitus in grades 2-4 in Tasikmadu 1 State Elementary School, Malang City

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## ABSTRACT

The increasing prevalence of Diabetes Mellitus (DM) in children is an urgent global health issue, along with changes in the lifestyle of elementary school-age children who tend to be sedentary and have unhealthy diets. This study aims to find out the overview and analyze the risk factors for DM incidence in grades 2-4 at SDN Tasikmadu 1 Malang City. The design of this study is descriptive quantitative with data collection techniques through Food Frequency Questionnaire (FFQ), PAQ-C for physical activity, and FINDRISC scores, as well as BMI measurements in 100 respondents. The results showed that 57% of students were obese, 44% often ate fast food and high in sugar, and 100% had screen time >2 hours per day. The physical activity carried out tends to be irregular and lacks intensity. This study concluded that unhealthy diet, sedentary lifestyle, and over-nutrition status were dominant factors in increasing the risk of type 2 DM in children. These findings emphasize the importance of school-based interventions and parental involvement in creating an environment that supports a child's healthy lifestyle. Furthermore, the results provide an evidence-based foundation for integrating early screening using the FINDRISC tool into school health programs. Such integration, when combined with targeted nutrition and physical activity interventions, has the potential to reduce the long-term incidence of type 2 DM among children, particularly in urban areas such as Malang. Further research is recommended using analytical methods and clinical measurements to strengthen the validity of the results.

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## INTRODUCTION

The increasing prevalence of Diabetes Mellitus (DM) among children has become a pressing global public health concern, closely associated with shifts toward sedentary lifestyles and unhealthy dietary patterns in school-aged populations (Obar et al., 2024). Rapid technological advancement

and the widespread use of digital devices have significantly reduced children's physical activity, contributing to excess caloric intake and obesity (WHO, 2019). Childhood obesity is a major precursor to insulin resistance, and if unmanaged, it can accelerate the onset of DM during early life stages (Purwandari, 2020)(GABRILASARI, 2020)(Asmasary, 2022).

Globally, DM cases are projected to rise from 10.7 million in 2019 to 13.7 million by 2030 (Federation, 2021). The World Health Organization estimates that more than 1.1 million children and adolescents are currently living with DM. In Indonesia, East Java ranks among the top five provinces with the highest DM prevalence at 2.5% (Ministry of Health of the Republic of Indonesia, 2020). The 2023 Indonesian Health Survey reported 138,465 cases among individuals aged 5–14 years in East Java, with Malang City exhibiting a particularly alarming trend, where 46.23% of pediatric DM cases occur in children aged 10–14 years. Data from the Indonesian Doctors Association indicate a 70-fold increase in pediatric DM prevalence compared to 2010 (IDI, 2023). While specific prevalence rates for pediatric DM in Malang City are not extensively documented, regional health reports indicate that the proportion of cases in the city is notably high compared to the provincial and national averages when adjusted for population size. This trend aligns with, and in some aspects may surpass, the increasing rates observed globally, suggesting that Malang is among the urban areas in Indonesia facing an acute pediatric DM challenge that warrants immediate, targeted public health action.

Previous studies highlight several interrelated risk factors, including high-sugar dietary intake, inadequate nutrition literacy, prolonged screen time, and low physical activity levels, compounded by genetic predisposition (Sanjaya (2024); Obar et al. (2024)). While genetic risks cannot be modified, adherence to balanced nutrition, weight management, and regular exercise can substantially reduce DM onset. However, in many primary school environments, easy access to calorie-dense snacks, limited opportunities for active commuting, and a lack of structured health education perpetuate risk behaviors Hermayetty et al. (2021)(Saleh, 2023)(Taufiq, 2024).

From a public health perspective, early prevention in school settings is essential. School-based health education, supported by parental engagement and healthcare collaboration, can promote healthier behaviors and mitigate modifiable risk factors Anani et al. (2021). One promising approach is the integration of early screening using the Finnish Diabetes Risk Score (FINDRISC) tool within school health programs. Although primarily validated in adult populations, its adaptation for children could enable early identification of at-risk students, allowing for timely nutritional counseling and physical activity interventions. Over the long term, such screening when systematically implemented and combined with school-based health promotion may contribute to reducing the incidence of type 2 DM among children in high-burden areas such as Malang

This study aims to describe dietary patterns, physical activity, and obesity status as determinants of DM risk in grades 2–4 at Tasikmadu 1 State Elementary School, Malang City. The novelty of this research lies in providing context-specific, empirical evidence that can inform culturally appropriate interventions for pediatric DM prevention, while also contributing to nursing science and community-based health promotion strategies in Indonesia.

