

Evaluating Sodium Guideline Limits in Saudi Arabia: A Distribution-Based Analysis Using the Saudi Food Composition Database

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Abstract

Background

Excessive sodium intake is a major risk factor for hypertension and cardiovascular disease. The evaluation of sodium reduction policies usually depends on nationally representative dietary surveys, which are often unavailable. Therefore, this study aimed to evaluate the sodium guideline values established in GSO 2612:2025 using the Saudi Food Composition Database (SFCD).

Methods

This study used a food composition distribution-based approach to model sodium distributions across foods in Saudi Arabia. Sodium data were extracted from the SFCD and matched with food categories included in GSO 2612:2025. Foods were grouped according to the standard classification. Sodium distributions were then modeled using Monte Carlo, and a cut-point approach was applied to estimate the proportion of foods below the corresponding sodium limits.

Results

A total of 305 foods representing 26 food categories were included in the analysis. Descriptive analyses demonstrated substantial variability in sodium concentrations across food subgroups. The cut-point analysis showed that several subgroups had more than 50% of foods below the current sodium limits, suggesting that lower sodium targets may be feasible. In some categories, including minced meat, frozen pizza, mayonnaise, and full- and low-fat labneh, this proportion exceeded 90%.

Conclusions

The proposed approach provides additional evidence for evaluating sodium guideline values across food categories. These findings may support future evaluations of sodium reduction strategies and food-specific sodium targets.

1. Background

Cardiovascular disease and other non-communicable diseases (NCDs) are among the leading causes of mortality worldwide, accounting for approximately 71% of all deaths [1–3]. Obesity and dietary factors are important risk factors for these conditions [4].

Dietary risk factors associated with chronic diseases include inadequate consumption of fruits, vegetables, and dietary fibers. These dietary patterns may be linked to an increased risk of cardiovascular diseases and stroke. They may also increase the risk of certain cancers [3, 4]. In addition, some dietary components may indirectly influence the risk of disease through physiological risk factors [4]. For example, total fat and saturated fat intakes may affect serum cholesterol concentrations. Dietary cholesterol and unsaturated fat intakes have also been associated with changes in serum cholesterol concentrations [4].

Sodium intake is another dietary factor that may indirectly influence health outcomes through its association with blood pressure [5]. Previous studies have suggested that reducing salt intake by 6 g/day is associated with a 5.8 mmHg reduction in systolic blood pressure [5]. Higher systolic blood pressure levels have been associated with an

increased risk of cardiovascular mortality [6]. These relationships have been incorporated into several epidemiological models used to estimate the potential impact of nutrition policies [4, 7–9].

Salt-related policies vary in scope and implementation. Some policies focus on food labeling requirements, while others target food service establishments. In Saudi Arabia, examples include menu labeling regulations, such as physical activity calorie labeling (SFDA.FD 5029) and the recently introduced high-salt warning icon (SFDA.FD 5026) [10–13].

Other policies focus on establishing mandatory or guideline limits for the salt content of specific food products, such as bread, as outlined in the GSO 2612:2025 [14]. Guideline limits on salt content may represent a more direct and effective regulatory approach. Their implementation depends primarily on compliance with food manufacturers' regulations.

In contrast, the effectiveness of food labeling policies depends on changes in consumer dietary behaviors. Salt reduction policies are often developed using dietary intake modeling. This approach can estimate population sodium consumption and evaluate the potential impact of alternative reduction targets [15]. Several countries have applied dietary intake modeling to assess the potential effects of salt reduction policies. These include the United Kingdom, Kazakhstan, and Turkey [16, 17]. Although implementation strategies differ across countries, many initiatives have adopted the World Health Organization's target of a 30% reduction in population salt intake [16, 17].

The development and evaluation of these policies require detailed dietary intake data. Such data are commonly obtained through nationally representative dietary surveys [16, 18]. In Saudi Arabia, sodium targets are informed by international references. These include the WHO Global Sodium Benchmarks and the United Kingdom Salt Reduction Targets for 2024 [19, 20]. However, detailed national dietary intake data remain limited. This may present challenges when adapting these values to reflect country-specific dietary patterns. Although national dietary intake data are scarce, the recent introduction of the Saudi Food Composition Database (SFCD) offers a novel source of nationally pertinent food composition information [21, 22]. This database was established by the National Nutrition Committee at the Saudi Food and Drug Authority (SFDA) [21, 22].

