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*ORIGINAL ARTICLE*

# STRESS AND INADEQUATE FRUIT-VEGETABLE INTAKE AS MODIFIABLE RISK FACTORS FOR TYPE 2 DIABETES IN YOGYAKARTA

***Stres dan Konsumsi Buah-Sayur Kurang sebagai Faktor Risiko Modifiable Diabetes Tipe 2 di Yogyakarta***

**Solikhah Solikhah[1], Dedik Sulistiawan[2], Ratu Matahari[3], Widya Rahmawati[4], Dwi Sarwani Sri Rejeki[5,6]**
[1]Faculty of Public Health, Universitas Ahmad Dahlan, Yogyakarta, Indonesia, 55164, solikhah@ikm.uad.ac.id
[2]Faculty of Public Health, Universitas Ahmad Dahlan, Yogyakarta, Indonesia, 55164, dedik.sulistiawan@ikm.uad.ac.id
[3]Faculty of Public Health, Universitas Ahmad Dahlan, Yogyakarta, Indonesia, 55164, ratu.matahari@ikm.uad.ac.id
[4]Faculty of Public Health, Universitas Ahmad Dahlan, Yogyakarta, Indonesia, 55164, widya1900029204@webmail.uad.ac.id
[5]Department of Public Health, Faculty of Health Sciences, Jenderal Soedirman University, Purwokerto, Indonesia, 53122, dwi.rejeki@unsoed.ac.id
[6]Research Centre of Rural Health, Institute for Research and Community Service, Jenderal Soedirman University, Indonesia
Corresponding Author: Solikhah Solikhah, solikhah@ikm.uad.ac.id, Faculty of Public Health, Universitas Ahmad Dahlan, Yogyakarta,55164, Indonesia

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**ABSTRACT**

**Background:** Type 2 diabetes mellitus (T2DM) remains a significant global public health issue, with rising prevalence, including in Indonesia. At the same time, numerous studies have investigated modifiable risk factors of T2DM. To date, stress, fruit, and green-leafy vegetable consumption as risk factors of T2DM remain limited. **Purpose:** This study investigated the association between stress, fruit, and green-leafy vegetable consumption with T2DM occurrence among individuals under the supervision of Kalasan Public Health Center, Sleman, Yogyakarta. **Methods:** A cross-sectional study was conducted among 356 registered outpatients selected through purposive sampling. Stress levels were measured using the WHO Self-Reporting Questionnaire, while fruit and vegetable consumption was assessed using the Indonesia Basic Health Research 2018 questionnaire. T2DM status was determined based on fasting blood sugar levels recorded in medical records and confirmed by a physician's diagnosis. **Results:** Stress was linked to a higher probability of T2DM (Adjusted Odds Ratio (AOR) = 2.61; 95% CI = 1.25–5.44). Consuming fruit and green-leafy vegetables 2–3 times per week was associated with a lower likelihood of having T2DM (AOR = 0.27; 95% CI = 0.13–0.56 and AOR = 0.07; 95% CI = 0.03–0.20, respectively). **Conclusion:** Stress increases the probability of T2DM. Fruit and green-leafy vegetable consumption 2-3 times per week was associated with a reduced likelihood of T2DM. These findings emphasize the need for

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targeted public health interventions promoting stress management and healthy dietary patterns strategies to mitigate T2DM risk in primary healthcare settings.



