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Central Obesity Analysis from the Aspect of Risky Foods and Food Consumption Patterns Related to Cultural Systems: The 2023 SKI Study

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Abstract

In Indonesia, central obesity among people aged 15-54 years has become a health problem that continues to increase from 2018 (30.8%) to 2023 (36.8%) and significantly contributes to degenerative diseases. This study aims to analyze dietary patterns and consumption of risky foods related to central obesity in Indonesia using a spatial analysis approach. Data are sourced from the 2023 Indonesian Health Survey (SKI) Report with 38 provinces as the analysis unit. The variables studied include consumption of risky foods (sweet foods and drinks, salty foods, markers, seasonings, and instant noodles) and consumption patterns of foods such as nuts, milk, sugar, oil, vegetables, and fruit. Data analysis was carried out using Moran's I and Local Indicator of Spatial Autocorrelation (LISA) to identify spatial autocorrelation and Ordinary Least Squares (OLS) as the regression analysis. The results show that the incidence of central obesity in Indonesia forms a clustered pattern across provinces. OLS regression analyzed the main variables that were significantly related, namely consumption of salty foods, fried/fatty foods, nuts, and vegetables and fruit. The negative association between salty foods and nuts is explained by local cultural factors and relatively low-calorie consumption, while the positive association between fruit and vegetable consumption indicates low consumption frequency, thus suboptimal preventive factors for central obesity. These findings demonstrate the need for community nutrition interventions that consider spatial variation across provinces to improve the effectiveness of central obesity prevention efforts in Indonesia.

Introduction

Central obesity is a type of obesity that occurs due to excess fat accumulation in the abdominal area. Central obesity is defined as someone aged 15 years or older who has a waist circumference of >90 cm for men and >80 cm for women (not pregnant) (Kemenkes RI, 2024). According to WHO data, more than 1.9 billion adults worldwide (approximately 39% of the total adult population) are overweight. In Indonesia, the prevalence of overweight increased dramatically from 8% in 1990 to 20% in 2022, particularly among children and adolescents. (WHO, 2024, 2025). In addition, based on the Indonesian health report, the proportion of central obesity incidents measured in subjects aged 15-54 years increased from 2018 (30.8%) to 2023 (36.8%).

The increase is also supported by the results of research in Bogor City, Indonesia, which concluded that central obesity increased by 55.4% over a 6-year period (Sudikno *et*

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al., 2018). Central obesity can lead to 1) heart disease and stroke, due to increased blood pressure, cholesterol and triglyceride levels, 2) type 2 diabetes, due to increased insulin resistance, 3) non-alcoholic liver disease and cirrhosis, due to fat accumulation in the liver, 4) respiratory disorders, osteoarthritis, due to increased pressure on the joints, 5) kidney disease and can even increase the risk of death. Research using a spatial approach in 34 provinces in Indonesia found a moderate positive correlation between the proportion of central obesity and stroke (Mona *et al*., 2022). Overweight, including central obesity, is an important factor related to the increase in cases of degenerative diseases, such as diabetes mellitus, hypertension, and cancer (Lasari *et al*., 2021; Nediani & Dinu, 2022).

Basic Health Research (Riskesdas) data in 2018 showed an increase in the percentage of degenerative disease incidents in line with the increase in central obesity cases in Indonesia, including hypertension (25.8% to 34.11%), diabetes mellitus (1.5% to 2%), stroke (7% to 10.9%), chronic kidney failure (0.2% to 0.38%), and cancer (1.4% to 1.79%). Degenerative diseases contribute to 72% of global deaths or can be said to be four times the total deaths due to infectious diseases, maternal, perinatal, and nutritional problems, which are mainly in developing countries (IDF, 2025; Kemenkes RI, 2024; Ramesh & Kosalram, 2023). Factors associated with central obesity include unhealthy eating patterns such as excessive consumption of fried foods, consumption of instant seasonings, sweet foods and salty foods (Muharry & Kumalasari, 2018; Syauqy *et al*., 2023). The highest obesity rates were found in the 45-54 age group who live in urban areas (Sudikno *et al*., 2018).