## RESEARCH METHOD

This study employed a quantitative descriptive research design to systematically portray the prevalence and characteristics of risk factors for diabetes mellitus in children. Primary data were collected using three validated instruments: the Food Frequency Questionnaire (FFQ) to assess dietary habits, the Physical Activity Questionnaire for Older Children (PAQ-C) to evaluate activity levels, and the Finnish Diabetes Risk Score (FINDRISC) to estimate diabetes risk, accompanied by body mass index (BMI) measurements for anthropometric assessment. Secondary data from books, peer-reviewed journals, and official reports were used to complement the primary findings.

The study population comprised 145 students in grades 2-4 at SDN Tasikmadu 1, Malang City. A total of 100 respondents were selected through cluster sampling to ensure proportional representation from each grade level. Inclusion criteria were active enrollment, willingness to participate as evidenced by informed consent, and attendance during the study period. Exclusion criteria included absence due to illness and voluntary withdrawal from participation.

Data collection involved on-site BMI measurements and supervised completion of the questionnaires to ensure accuracy and completeness. All responses were statistically processed and analyzed to generate factual and reliable insights consistent with the research objectives. Validity was ensured through the use of standardized tools, adherence to ethical research procedures, and reference to established methodological guidelines (Sugiyono (2023); Kowalski et al. (2004)). Tables and figures are presented centered, as shown in table 1 and figure 1, and are cited in the manuscript prior to their appearance.

## RESULTS AND DISCUSSIONS

### Respondent Characteristics Data

**Table 1.** Data on the characteristics of grades 2-4 in Tasikmadu 1 State Elementary School, Malang City

Caracterisis	Number of respondents	Presentase (%)
Age	7 Year	1
	8 Year	18
	9 Year	28
	10 Year	31
	11 Year	22
Gender	Male	49
	Female	51
Class	2	26
	3	30
	4	44

Table 1 shows that the largest proportion of students were aged 10 years (31%), slightly more than half were female (51%), and Grade 4 had the highest proportion (44%).

### Diet in Grades 2-4 in Tasikmadu 1 State Elementary School Environment Malang City

**Table 2.** Distribution of extreme data diet in grades 2-4 in Tasikmadu 1 State Elementary School, Malang City

Category	Student	
	N	%
Feeling good when eating	Frequent (5-6x/week)	58 58
	Sometimes (3-4x/week)	22 22
	Rarely (2-3x/week)	10 10
	Always (Always (every day)	10 10
	Total	100 100
Feeding Frequency	Frequent (5-6x/week)	57 57
	Sometimes (3-4x/week)	22 22
	Always (Always (every day)	19 19
	Rarely (2-3x/week)	2 2
	Total	100 100
Fast Food Consumption	Frequent (5-6x/week)	47 47
	Sometimes (3-4x/week)	21 21
	Rarely (2-3x/week)	17 17
	Always (Always (every day)	13 13
	Total	100 100
Custom Cakes	Frequent (5-6x/week)	44 44
	Rarely (2-3x/week)	19 19
	Always (Always (every day)	19 19
	Sometimes (3-4x/week)	18 18

	Total	100	100
	Frequent (5-6x/week)	44	44
	Rarely (2-3x/week)	19	19
Consumption of High-Sugar Foods	Always (Always every day)	18	18
	Sometimes (3-4x/week)	18	18
	Total	100	100
	Frequent (5-6x/week)	41	41
	Sometimes (3-4x/week)	27	27
Breakfast	Always (Always every day)	18	18
	Rarely (2-3x/week)	14	14
	Total	100	100
	Rarely (2-3x/week)	40	40
	Frequent (5-6x/week)	27	27
Consumption of Foods High in Salt	Sometimes (3-4x/week)	24	24
	Always (Always every day)	9	9
	Total	100	100
	Kadang-Kadang (3-4x/minggu)	39	39
	Frequent (5-6x/week)	26	26
Consumption of High-Fat Foods	Rarely (2-3x/week)	25	25
	Always (Always every day)	8	8
	Never	2	2
	Total	100	100
	2x a day	35	35
	3x a day	29	29
Frequency of Meals in a Day	1x a day	22	22
	>3 a day	14	14
	Total	100	100
	Frequent (6-7x/week)	33	33
	Always (Always every day)	25	25
Consuming 1 Serving of Food	Sometimes (3-4x/week)	23	23
	Rarely (2-3x/week)	19	19
	Total	100	100
	Sometimes (3-4x/Week)	32	32
	Always (Always every day)	32	32
Consumption of Side Dishes, Vegetables and Fruits	Frequent (6-7x/week)	24	24
	Rarely (2-3x/week)	12	12
	Total	100	100

