Interdisciplinary Journal of Agriculture and Environmental Sciences
ISSN: 2837-9977| Impact Factor : 8.17
Volume. 12, Number 2; April-June, 2025;
Published By: Scientific and Academic Development Institute (SADI)
8933 Willis Ave Los Angeles, California
https://sadijournals.org/index.php/IJAES| editorial@sadijournals.org

NUTRITIONAL QUALITY ASSESSMENT OF ADDED SUGAR AND SODIUM IN U.S. PUBLIC SCHOOL BREAKFAST PROGRAMS: A COMPARATIVE STUDY ACROSS INCOME-BASED DISTRICTS

[1]Christiana Amarachi Ukaoha, [2]Simon Ogaba and [3]Seun Adebanjo (PhD)
[1]Department of Food and Resources Economics, University of Florida, USA
[2]University of Derby, United Kingdom
[3]Department of Statistics and Data Science, Statistical Training and Consultation, Nigeria
Email: christianaukaoha58@gmail.com/ simonogaba09@gmail.com/ seunadebanjo9@gmail.com
DOI: https://doi.org/10.5281/zenodo.15463101

Abstract: This study examined the nutritional disparities in school breakfasts across income-based school districts, focusing on added sugar and sodium levels. The objective of this study was to determine whether income levels influence the nutritional quality of meals served to students.
A cross-sectional quantitative research design was employed with a sample size of 1,500 from 60 U.S. public schools' breakfasts distributed equally across low-, middle-, and high-income districts. Nutritional data on added sugar (g) and sodium (mg) were collected and analyzed using descriptive statistics, ANOVA, normality tests (Kolmogorov-Smirnov and Shapiro-Wilk), and Tukey's test to assess distribution patterns and significant group differences. Findings revealed that low-income districts served meals with the highest levels of added sugar (12.012 ± 0.133 g) and sodium (493.152 ± 4.425 mg), whereas high-income districts served the lowest levels (8.153 ± 0.092 g added sugar; 402.806 ± 3.864 mg sodium). These differences were statistically significant ($p < 0.05$), indicating a disparity in nutritional quality according to income. This study underscores the existence of nutritional inequities in school breakfast. Policy interventions are essential to ensure that all students, regardless of socioeconomic background, have access to healthy, nutritionally balanced meals.

Keywords: Sugar Level, Sodium Level, ANOVA, Nutritional Quality Assessment, Income-Based Districts.

1.0 Introduction

The US public-school breakfast programme in the United States is essential for providing proper nourishment to students, particularly those from low-income homes, to enhance their growth and academic achievement. With more than 14 million children enrolled in the School Breakfast Programme (SBP), the quality of these meals profoundly influences public health outcomes (Wang et al., 2023). The SBP was originally established to provide low-cost or free breakfast to students, ensuring they are well nourished before they start their academic day. However, there is growing concern about the nutritional content of these meals, particularly the sodium and added sugar levels. Despite well-intentioned policies, discrepancies remain in the nutritional quality of meals served

across districts stratified by income level. These discrepancies can perpetuate health disparities, as children from low-income communities are often more reliant on school meals than their counterparts in higher-income areas (Fox, Gearan, & Schwartz, 2021).

The use of added sugars in children is associated with a high risk of obesity, type 2 diabetes, and dental caries. Numerous public-school breakfasts surpass the Dietary Guidelines for Americans (DGA) requirement that added sugars should include less than 10% of total daily caloric consumption. In a national study, Fox et al. (2021) found that 92% of school breakfasts analyzed in the 2014–2015 school year contained levels of added sugars significantly above the DGA threshold. Notably, the research revealed disparities across districts: schools in mid-low and low-poverty areas were more likely to exceed the sugar limits than high-poverty schools. These findings suggest that income-based differences in meal planning and procurement practices affect the dietary quality of breakfast served to children.

