Jurnal Info Kesehatan
Vol. 24, No. 2, June 2026, pp. 409-420
P-ISSN 0216-504X, E-ISSN 2620-536X
DOI: *10.31965/infokes.Vol24.Iss2.2493*
Journal homepage: *https://jurnal.poltekkeskupang.ac.id/index.php/infokes*

RESEARCH Open Access

Association of Behavioral, Genetic, and Environmental Factors with Type 2 Diabetes Mellitus Among Adults Aged 30-65 Years in Urban Areas

Ni Putu Setya Puri Cahyani[1a*], Ni Ketut Sutiari[2b], I Wayan Gede Artawan Eka Putra[2c]

[1] Master Program of Public Health Science, Faculty of Medicine, Udayana University, Bali, Denpasar, Indonesia
[2] Department of Community and Preventive Medicine, Faculty of Medicine, Udayana University, Denpasar, Bali, Indonesia

[a] Email address: setyacahyani22@gmail.com
[b] Email address: ketut_sutiari@unud.ac.id
[c] Email address: gedeartawan@unud.ac.id

Received: 10 April 2026 Revised: 04 June 2026 Accepted: 26 June 2026

Abstract

The increasing prevalence of type 2 diabetes mellitus (T2DM) in urban populations reflects the complex interaction of sociodemographic, behavioral, genetic, and environmental factors. Rapid urbanization has contributed to lifestyle changes, including increased consumption of ultra-processed foods (UPFs), which may increase the risk of T2DM. This study aimed to identify factors associated with T2DM among adults aged 30-65 years in urban areas. An observational analytic study with an unmatched case-control design was conducted among 152 respondents, consisting of 76 cases and 76 controls, selected from four primary healthcare centers implementing the Free Health Check Program (Cek Kesehatan Gratis/CKG) in Denpasar City. Data were collected through structured interviews and medical record verification. Variables analyzed included age, sex, UPF consumption, physical activity, family history of diabetes mellitus, and socioeconomic status (SES). Data were analyzed using simple and multiple logistic regression to estimate adjusted odds ratios (AORs) and 95% confidence intervals (CIs). The multivariable analysis showed that age, sex, UPF consumption, physical activity, and family history of diabetes mellitus were independently associated with T2DM and compared with participants aged 30-44 years, those aged 45-54 years had higher odds of T2DM (AOR = 4.399; 95% CI: 1.508-12.827), while those aged 55-65 years also had increased odds (AOR = 2.369; 95% CI: 0.704-7.970). Male participants had higher odds of T2DM than female participants (AOR = 3.533; 95% CI: 1.438-8.678). Frequent UPF consumption was strongly associated with T2DM (AOR = 5.408; 95% CI: 2.162-13.527), as was family history of diabetes mellitus (AOR = 6.108; 95% CI: 2.592-14.393). Low physical activity was also associated with higher odds of T2DM compared with high physical activity (AOR = 4.188; 95% CI: 1.257-13.954), whereas socioeconomic status was not significantly associated with T2DM. In conclusion, age, sex, frequent UPF consumption, low physical activity, and family history of diabetes mellitus were independently associated with T2DM among adults aged 30-65 years in urban areas. These findings highlight the importance of strengthening nutrition education, promoting physical activity, and prioritizing early diabetes screening among high-risk groups.

Keywords: Type 2 Diabetes Mellitus, Ultra-Processed Foods, Family History, Socioeconomic Status, Urban Population, Case-Control Study.

Corresponding Author:

Ni Putu Setya Puri Cahyani
Master Program of Public Health Science, Faculty of Medicine, Udayana University, Bali, Denpasar, Indonesia
Email: setyacahyani22@gmail.com

1. INTRODUCTION

Type 2 diabetes mellitus (T2DM) is one of the fastest-growing non-communicable diseases worldwide and a major contributor to morbidity, mortality, and healthcare burden due to its long-term complications, including cardiovascular disease, nephropathy, and neuropathy (Omotayo et al., 2024; Cesare et al., 2024). In Indonesia, the prevalence of diabetes increased from 6.9% in 2013 to 10.9% in 2018 (Riskesdas, 2018), while recent estimates indicate that more than 20 million adults are living with diabetes (Survey Kesehatan Indonesia, 2023). In Bali Province, 52,282 residents have been diagnosed with T2DM, with Denpasar City reporting one of the highest case burdens in the province (Dinas Kesehatan Provinsi Bali, 2022). The increasing prevalence of T2DM highlights the need to understand better the multiple determinants contributing to disease occurrence in urban populations.