The study found that among students in grades 2–4 at SDN Tasikmadu 1 Malang City, dietary patterns were dominated by high pleasure in eating (58%) and a high frequency of eating (57%). While quantity was adequate, quality was concerning, with 44% regularly consuming high-sugar foods and 47% frequently eating fast food. Only 32% consumed fruits and vegetables regularly, indicating a predominantly obesogenic diet. The school environment, with easy access to processed snacks, fried foods, and sugary drinks, further contributed to unhealthy eating habits. These patterns are strongly linked to the risk of chronic diseases such as type 2 diabetes mellitus (DM), *especi*

Unhealthy diets have long been recognized as a major risk factor for type 2 DM. Putra, (2015) explains that high sugar, saturated fat, and low fiber intake can increase blood glucose and cause insulin resistance in children. Federation (2021) emphasizes that increased energy intake without matching physical activity leads to visceral fat accumulation and eventual pancreatic beta-cell dysfunction. WHO (2022) also notes that high-calorie, low-fiber diets increase the risk of abdominal obesity, a strong predictor of type 2 DM. The high consumption of fast food and sugary snacks among SDN Tasikmadu 1 students reflects a tendency towards early metabolic syndrome. Previous studies support these findings, such as Pibriyanti & Hidayati (2018), who found that 40% of childhood DM risk is related to frequent consumption of unhealthy snacks, and Nurhasanah et al. (2022), who reported that eating fast food more than three times a week increases the risk of impaired glucose tolerance by 1.8 times. Low fruit and vegetable intake further exacerbates the problem, as highlighted by Anderson et al. (2021) and Kirk et al. (2023), who show that dietary

fiber and micronutrients help regulate insulin function and protect against oxidative stress. This pattern aligns with previous studies ((Putra, 2015); (Pibriyanti & Hidayati, 2018); (Nurhasanah et al., 2022); (Anderson et al., 2021); (Kirk et al., 2023)), reinforcing the notion that unhealthy dietary habits in childhood particularly frequent consumption of high-sugar and high-fat foods combined with low fruit and vegetable intake create an early metabolic environment conducive to insulin resistance. In the context of Malang, where easy access to calorie-dense snacks is prevalent, these dietary patterns may amplify the risk trajectory compared to populations with more controlled food environments.

### Physical Activity in Grades 2-4 in Tasikmadu 1 State Elementary School Environment Malang City

**Table 3.** Distribution of physical activity factors in grades 2-4 in Tasikmadu 1 State Elementary School, Malang City

Variable	Category	Student	
		N	%
Sports for the last 7 days, after school	5x last week	97	97
	2-3x last week	2	2
	1 week ago	1	1
	4x last week	0	0
	Never	0	0
	Total	100	100
Last Sunday, sports and activities that required to be active	5x last week	96	96
	2-3x last week	2	2
	1x last week	2	2
	4x last week	0	0
	Never	0	0
	Total	100	100
Physical Activity Last 7 Days, At Rest Hour 1	Running around and playing throughout the break	95	95
	Just stand or take a walk	3	3
	Run or play for a while	2	2
	Running around and playing throughout the break	0	0
	Sitting (talking, reading, doing assignments)	0	0
	Total	100	100
Physical Activity for the Last 7 Days, at Rest Time 2	Running around and playing throughout the break	95	95
	Just stand or take a walk	3	3
	Run or play for a while	2	2
	Running around and playing throughout the break	0	0
	Sitting (talking, reading, doing assignments)	0	0
	Total	100	100
Last 7 Days of Sports, In the Afternoon	5x last week	94	94
	2-3x last week	2	2
	1x last week	2	2
	4x last week	0	0
	Never	0	0
	Total	100	100
Self-Description	I very often do physical activity in my spare time 7 times a week	94	94
	I often do physical activity 3-4 times a week in my spare time	5	5
	I sometimes do physical activity in my spare time 1-2x a week	1	1
	I do physical activity in my spare time quite often 5-6 times a week	0	0
	All or most of my free time is spent on activities that don't move much/physically active	0	0
	Total	100	100
Physical Activity for the Last 7 Days, During Sports Lesson Hours	Always	86	86
	Infrequently	6	6
	Dislike sports	5	5