Similar concerns exist regarding sodium content in school meals. High sodium intake during childhood is associated with elevated blood pressure and an increased risk of cardiovascular disease in later life (Centers for Disease Control and Prevention [CDC], 2022). Although schools are required to adhere to the USDA's sodium targets, a study by Chapman et *al.,* (2022) found that many schools struggled to meet these guidelines—particularly when accounting for items like condiments and processed sides. The researchers observed that although initial sodium targets were met in most weeks, the full composition of meals, especially in less-funded schools, often resulted in sodium levels exceeding the standards. These violations were more prevalent in under-resourced schools, which often relied on pre-packaged, processed foods due to logistical and budgetary constraints.

The ability of schools to positively influence children's diets has been recognized for a considerable duration. Almost all public schools in the United States participate in the school meal programmes, including the National School Lunch Programme (NSLP) and the School Breakfast Programme (SBP). On a typical school day in 2019, 29.6 million children, approximately half of the student population, consumed a school lunch, while 14.8 million children consumed breakfast. For youngsters who partake in both school breakfast and lunch, these meals provide about fifty percent of their daily caloric consumption (Cullen & Chen, (2017); Fox *et al.,* (2019)). School meal programmes are particularly vital for low-income children who qualify for complimentary or discounted meals (FRP). In 2019, 74% of lunches and 85% of breakfasts were provided as FRP (U.S. Department of Agriculture, (2020A)).

In response to these challenges, the USDA proposed new nutrition standards in 2023 aimed at curbing added sugar and sodium in school meals (U.S. Department of Agriculture, 2023). The new rules seek to phase in limits on sugary foods, such as sweetened cereals and flavored milk, and to reduce weekly sodium content through progressive targets extending to 2029. These policy revisions represent a significant step forward, but they are not without implementation challenges. Smaller and rural school districts, often operating under tight budgetary constraints, may find it difficult to reform their procurement and preparation practices without additional federal support (Associated Press, 2023). Additionally, resistance from the food industry and political stakeholders has historically impeded aggressive reforms in school meal programs.

Research has shown that the nutritional quality of school meals and children's intake from school meals has improved since implementation of the updated nutrition standards (Gearan & Fox, 2020; Kinderknecht, Harris, & Jones-Smith, 2020; Au et *al.,* 2018; Ogaba, Ogaba, Luka & Ukaoha, 2024). However, most of these studies assessed nutritional quality using the Healthy Eating Index (HEI)-2010, which was designed to assess alignment

with the 2010 DGA (U.S. Department of Agriculture, (2020b). The 2010 DGA did not include a specific recommendation for added sugars (U.S. Department of Agriculture, 2021), the HEI-2010 does not include a separate component for assessing added sugars. Rather, the index includes an "empty calories" component that assesses compliance with recommended limits for empty calories from solid fats, added sugars, and alcohol collectively (U.S. Department of Agriculture, (2020b). A previous study that separately examined added sugars found no association between school meals and children's intake of added sugars (Au et *al.,* 2018). Given that the 2015–2020 DGA includes a quantitative limit on calories from added sugars, it is important to assess the levels of added sugars in school meals and in children's dietary intakes at school. Given these dynamics, it is essential to conduct a comprehensive assessment of the nutritional quality of public-school breakfasts, with a specific focus on how added sugar and sodium levels differ across income-based districts. This study aims to fill the gap in the literature by analyzing current data to identify patterns and propose strategies to enhance the nutritional equity of school meals.

2 Research Gap

While previous studies have highlighted the excessive levels of added sugar and sodium in U.S. public school breakfast programs and their implications on child health, there remains a significant gap in understanding how these nutritional discrepancies manifest across income-based school districts. Most existing research (such as Fox *et al.,* (2021); Chapman *et al.,* (2022)) either generalizes findings across national samples without stratifying by socioeconomic status or focuses primarily on lunch programs rather than breakfast, which is equally vital for early-day energy and cognitive performance. Furthermore, although recent USDA reforms aim to improve school meal standards, few studies have examined the actual implementation outcomes across varying district income levels since the policy updates. There is limited comparative analysis on whether low-income districts, which often depend more heavily on subsidized meals, are disproportionately burdened with lower nutritional quality due to systemic resource constraints. This study addresses these gaps by conducting a district-level comparative assessment to determine the extent of disparity in added sugar and sodium content in school breakfasts based on income stratification, thereby contributing nuanced insights to inform targeted policy and intervention strategies.