The SFCD has been applied in national public health and food safety studies. Protein composition data and dietary exposure models have ranked common food allergens using a multi-criteria profiling approach [23, 24]. This database incorporates targeted food lists for national dietary evaluations, including a list of approximately 2,800 Saudi food items detailing flour presence and quantity. This enabled estimation of fortified flour intake and simulation of iron fortification scenarios [25]. Specific parameters, such as the sheep-to-beef ratio, were integrated into microbial risk assessments to evaluate *Escherichia coli* O157 exposure from sheep meat consumption [26].

Food composition data may provide an alternative approach for evaluating sodium intake-related policy. Using these data, the statistical distributions of sodium concentrations were estimated across different food categories. Modeling these distributions may help assess the position of current guideline values relative to the observed food distribution. This approach may help examine existing guideline limits within the context of sodium concentrations in foods currently available in the market.

Therefore, this study aimed to explore the potential application of SFCD in evaluating current sodium guideline values established under GSO 2612:2025 across different food categories. Specifically, this study applied a food composition distribution-based approach to characterize the distribution of sodium concentrations and examine their relationship with existing guideline limits.

2. Methods

2.1 Method Overview

This study developed a food composition distribution-based Approach for evaluating sodium guideline values across food categories. [21]. This approach characterized the distribution of sodium concentrations within each food subgroup and evaluated these distributions in relation to the corresponding sodium guideline limits. The proportion of foods complying with the established sodium guidelines was then estimated using the cut-point approach [27, 28].

As illustrated in Fig. 1, the workflow of the distribution-based method comprised five sequential steps: 1) extraction of food items and their sodium concentrations from the SFCD; 2) exclusion of foods without a corresponding sodium limit in GSO 2612:2025; 3) classification of eligible foods according to the food subgroups defined in the standard; 4) descriptive analysis of sodium concentrations, followed by modeling of subgroup-specific sodium distributions using Monte Carlo (10,000 iterations); and 5) application of a probabilistic cut-point analysis to estimate the proportion of foods below the corresponding sodium limit within each subgroup. This workflow enabled the identification of food subgroups in which the observed sodium distribution may support the consideration of lower guidance limits for sodium intake.

Based on this distribution-based approach, the observed sodium distributions provide a basis for interpreting the potential applicability of lower sodium targets within different food subgroups. A higher proportion of foods below the established sodium limit was considered indicative of a greater potential for adopting a lower-sodium target. Accordingly, the proportion of foods meeting the current sodium guidelines was used as an indicator to evaluate the potential applicability of lower sodium targets in different food categories.

2.2 Sodium Guidelines limits and Food Classification

This study used food categories with established sodium guideline limits defined in GSO 2612:2025 [14]. These guidelines classify foods into major food categories to facilitate the evaluation of sodium content in similar products. These categories include meat products, soy products, breakfast products, cheese products, milk products, nuts, oils and fats, cooked and canned products, ready meals, soups and appetizers, fish products, snack foods, biscuits, and pastries. Each major category is further divided into specific food subgroups.

A sodium limit was assigned to each food subgroup and expressed as milligrams of sodium per 100 g of the food product. These values serve as reference limits for evaluating the sodium levels in food products. Sodium guideline values were established based on international sodium reduction frameworks, including the WHO Global Sodium Benchmark and the United Kingdom Salt Reduction Targets for 2024 [16, 17].

2.3 Data Sources and Data Extraction

The data were primarily extracted from the SFCD, a national source for Saudi food composition data developed by the National Nutrition Committee at the SFDA [21, 22]. The SFCD was established as an electronic system for compiling and organizing national food composition data, with its first version being launched in 2026.

The database contains approximately 2,800 foods and traditional Saudi dishes from various food groups, including fruits, vegetables, and cereal products. Many of these food groups and their classifications correspond to those specified in GSO 2612:2025 [14]. This alignment facilitated the mapping of SFCD food items to the relevant categories and subgroups defined in the standard and supported subsequent subgroup analyses.

2.4 Food Inclusion and Exclusion Criteria

As shown in Fig. 1, the SFCD initially included 2,800 food items. After grouping the foods by food type, 1,010 food items were selected for analysis. Foods of the same type were then grouped. For example, different types of bread,

such as white and whole-grain bread, were grouped as the same food type.

