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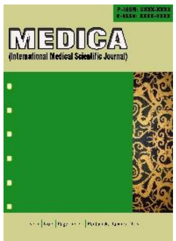

Selected Risky Food Consumption and Diabetes Mellitus Among Adults in West Sumatra

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Abstract

Dietary patterns may contribute to diabetes burden, but evidence from Indonesian provincial populations remains limited. This study assessed associations between selected processed/instant food and beverage indicators and doctor-diagnosed diabetes mellitus (DM) in West Sumatera. We analysed 31,921 survey respondents from West Sumatera using complex-sample weights. DM was defined as self-reported doctor diagnosis. Exposures were ever vs never consumption of salty foods, grilled foods, preserved meat/fish with additives, carbonated soft drinks, and instant noodles. Multivariable survey logistic regression produced adjusted odds ratios (AORs) with 95% confidence intervals (CIs). The weighted prevalence of diagnosed DM was 1.4% (≈71,486 of 5,272,303). In adjusted models, respondents reporting ever consumption of preserved meat/fish (AOR = 0.64; 95% CI: 0.47–0.89), carbonated soft drinks (AOR = 0.38; 95% CI: 0.28–0.52), and instant noodles (AOR = 0.56; 95% CI: 0.40–0.78) had lower odds of doctor-diagnosed diabetes mellitus than those reporting never consumption. Salty foods (AOR = 0.97; 95% CI: 0.64–1.46) and grilled foods (AOR = 1.27; 95% CI: 0.88–1.82) were not significantly associated. These inverse associations should be interpreted cautiously because they are likely to reflect reverse causality, post-diagnosis dietary modification, and residual confounding rather than protective effects of these foods. The prevalence of doctor-diagnosed diabetes mellitus in West Sumatra was low. Although several processed-food indicators showed inverse associations with diagnosed diabetes mellitus, these findings should not be interpreted as evidence of protective effects. Instead, they are more likely explained by reverse causality, behavioral modification following diagnosis, underdiagnosis, and residual confounding. Prospective longitudinal studies are warranted to clarify the causal relationship between dietary behaviors and diabetes risk.

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1. INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a major contributor to premature mortality and disability worldwide, with the burden increasing rapidly in low- and middle-income countries (LMICs). Recent global estimates indicate a continuing rise in diabetes prevalence, accompanied by substantial unmet needs in prevention, early detection, and long-term disease management, particularly in countries undergoing rapid nutritional transition (International Diabetes Federation, 2021; World Health Organization, 2023). In Indonesia, national health surveys have shown that diabetes remains an important public health concern, with considerable gaps between diagnosed cases and underlying metabolic risk, suggesting substantial underdiagnosis and delayed treatment (Kementerian Kesehatan Republik Indonesia, 2018; Kementerian Kesehatan Republik Indonesia, 2023). Therefore, identifying modifiable dietary risk factors is essential to support effective prevention strategies.

Dietary behavior plays a central role in the prevention and management of T2DM. Previous studies have demonstrated that dietary patterns characterized by minimally processed foods, high fiber intake, and balanced nutrition are associated with lower diabetes risk, whereas diets high in refined carbohydrates, sodium, sugar, and processed foods may increase metabolic risk through obesity, chronic inflammation, and insulin resistance pathways (Ley et al., 2014; Malik & Hu, 2015). In recent decades, many LMICs have experienced a "nutrition transition," marked by a shift from traditional diets toward increased consumption of processed and ultra-processed foods (Monteiro et al., 2019).

Ultra-processed foods (UPFs) are industrial formulations containing high levels of added sugar, sodium, unhealthy fats, and food additives. Increasing evidence suggests that UPF consumption contributes to excessive energy intake and weight gain, thereby increasing the risk of obesity and diabetes (Hall et al., 2019). Large cohort studies in Europe and the United States have reported positive associations between UPF intake and incident T2DM (Srour et al., 2020; Levy et al., 2021). However, the relationship between processed food consumption and diabetes may differ across regions due to variations in dietary patterns, cooking methods, socioeconomic conditions, and healthcare access.