Factors that can cause overweight, including central obesity, include: increased consumption of ultra-processed foods (UPF), low physical activity, genetic and psychological factors, socioeconomic and cultural status, age, and gender (Fajriyah *et al*., 2020; Koceva *et al*., 2024; Rauber *et al*., 2021; Valicente *et al*., 2023; Westerterp, 2018). Increased consumption of UPF is part of the consumption of risky foods that can lead to excess weight, because this type of food can increase calorie, sugar, and fat intake, which has the potential to cause fat accumulation in the body (Rauber *et al*., 2020). Research concludes that a lack of regular consumption of fruits and healthy nuts has a strong link to overweight and obesity (Nishi *et al*., 2021; Wu *et al*., 2022). Risky food consumption, dietary patterns, and physical activity are dominant factors associated with central obesity. Furthermore, cultural factors, such as traditional foods, influence food consumption habits and are aspects that can affect (Bernsdorf *et al*., 2024; Handayani *et al*., 2020). Indonesia has a geographical condition in the form of an archipelago, with 17,380 islands, of which 6 are large islands (Sumatra, Java, Kalimantan, Sulawesi, Timor, Papua). This geographical condition which has many regions with heterogeneous cultures and characteristics, will cause different lifestyles, both related to eating habits, diet, processed food products, coupled with low knowledge, the environment, including facilities and inadequate policy support can be a triggering factor for the occurrence of central obesity and an increase in cases of degenerative diseases such as diabetes (Fauzi *et al*., 2022; Wong *et al*., 2024; Woro *et al*., 2021).

In this study, risky food consumption was defined as the type of food with the highest consumption frequency among the population in each subcategory that has the potential to increase the risk of degenerative diseases, including central obesity. The dietary consumption pattern included nuts, fruits/vegetables, milk, fats/oils, sugar, and its processed products, which were determined based on the highest consumption frequency of the population. Spatial analysis was used because it can illustrate regional variations (per province) in central obesity and its association with risky dietary patterns. Research in India revealed that regions with a high prevalence of central obesity are associated with increased consumption of fast food and unhealthy eating patterns (Kundu *et al*., 2023). In addition, research in China found a geographic distribution of central obesity that forms regional clusters and is closely related to changes in modern dietary patterns and urbanization (Yin *et al*., 2024). The results of research using this approach can form the basis

for more targeted nutritional interventions and specific, region-based public health policies.

Methods

This study was conducted using secondary data from the 2023 Indonesian Health Survey (SKI) collected through multi-stage probability sampling with urban/rural area stratification and census block selection using probability proportional to size (PPS). The unit of analysis was the population aged ≥ 15 across 38 provinces in Indonesia, using provincial aggregate data from the official publication of the 2023 SKI in Figures. The dependent variable in this study was the percentage of central obesity incidence measured by waist circumference (men > 90 cm and women > 80 cm). The independent variables in this study included consumption of risky foods, food consumption patterns, and physical activity. Consumption of risky foods included consumption of sweet foods and drinks, salty foods, high-fat/cholesterol or fried foods, and instant noodles/other instant food products (1–6 times per week), as well as seasonings (≥1 time per day). Food consumption patterns include consumption of nuts/processed foods (1–6 times per week), fruits/vegetables/ processed foods (≥1–2 servings per week), milk/processed foods (<3 times per month), fat/oil (≥1 time per day), and sugar/processed foods (≥1 time per day). Cultural system data were obtained from secondary data from previous research by the Team (Handayani *et al.*, 2020)

Data analysis in this study was conducted using the GeoDa and QGIS 3.42.2 applications. Spatial autocorrelation was analyzed with Global Moran's I to detect the distribution pattern of central obesity prevalence, with interpretations of values -1 (scattered), +1 (clustered), and 0 (random), and significance at $p < 0.05$. In addition, Ordinary Least Squares (OLS) analysis was performed, and symmetric weighting (W) was applied with the K-Nearest Neighbors (KNN) distance setting = 5. This weighting method was used to estimate the initial relationship between the independent variables and the dependent variable in each island, including small islands that are spread out and shows the results of the analysis in the form of significance values ($p < 0.05$), strength of the relationship (R^2), direction of the relationship (regression coefficient), and OLS residual values.