Variable	Category	Student	
		N	%
Saturday's Activities	Sometimes	2	2
	Quite often	1	1
	Total	100	100
	Never	50	50
	A little	34	34
	Often	8	8
	Passable	7	7
	Very Often	1	1
	Total	100	100
	Never	49	49
Sunday Activities	A little	30	30
	Often	10	10
	Very Often	6	6
	Passable	5	5
	Total	100	100
Aerobic Gymnastics	1-2x	49	49
	Never	30	30
	3-4x	14	14
	7x or more	4	4
	5-6x	3	3
volleyball	Total	100	100
	Never	49	49
	1-2x	26	26
	5-6x	10	10
	7x or more	9	9
Thursday's Activities	3-4x	6	6
	Total	100	100
	Never	44	44
	A little	36	36
	Passable	13	13
Sunday Activities	Often	7	7
	Very Often	0	0
	Total	100	100
	Never	49	49
	A little	30	30
Dance	Often	10	10
	Very Often	6	6
	Passable	5	5
	Total	100	100
	1-2x	39	39
Football	Never	36	36
	3-4x	12	12
	5-6x	10	10
	7x or more	3	3
	Total	3	3
Badminton	Total	100	100
	Never	39	39
	1-2x	25	25
	3-4x	21	21
	5-6x	12	12
Table tennis	7x or more	3	3
	Total	100	100
	Never	39	39
	1-2x	36	36
	3-4x	17	17
Dance	5-6x	7	7
	7x or more	1	1
	Total	100	100
	Never	39	39
	1-2x	28	28
Football	3-4x	18	18

Variable	Category	Student	
		N	%
Jogging or Running	5-6x	10	10
	7x or more	5	5
	Total	100	100
	1-2x	38	38
	Never	24	24
	3-4x	21	21
	5-6x	11	11
	7x or more	6	6
	Total	100	100
	Never	38	38
Friday's Activities	A little	31	31
	Passable	24	24
	Very Often	4	4
	Often	3	3
	Total	100	100
Wednesday's Activities	Never	36	36
	A little	33	33
	Often	13	13
	Passable	12	12
	Very Often	6	6
Cycling	Total	100	100
	1-2x	36	36
	3-4x	20	20
	5-6x	18	18
	Never	14	14
Tuesday's Activities	7x or more	12	12
	Total	100	100
	A little	34	34
	Never	29	29
	Passable	25	25
Monday's Activities	Often	12	12
	Very Often	0	0
	Total	100	100
	A little	31	31
	Never	25	25
Walk	Passable	25	25
	Very Often	10	10
	Often	9	9
	Total	100	100
	1-2x	27	27
Walk	5-6x	24	24
	Never	21	21
	3-4x	18	18
	7x or more	10	10
	Total	100	100

The study found that 97% of students in grades 2-4 at SDN Tasikmadu 1 Malang City engaged in after-school sports five times a week, making it the highest participation rate among all physical activity indicators. In addition, 95% were active during school breaks, and 94% participated in afternoon physical activities. These findings suggest that students generally have high levels of physical activity, especially in unstructured forms such as free play. However, participation in structured sports like volleyball, badminton, and dancing remained relatively low, averaging below 40%. This pattern indicates that while children are naturally active, they have not been optimally engaged in sustained and organized exercise programs. Informal activities such as running, chasing games, and afternoon play provide protective benefits against type 2 diabetes mellitus (DM) by improving insulin sensitivity, reducing blood glucose, and helping maintain a

healthy weight. Yet, to maximize these benefits, physical activity should be more structured and regularly scheduled.