Urbanization has accelerated lifestyle transitions that may increase susceptibility to T2DM. One important change is the rising consumption of ultra-processed foods (UPFs), which are typically high in added sugars, saturated fats, sodium, and food additives, and low in dietary fiber and micronutrients (Rahmawati et al., 2025). Previous studies have reported that high UPF consumption is associated with obesity, insulin resistance, and metabolic disorders related to T2DM (Setyaningsih et al., 2024). In addition, family history of diabetes remains a well-established determinant reflecting genetic susceptibility, with individuals who have diabetic relatives demonstrating substantially higher odds of developing T2DM (Tahapary et al., 2023). Socioeconomic status may also influence diabetes risk through its effects on dietary behaviors, lifestyle patterns, and access to healthcare services (Badan Pusat Statistik Kota Denpasar, 2024). Furthermore, adequate access to healthcare enables early detection and management of diabetes, whereas limited access may delay diagnosis and treatment (Ahsan et al., 2025).

Although numerous studies have identified behavioral, genetic, environmental, and healthcare-related factors associated with T2DM, these determinants are often examined separately rather than within an integrated framework (Setyaningsih et al., 2024; Tahapary et al., 2023; Ahsan et al., 2025). Consequently, evidence on the relative contributions of modern dietary and physical activity behaviors, genetic predisposition, and socioeconomic conditions within a single analytical model remains limited, particularly in Indonesia. It represents an important research gap because T2DM develops through the interaction of multiple determinants rather than a single risk factor. A more comprehensive understanding of these factors is needed to support the development of targeted and evidence-based prevention strategies for urban populations.

Denpasar City provides a relevant setting for addressing this gap because it has one of the largest productive-age populations in Bali Province and has implemented the Cek Kesehatan Gratis (CKG) program as part of efforts to strengthen early detection of chronic diseases (Badan Pusat Statistik Kota Denpasar, 2024). At the same time, rapid urbanization and lifestyle transitions in the city may increase exposure to behavioral and environmental factors associated with T2DM. Examining these determinants simultaneously in an urban population may provide a more comprehensive understanding of factors associated with T2DM and identify priority areas for prevention and control.

Therefore, this study aimed to determine the independent associations of ultra-processed food consumption, physical activity, family history of diabetes, and socioeconomic status with T2DM among adults aged 30-65 years in urban areas using a multivariable analytical model.

2. RESEARCH METHOD

This observational analytic study employed an unmatched case-control design and was conducted from February to April 2026 in Denpasar City, Bali, Indonesia. The study was carried out in four primary healthcare centers (Puskesmas), North Denpasar I, East Denpasar I, South Denpasar IV, and West Denpasar II, selected through multistage random sampling. These

centers implement the Free Health Check Program (Cek Kesehatan Gratis/CKG), a community-based screening program for non-communicable diseases, including type 2 diabetes mellitus (T2DM).

The study population consisted of adults aged 30-65 years who participated in the CKG program. Cases were individuals diagnosed with T2DM based on medical records and fasting blood glucose levels ≥126 mg/dL, while controls were individuals without T2DM with fasting blood glucose levels <126 mg/dL. A total of 152 respondents were included, comprising 76 cases and 76 controls. Matching was not performed because the study aimed to evaluate the independent effects of multiple risk factors on the occurrence of T2DM. Potential confounding was controlled through multivariable analysis.

Data were collected through structured face-to-face interviews and medical record reviews. Ultra-processed food (UPF) consumption was assessed using a 60-item Food Frequency Questionnaire (FFQ) based on the NOVA classification system. Respondents were categorized into frequent and infrequent UPF consumers using the mean score as the cut-off point. Physical activity was measured using the International Physical Activity Questionnaire-Short Form (IPAQ-SF) and classified into low, moderate, and high activity levels according to standard IPAQ guidelines. Information on family history of diabetes mellitus and socioeconomic status was also obtained.