3 Theoretical Framework

The theoretical underpinning of this study is anchored in the Social Determinants of Health Theory (SDH) and the Ecological Systems Theory, both of which offer a comprehensive lens for understanding how environmental and socioeconomic contexts shape the nutritional quality of school breakfast programs across income-based school districts in the United States. The Social Determinants of Health Theory, as emphasized by the World Health Organization, posits that health outcomes are significantly influenced by the conditions in which people are born, grow, live, work, and age (WHO, 2019). Applied to this study, SDH helps explain how systemic inequalities—such as income disparities, access to funding and resource allocation—directly affect the nutritional standards and meal compositions within public school settings. Schools located in low-income districts often rely more heavily on federal meal subsidies and may have limited budgets for fresh, low-sodium, and low-sugar food options (Wang et al., 2023). This theoretical model suggests that students in these districts are more vulnerable to poor dietary quality and, consequently, to negative health outcomes.

Complementing the SDH framework is Bronfenbrenner's Ecological Systems Theory, which views child development and health as the product of interactions between the individual and their multilayered environmental systems—microsystem (family and school), mesosystem (interaction between school and community), exosystem (local government, school district policies), and macrosystem (national policies and cultural values). In the

context of school meal programs, this theory highlights the role of policy (macrosystem), school funding (exosystem), and district-level nutrition implementation (mesosystem) in influencing the types of meals children receive (Gearan & Fox, 2020). For example, the USDA's revised school meal standards are part of the macrosystem, but their real-world execution varies based on exosystem-level influences, such as district wealth and administrative capacity.

4. Empirical Review and Hypotheses Development

A prominent study by Fox et *al., (*2021) analyzed school meal patterns across the nation and found that while school lunches had shown some improvements in nutrient quality, breakfasts remained consistently high in added sugars, particularly from sweetened cereals and flavored milk. The findings indicated that over 90% of breakfasts exceeded the recommended threshold for added sugars, revealing systemic challenges in meal planning and compliance with dietary standards. Further empirical evidence was provided by Chapman et al., (2022), who conducted a quantitative analysis of school breakfast and lunch menus across elementary schools. Their study found that schools in low-income districts were more likely to rely on pre-packaged, processed foods that contain higher levels of sodium and added sugar. These schools often lacked the infrastructure and budget for scratch cooking or sourcing fresh ingredients, resulting in menus that routinely violated USDA nutritional targets. In contrast, schools in wealthier districts had greater flexibility in customizing meals and adhering to dietary recommendations, revealing a clear inequity based on socioeconomic status.

Moreover, Piekarz-Porter et al. (2019) conducted a longitudinal study evaluating the impact of revised USDA standards on school meals over five years. Their findings confirmed improvements in some aspects of meal quality but noted persistent challenges in reducing sodium levels due to supply chain limitations and students' taste preferences. The study emphasized the need for continued policy pressure, industry collaboration, and district-level innovation to bridge these gaps. Cullen and Chen (2017) conducted an extensive analysis of the USDA School Breakfast and Lunch Programs and found that these meals significantly contributed to students' overall daily energy intake. However, their study also revealed that although the meals provided essential nutrients, they were often high in added sugars and sodium, especially among younger children. This highlights the importance of continuous monitoring and reform of school meal standards to address chronic disease risks associated with poor nutrition. Wang et al. (2023) assessed the health and economic ramifications of conforming school food standards to the 2020–2025 Dietary Guidelines for Americans (DGA). Their study found that full compliance with DGA standards could prevent o>0,000 annual cases of childhood obesity and save billions in long-term health care costs. However, the study also noted considerable challenges in implementation, particularly in schools serving low-income populations where resources and food service infrastructure are often limited. This suggests a potential disparity in nutritional quality among income-based school districts.