Result and Discussion

Based on Figure 1, the provinces with the highest incidence of obesity are DKI Jakarta (45.7%), North Sulawesi (45.7%), and Central Papua (44.3%). The highest consumption of sweet foods is in Bangka Belitung (66.3%), the highest consumption of seasonings is in West Java (86.5%), the highest consumption of salty foods is in Bangka Belitung (65.1%), the highest consumption of sweet drinks is in Central Java (60.3%), the lowest consumption of milk is in North Maluku (48%), the highest consumption of sugar is in D.I Yogyakarta (60.4%), and the highest consumption of fat is in Central Java

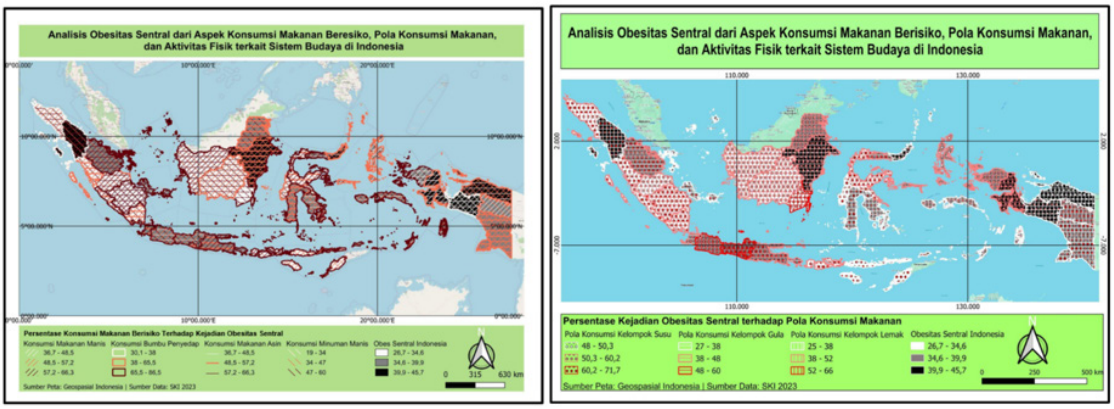

Figure 1. Analysis of Consumption and Dietary Pattern Mapping on Central Obesity in 38 Provinces

TABLE 1. Moran's Value Analysis of Risky Diet and Physical Activity on Central Obesity

Variable	n	Moran's I	E[I]
Prevalence of Central Obesity	38	0.0475	-0.02
Percentage of Sweet Food Consumption	38	0.3683	-0.02
Percentage of Sweet Drink Consumption	38	-0.1070	-0.02
Percentage of Salty Food Consumption	38	0.3701	-0.02
Percentage of Fatty/Cholesterol/Fried Food Consumption	38	0.3746	-0.02
Percentage of Seasoning Consumption	38	0.3816	-0.02
Percentage of Instant Noodles/Other Instant Foods Consumption	38	0.1813	-0.02
Percentage of Nuts and Their Derivatives	38	0.4844	-0.02
Percentage of Fruit, Vegetable, and Derivatives Consumption	38	0.3874	-0.02
Percentage of Milk and Its Derivatives	38	0.1381	-0.02
Percentage of Fat and Oil Consumption	38	0.4348	-0.02
Percentage of Sugar Consumption	38	0.0769	-0.02
Percentage of Adequate Physical Activity	38	0.3165	-0.02
Percentage of Insufficient Physical Activity	38	0.3165	-0.02