The study procedures included the selection of study sites, the identification of eligible participants from the CKG database, the random selection of cases and controls, data collection through interviews and medical record verification, and data processing. Descriptive analysis was used to summarize respondent characteristics. Bivariate analysis using simple logistic regression was conducted to identify candidate variables, followed by multiple logistic regression to estimate adjusted odds ratios (AORs) and 95% confidence intervals (CIs). Variables with $p<0.25$ in bivariate analysis and those considered theoretically relevant were included in the multivariable model. Statistical significance was set at $p<0.05$.

The study was approved by the Ethics Committee of the Faculty of Medicine, Udayana University (No. 0346/UN14.2.2.VII.14/LT/2026) and received research permission from the Denpasar City Health Office (No. B/000.9.2/319/DIKES).

3. RESULTS AND DISCUSSION

Table 1. Distribution and Comparison of Respondent Characteristics by Case and Control Groups

Individual Characteristics	Cases (n=76)	Controls (n=76)	p-value
Sociodemographic Characteristics			
Age at Index Date			
30 - 44 years	24 (31.6%)	35 (46.1%)	0.135
45 - 54 years	31 (40.8%)	21 (27.6%)	
55 - 65 years	21 (27.6%)	20 (26.3%)	
Sex			
Male	43 (56.6%)	20 (26.3%)	<0.001*
Female	33 (43.4%)	56 (73.7%)	
Marital Status			
Married	75 (98.7%)	74 (97.4%)	1.000
Unmarried	1 (1.3%)	2 (2.6%)	
Education Level			
Higher education (University)	43 (56.6%)	31 (40.8%)	0.034*
Secondary education (High school or equivalent)	24 (31.6%)	43 (56.6%)	

Primary education (≤ Junior high school)	9 (11.8%)	2 (2.6%)	
Occupation			0.465
Formal employment	46 (60.5%)	39 (51.3%)	
Informal employment	21 (27.6%)	19 (25.0%)	
Unemployed	9 (11.8%)	18 (23.7%)	
Income			
< IDR 2.000.000	7 (9.2%)	10 (13.2%)	
IDR 2.000.000 - 4.999.999	23 (30.3%)	41 (53.9%)	0.003*
≥ IDR 5.000.000	46 (60.5%)	25 (32.9%)	
Behavioral Factors			
UPF Consumption			
Frequent consumption (≥5.61)	51 (67.1%)	25 (32.9%)	<0.001*
Rare consumption (<5.61)	25 (32.9%)	51 (67.1%)	
Physical Activity			
Low	40 (52.6%)	27 (35.5%)	
Moderate	24 (31.6%)	28 (36.8%)	0.071
High	12 (15.8%)	21 (27.6%)	
Genetic Factors			
Family History of DM			<0.001*
Yes	50 (65.8%)	19 (25.0%)	
No history	26 (34.2%)	57 (75.0%)	
Environmental Factors			
Socioeconomic Status (SES)			0.015*
Low SES	10 (13.2%)	9 (11.8%)	
Middle SES	14 (18.4%)	30 (39.5%)	
High SES	52 (68.4%)	37 (48.7%)	

*p-values were obtained using Chi-square test or Fisher's exact test, as appropriate, and *Statistically significant at p < 0.05*

Table 1 presents the distribution of sociodemographic, behavioral, genetic, and environmental characteristics among cases and controls. Significant differences between the two groups were observed for sex, education level, income, ultra-processed food (UPF) consumption, family history of diabetes mellitus, and socioeconomic status ($p<0.05$). In contrast, age, marital status, occupation, and physical activity did not differ significantly between groups ($p>0.05$).

Overall, significant differences were observed across several domains, including sociodemographic, behavioral, genetic, and environmental factors. Cases tended to have a higher proportion of frequent UPF consumption, a family history of diabetes mellitus, and a higher socioeconomic status compared with controls. Variables identified in the bivariate analysis were subsequently evaluated in the multivariable logistic regression model to determine factors independently associated with T2DM.