The variability in sodium content among these foods was retained and represented in the modeled distribution from the 2.5th to the 97.5th percentile range. Foods with different preparation or cooking methods were kept separate when they had separate food categories or sodium limits in GSO 2612:2025 [14]. Thus, foods were kept separate when the standard assigned them to different categories or specified different sodium limits.

Following alignment with the food categories specified in GSO 2612:2025, 305 of the 1,010 food items corresponded to categories with established sodium limits. These food items were retained for subsequent analysis. Food items with unspecified sodium limits were excluded from the study.

The main purpose of food grouping was to align the SFCD data with the food categories defined in the SFDA Guidelines. For example, when the standard specifies a sodium limit for bread regardless of its type, different bread types are grouped together. This approach allowed the SFCD data to be directly matched with food categories and sodium limits specified in the standard.

2.5 Statistical Analysis

Descriptive analyses were conducted to characterize sodium concentrations within each food subgroup using the 2.5th, 25th, 50th, 75th, and 97.5th percentiles. These percentiles were used to describe the variability in sodium concentrations and the position of the GSO 2612:2025 sodium limit within the observed distribution. Subsequently, the mean and standard deviation of each subgroup were used to model sodium distributions using Monte Carlo.

A cut-point analysis was then applied, as illustrated in Fig. 2. The sodium limit was treated as the cut-point, and the proportion of the modeled distribution below this value ($p\%$) was calculated for each food subgroup. The remaining proportion ($1 - p\%$) represented values above the sodium limit.

3. Results

3.1 Sodium Content in Relation to Regulatory Limits

Figure 3 shows substantial variation in sodium content across the evaluated food categories when compared with the GSO 2612:2025 sodium limits. Several food groups showed mean sodium concentrations above their corresponding regulatory limits. The most pronounced difference was observed for flavor enhancers, with a mean sodium content of 12,060 mg/100 g and a maximum value of 16,800 mg/100 g, compared with a regulatory limit of 360 mg/100 g. Mashed potatoes also showed a relatively high mean sodium content of 490 mg/100 g compared with its limit of 60 mg/100 g. Similarly, fresh cheese had a mean sodium content of 740 mg/100 g relative to a limit of 190 mg/100 g, while dried beverage powders had a mean of 215 mg/100 g compared with a limit of 55 mg/100 g.

Significant within-category variability was also evident across several groups. Canned fish showed a particularly wide range of sodium concentrations, extending from 43 to 5,870 mg/100 g. Cooking sauces and pastes ranged from 0 to 5,500 mg/100 g, while soups ranged from 11 to 3,740 mg/100 g. These wide ranges indicate substantial heterogeneity in sodium content among individual foods within the same regulatory category.

3.2 Modeled Sodium Distributions in Relation to Regulatory Limits

As shown in Table 1, the pattern observed in Fig. 3 was maintained following Monte Carlo modeling. Food subgroups with higher sodium concentrations generally remained elevated relative to their corresponding sodium limits. Subgroups with greater within-category variability also showed wider modeled distributions. Detailed scatter plots

showing the modeled distributions, percentile levels, and sodium limits for all food subgroups are provided in Appendix 1 (Figures A1–A3).

3.3 Cut-Point Assessment of Foods Below Regulatory Sodium Limits

As shown in Table 1, cut-point analysis showed substantial variation in the proportion of modeled values below the corresponding sodium limits. No modeled values fell below the limit for several subgroups, including fresh cheese, processed cheese, puffed grain snacks, salted popcorn, sweetened popcorn, and flavor enhancers. The same result was observed for nut butters, ketchup, hot pepper sauce, and mashed potatoes. However, each of these subgroups was represented by a single food item.

Low proportions below the sodium limit were also observed for beans in tomato sauce (6%), prepared vegetables (11%), bread products (14%), and dry beverage powders (18%). Proportions below 30% were observed for sausage products (22%), cakes, muffins, and donuts (23%), sweet biscuits (23%), soups (24%), canned fish (25%), puddings and desserts (26%), brown, curry, and BBQ sauces (27%), and cooking sauces and pastes (29%).