*p-value: <0.05 (Significant)
Source: Primary Data (2025)

(66%). The results of the global univariate Moran's I can be seen in Table 1. The results of the autocorrelation test show that almost all Moran's values have a positive direction, except for the percentage of consumption of sweet drinks (-0.1070). Furthermore, Moran's I value in the variables of this study is greater than E[1], which is -0.0270. These results indicate a clustered pattern and have similar characteristics in adjacent locations. The results of Moran's I bivariate analysis in Table 2 show that 11 variables related to food consumption, risky beverages, and eating patterns have diverse spatial relationships. Nine of these variables showed a statistically significant relationship to the prevalence of central obesity ($p < 0.05$).

The results show that most variables have Moran's I values that vary, both positive and negative. Based on the analysis, four variables with the highest absolute Moran's I values were identified: the percentage of salty food consumption, fruit/vegetables and their processed products, nuts and their processed products, and sweet foods. The patterns are shown in Figure 2. The percentage of salty food consumption variable ($I = -0.2826$, $p = 0.002$) identified a low-low pattern in South Papua, Highland Papua, and the Maluku Islands, and a high-low pattern in Central Papua, Papua, West Papua, and Southwest Papua. This pattern indicates that provinces with high central obesity tend to be adjacent to provinces with low salt consumption, or vice versa (low-high), referred to as spatial outliers (Pusdiktasari *et al*., 2022; Wang *et al*., 2024).

This phenomenon is in line with previous research, which stated that sodium consumption in Indonesia comes from traditional products such as salted fish, fermented products, and the use of table salt or cooking spices that contain calcium and potassium, so they are preferred over industrially processed foods that have more general characteristics (Andarwulan *et al*., 2021; Julmohammad *et al*., 2025). In addition, this spatial distribution pattern of sodium is not a causal relationship, but rather the impact of diversity in cooking methods, local culture, and habits of consuming salty foods such as processed salted seafood (Mizutani *et al*., 2023; Sari *et al*., 2022). Furthermore, the percentage of fruit and vegetable consumption ($I = -0.2454$, $p = 0.001$) identified a High-Low pattern in Papua, Central Papua, West Papua, and Southwest Papua, indicating a high prevalence of central obesity adjacent to areas with low fruit and vegetable consumption. Conversely, a Low-High pattern was seen in several provinces in Sumatra and Kalimantan,