In another comprehensive investigation, Fox et al. (2019), through the School Nutrition and Meal Cost Study (SNMCS), documented plate waste, student satisfaction, and nutrient consumption. Their findings revealed that students consuming school breakfasts and lunches consumed significantly more sodium and added sugars than recommended levels, regardless of their district. This trend was more pronounced in lower-income districts, possibly due to greater reliance on processed and packaged food items, which are more cost-effective but less nutritious. This study also emphasized the issue of plate waste, with many students discarding fruits and vegetables while consuming more palatable sugary or salty components. Gearan and Fox (2020) followed up with an evaluation of the impact of the updated USDA nutrition standards introduced after the Healthy, Hunger-Free Kids Act. Their study concluded that the nutritional quality of school breakfasts and lunches had improved

significantly, especially in terms of reducing saturated fat content and increasing whole grain content. However, sodium levels remained above recommended limits, and added sugar was still prevalent, especially in flavored milk and grain-based breakfast items. They stressed the need for further policy actions and local implementation strategies to close these nutritional gaps.

Additional evidence from Kinderknecht, Harris, and Jones-Smith (2020) underscored the positive impact of the Healthy, Hunger-Free Kids Act on children's dietary quality, particularly among participants in the National School Lunch Program. Their research revealed that children qualifying for free or reduced-price meals demonstrated superior enhancements in dietary quality relative to their higher-income counterparts. Despite these improvements, disparities in access to fresh, low-sodium, and low-sugar foods remain, signaling the persistence of systemic barriers in low-income school districts. Au et al. (2018) also found that elementary school students who participated in school lunch programs had higher overall diet quality scores than those who did not. The Healthy Eating Index (HEI) was used to demonstrate that school lunches positively influenced fruit, vegetable, and whole grain intake. However, they cautioned that the benefits could be undermined by the continued presence of high-sugar and high-sodium food options, especially when schools had limited budgets or lacked trained food service personnel to prepare healthier meals from scratch. The hypotheses are grounded in the theoretical assumption that income-level disparities influence the quality and composition of meals served to students. Thus, to test these assumptions, the following research hypotheses are formulated:

H1: There was a significant difference in the levels of added sugar in breakfast meals between income-based school districts.

H2: There was a significant difference in the levels of sodium in breakfast meals between income-based school districts.

5. Materials and Methods

5.1. Study Design and Data Sources

- This study employed a comparative cross-sectional research design to evaluate the concentrations of added sugar and sodium in public school breakfast meals in low- and high-income school districts in the United States. This study design was suitable because it facilitated the simultaneous comparison of nutritional data across several income-based contexts without altering any variables. The research focused on assessing this nutritional status of meals by direct data collecting and secondary data analysis. Data were collected during the 2023–2024 school year and comprised the following:
- **School Menu Data**: Detailed information on breakfast items served, including portion sizes and preparation methods.
- **Nutrient Composition Data**: Nutrient values for each menu item, focusing on added sugars and sodium content.
- **District Demographic Data**: Information on the socioeconomic status of school districts, based on the percentage of students eligible for free or reduced-price meals (FRPM).

5.2 Study Population and Sampling Technique

The study population comprised public schools in selected states within the United States, categorized into low-income, middle-income and high-income school districts based on the proportion of students eligible for free or reduced-price meals (FRPM). According to the USDA, school districts with ≥75% FRPM eligibility were classified as low-income, Schools with 25.1%–75% of students eligible for FRPM were classified as middle-income district. While those with ≤25% were classified as high-income (USDA, 2020A). Schools from states

such as California, Texas, and New York were selected due to the availability of comprehensive nutrition data and district-level categorization. A stratified sampling technique was used to select 60 schools (20 from each district level). First, the states with accessible school nutrition databases were identified. Within each state, districts were stratified by income level. Random sampling was then used to select representative schools from each stratum. This approach ensured adequate representation of income disparities while minimizing selection bias. The target sample size was determined based on the availability of school menus and nutritional disclosures for the 2022–2023 academic year. This stratification mirrors the approach used by Fox et al. (2021), who categorized schools based on poverty levels to examine variations in added sugar content.