Table 2. Association Between Sociodemographic Factors and Type 2 Diabetes Mellitus

Independent Variables	**DM Status**		**OR**	**95% CI**	**P-Value**
	Cases	**Control**			
Age at Index Date					**0.139**
55 - 65 years	21 (27.6%)	20 (26.3%)	1.531	0.686-3.418	0.298
45 - 54 years	31 (40.8%)	21 (27.6%)	2.153	1.007-4.600	0.048*

30 - 44 years	24 (31.6%)	35 (46.1%)	ref	-	-
Sex					
Male	43 (56.6%)	20 (26.3%)	3.648	1.843-7.223	<0.001*
Female	33 (43.4%)	56 (73.7%)	ref	-	-
Marital Status					
Married	75 (98.7%)	74 (97.4%)	2.027	0.180-22.838	0.567
Unmarried	1 (1.3%)	2 (2.6%)	ref	-	-

**Statistically significant at p < 0.05*

Table 2 shows the association between sociodemographic factors and T2DM. Male respondents had significantly higher odds of T2DM than females (OR=3.648; 95% CI: 1.843-7.223; p<0.001). Although age was not significantly associated with T2DM overall (global p=0.139), respondents aged 45-54 years had higher odds of T2DM compared with those aged 30-44 years (OR=2.153; 95% CI: 1.007-4.600; p=0.048).

No significant associations were observed for marital status (p=0.567). Variables with p<0.25 in the bivariate analysis were considered for inclusion in the multivariable logistic regression model.

Table 3. Association Between Behavioral, Genetic, and Environmental Factors and Type 2 Diabetes Mellitus

Independent Variables	**DM Status**		**OR**	**95% CI**	**P-Value**
	Cases	**Control**			
Behavioral Factor					
UPF Consumption					
Frequent consumption (≥5.61)	51 (67.1%)	25 (32.9%)	4.162	2.155-8.188	<0.001*
Rare consumption (<5.61)	25 (32.9%)	51 (67.1%)	ref	-	-
Physical Activity					0.075
Low	40 (52.6%)	27 (35.5%)	2.593	1.096-6.133	0.030*
Moderate	24 (31.6%)	28 (36.8%)	1.500	0.613-3.670	0.374
High	12 (15.8%)	21 (27.6%)	ref	-	-
Genetic Factor					
Family History of DM					
Yes	50 (65.8%)	19 (25.0%)	5.769	2.856-11.652	<0.001*
No history	26 (34.2%)	57 (75.0%)	ref	-	-
Environmental Factors					
Socioeconomic Status (SES)					0.017*
High SES	52 (68.4%)	37 (48.7%)	3.012	1.406-6.450	0.005*
Low SES	10 (13.2%)	9 (11.8%)	2.381	0.791-7.164	0.123
Middle SES	14 (18.4%)	30 (39.5%)	ref	-	-

**Statistically significant at p < 0.05*

Table 3 presents the bivariate associations between behavioral, genetic, and environmental factors and T2DM. Frequent ultra-processed food (UPF) consumption was significantly associated with higher odds of T2DM (OR=4.162; 95% CI: 2.155-8.188; p<0.001). Family history of diabetes mellitus showed the strongest association, with respondents who had a positive family history having higher odds of T2DM (OR=5.769; 95% CI: 2.856-11.652; p<0.001).

Socioeconomic status was significantly associated with T2DM overall (global p=0.017), and respondents with high socioeconomic status had higher odds of T2DM than those with middle socioeconomic status (OR=3.012; 95% CI: 1.406-6.450; p=0.005). Physical activity showed a borderline association in the global test (p=0.075), although respondents with low physical activity had higher odds of T2DM compared with those with high physical activity (OR=2.593; 95% CI: 1.096-6.133; p=0.030).

Table 4. Assessment of multicollinearity among independent variables included in the logistic regression model.