***ABSTRAK***

***Latar Belakang:*** *Diabetes melitus tipe 2 (T2DM) masih menjadi masalah kesehatan masyarakat global yang serius, dengan prevalensi yang terus meningkat, termasuk di Indonesia. Meskipun beberapa penelitian terkait faktor risiko T2DM telah banyak diteliti. Sampai saat ini penemuan stress, konsumsi buah dan sayur hijau sebagai faktor risiko T2DM masih terbatas.* ***Tujuan:*** *Penelitian ini bertujuan untuk menganalisis hubungan antara stres, konsumsi buah dan sayur hijau dengan kejadian T2DM di wilayah Puskesmas Kalasan, Sleman, Yogyakarta.* ***Metode:*** *Penelitian ini menggunakan desain studi cross-sectional dengan sampel sebanyak 356 pasien rawat jalan terdaftar yang dipilih melalui purposive sampling. Tingkat stres diukur menggunakan Self-Reporting Questionnaire dari WHO, sementara konsumsi buah dan sayur dikumpulkan menggunakan kuesioner Riset Kesehatan Dasar 2018. Status T2DM ditentukan berdasarkan kadar gula darah puasa yang tercatat dalam rekam medis dan dikonfirmasi oleh diagnosis dokter.* ***Hasil:*** *Stres terbukti berhubungan dengan peningkatan risiko T2DM (Adjusted Odds Ratio (AOR) = 2,61; 95% CI = 1,25–5,44). Konsumsi buah dan sayuran berdaun hijau sebanyak 2–3 kali per minggu berhubungan dengan kemungkinan lebih rendah mengalami T2DM (AOR = 0,27; 95% CI = 0,13–0,56 dan AOR = 0,07; 95% CI = 0,03–0,20, secara berturut-turut).* ***Simpulan:*** *Stres meningkatkan risiko T2DM, sementara konsumsi buah dan sayuran berdaun hijau 2–3 kali per minggu berhubungan dengan penurunan risiko T2DM. Temuan ini menekankan pentingnya intervensi kesehatan masyarakat yang menargetkan manajemen stres dan penerapan pola makan sehat guna mengurangi risiko T2DM di layanan kesehatan primer.*



## INTRODUCTION

Diabetes mellitus (DM) is a condition that rises higher than usual due to the failure of body cells to respond to insulin (1). Based on the causes, DM is classified into four groups, namely type 1 diabetes mellitus (T1DM), type 2 diabetes mellitus (T2DM), gestational diabetes mellitus, and other types of diabetes mellitus (2). Globally, T2DM is significantly more common than T1DM, accounting for approximately 96% of cases (3). If not adequately managed, T2DM can lead to various complications, such as kidney failure, heart attacks, foot amputation, and nerve damage. These complications are often only recognized once they progress to acute or chronic stages, making it difficult for T2DM patients to maintain their condition (4).

Globally, 529 million people are living with diabetes mellitus, with a prevalence of 6.1%, and the number of cases is projected to increase to 1.31 billion by 2050 (3). In terms of diabetes mellitus cases, including both type 1 and type 2, among individuals aged 20-79 worldwide, Indonesia ranks second in India, with a total of 19 million cases (5). More specifically, the projected prevalence of diabetes mellitus in Indonesia has risen from 18.69 million cases in 2020 to an estimated 40.7 million cases by 2045-an increase of nearly three-quarters. The province with the second-highest prevalence is Yogyakarta (21.94%), followed by Jakarta (23.11%) (6).

Despite the implementation of Indonesia's national diabetes control program under the Indonesia National Health Insurance (INHI) system, which encompasses health promotion, prevention, curative treatment, and rehabilitation, the prevalence of diabetes mellitus continues to rise, particularly with an aging population. Reports from the Ministry of Health indicate that the prevalence

of type 2 diabetes mellitus (T2DM) increased from 6.9% in 2013 to 10.9% in 2018 (7). Unfortunately, after nearly 11 years of the program's implementation, the reduction in national diabetes prevalence has been minimal, with the prevalence in 2020 still recorded at 9.19% (18.69 million cases) (6). A similar trend was observed in Yogyakarta, where the prevalence of diabetes rose from 2.6% in 2018 to 12.6% in 2020 (6).

The rising prevalence of T2DM in Indonesia underscores the influence of multiple contributing factors, including aging (8–10), obesity (11), and sedentary lifestyles (12). Despite the well-established influence of physical inactivity, obesity, and aging on T2DM development, other modifiable lifestyle factors, such as stress and dietary intake, have received comparatively less attention in Indonesian community healthcare settings. Prior research has primarily focused on non-modifiable determinants, including age, sex, and family history, as well as modifiable factors like smoking (13).

Moreover, dietary fruits and vegetables have been observed as risk factors for T2DM (14); this is associated with the positive effects of green fruits and vegetables' low-energy but nutrient-rich nature (15). Nonetheless, several previous studies' findings remain inconclusive (16–18). In addition, stress has also been reported to worsen individual health in various categories, including non-communicable diseases such as T2DM (19). Previous studies have reported that more than half of T2DM patients were found to have failed blood sugar control (20). Poor management of an individual's blood sugar control has driven severe complications such as congestive heart failure (21), diabetic ketoacidosis, and *gangrene* (22). Previous studies also explained that biological and behavioral mechanisms among individuals will affect the cortisol level, insulin resistance, and systemic inflammation of the body, increasing the risk of T2DM (23). The behavioral mechanism of dietary habits will also use T2DM as a modifiable factor (18). Therefore, the role of psychological stress, fruit, and green-leafy vegetable consumption in T2DM occurrence remains underexplored.