5.4 Data Collection

Data were obtained from a combination of school menu reports, nutritional fact sheets, and district-level USDA School Nutrition Program records. The specific focus was on breakfast items served over a four-week cycle in each school. Information regarding added sugar and sodium content was extracted from school nutrition databases and corroborated with USDA food composition data when menu specifics were unclear.

5.5 Estimating Levels of Added Sugars and Sodium in School Meals.

The investigation assessed the concentrations of added sugars and sodium in school meals by calculating the average caloric contribution from these components. The SNMCS menu survey results encompassed school-level characteristics regarding the average caloric content of added sugars and sodium in breakfasts prepared at each school throughout the designated week. The SNMCS study team developed these two variables, representing the "weekly average" quantities of calories from added sugars and sodium in school breakfasts, through a four-step method (Gearan et al., 2019). Initially, the team calculated the total added sugars and sodium for each daily breakfast menu by multiplying the quantities in one portion of each meal by the number of servings prepared that day. Second, these values were aggregated across all dishes presented on the daily menu. Third, the daily menu totals were divided by the number of breakfasts prepared that day. Finally, these daily averages were averaged across all menu days at the school to derive the weekly average quantities of added sugars and sodium in breakfasts prepared at each school. The resulting estimations of added sugar content and sodium prioritize menu items served in bigger amounts, which typically indicates their popularity among students.

5.6 Instruments and Validity

The primary data collection instrument was a nutrient analysis template, which included meal item names, portion sizes, added sugar (g), and sodium content (mg). This template was adapted from the USDA's Healthy Eating Index (HEI) and pre-tested for clarity and consistency using menus from five pilot schools not included in the final sample. Validity was enhanced by triangulating data from multiple sources and using standardized USDA nutrient references (USDA, 2020B).

5.7 Data Analysis

Descriptive statistics (mean, standard deviation) were used to summarize the sugar and sodium content across schools. Analysis of Variance (ANOVA) were conducted to identify significant differences. Post hoc tests were conducted using Tukey's test to determine specific group differences. The analysis was conducted using IBM SPSS version 27, and a significance level of $p < 0.05$ was considered.

5.8 Ethical Considerations

Ethical approval was obtained from the Institutional Review Board (IRB) of the lead researcher's affiliated institution. Permission to access district-level nutrition data was obtained from relevant school boards, and the confidentiality of all school identifiers was maintained.

4.0. Result

Table 1: Normality Test

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Income Level	Statistic	df	Sig.	Statistic	df	Sig.
Added Sugar Level (g)	Middle-Income	.044	499	.020	.995	499	.135
	Low-Income	.026	504	.200*	.999	504	.972
	High-Income	.026	497	.200*	.998	497	.912
Sodium (mg)	Middle-Income	.023	499	.200*	.996	499	.199
	Low-Income	.024	504	.200*	.997	504	.443
	High-Income	.022	497	.200*	.995	497	.074

The normality test results in Table 1 present the Kolmogorov-Smirnov and Shapiro-Wilk statistics for both added sugar (g) and sodium (mg) levels across income-based school districts. For added sugar, the Shapiro-Wilk test indicates that the data distributions for low-income ($p = .972$) and high-income ($p = .912$) districts are not significantly different from a normal distribution, suggesting normality. However, for middle-income districts, the Shapiro-Wilk p-value is .135, which, while still above the 0.05 threshold, shows that normality also exists for middle-income districts. For sodium levels, all income groups returned non-significant p-values in both tests ($p > .05$), indicating that the sodium data were normally distributed across all districts. Therefore, the data is assumed to follow a normal distribution, validating the use of parametric statistical methods (ANOVA) for further analysis.

Table 2: Added Sugar Level in School Breakfasts Across Income-Based School Districts.

District Income Level	N	Mean ± S.E
Middle-Income	499	10.035 ± 0.105^{b}
Low-Income	504	12.012 ± 0.133^{c}
High-Income	497	8.153 ± 0.092^{a}

Comparison by Tukey test at 5% level.