In contrast, more than 90% of the modeled values were below the corresponding sodium limits in several subgroups. These included animal ghee, potato chips, minimally processed cereals, vegetarian burgers, pastries and pies, and pasta. Values of 99–100% were observed for minced meat, full- and low-fat labneh, frozen pizza, mayonnaise, and salted sweetened nuts.

4. Discussion

4.1 Key Findings and Implications

This study developed a food composition distribution-based approach for evaluating current sodium guideline limits across different food categories. The proposed approach integrates the SFCD with distribution modeling analysis. This approach provides additional evidence for assessing sodium guideline values across foods currently available in Saudi Arabia. It may also provide an alternative approach to dietary surveys for establishing sodium targets for food products according to predefined reduction goals.

Among the food subgroups, 12 had at least 90% of their foods with modeled sodium values below the respective sodium limit. These proportions ranged from 93% for pasta (limit: 230 mg/100 g) to 100% for minced meat, full- and low-fat labneh, frozen pizza, and mayonnaise (limits: 260–500 mg/100 g). In contrast, 22 subgroups had $\geq 70\%$ of modeled values above their respective sodium limits, ranging from 71% for cooking sauces and pastes (limit: 330 mg/100 g) to 100% for 10 subgroups, with sodium limits ranging from 60 to 720 mg/100 g. These results suggest that lower sodium limits may be considered, particularly for the 12 subgroups with $\geq 90\%$ of foods already below the current limit.

4.2 Strengths and Limitations

This study had several strengths. First, it introduced a food composition distribution-based approach for evaluating sodium guideline limits across food categories. This approach may provide an alternative analytical framework for countries without nationally representative dietary surveys. It can be applied when food composition databases are available. Second, the proposed framework incorporates uncertainty and variability through Monte Carlo modeling. This allowed the analysis to characterize sodium distributions within food subgroups. It also reduced reliance on average values alone, as commonly used in deterministic approaches.

Despite these strengths, several limitations must be considered. The analysis was based on a national food composition database. Therefore, the findings should be interpreted at the population level. The database was not designed to represent specific geographic regions or demographic subgroups. Consequently, the included foods may not equally reflect all regions or population groups in Saudi Arabia. Evaluating sodium distributions for specific age groups or geographic regions requires more detailed dietary data. Therefore, this limitation is primarily related to data availability rather than the analytical framework itself.

4.3 Applications and Future Directions

The findings of this study extend beyond the direct assessment of sodium guideline values and demonstrate the potential applicability of the proposed approach. One potential application involves integrating the estimated sodium distributions with dietary consumption models to evaluate the impact of existing or proposed sodium targets on population intake. This approach could be incorporated into established dietary assessment models [29–31]. Thus, providing a quantitative framework for evaluating future sodium reduction scenarios.

The distribution-based approach may also support the development and refinement of national dietary guideline in Saudi Arabia. Integrating the estimated sodium distributions into models such as the Saudi Healthy Plate 2024 (SHP-2024) could improve the evaluation of sodium intake across different dietary patterns [31]. Furthermore, this may support future updates to national dietary recommendation.

Another potential application involves supporting ongoing sodium reduction initiatives in Saudi Arabia. Previous studies have described several complementary strategies, including public awareness campaigns, front-of-package nutrition labeling, category-specific sodium targets, and food reformulation programs [32]. Integrating the estimated sodium distributions with these initiatives could help identify food categories with the greatest potential for sodium reduction and support the prioritization of future reformulation efforts.

This approach may be particularly valuable for food groups currently classified within broad regulatory categories. Substantial variability in sodium content was observed across several food categories in the present study, suggesting that additional subgroup classifications may improve the development of future sodium targets. Establishing subgroup-specific targets based on the actual distribution of sodium within foods could provide a more precise and evidence-based approach to sodium reduction.

Food-labeling strategies may represent another important application. Different front-of-package labeling systems have been shown to influence consumer food choices [33, 34]. A computational modeling studies conducted in Saudi Arabia have demonstrated the potential effects of front-of-package labels on dietary intake and consumer behavior [9]. In addition, labeling systems based on daily reference values may improves total daily nutrient intake. Integrating sodium distributions with alternative labeling strategies may therefore provide a useful framework for evaluating potential policy interventions before implementation [9].