From a theoretical perspective, Nurdiyanti et al. (2024) found that a lack of structured physical activity increases the risk of type 2 DM in children, with those exercising less than twice a week having a 4.5 times higher risk of impaired glucose metabolism. The WHO, (2021) recommends at least 60 minutes of moderate-to-vigorous activity daily, including activities like running, swimming, or gymnastics. While SDN Tasikmadu 1 students reported high engagement in free play, the limited participation in structured activities such as aerobic gymnastics, practiced by only 49% suggests a gap in meeting these guidelines. Pibriyanti & Hidayati (2018) research also supports this, noting that spontaneous play alone does not produce optimal metabolic benefits unless combined with structured aerobic exercise. Anderson et al., (2021) explain that physical activity lowers blood glucose through mechanisms such as increased GLUT-4 protein expression and enhanced fatty acid oxidation, while also reducing HbA1c levels in obese children. Kirk et al. (2023) emphasize that the effectiveness of activity depends on its duration, intensity, and regularity, highlighting that frequency alone is not enough to reduce DM risk if movement quality is insufficient. These findings are consistent with Nurhasanah et al. (2022) and Pibriyanti & Hidayati (2018), who highlight that while unstructured physical activity can provide partial metabolic benefits, the absence of regular structured exercise limits its protective effect against type 2 DM. In comparison with WHO (2021) recommendations, the children in this study meet the frequency criteria but fall short on activity quality and intensity. This suggests that intervention strategies in Malang should focus not only on increasing activity duration but also on structuring it to maximize metabolic gains.

#### **BMI in grades 2-4 in Tasikmadu 1 state elementary school, Malang city**

**Table 4.** Distribution of BMI factors in grades 2-4 in Tasikmadu 1 State Elementary School, Malang City

Category	Student	
	N	%
23,8 - 26 (Fat)	57	57
< 23,8 (Normal)	18	18
IMT < 17 (Thin)	16	16
> 26 (Obesity)	9	9
Total	100	100

The study found that 57% of students in grades 2–4 at SDN Tasikmadu 1 Malang City were classified as “obese” based on BMI measurements, compared to 18% in the “normal” category and 16% in the “thin” category. This means that more than half of the students are overweight, making obesity the most prevalent nutritional status in this population. Childhood obesity is a well-established predictor of type 2 diabetes mellitus (DM) because it is closely linked to insulin resistance and metabolic syndrome, often marked by central fat accumulation. In this study, the high obesity rate highlights the importance of immediate nutrition interventions and structured physical activity in schools. Since BMI reflects the balance between energy intake and expenditure, the 57% prevalence signals a serious disruption in students’ energy balance. Beyond increasing DM risk, obesity in children may also hinder growth, cognitive development, and motor skills.

Theoretically, WHO (2022) defines childhood obesity as a BMI above the 95th percentile for age and gender, which is clinically associated with a higher risk of DM, hypertension, and dyslipidemia. Kirk et al. (2023) explain that visceral fat in obesity promotes insulin resistance by increasing inflammatory cytokines such as TNF- $\alpha$  and IL-6, which disrupt insulin signaling. This means that obese students at SDN Tasikmadu 1 are at risk of reduced insulin sensitivity from an early age, reinforcing the need for BMI monitoring as part of long-term metabolic risk prevention. Pibriyanti & Hidayati (2018) also reported that 30% of childhood DM risk is directly associated with high BMI, with obese children showing higher fasting blood glucose and chronic fatigue.

Sedentary behavior, such as sitting more than three hours daily, increased obesity risk by 1.6 times, especially in environments offering sugary snacks but lacking structured physical activity. Similarly, the Association (2022) notes that children with high BMI in elementary school are twice as likely to develop impaired glucose tolerance before age 18. Anderson et al. (2021) further found that obesity persisting for more than two years strongly correlates with adolescent DM and elevated insulin levels. Similar to findings by WHO (2021), Kirk et al. (2023), and Pibriyanti & Hidayati (2018), the high prevalence of overweight and obesity observed in this study underscores BMI as a robust predictor of pediatric DM risk. However, the combined rate of overweight and obesity (66%) in this Malang sample appears to exceed figures reported in several national surveys, suggesting that local environmental and behavioral factors such as dietary patterns and sedentary habits may exert a stronger influence here than in other regions.