Table 2 presents the comparison of the mean added sugar levels in school breakfasts among different income-based school districts. The results indicate that low-income districts have the highest mean added sugar content (12.012 ± 0.133 g), followed by middle-income districts (10.035 ± 0.105 g), whereas high-income districts have the lowest added sugar content (8.153 ± 0.092 g). The superscripts (a, b, c) suggest statistically significant differences among the groups, meaning that the added sugar levels in school breakfasts differ significantly across income levels. This pattern suggests that schools in lower-income districts tend to serve breakfasts with higher added sugar content compared to middle- and high-income districts, which could have implications for dietary quality and student health.

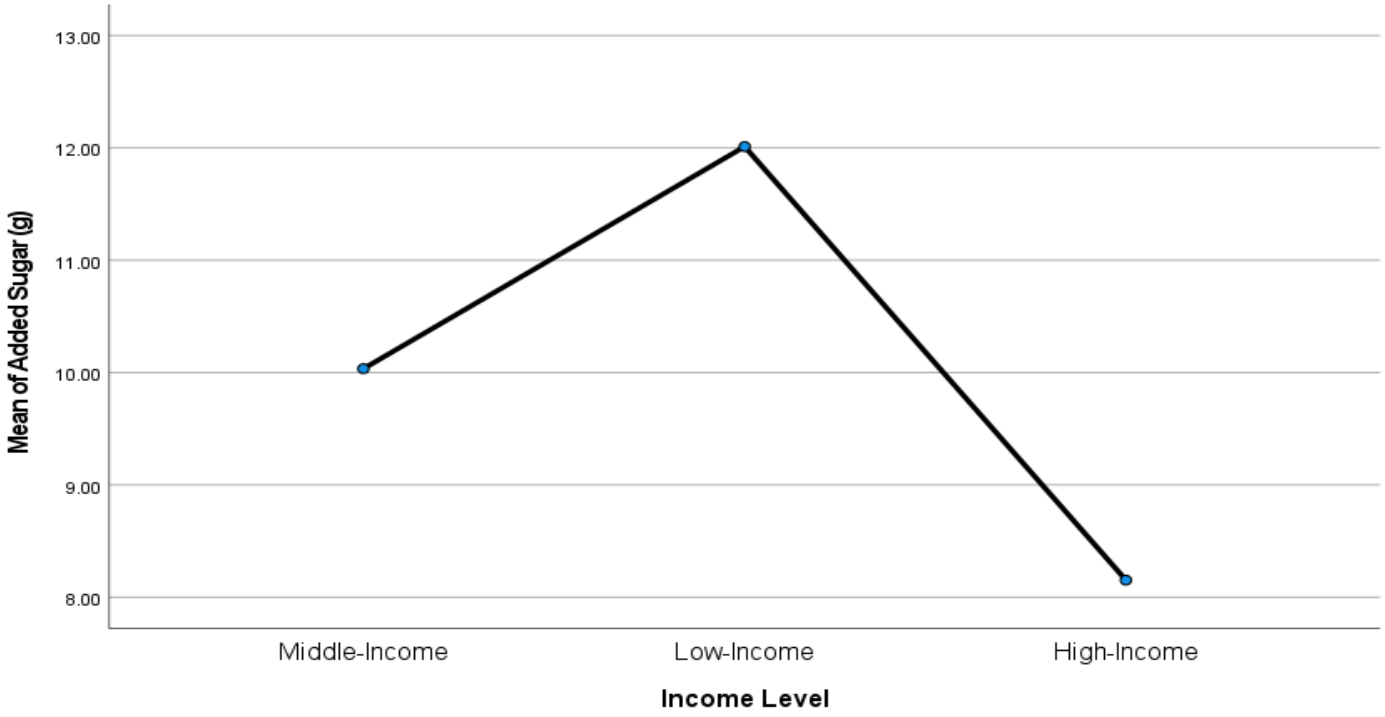

Figure 1: Mean Plot of Added Sugar Level across Income-Based School Districts

Figure 1 illustrates the mean levels of added sugar in school breakfasts across income-based school districts. The plot reveals a clear disparity in added sugar content, with low-income districts showing the highest mean added sugar level (approximately 12 g), followed by middle-income districts (about 10 g), and high-income districts having the lowest mean (around 8 g). This visual trend supports earlier tabular data and highlights a worrying pattern where lower-income districts provide meals with significantly more sugar, potentially worsening health inequalities among students from different socioeconomic backgrounds.