Several specific dietary behaviors common in Asian populations may also contribute to diabetes risk. High consumption of refined carbohydrate staples such as white rice has been associated with increased T2DM incidence (Hu et al., 2012). Similarly, sugar-sweetened beverages (SSBs) are consistently linked to higher diabetes risk, supported by multiple systematic reviews and meta-analyses (Imamura et al., 2015). The WHO recommends limiting free sugar intake to reduce obesity and noncommunicable diseases, including diabetes (World Health Organization, 2015). In addition, excessive sodium intake and high-salt dietary patterns may contribute to diabetes development through pathways involving adiposity, inflammation, and hypertension (Ma et al., 2020).

Food processing methods may also influence metabolic health. High-temperature cooking methods such as grilling and roasting can produce harmful compounds including advanced glycation end products (AGEs) and heterocyclic amines, which are associated with oxidative stress and insulin resistance (Uribarri et al., 2010). Processed meat consumption has similarly been associated with increased T2DM risk in several prospective studies (Neuenschwander et al., 2019). Furthermore, instant noodles widely consumed in many Asian countries contain refined carbohydrates, high sodium levels, saturated fats, and additives that may adversely affect cardiometabolic health (Shin et al., 2014).

Despite growing international evidence linking unhealthy dietary behaviors with type 2 diabetes mellitus, evidence from Indonesia remains limited, particularly at the provincial level. Most previous Indonesian studies have reported national estimates or focused on individual dietary components without adequately considering regional differences in dietary practices and food environments. Given Indonesia's considerable cultural and dietary diversity, findings from national analyses may not fully reflect province-specific risk profiles.

West Sumatra represents a distinctive dietary setting because traditional Minangkabau cuisine is characterized by the frequent consumption of coconut milk-based dishes, salted and preserved foods, grilled meat products, and other energy-dense traditional foods, while the province is also experiencing increasing availability and consumption of processed and ultra-processed foods as part of the ongoing nutrition transition. These unique dietary characteristics may influence diabetes risk differently from other Indonesian provinces, underscoring the need for region-specific epidemiological evidence.

Therefore, this study extends previous national evidence by examining the association between selected risky food consumption indicators and doctor-diagnosed diabetes mellitus among adults in West Sumatra using data from the 2023 Indonesian Health Survey and applying complex survey-weighted analyses to obtain representative population estimates.

2. METHOD

This study was a cross-sectional secondary analysis using population-based health survey data from respondents residing in West Sumatra, Indonesia. The study aimed to examine the association between selected risky food consumption indicators and doctor-diagnosed diabetes mellitus (DM). The analysis used secondary data derived from a nationally conducted health survey employing a complex sampling design consisting of stratification and multistage cluster sampling. Sampling weights, strata, and primary sampling unit (PSU) identifiers provided in the dataset were incorporated into all analyses to obtain representative population estimates and appropriate variance estimation. The West Sumatra analytic dataset included 31,921 unweighted respondents, representing an estimated population of 5,272,303 individuals. The survey design consisted of 35 strata and 1,222 PSUs, with survey design degrees of freedom of 1,187. Given the cross-sectional design, temporal relationships between exposures and the outcome could not be established; therefore, causal inferences could not be made.

The study population included all respondents with complete information on doctor-diagnosed diabetes mellitus and all dietary exposure variables included in the analysis. Records containing missing or invalid responses for variables used in the regression model were excluded from the analysis. Complete-case analysis was applied because no substantial missing data were identified among the variables included in the final model.

The primary outcome variable was doctor-diagnosed diabetes mellitus, assessed using the survey question, “Have you ever been diagnosed with diabetes mellitus (DM) by a doctor?” Responses were categorized as “Yes” and “No,” with “No” used as the reference category. The exposure variables consisted of self-reported consumption of selected risky food items, including salty foods, grilled foods, instant noodles or other instant foods, processed meat/chicken/fish containing preservatives, and carbonated soft drinks. Each exposure variable was categorized into “ever consumed” and “never consumed”, with the latter serving as the reference category. All exposure variables were treated as binary categorical indicators in the analysis.