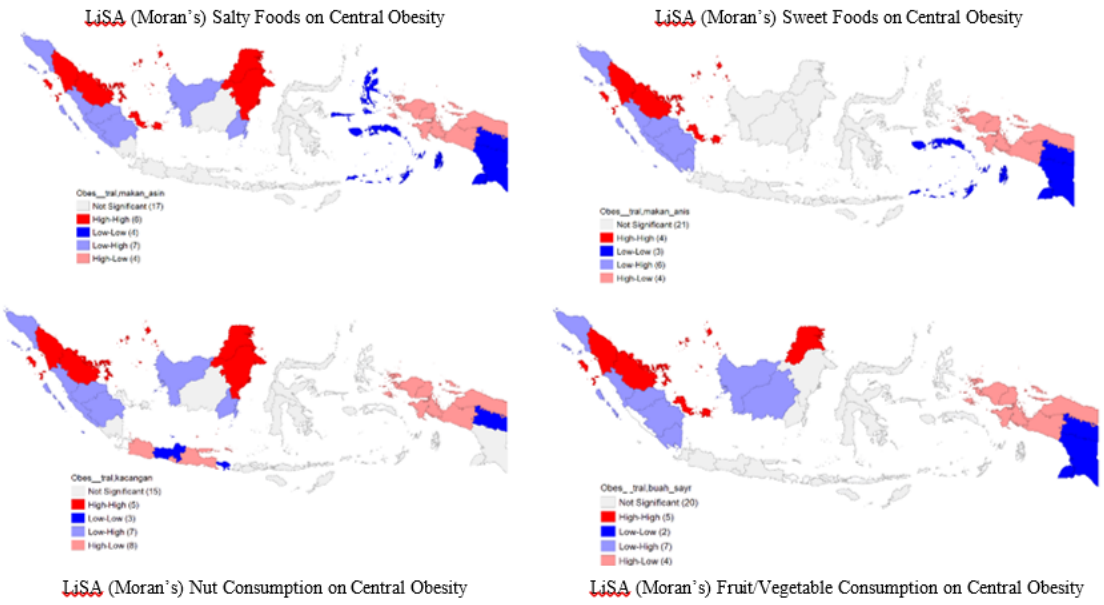

Figure 2. Clustering Pattern (LiSA) of Most Risky Variables

TABLE 2. Spatial Autocorrelation Analysis of Risky Diet Consumption and Physical Activity on Central Obesity

Variabel	n	p-value	Moran's I	E[I]
Percentage of Sweet Food Consumption	38	*0.001	-0.2178	-0.0270
Percentage of Sweet Drink Consumption	38	*0.017	0.1274	-0.0270
Percentage of Salty Food Consumption	38	*0.002	-0.2826	-0.0270
Percentage of Fatty/Cholesterol/Fried Food Consumption	38	*0.007	-0.1793	-0.0270
Percentage of Seasoning Consumption	38	*0.027	-0.1365	-0.0270
Percentage of Instant Noodles/Other Instant Foods Consumption	38	*0.007	-0.1737	-0.0270
Percentage of Nuts and Their Derivatives	38	*0.002	-0.2398	-0.0270
Percentage of Fruit, Vegetable, and Derivatives Consumption	38	*0.001	-0.2454	-0.0270
Percentage of Milk and Its Derivatives	38	0.115	-0.0778	-0.0270
Percentage of Fat and Oil Consumption	38	0.172	-0.0536	-0.0270
Percentage of Sugar Consumption	38	*0.036	0.1096	-0.0270
Percentage of Adequate Physical Activity	38	0.062	-0.0955	-0.0270
Percentage of Insufficient Physical Activity	38	0.062	-0.0955	-0.0270

*p-value: <0.05 (Significant)

where a low prevalence of central obesity was surrounded by provinces with higher fruit and vegetable consumption. This finding may occur due to the low frequency of fruit and vegetable consumption in most provinces (an average of only 1–2 servings per week), whereas according to the 2014 Indonesian Minister of Health Regulation, the minimum daily consumption of fruit is 2–3 servings per day and 3–4 servings of vegetables per day. Furthermore, although there are areas with high fruit and vegetable consumption in the spatial analysis, the amount of consumption is still low according to national nutritional standards, so its benefits in preventing central obesity are not apparent (Folkvord *et al.*, 2022). This is in line with previous research, which stated that low consumption of fruit and vegetables can tend to increase the risk of central obesity due to the difficulty of accessing healthy foods (fruit and vegetables) or economic factors, resulting in a lack of fiber, antioxidants, and micronutrient intake (Huang, 2021; Wu *et al.*, 2022).

The nut consumption pattern (I =

–0.2398, p = 0.002) shows a Low-Low pattern spread across three regions of Indonesia: Central Java, Bali, and the Papua Highlands. Meanwhile, the High-Low pattern appears in densely populated provinces on the island of Java and is widespread in Papua. This explains spatially how provinces with high central obesity are flanked by provinces with low nut consumption, or vice versa (Low-High), such as in Kalimantan and Sumatra. In general, regular consumption of natural nuts can prevent over weight (Gonçalves *et al*., 2023). However, the frequency of nut consumption in Indonesia is mostly only 1-6 times per week, which may not be optimal in preventing central obesity, because the recommendation for nut consumption is 20-30 grams per day (Blomhoff *et al*., 2024; Pérez-Jiménez *et al*., 2018). This is in line with previous research, which stated that consuming nuts infrequently or frequently ignored can increase the risk of central obesity (Baer *et al*., 2023; Sakir *et al*., 2024). These spatial differences can be influenced by variations in the types of nuts consumed, local processed nut products, and nut consumption habits based on the uniqueness of each region (Astuti *et al*., 2023; Nurhasan *et al*., 2022, 2024).