Integrating the current findings with the Saudi Food Composition Tables may provide additional opportunities for evaluating recipe reformulation strategies in traditional Saudi foods [34]. The database includes standardized recipes and laboratory-derived nutrient profiles for 130 traditional Saudi dishes representing different regions of the Saudi Arabia. Combining these data with the proposed approach could facilitate the evaluation of ingredient substitution scenarios. Moreover, this may provide quantitative estimates of changes in sodium content following recipe modifications while preserving the nutritional and cultural characteristics of traditional Saudi foods [35].

Patterns of beverage consumption in Saudi Arabia may provide an additional opportunity for applying the proposed approach to sodium reduction policies. Variations in beverage consumption across population groups suggest that

treating beverages as a single regulatory category may not adequately capture differences in dietary exposure [36]. Integrating consumption data with sodium distributions could support the development of more refined beverage classifications and contribute to the prioritization of future sodium reduction strategies.

5. Conclusions

The proposed food composition distribution-based approach provided additional evidence for evaluating sodium guideline values across different food categories in Saudi Arabia. The observed variability in sodium distributions suggests that the applicability of current sodium limits differs across food subgroups and that lower targets may be achievable in selected categories.

Abbreviations

GSO Gulf Standardization Organization

NCDs Non-Communicable Diseases

SFCD Saudi Food Composition Database

SFCT Saudi Food Composition Tables

SFDA Saudi Food and Drug Authority

SHP-2024 Saudi Healthy Plate 2024

WHO World Health Organization

Declarations

“The views expressed in this study are those of the authors and do not necessarily reflect those of the SFDA or its stakeholders. Guaranteeing the accuracy and validity of the data was the responsibility of the research team.”

Ethics approval and consent to participate: Not applicable.

Consent for publication: Not applicable.

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Competing interests: The authors declare that they have no competing interests.

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Author contributions: Conceptualization, OA and GF; methodology, OA, GF, SA, SA2 and MA; formal analysis, OA; writing—original draft preparation, OA, GF, SA, Sa2 and MA; writing—review and editing, OA, GF, SA, SA2 and MA; supervision, OA and MA ; project administration, OA and MA. All authors have read and agreed to the final version of the manuscript.

Acknowledgements:

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Table 1

Table 1 is available in the Supplementary Files section.