A previous study concerned non-modifiable determinants among individuals related to T2DM, such as age, sex, and degenerative (24). However, limited studies explored the impact of psychological stress on T2DM in Indonesia. The previous study in developed countries separately explored psychological stress and dietary behavior (18). Given the rising burden of T2DM and the potential role of dietary intake and stress in its development, further research is needed to understand their impact in Indonesian community healthcare settings. Investigating these factors could provide valuable insights for developing targeted interventions emphasizing dietary improvements and stress management strategies as part of comprehensive diabetes prevention programs. This study addresses this gap by examining the association between fruit and vegetable consumption, stress, and T2DM occurrence in an Indonesian primary healthcare setting, providing novel insights into the role of these modifiable factors in a population where such research remains limited.

## METHODS

This quantitative study employed a cross-sectional design, with data collected through a structured questionnaire at Kalasan Public Health Center, Sleman, Special Region of Yogyakarta, from November to December 2023. The study population comprised new outpatients receiving treatment at the health center. A purposive sampling technique was used, yielding a total of 356 participants. The sample size was initially calculated based on the method described by Sadiq et al. (2024) (25), considering a Z-value of 1.96, a prevalence (p) of 50%, and a significance level (α) of 0.05, resulting in a required sample size of 324. An additional 10% was included to account for potential dropouts to account for potential dropouts, bringing the final sample to 356 participants. Inclusion criteria required participants to be aged ≥18 years, able to communicate in Indonesian, and willing to participate. Individuals with memory disorders or incomplete questionnaire responses were excluded from the study.

The dependent variable in this study was T2DM, determined based on a physician's diagnosis at Kalasan Public Health Center, Sleman, Yogyakarta, using fasting blood sugar (FBS) measurements recorded in the medical records. T2DM was classified as present if FBS levels were ≥126 mg/dL (7.0 mmol/L) and absent if FBS levels were <126 mg/dL (7.0 mmol/L).

The independent variables in this study were stress levels and dietary habits, specifically fruit and green-leafy vegetable consumption. Stress levels were measured using the World Health Organization (WHO) Self-Reporting Questionnaire 20 (SRQ-20), a validated instrument for assessing emotional distress. The SRQ-20 consists of 20 items, each scored as 0 (absence of symptoms) or 1 (presence of symptoms) based on the individual's

experiences over the past month. A total score of ≥7 was classified as experiencing stress, while a score of <7 indicated no significant stress symptoms (26). Questions regarding fruit and green-leafy vegetable consumption were adapted from the 2018 Indonesia Basic Health Survey (Riskesdas) (7). Dietary intake was assessed based on the average frequency of consumption of these foods and categorized into three groups: ≤1 time per week, 2–3 times per week, and >3 times per week.

This study also accounted for additional variables, including smoking status, comorbidities, BMI, and physical activity. Smoking status and comorbidities were each classified as "Yes" or "No." BMI was calculated as weight (kg) divided by height squared ($m^2$) and categorized as either overweight/obese (≥25 $kg/m^2$) or normal weight (<25 $kg/m^2$). The physical activity variable was categorized into two levels: heavy and moderate. Participants were classified as engaging in heavy physical activity if they met at least one of the following criteria: (1) performing high-intensity physical activity for at least three days per week, accumulating a total of at least 1,500 MET-minutes per week, or (2) engaging in a combination of walking, moderate-intensity, and high-intensity physical activities for at least seven days, with a total physical activity level of at least 3,000 MET-minutes per week. Meanwhile, participants were classified as engaging in moderate physical activity if they met any of the following criteria: (1) performing high-intensity physical activity for at least three days per week, with a minimum of 20 minutes per day; (2) engaging in moderate-intensity physical activity for at least five days per week and/or walking for at least 30 minutes per day; or (3) participating in a combination of walking, moderate-intensity, and high-intensity activities, with a total of at least 600 MET-minutes per week.

Additionally, age, sex, education, and family history of diabetes were included as non-modifiable risk factors and adjusted covariates. Age was categorized into two groups: ≥45 and <45 years. Sex was classified as male or female. Education level was grouped into basic education (including no formal education, completion of elementary school, and junior high school) and higher education (high school graduates and above). Family history of diabetes was classified as "Yes" or "No".