Sweet foods (I = –0.2178, p = 0.001) have a wider spatial pattern and are spread with a High–High pattern in densely populated areas such as North Sumatra, Riau, the Riau Islands, and Bangka Belitung, and Low–Low in most provinces in eastern Indonesia. This distribution indicates that sweet food consumption is higher in areas with good food distribution infrastructure and higher purchasing power (Ferretti & Mariani, 2019). In line with previous research findings, which show that physical access to food and economic capacity play an important role in the availability and consumption of sugar or sweet foods in a region (Joost *et al*., 2019).

Other significant variables showed lower spatial autocorrelation strength, including sweet drinks (I = 0.1274, p = 0.017) showed positive clustering but no High–High and High–Low patterns were found, while fatty/fried foods/ cholesterol (I = –0.1793, p = 0.007), seasonings (I = –0.1365, p = 0.027), instant noodles/instant food (I = –0.1737, p = 0.007), and sugar (I = 0.1096, p = 0.036) showed variations in spatial patterns that reflect differences in consumption and geographic associations with central obesity (Astuti *et al*., 2023; Colozza, 2024; Ferretti & Mariani, 2019; Joost *et al*., 2019; Sakai *et al*., 2022). Overall, these results indicate that the spatial relationship between consumption patterns and central obesity in Indonesia is heterogeneous and influenced by local factors. Based on the results of the multivariate analysis of Moran's I and LiSA in Table 3, variables with a p-value <0.25 were entered into a multivariate model using Ordinary Least Squares (OLS) to identify factors independently influencing the

TABLE 3. OLS Modeling Regression Test on Central Obesity

Variable	**Coeficient (β)**	**t-Statistics**	**p-Value**
Intercept	41.58	4.057	<0.001
Percentage of Salty Food Consumption (1-6 times per week)	-0.303	-2.483	<0.001
Percentage of Fried/Fatty/Cholesterol-Rich Food Consumption (1-6 times per week)	0.532	3.072	0.004
Percentage of Nut and Nut-Rich Food Consumption (1-6 times per week)	-0.474	-3.789	<0.001
Percentage of Fruit/Vegetable and Nut-Rich Food Consumption (1-2 servings per week)	0.349 -0.201	3.387 -1.796	<0.001 0.081

Adjusted R^2 = 0.419

p-value (F) = <0.001

Moran's Residual (p-value = 0.093)
Source: Primary Data (2025)

prevalence of central obesity simultaneously. After adjusting for other variables, the final OLS model identified four main variables that were statistically significant, namely, salty foods (1-6 times per week) (β = -0.3038, p = 0.018), fried/fatty/cholesterol foods (1-6 times per week) (β = 0.532, p < 0.001), nuts (1-6 times per week) (β = -0.4746, p < 0.001), and fruits and vegetables (1-2 servings per week) (β = 0.3493, p = 0.0019). The milk consumption variable (β = –0.2013, p = 0.081) was still included because the p-value was close to significant, relevant to community nutrition, and was confounding.

Testing the model assumptions showed no spatial autocorrelation in the residuals (Moran's I residual p > 0.05). Therefore, this OLS model is sufficient and does not require further modeling using the Spatial Lag Model (SLM) or Spatial Error Model (SEM). Indonesia is an archipelagic country with many ethnicities, cultures, and other diversities, one of which is processed food with a salty taste (Sutrisna & Sidik, 2024; Wijaya, 2019). Indonesian people have a unique way of preparing salty foods, such as salted fish, salted vegetables in soup, or chili sauce with salt, which, for some of the population, is actually consumed with other foods, so that it does not always increase the total daily calories (Cha & Yu, 2024). This is different from the context of salty foods in developed countries, which are often associated with fast food/junk food, accompanied by high fat content (Andarwulan *et al*., 2021).