### Risk factors for DM in grades 2-4 in the Tasikmadu 1 state elementary school environment in Malang city

**Table 5.** Distribution of DM risk factors in grades 2-4 in Tasikmadu 1 State Elementary School, Malang City

Category		Student	
		N	%
Screen Time	> 2 hours	100	100
	< 2 hours	0	0
	Total	100	100
Physical Activity	Yes	99	99
	No	1	1
	Total	100	100
History of Gestational DM Mothers	No	97	97
	Yes	3	3
	Total	100	100
Birth Weight	2.500-4.000 gr	76	76
	< 2.500 gr	21	21
	> 4000 gr	3	3
	Total	100	100
IMT	23,8 - 26 (Fat)	57	57
	< 23,8 (Normal)	18	18
	< 17 (Thin)	16	16
	> 26 (Obesity)	9	9
	Total	100	100
DM Family History	Tidak	47	47
	Parents, brother and sister	27	27
	Grandpa, grandma, uncle, aunt	26	26
Abdominal Circumference	Total	100	100
	<59 cm	38	38
	> 62 cm	36	36
	59-62 cm	26	26
	Total	100	100

The results of FINDRISC measurements for students in grades 2-4 at SDN Tasikmadu 1 Malang City showed that the most striking finding was that 100% of students had screen time exceeding two hours per day, indicating a universally high sedentary lifestyle one of the primary triggers of insulin resistance. In addition, 44% regularly consumed high-sugar foods, 47% frequently ate fast food, and 47% had a family history of DM. This combination of excessive energy intake, low structured physical activity, and prolonged sedentary behavior forms a cumulative risk profile that significantly increases the likelihood of prediabetes. These high FINDRISC scores are not random but the result of consistent unhealthy daily habits, particularly overexposure to gadgets and reliance on processed foods. If left unaddressed, these children may develop impaired glucose tolerance even before adolescence, highlighting the need for immediate strategic intervention from both schools and parents.

According to Perkeni (2021), type 2 DM risk factors are categorized into modifiable (e.g., obesity, diet, physical activity) and non-modifiable (e.g., family history, age, genetics) groups. In the case of SDN Tasikmadu 1 students, modifiable factors dominate, underscoring the urgency for targeted preventive measures. WHO (2019) stresses the importance of early DM risk identification using tools like FINDRISC to prevent future complications. The findings in this study align with these recommendations, as school-based screening offers a promotive and preventive approach within primary healthcare principles. Pibriyanti & Hidayati (2018) found that children with a combination of three modifiable factors high BMI, high sugar intake, and insufficient physical activity had a 3.7 times higher risk of DM compared to children with healthy habits, with many nearing prediabetes-level fasting glucose. Similarly, Suryadi & Hartono, (2022) reported a linear relationship between FINDRISC scores and HbA1c levels in obese children, showing that environmental and lifestyle factors may outweigh genetic predisposition. The convergence of multiple modifiable risk factors high BMI, prolonged screen time, frequent high-sugar and fast-food consumption mirrors patterns identified in prior research (Perkeni (2021); WHO (2019), Pibriyanti & Hidayati (2018); Suryadi & Hartono (2022)). What differentiates this study is the uniformly high screen time (>2 hours/day) among all respondents, which, when combined with dietary and BMI data, paints a more alarming composite risk profile than typically reported in similar school-based populations. This reinforces the potential value of incorporating early risk screening tools, such as FINDRISC, into routine school health assessments in Malang.

## CONCLUSION

Despite its contributions, the study is limited by its focus on a single school and reliance on self-reported behaviors, which may affect generalizability. To test the potential for generalizing these findings, future research should adopt a multi-site design across schools in different socio-cultural settings and conduct longitudinal monitoring to track changes in dietary patterns, activity levels, and DM risk over time. Such approaches would help determine whether the obesogenic patterns observed here are consistent across broader populations.

Moreover, integrating early risk screening using the FINDRISC tool into school health programs especially when paired with nutrition and physical activity interventions offers the potential to identify at-risk children early and intervene before metabolic complications develop. Over the long term, such preventive strategies could contribute to reducing the incidence of type 2 DM in high-burden areas like Malang, although longitudinal evaluation is needed to measure actual impact. Future research could also incorporate biochemical testing and examine the influence of cultural food practices to develop more comprehensive and contextually relevant DM prevention programs.

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