All statistical analyses were conducted using complex-sample procedures to account for survey stratification, clustering, and sampling weights. Weighted prevalence estimates of doctor-diagnosed DM were calculated for the West Sumatra population, along with weighted frequencies and percentages for each dietary exposure variable. Standard errors, 95% confidence intervals (CIs), and design effects were estimated using complex survey procedures. Associations between risky food consumption indicators and doctor-diagnosed DM were examined using survey-weighted multivariable logistic regression analysis. Doctor-diagnosed DM was specified as the dependent variable, while the five dietary exposure indicators were entered simultaneously into the regression model. Adjusted odds ratios (AORs) and corresponding 95% confidence intervals were calculated by exponentiating regression coefficients. Statistical significance was assessed using adjusted Wald F statistics based on survey design degrees of freedom, and a two-sided p-value of less than 0.05 was considered statistically significant. The regression model included the selected risky food consumption indicators as independent variables. Because the analysis was based on the predefined study objectives and the available analytical framework, other potential confounding variables were not included in the final model. This issue is acknowledged as a limitation when interpreting the findings.

Model stability was evaluated by examining standard errors and confidence interval widths to identify potential sparse-data problems or unstable parameter estimates. No imputation procedures were performed because the analytic dataset contained complete information for all included variables. All analyses were conducted using IBM SPSS Statistics with the Complex Samples module (IBM Corp., Armonk, NY, USA), or equivalent statistical software capable of handling complex survey data analysis. This study analyzed secondary anonymized survey data. Ethical approval and informed consent had been obtained by the original survey organizers before data collection. The present study used de-identified data and complied with applicable institutional and national ethical standards.

3. RESULTS AND DISCUSSION

Table 1. Weighted prevalence of doctor-diagnosed diabetes mellitus and distribution of risky-food indicators in West Sumatra.

Variable	Category	Weighted count	Weighted %	95% CI (%)
Doctor-diagnosed diabetes mellitus	Yes	71.486	1.4	1.2–1.5
	No	5.200.817	98.6	96.0–101.3
Salty foods	Ever	4.819.280	91.4	88.8–94.0
	Never	453.023	8.6	7.7–9.5
Grilled foods	Ever	4.546.497	86.2	83.7–88.8
	Never	725.806	13.8	12.5–15.1
Instant noodles/other instant foods	Ever	4.745.477	90.0	87.5–92.5
	Never	526.826	10.0	9.3–10.7
Processed meat/chicken/fish with preservatives	Ever	4.317.958	81.9	79.3–84.5
	Never	954.345	18.1	16.7–19.5
Carbonated soft drinks	Ever	1.966.487	37.3	—
	Never	3.305.816	62.7	—

Table 1 presents the weighted prevalence of doctor-diagnosed diabetes mellitus (DM) and the distribution of risky-food consumption indicators among respondents in West Sumatra. The weighted prevalence of doctor-diagnosed DM was 1.4% (95% CI: 1.2–1.5), representing approximately 71,486 individuals from an estimated population of 5,272,303. Most respondents reported ever consuming salty foods (91.4%), grilled foods (86.2%), instant noodles or other instant foods (90.0%), and processed meat/chicken/fish with preservatives (81.9%). Meanwhile, 37.3% of respondents reported ever consuming carbonated soft drinks.

Table 2. Survey-weighted multivariable logistic regression for doctor-diagnosed diabetes mellitus.