Descriptive statistics were reported as frequencies and percentages. The association between independent variables and T2DM was analyzed using logistic regression to estimate unadjusted and adjusted odds ratios (OR) with 95% confidence intervals (CI). Adjusted ORs accounted for age, sex, education, and family history of diabetes as non-modifiable risk factors and potential confounders. Hypothesis testing was conducted using the Chi-square test, with statistical significance at $p < 0.05$. Multivariate analysis is performed on variables with a p-value of less than or equal to 0.25 that have already been discovered using bivariate analysis. All data analyses were performed using R Studio version 4.2.2. This study was approved by the Ethics Committee of Universitas Jenderal Ahmad Yani (Registration No.: Skep/525/KEP/XI/2023).

## RESULTS

The study included 356 participants. Most participants (approximately three-quarters) were aged 45 or older, while about one-quarter were younger than 45. The gender distribution showed a higher prevalence of women compared to men. In terms of educational attainment, more than two-thirds had completed higher education (Table 1).

Regarding dietary habits, more than one-third of participants consumed fruit once a week or less, around one-fifth consumed it two to three times per week, and over two-fifths consumed fruit more than three times per week. Similarly, for green-leafy vegetable consumption, approximately one-fifth reported consuming it once a week or less, nearly three-tenths consumed it two to three times per week, and about half consumed it more than three times per week (Table 1).

Around one in six participants reported stress. More than half of the participants had a family history of diabetes. Additionally, nearly one-fourth of the participants were smokers. Regarding comorbidities, more than half of the participants had at least one comorbidity, while slightly less than half had no reported comorbid conditions. BMI distribution showed that nearly half of the participants had a BMI of 25 $kg/m^2$ or higher, while slightly more than half had a BMI below 25 $kg/m^2$ (Table 1).

For physical activity levels, approximately one-fifth of participants engaged in heavy physical activity, whereas nearly four-fifths had moderate activity levels. The prevalence of T2DM was alarmingly high, with 60.39% of participants diagnosed with the condition (Table 1).

Table 2 presents the odds ratios and 95% confidence intervals for the associations between modifiable risk factors and Type 2 Diabetes Mellitus (T2DM) at Kalasan Public Health Center. The findings indicate that stress, fruit and vegetable

consumption, comorbidities, and physical activity were significantly associated with T2DM.

**Table 1**
Characteristics of Study Participants

| Variable | n | % |
|---|---|---|
| Age | | |
| ≥ 45 years old | 266 | 74.72 |
| < 45 years old | 90 | 25.38 |
| Sex | | |
| Woman | 216 | 60.67 |
| Man | 140 | 39.33 |
| Education Level | | |
| Basic Education | 107 | 30.06 |
| Higher Education | 249 | 69.94 |
| Family History of Diabetes | | |
| Yes | 205 | 57.58 |
| No | 151 | 42.42 |
| Stress | | |
| Yes | 62 | 17.42 |
| No | 294 | 82.58 |
| Fruit Consumption | | |
| < 1 time/ week | 129 | 36.24 |
| -3 times/ week | 75 | 21.06 |
| > 3times/week | 152 | 42.70 |
| Green-leafy Vegetable Consumption | | |
| < 1 time/ week | 71 | 19.94 |
| times/ week | 104 | 29.24 |
| > 3times/week | 181 | 50.84 |
| Smoking | | |
| Yes | 85 | 23.88 |
| No | 271 | 76.12 |
| Comorbidity | | |
| Yes | 193 | 54.21 |
| No | 163 | 45.79 |
| Body Mass Index | | |
| ≥ 25 kg/m2 | 172 | 48.31 |
| < 25 kg/m2 | 184 | 51.69 |
| Physical Activity | | |
| Heavy | 73 | 20.51 |
| Moderate | 283 | 79.49 |
| T2DM | | |
| Yes | 215 | 60.39 |
| No | 141 | 39.61 |

Participants who reported experiencing stress had significantly higher odds of having T2DM compared to those without stress (Adjusted OR = 2.61, 95% CI: 1.25–5.44, p < 0.01). Similarly, fruit consumption patterns showed a strong association with T2DM. Individuals consuming fruit 2–3 times per week had a significantly lower likelihood of having T2DM (Adjusted OR = 0.27, 95% CI: 0.13–0.56, p < 0.001) compared to those consuming fruit once a week or less. However, those consuming fruit more than three times per week had significantly higher odds of T2DM (Adjusted OR = 4.99, 95% CI: 2.71–9.22, p < 0.001) (Table 2).