Variable	Tolerance	VIF
Age at Index Date	0.898	1.113
Sex	0.897	1.115
UPF consumption	0.861	1.162
Physical Activity	0.915	1.093
Family history of DM	0.919	1.088
Socioeconomic status	0.914	1.094

Table 4 presents the results of the multicollinearity assessment for variables included in the multivariable logistic regression model. Tolerance values ranged from 0.861 to 0.919, and VIF values ranged from 1.088 to 1.162, indicating no evidence of significant multicollinearity.

The final logistic regression model demonstrated good fit according to the Hosmer-Lemeshow goodness-of-fit test ($\chi^2 = 2.367$, df = 8, p = 0.968).

Table 5. Risk factor analysis of type 2 diabetes mellitus.

Independent Variables	AOR	95% CI	P-Value
Age at Index Date			**0.025***
45 - 54 years	4.399	1.508-12.827	0.007*
55 - 65 years	2.369	0.704-7.970	0.163
30 - 44 years	ref	-	-
Sex			
Male	3.533	1.438-8.678	0.006*
Female	ref	-	-
UPF Consumption			
Frequent consumption	5.408	2.162-13.527	<0.001*
Rare consumption	ref	-	-
Physical Activity			**0.054**
Low	4.188	1.257-13.954	0.020*
Moderate	1.886	0.582-6.110	0.290
High	ref	-	-
Family History of DM			
Yes	6.108	2.592-14.393	<0.001*
No history	ref	-	-
Socioeconomic Status (SES)			**0.393**
High SES	1.464	0.523-4.096	0.468
Low SES	2.761	0.639-11.932	0.174
Middle SES	ref	-	-

**Statistically significant at p < 0.05*

Table 5 presents the results of the multivariable logistic regression analysis. Age at index date (global p=0.025), sex (p=0.006), ultra-processed food (UPF) consumption (p<0.001),

family history of diabetes mellitus (p<0.001), and low physical activity (p=0.020) were independently associated with T2DM. Family history of diabetes mellitus was the strongest predictor (AOR=6.108; 95% CI: 2.592-14.393), followed by frequent UPF consumption (AOR=5.408; 95% CI: 2.162-13.527).

Compared with their respective reference groups, respondents aged 45-54 years (AOR=4.399; p=0.007), males (AOR=3.533; p=0.006), those with frequent UPF consumption (AOR=5.408; p<0.001), those with low physical activity (AOR=4.188; p=0.020), and those with a family history of diabetes mellitus (AOR=6.108; p<0.001) had significantly higher odds of T2DM. Socioeconomic status was not significantly associated with T2DM after adjustment (global p=0.393).

The Effect of Sociodemographic Factors (Age and Sex)

The present study demonstrated that participants aged 4554 years had significantly higher odds of T2DM compared with those aged 3044 years (AOR = 4.399). This finding supports the well-established role of age as an important determinant of glucose metabolism. Increasing age is associated with progressive decline in pancreatic β-cell function, reduced insulin sensitivity, and cumulative exposure to metabolic risk factors such as unhealthy diet, physical inactivity, and obesity. Consequently, individuals entering middle adulthood may be more susceptible to impaired glucose regulation and the subsequent development of T2DM. Interestingly, the association was not statistically significant among participants aged 5565 years despite a higher odds ratio. This non-linear pattern may be related to the relatively small subgroup size, wider confidence intervals, and possible behavioral modifications following diagnosis of other chronic conditions, which may have attenuated the observed association (Kemenkes RI, 2024; Lisna, 2021; Aprilia et al., 2025).

Male participants had significantly higher odds of T2DM than females. This finding is consistent with evidence suggesting that men tend to accumulate greater amounts of visceral adipose tissue, which is metabolically active and strongly associated with insulin resistance. In addition, men may be more likely to engage in unhealthy lifestyle behaviors, including smoking, alcohol consumption, and lower healthcare utilization, which can contribute to poorer metabolic health outcomes. These findings suggest that middle-aged men should be prioritized in diabetes prevention and screening programs (Chandrasekaran & Weiskirchen, 2024).