Risky-food indicator	**AOR**	**95% CI**	**P value**
Salty foods (ever vs never)	0.966	0.638–1.464	0.871
Grilled foods (ever vs never)	1.267	0.880–1.823	0.202
Processed meat with preservatives (ever vs never)	0.644	0.465–0.892	0.008
Carbonated soft drinks (ever vs never)	0.381	0.281–0.517	<0.001
Instant noodles/other instant foods (ever vs never)	0.555	0.396–0.777	0.001

Table 2 shows the results of the survey-weighted multivariable logistic regression analysis. The overall model was statistically significant (Adjusted Wald F = 15.231; $p < 0.001$), although the pseudo R^2 values were relatively small (Cox–Snell = 0.004; Nagelkerke = 0.030; McFadden = 0.028), indicating that the included dietary indicators explained only a small proportion of variation in doctor-diagnosed DM. The low pseudo-R^2 values indicate that the selected dietary indicators had limited explanatory power for doctor-diagnosed diabetes mellitus. This finding is expected given the multifactorial etiology of diabetes, which is influenced by demographic, genetic, behavioral, metabolic, and socioeconomic factors beyond dietary behaviors alone. Therefore, although several dietary indicators were statistically associated with the outcome, most of the variation in diabetes status is likely explained by other determinants that were not included in the present model. After mutual adjustment, salty foods and grilled foods were not significantly associated with doctor-diagnosed DM. In contrast, ever consumption of processed meat/chicken/fish with preservatives (AOR = 0.644; 95% CI: 0.465–0.892; $p = 0.008$), carbonated soft drinks (AOR = 0.381; 95% CI: 0.281–0.517; $p < 0.001$), and instant foods or instant noodles (AOR = 0.555; 95% CI: 0.396–0.777; $p = 0.001$) showed statistically significant inverse associations with diagnosed DM.

The inverse associations observed for carbonated soft drinks, processed preserved foods, and instant foods should not be interpreted as protective effects. Extensive prospective evidence consistently demonstrates that higher consumption of sugar-sweetened beverages, processed meat, and ultra-processed foods increases the risk of type 2 diabetes mellitus (Malik et al., 2010; Srour et al., 2020; Neuenschwander et al., 2022). Therefore, the findings in the present study are more plausibly explained by reverse causality, diagnosis-related behavioral modification, residual confounding, and limitations inherent to cross-sectional analysis. Individuals diagnosed with diabetes often reduce their intake of sugary drinks, processed foods, and instant foods after receiving medical advice or lifestyle counseling, leading to apparently inverse associations in cross-sectional surveys (Zheng et al., 2018). In addition, these findings should be interpreted as statistical associations rather than evidence that unhealthy food consumption reduces diabetes risk.

The low prevalence of doctor-diagnosed DM observed in this study may also reflect underdiagnosis within the population. Previous studies in Indonesia and other low- and middle-income countries have reported substantial proportions of undiagnosed diabetes due to limited access to screening, low awareness, and healthcare inequalities (Soewondo et al., 2013; Chan et al., 2020). In addition, disparities in healthcare accessibility between urban and rural areas, differences in health-seeking behavior, and unequal utilization of preventive health services may further reduce opportunities for early diabetes detection. Consequently, respondents classified as not having diagnosed diabetes may include individuals with undetected hyperglycemia, potentially attenuating or biasing the observed associations between dietary behaviors and diabetes status.

The inverse association between carbonated soft drink consumption and diagnosed DM contrasts with strong epidemiological evidence linking sugar-sweetened beverage intake with increased diabetes risk. Meta-analyses and prospective cohort studies have consistently shown that regular consumption of sugary beverages contributes to obesity, insulin resistance, and incident T2DM (Imamura et al., 2015; Qin et al., 2020). In cross-sectional settings, however, diagnosed individuals may intentionally avoid soft drinks after diagnosis, thereby creating reverse associations between current consumption and known disease status. Similar explanations have been reported in previous nutritional epidemiology studies examining diabetes-related dietary modification after diagnosis (Drouin-Chartier et al., 2019).

Likewise, the inverse association observed for processed preserved meat/chicken/fish differs from findings of prospective studies showing increased diabetes risk associated with processed meat intake (Neuenschwander et al., 2019; Kim et al., 2016). Processed meats are known to contain high levels of sodium, saturated fat, nitrates, and advanced glycation end products (AGEs), which may contribute to oxidative stress, inflammation, and impaired insulin sensitivity. However, the present study used a simple binary "ever versus never" measure that did not capture intake frequency, portion size, or duration of exposure, increasing the possibility of exposure misclassification. In addition, dietary avoidance among diagnosed diabetic individuals may have contributed to the inverse association.