Figures

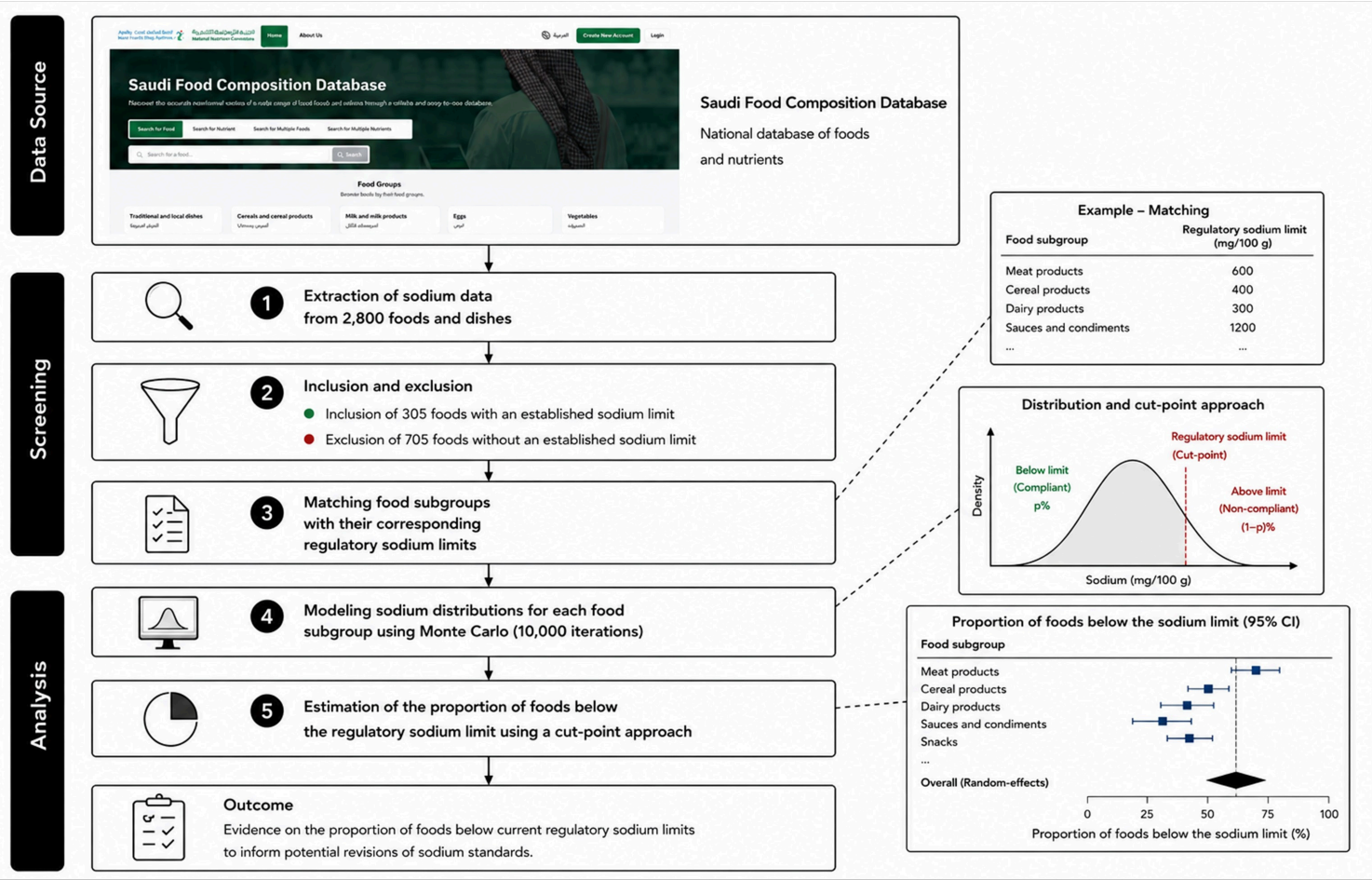


Figure 1

Workflow for Evaluating Sodium Guideline Limits Using a Food Composition–Based Distribution Analysis