The Effect of Behavioral Factor (Ultra-Processed Food Consumption and Physical Activity)

Frequent consumption of ultra-processed foods emerged as one of the strongest predictors of T2DM in this study (AOR = 5.408). Participants with frequent UPF consumption had more than five times higher odds of developing T2DM compared with those who rarely consumed such foods. This finding highlights the growing importance of dietary transition in urban settings, where convenient, ready-to-eat products increasingly replace traditional diets. Beyond their high sugar, saturated fat, and sodium content, UPFs often contain additives, emulsifiers, and artificial ingredients that may contribute to systemic inflammation, alterations in gut microbiota composition, and metabolic dysregulation. These mechanisms have been proposed as pathways linking UPF consumption to insulin resistance and impaired glucose homeostasis. Given the rapid expansion of the processed food market in urban Indonesia, reducing UPF consumption should be a priority in diabetes prevention strategies.

This finding is consistent with previous studies. Srour et al. (2020) reported that high UPF consumption significantly increased the risk of T2DM in a French population, while Pramono et al. (2023) found that Indonesians with high UPF intake had approximately a 3.2-fold higher risk of T2DM. The stronger association observed in the present study may reflect the characteristics of the study population, which consisted of urban adults living in an environment where processed and convenience foods are increasingly accessible and widely consumed. Frequent

consumption of UPFs may increase the risk of diabetes through obesity, insulin resistance, oxidative stress, and chronic inflammation (Prasad et al., 2025; Almarshad et al., 2022; Lee et al., 2024; Ferdina et al., 2025).

Based on the study results, the most frequently consumed UPFs included instant noodles, instant seasonings, packaged beverages, sweet snacks, and packaged sauces. High levels of sodium, added sugars, saturated fats, and food additives generally characterize these products and have been associated with obesity, insulin resistance, and chronic inflammation. The predominance of these products in respondents' diets suggests a dietary pattern characterized by high energy density and low nutritional quality, which may contribute to the increased risk of T2DM observed in this population. Frequent UPF consumption was particularly common among working-age adults, which may reflect time constraints and greater reliance on convenience foods.

The high consumption of UPFs among case participants suggests a shift in urban dietary patterns toward more convenient and ready-to-eat food choices. This trend may be associated with urbanization, high work-related mobility, and increasing dependence on ready-to-consume foods. Among working-age adults, limited time available for food preparation may lead respondents to choose fast foods and packaged products that are easily accessible. Moreover, ultra-processed foods are available in a wide variety of products and price ranges, making them accessible across different socioeconomic groups. Similar patterns have been reported in urban populations where increased work-related demands and greater availability of convenience foods have contributed to higher UPF consumption (Rahmawati et al., 2025).

Low physical activity was also associated with higher odds of T2DM (AOR = 4.188). This finding is consistent with studies conducted in Indonesia, where Jati et al. (2023) reported that individuals with low physical activity had 7.429 times greater odds of developing T2DM, while Bujawati et al. (2021) found that urban populations tended to have lower physical activity levels and higher diabetes prevalence than rural populations. Physical activity improves insulin sensitivity and glucose uptake by skeletal muscles, whereas insufficient activity may promote insulin resistance and adiposity (Machrina et al., 2023). In the present study, most participants reported moderate levels of physical activity, which may explain why the moderate activity category was not significantly associated with T2DM.

In the present study, most participants reported moderate levels of physical activity, including household and daily activities such as sweeping, gardening, carrying light loads, and recreational cycling. The predominance of moderate physical activity may explain why the moderate activity category was not significantly associated with T2DM. Nevertheless, participants with low physical activity had substantially higher odds of developing T2DM than those reporting high physical activity. This finding suggests that regular engagement in physical activity, even at light-to-moderate intensity, may help maintain glucose metabolism and insulin sensitivity compared with a sedentary lifestyle (Ali et al., 2023).

Low physical activity was more frequently observed among older adults aged 45-65 years. This pattern may be related to age-related declines in physical capacity, changes in occupational demands, and certain health limitations. In addition, many participants reported occupations that involved prolonged sitting and limited physical exertion. The widespread use of motorized transportation and limited participation in structured exercise may further contribute to sedentary behavior and increase the risk of T2DM in urban populations (Hill-Briggs et al., 2021; Bujawati et al., 2021).