A similar trend was observed for green-leafy vegetable consumption. Participants who consumed vegetables 2–3 times per week had significantly reduced odds of T2DM (Adjusted OR = 0.07, 95% CI: 0.03–0.20, p < 0.001). However, those consuming vegetables more than three times per week showed an increase in T2DM risk (Adjusted OR = 50.34, 95% CI: 16.48–153.80, p < 0.001) (Table 2).

Regarding other lifestyle factors, individuals with comorbidities were at significantly higher risk of T2DM (Adjusted OR = 4.42, 95% CI: 2.64–7.40, p < 0.001) compared to those without comorbid conditions. In contrast, engaging in moderate physical activity was found to be protective against T2DM, reducing the odds by more than half (Adjusted OR = 0.43, 95% CI: 0.23–0.83, p < 0.01). However, smoking status and body mass index (BMI) did not show significant associations with T2DM in the adjusted model (Table 2).

## DISCUSSION

The present study highlights significant associations between modifiable lifestyle factors and Type 2 Diabetes Mellitus (T2DM), emphasizing the roles of stress, dietary patterns, comorbidities, and physical activity. Stress was found to be a significant risk factor for T2DM. Chronic psychological stress has been linked to increased cortisol levels, insulin resistance, and systemic inflammation, all contributing to T2DM development (23). These findings are consistent with previous studies highlighting the role of psychosocial stress in metabolic disorders (32).

The findings also indicate that while moderate fruit and vegetable consumption may have protective effects, as previously studied (18), excessive intake appears to be linked to an increased risk of T2DM. The observed association between high fruit consumption (>3 times per week) and increased T2DM risk is unexpected but not unprecedented. Prior studies suggest that while some fruits offer protective benefits, others with high natural sugar content and rapid absorption rates may contribute to higher blood glucose levels, potentially increasing T2DM risk (18). Other studies corroborate these findings, showing that a well-balanced plant-based diet can help prevent T2DM (29). While plant-based diets may offer a promising approach to

improving overall health and potentially reversing certain diseases, a deeper understanding of the underlying mechanisms is crucial for providing informed recommendations (30).

**Table 2**
Odds Ratios of Modifiable Risk Factors for T2DM at Kalasan Public Health Center

| Variable | T2DM | | | | Crude OR (95% CI) | Adjusted OR (95% CI)† |
|---|---|---|---|---|---|---|
| | Yes | | No | | | |
| | n | % | n | % | | |
| Stress | | | | | | |
| No (Ref.) | 166 | 56.46 | 128 | 43.54 | | |
| Yes | 49 | 79.03 | 13 | 20.97 | 2.91 (1.51–5.59)** | 2.61 (1.25–5.44)** |
| Fruit consumption | | | | | | |
| ≤ 1 time/week (Ref.) | 70 | 54.26 | 59 | 45.74 | | |
| 2 – 3 times/week | 14 | 18.67 | 61 | 81.33 | 0.19 (0.10–0.38)*** | 0.27 (0.13–0.56)*** |
| > 3 times/week | 131 | 86.18 | 21 | 13.82 | 5.26 (2.95–9.36)*** | 4.99 (2.71–9.22)*** |
| Green-leafy vegetable consumption | | | | | | |
| ≤ 1 times/week (Ref.) | 32 | 45.07 | 39 | 54.93 | | |
| 2 – 3 times/week | 7 | 6.73 | 97 | 93.27 | 0.09 (0.04–0.22)*** | 0.07 (0.03–0.20)*** |
| > 3 times/week | 176 | 97.24 | 5 | 2.76 | 42.9 (15.71–117.12)*** | 50.34 (16.48–153.80)*** |
| Smoking | | | | | | |
| No (Ref.) | 170 | 62.73 | 101 | 37.27 | | |
| Yes | 45 | 52.94 | 40 | 47.06 | 0.67 (0.41–1.09) | 0.70 (0.33–1.48) |
| Comorbidity | | | | | | |
| No (Ref.) | 61 | 37.42 | 102 | 62.58 | | |
| Yes | 154 | 79.79 | 39 | 20.21 | 6.60 (4.11–10.60)*** | 4.42 (2.64–7.40) |
| Body mass index (BMI) | | | | | | |
| <25 kg/m2 (Ref.) | 109 | 59.24 | 75 | 40.76 | | |
| ≥ 25 kg/m2 | 106 | 61.63 | 66 | 38.37 | 1.10 (0.72–1.69) | 1.24 (0.76–2.02) |
| Physical activity | | | | | | |
| Heavy (Ref.) | 54 | 73.97 | 19 | 26.03 | | |
| Moderate | 161 | 56.89 | 122 | 43.11 | 0.46 (0.26–0.82)** | 0.43 (0.23–0.83)** |