Furthermore, the consumption pattern of fatty/fried foods is positively correlated with central obesity, which is consistent with dietary trends in urban areas, where generally foods containing coconut milk or fried foods are categorized as snacking habits (Anwar, 2024; Oddo *et al*., 2019). Previous research also showed that the large number of fast food restaurants and fried snacks contributed to an increase in fat in daily intake (Andarwulan *et al*., 2021; Huang, 2021; Mahardika *et al*., 2024). Clusters with this (High-High) pattern are common on large islands such as Java, Kalimantan, and Sumatra (Ayuningtyas *et al*., 2022; Oktaviani *et al*., 2024; Thamrin *et al*., 2022). Consumption of nuts or legumes in Indonesia is generally processed into foods high in fat and salt, such as fried tempeh, fried peanuts, and others (Anyanwu *et al*., 2023; Nurhasan *et al*., 2024; Sistia *et al*., 2023). In addition, low frequency of nut consumption can also increase the risk of uncontrolled weight gain (Sakir *et al*., 2024; Wu *et al*., 2022).

A study conducted in Malaysia also showed that infrequent consumption of nuts or legumes is positively associated with obesity because the need for fiber and good fats is not sufficient (Jaafar *et al*., 2023). The percentage of fruit and vegetable consumption variable has a significant positive value, which requires contextual explanation. The data used shows an average consumption of only 1–2 servings per week, far below the WHO recommendation of ≥5 servings per day (Permenkes RI, 2014). This very low intake means that fruit and vegetable intake is insufficient to provide a preventive effect against central obesity. This aligns with previous research that suggests that unbalanced fruit and vegetable consumption increases the risk of central obesity and cardiovascular disease (Sakir *et al*., 2024; Su *et al*., 2022; Xu *et al*., 2025).

On the other hand, positive findings could reflect the existence of factors where groups with higher purchasing power are able to buy fruit, but at the same time still have high consumption of modern, high-calorie foods (Darmawan *et al*., 2023; Hidayah *et al*., 2019). Previous research also confirmed that obesity clusters are more concentrated in urban areas with better access to nutrition, including fruits/vegetables, but accompanied by a high-energy diet (Kamkuemah *et al*., 2023; Kundu *et al*., 2023; Wong *et al*., 2024). Based on the results of this OLS analysis it explains that food consumption patterns contribute to variations in the incidence of central obesity in Indonesia. The role of this food consumption is protective, reviewed from traditional foods such as salty foods and risky consumption of fatty/fried foods, low fruit and vegetable intake, and more regular consumption of healthy nuts. Other studies also state that unhealthy lifestyles can be formed due to socio-cultural factors, such as habits, knowledge, environment, lack of healthy food available or sold in the environment, including inadequate facilities and policy support (Al-Sejari, 2017; Aye et al., 2014; De Silva et al., 2012).

Conclusion

Based on the results of spatial analysis, the prevalence of central obesity in Indonesia forms a clustered pattern across provinces. In the OLS regression results, there are main factors that have a strong correlation with a positive relationship, namely fried or fatty foods (β = 0.532) and fruit and vegetable consumption (β = 0.349). This may occur due to the low frequency of fruit and vegetable consumption, so their protective effect in preventing central obesity is not optimal. Furthermore, consumption of nuts (β = -0.474) and salty foods (β = -0.303) showed a strong correlation but a negative relationship, due to factors such as traditional consumption patterns that are lower in calories, diversity in cooking methods, local culture, or food consumption habits in each region. Based on these findings, interventions to prevent central obesity need to consider spatial differences between provinces in Indonesia. The direction of public nutrition policies should focus on efforts to reduce the consumption of high-fat foods and strategies to increase the accessibility and frequency of fruit, vegetable, and nut consumption in accordance with national balanced nutrition guidelines.

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