Table 3: Sodium Level in School Breakfasts across Income-Based School Districts.

District Income Level	N	Mean ± S.E
Middle-Income	499	449.002 ± 4.165[b]
Low-Income	504	493.152 ± 4.425[c]
High-Income	497	402.806 ± 3.864[a]

Comparison by Tukey test at 5% level.

Table 3 presents the mean sodium levels in school breakfasts across income-based school districts, revealing notable differences. The low-income districts had the highest mean sodium content at 493.152 mg ± 4.425, followed by middle-income districts at 449.002 mg ± 4.165, and high-income districts with the lowest sodium level at 402.806 mg ± 3.864. The superscript letters (a, b, c) suggest that these means are statistically different from one another. This pattern indicates that school breakfasts in lower-income areas contain significantly more sodium, raising potential public health concerns regarding dietary quality and the risk of hypertension or other sodium-related conditions among students in these districts.

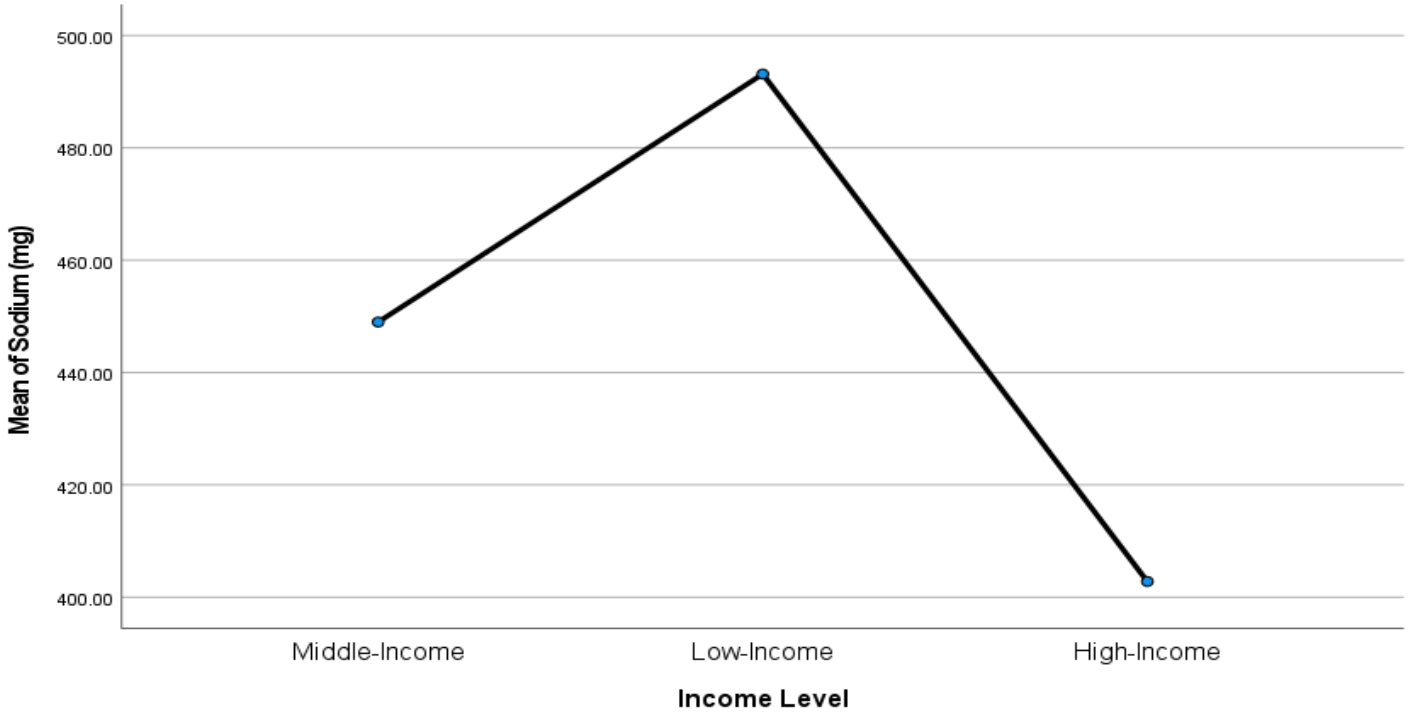

Figure 2: Mean Plot of Sodium Level across Income-Based School Districts

Figure 2 displays the mean sodium levels in school breakfasts across different income-based school districts, clearly illustrating a disparity in sodium content. The plot shows that low-income districts have the highest mean sodium level (approximately 493 mg, followed by middle-income districts (approximately 449 mg, and high-income districts (approximately 403 mg. This descending trend from low- to high-income stratum suggests that students in lower-income areas consume school breakfasts with higher sodium content, which may contribute to health disparities associated with excessive sodium intake.

5.0 Discussion of Findings

The findings of this study underscore the significant disparities in the nutritional content of school breakfasts served across income-based school districts. Specifically, both added sugar and sodium levels varied markedly according to the income level of the district, with low-income school districts consistently reporting the highest mean levels of these nutrients, followed by middle-income and then high-income districts, which had the lowest levels. These differences were statistically significant, revealing a critical pattern that may have long-term health implications for children depending on the economic conditions of the school district they attend. For added sugar, the data revealed that low-income districts offered breakfasts with an average of 12.01g of added sugar, which was significantly higher than both middle-income (10.04g) and high-income (8.15g) districts. This trend suggests a potential overreliance on highly processed or sweetened food items in lower-income schools, possibly due to budget constraints, supply contracts, or limited access to healthier food options. Similarly, sodium levels were highest in