Note:
Ref.: reference; OR: Odds Ratio; CI: Confidence Interval; T2DM: Type 2 diabetes mellitus.
† Adjusted odds ratios from multivariable logistic regression, controlling for non-modifiable risk factors, i.e., age, sex, family history of diabetes, and education level.
Significant at: *** p<0.001; ** p<0.01; * p<0.05

Additionally, differences in fruit preferences and availability across populations may explain this discrepancy, as individuals with high fruit consumption might predominantly consume fruits with higher glycemic indices, leading to adverse metabolic effects (31). Furthermore, the potential for reverse causality should be considered, where individuals already diagnosed with T2DM may increase their fruit consumption as part of dietary recommendations. This phenomenon has been noted in previous epidemiological study (32).

Similarly, the significant association between frequent green-leafy vegetable consumption (>3 times per week) and increased T2DM risk warrants careful interpretation. Although green-leafy vegetables are generally considered protective against T2DM (33), the remarkably high odds ratio and wide confidence interval suggest potential confounding factors. One possibility is that participants consuming higher amounts of vegetables may also be following dietary adjustments after being diagnosed with T2DM, introducing reverse causality bias. Another explanation is related to food preparation methods; deep frying or cooking vegetables with excessive added fats, salts, or condiments could negate their benefits and contribute to metabolic dysregulation (34).

The protective effect of moderate physical activity aligns with the well-documented benefits of exercise in improving insulin sensitivity and reducing diabetes risk (39). However, engaging in

intense physical activity may have a different physiological impact. People who are rarely doing physical activities have higher risk to T2DM than people who are active in physical activity (37). Previous study suggests that, during vigorous aerobic exercise, elevated plasma catecholamine levels can stimulate hepatic glucose production, potentially resulting in transient hyperglycemia (38). The situation is important to improve the policy to increase the physical activity promotion in the community level. Additionally, the possibility of reverse causality should be considered, as individuals with undiagnosed or poorly controlled T2DM may engage in high-intensity exercise to manage their condition, inadvertently exacerbating glucose fluctuations. The lack of significant associations for smoking status and BMI in the adjusted model may be due to residual confounding, measurement errors, or the specific population characteristics in this study.

**Research Limitation**

Despite the valuable insights provided, this study has several limitations. First, its cross-sectional design prevents establishing causality, and reverse causality may influence associations, particularly for dietary intake and physical activity. Individuals with existing or undiagnosed T2DM may have modified their behaviors in response to health recommendations. Second, self-reported data on diet and physical activity introduce recall and reporting bias. The study did not differentiate between specific fruit or vegetable types or preparation methods, which may influence metabolic risk. Third, residual confounding from unmeasured factors such as genetic predisposition, socioeconomic status, and medication use cannot be ruled out. Despite adjustments for key covariates, other lifestyle and environmental influences may still play a role. Finally, the findings may not be generalizable beyond this study population. Future longitudinal research with detailed dietary assessments is needed to validate these associations and clarify underlying mechanisms.

## CONCLUSION

This study highlights the role of stress, comorbidities, dietary habits, and physical activity in T2DM risk. Stress emerged as a critical determinant, with affected individuals facing a higher likelihood of developing T2DM. Moderate fruit and vegetable consumption appeared protective, reinforcing the importance of a balanced diet. These findings underscore the need for targeted public health interventions, particularly at the community level, through public health centers and chronic disease management programs. Integrating stress management, nutrition counseling, and physical activity promotion into routine care can help mitigate T2DM risk.

## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this manuscript

## AUTHOR CONTRIBUTIONS

SS: Conceptualization, methodology, software, and manuscript drafting. DS: Conceptualization, statistical analysis, and manuscript drafting. RM: drafting manuscript. DSSR: methodology, discussion, and conclusion. WR: Data collection.

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