Distribution and cut-point approach

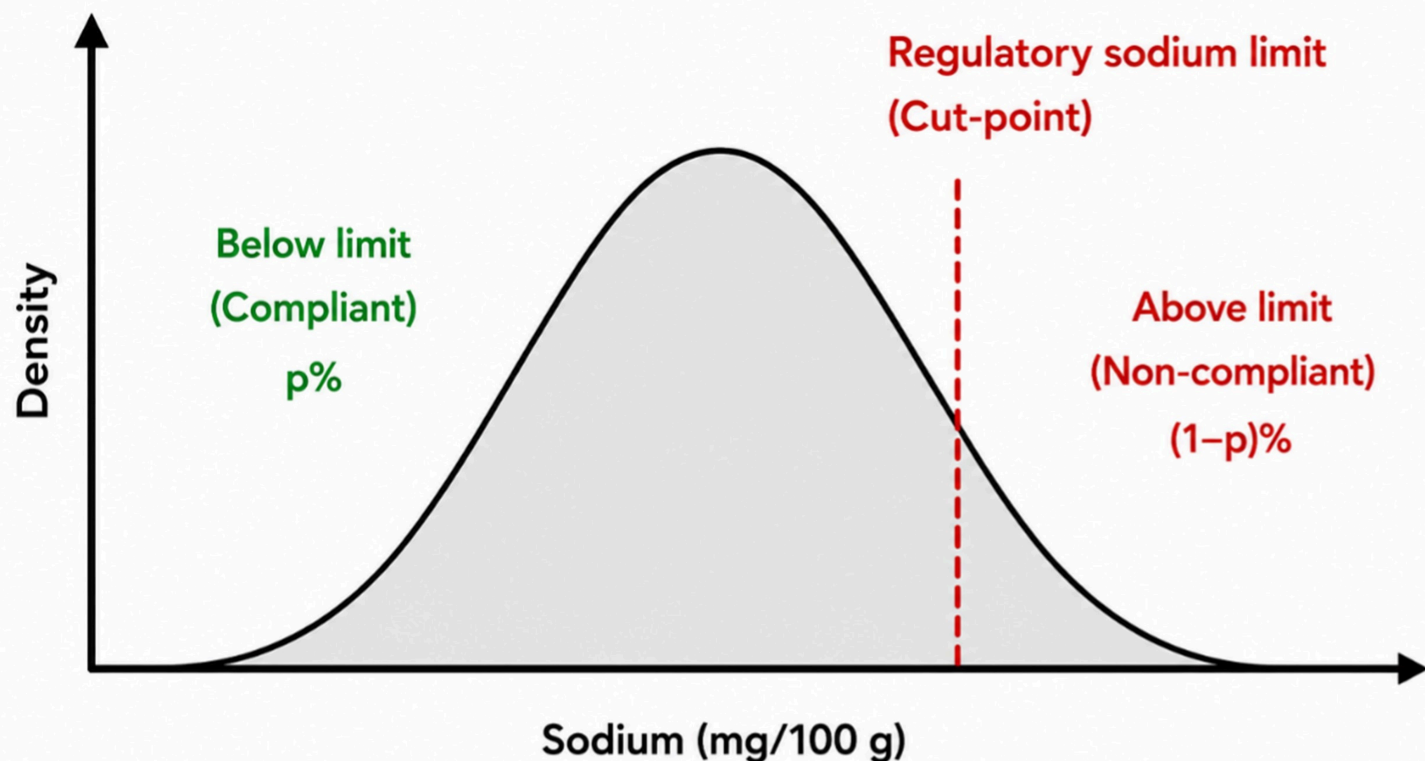


Figure 2

Probabilistic Cut-Point Approach for Assessing Sodium Distributions Relative to Regulatory Limits

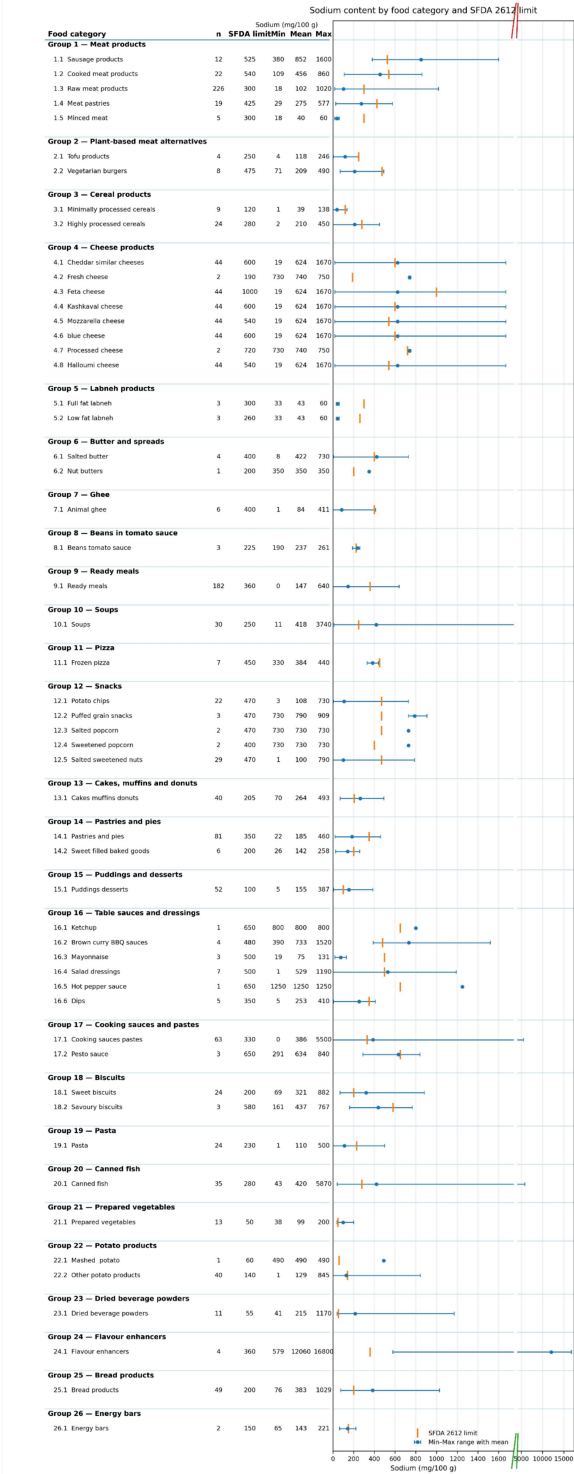


Figure 3

Sodium content across food categories in relation to GSO 2612:2025 Sodium Limits

Supplementary Files

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- [Table1.docx](#)