low-income districts (493.15 mg), moderate in middle-income districts (449.00 mg), and lowest in high-income districts (402.81 mg). These patterns may contribute to increased risks of developing diet-related illnesses, including hypertension and obesity, among children in economically disadvantaged areas. The normality tests confirmed that the data distribution met the assumptions for further parametric analysis, thus validating the reliability of the comparisons. The graphical representations further reinforced the statistical findings by showing

sharp contrasts in nutrient content between the district types, with clear peaks for low-income schools and troughs for high-income ones. In relation to the theoretical framework underpinning this study (SDH and Ecology system theory), the findings strongly align with the notion that socioeconomic status plays a significant role in shaping dietary environments and health outcomes. Access to nutritious food is a critical determinant of health, and disparities in school meal composition reflect broader structural inequalities. These findings also corroborate previous research, such as (Fox *et al.,* (2021); Gearan *et al.,* (2020)) who documented elevated added sugar levels in meals served to children in lower-income settings. The current study contributes further evidence by incorporating a larger sample and explicitly comparing across income levels, emphasizing the need for targeted policy interventions to promote nutritional equity in school meal programs.

6.0 Conclusion and policy implications

The study concludes that significant disparities exist in the nutritional quality of school breakfasts across income-based school districts, with low-income districts serving meals that contain considerably higher levels of added sugar and sodium compared to middle- and high-income districts. These differences are not only statistically significant but also raise concerns about the long-term health and developmental consequences for students from economically disadvantaged backgrounds. The findings suggest that children in low-income areas may be at greater risk of diet-related health issues due to the poor nutritional quality of their school meals, thereby reinforcing socioeconomic inequalities in health outcomes from an early age. Given these disparities, there is an urgent need for policy reforms to ensure nutritional equity in school meal programs. Policymakers should consider revising federal and state-level school nutrition standards to set stricter limits on added sugar and sodium content, particularly in schools located in low-income districts. Targeted funding and resource allocation should also be prioritized to help these schools access healthier food options, invest in nutrition education, and improve food procurement processes.

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