Taken together, these findings suggest that behavioral factors play a substantial role in diabetes risk. In urban settings, frequent UPF consumption and low physical activity may reflect broader lifestyle changes characterized by sedentary occupations, limited time for food preparation, and increasing reliance on convenient processed foods (Pramono et al., 2023; Rahmawati et al., 2025). The comparable magnitude of the associations observed for UPF

consumption and family history highlights the potential importance of lifestyle interventions in diabetes prevention.

The Effect of Genetic Factor (Family History of DM)

Family history of diabetes mellitus was identified as the strongest predictor of T2DM in the present study (AOR = 6.108). This finding is consistent with previous studies identifying family history as an important determinant of T2DM (Smith et al., 2024; Kurniawan et al., 2024; Rahmawati et al., 2024). Genetic susceptibility may contribute through inherited defects in insulin secretion and glucose metabolism, increasing vulnerability to insulin resistance and impaired glucose regulation (Esmiralda & Karyus, 2021; Chandrasekaran & Weiskirchen, 2024).

However, family history may also reflect shared environmental and behavioral exposures because family members often adopt similar dietary patterns, physical activity habits, and health-related behaviors (Tahapary et al., 2023; Susanti et al., 2024). Therefore, the strong association observed in this study suggests that individuals with a family history of diabetes may particularly benefit from earlier screening and targeted lifestyle-based prevention strategies (Ginting, 2023; Kurniawan et al., 2024; Rahmawati et al., 2024).

The Effect of Environmental Factor (Socioeconomic Status/SES)

Socioeconomic status was not significantly associated with T2DM after adjustment for behavioral and genetic factors. This finding suggests that the influence of SES on diabetes risk may operate indirectly through lifestyle-related pathways such as dietary behaviors and physical activity rather than through a direct effect. Although higher SES was associated with greater odds of T2DM in the crude analysis, the association diminished after controlling for UPF consumption and physical activity, indicating potential mediation by behavioral factors. This finding highlights the complex and context-dependent relationship between socioeconomic conditions and diabetes risk in urban populations.

This finding differs from several studies conducted in Indonesia that reported a significant association between socioeconomic status and the risk of T2DM (Irbah, 2022; Sari et al., 2021). One possible explanation is that the effect of SES may be mediated through behavioral factors, particularly dietary patterns. After adjustment for UPF consumption, age, sex, physical activity, and family history of diabetes, SES no longer remained an independent predictor. It suggests that behavioral and biological factors may be more proximal determinants of diabetes risk than socioeconomic status itself.

The non-significant association may also reflect the complex relationship between SES and diabetes in urban populations. Individuals with lower SES may face barriers to healthy lifestyles, whereas those with higher SES may be more exposed to sedentary behaviors and energy-dense diets associated with urbanization (Indrahadi et al., 2021; Yang, Zhang, and Luo, 2023; Ferdina et al., 2025). In addition, the relatively wide confidence intervals observed for SES categories indicate limited precision of the estimates and suggest that larger studies are needed further to clarify the role of socioeconomic status in T2DM risk.

This study provides a comprehensive assessment of sociodemographic, behavioral, genetic, and environmental determinants of T2DM within a single analytical model. However, the findings should be interpreted with caution due to potential selection bias from recruitment through the CKG program, reliance on self-reported data, and residual confounding. Despite these limitations, the results highlight the importance of frequent consumption of ultra-processed foods, low physical activity, and a family history of diabetes as key determinants of T2DM. These findings support integrating behavioral risk assessment, dietary counseling, physical activity promotion, and family-based screening into routine diabetes prevention and early detection programs in urban populations.

4. CONCLUSION

This study identified several factors independently associated with type 2 diabetes mellitus among adults aged 30-65 years in urban Denpasar. Age 45-54 years, male sex, frequent ultra-processed food consumption, low physical activity, and family history of diabetes mellitus were significantly associated with higher odds of T2DM. Family history of diabetes mellitus and frequent consumption of ultra-processed foods showed the strongest associations, indicating the importance of both genetic predisposition and behavioral factors in the occurrence of T2DM.

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