The findings regarding instant noodles and other instant foods should also be interpreted cautiously. Instant noodles are commonly characterized by refined carbohydrates, high sodium content, saturated fats, and food additives, which have been linked to adverse cardiometabolic outcomes in Asian populations (Shin et al., 2014; Park et al., 2014). Previous evidence has suggested that instant noodle consumption may be associated with metabolic syndrome, obesity, hypertension, and diabetes risk. Nevertheless, younger individuals and populations with lower healthcare utilization may consume instant foods more frequently while simultaneously being less likely to undergo diabetes screening or receive a medical diagnosis. Conversely, individuals who regularly access healthcare services are more likely to receive a diabetes diagnosis and subsequently modify their dietary behaviors following medical advice. These differences in healthcare-seeking behavior may have contributed to the inverse associations observed in this study.

No statistically significant associations were observed for salty foods and grilled foods. These null findings may reflect limitations in exposure assessment rather than absence of biological effects. Sodium intake and high-temperature cooking methods have been associated with inflammation, oxidative stress, endothelial dysfunction, and impaired glucose metabolism in previous studies (Uribarri et al., 2015). High-temperature cooking processes such as grilling may increase dietary exposure to AGEs and heterocyclic amines, compounds implicated in metabolic dysfunction and insulin resistance. However, the broad binary categorization used in this study may have lacked sufficient sensitivity to detect these relationships. Another potential source of bias is survivorship bias. Individuals with severe diabetes complications may have experienced premature mortality or been less likely to participate in the survey, whereas healthier individuals with diagnosed diabetes were more likely to be included. Consequently, the study population may not fully represent the entire spectrum of diabetes severity, potentially influencing the observed associations between dietary behaviors and diagnosed diabetes mellitus.

This study has several strengths. The analysis used a large population-based dataset and applied complex-sample weighting procedures, enabling representative estimates for the West Sumatra population while accounting for stratification and clustering effects. However, several limitations should be acknowledged. First, the cross-sectional design prevents determination of temporal relationships and is highly susceptible to reverse causality. Second, the outcome relied on self-reported doctor-diagnosed diabetes, which may underestimate the true burden of disease because undiagnosed diabetes is common in many LMIC settings. Third, the dietary exposure variables were limited to binary indicators and did not capture frequency, quantity, or long-term dietary patterns. Finally, important confounding variables such as age, obesity, smoking status, physical activity, hypertension, and socioeconomic status were not included in the final regression model, potentially influencing the observed associations.

Overall, these findings suggest that dietary associations with doctor-diagnosed diabetes mellitus identified in cross-sectional surveys should be interpreted cautiously. The observed inverse associations are unlikely to represent protective effects of unhealthy food consumption and are more plausibly explained by reverse causality, diagnosis-related behavioral modification, underdiagnosis, healthcare-seeking behavior, survivorship bias, and residual confounding. Future studies in Indonesia should prioritize longitudinal designs, objective glycemic measurements, comprehensive dietary assessments, and adjustment for major demographic and metabolic confounders to better clarify the causal relationship between dietary behaviors and diabetes risk.

4. CONCLUSION

Several selected risky food consumption indicators were inversely associated with doctor-diagnosed diabetes mellitus among adults in West Sumatra, whereas salty foods and grilled foods showed no significant associations. These inverse associations should not be interpreted as evidence that unhealthy food consumption protects against diabetes. Rather, they are more likely explained by reverse causality, post-diagnosis dietary modification, underdiagnosis, healthcare-seeking behavior, and residual confounding inherent in the cross-sectional study design. Therefore, the findings should be interpreted with caution. Future longitudinal studies incorporating objective glycemic measurements, comprehensive dietary assessments, and adjustment for major confounding factors are needed to better clarify the relationship between dietary behaviors and diabetes risk in Indonesian populations.

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