Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Modeling the Public Health Impact of Sodium Reduction in Nigerian Bread: An Intake Assessment and Risk Reduction Simulation Analysis

CHRISTOPHER ENASOR FREGENE

chrisfregene@gmail.com

UNIABUAJ https://orcid.org/0009-0005-0126-6104

Dike Bevis Ojji

Uniabuja

Abimbola Opeyemi Adegboye

Federal University of Technology

Research Article

Keywords:

Posted Date: July 16th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10371488/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: The authors declare no competing interests.

Abstract

• Background

Excess dietary sodium is a key driver of hypertension and cardiovascular diseases (CVDs). In Nigeria, commercially baked bread is a vital, universally consumed staple food. This paper evaluates the sodium content of popular bread brands in Lagos, Nigeria against global standards, analyzes the economic, trade, and technical implications of mandatory policy shifts, and simulates the age-stratified public health impact of regulatory reform.

• Methods

Sodium levels from 11 prominent Nigerian bread brand labels were benchmarked against the World Health Organization (WHO) global sodium benchmark for leavened bread (370 mg/100g) and the WHO Nutrient Profile Model (NPM) for marketing restrictions (250 mg/100g). A risk reduction simulation model was deployed using age-stratified consumption baselines—an adult daily baseline of 150g and a child daily baseline of 75g—to estimate population-level exposure shifts across two progressive regulatory scenarios.

• Results

The baseline mean sodium content across the analyzed brands was critically high at 597.91 mg/100g (range: 132.00–900.00 mg/100g), with 90.9% of brands violating both the global benchmark and child-centric NPM limits. At baseline, eating 150g of bread yields a daily adult sodium load of 896.86 mg (44.8% of the total daily limit recommended by the WHO), while a child consuming 75g experiences a daily load of 448.43 mg (37.4% of the pediatric limit). Under Scenario 1 (reformulation capping all brands at the 370 mg/100g benchmark), adult daily exposure dropped to 522.55 mg and child exposure to 261.27 mg (41.7% reduction). Scenario 2 (reformulation to the 250 mg/100g NPM limit) slashed daily exposure by 60.0% across both demographics (adults: 358.91 mg; children: 179.45 mg).

• Conclusion

Bread in Nigeria is a hidden, massive vector for dietary sodium across all age groups. Implementing mandatory absolute target thresholds—rather than arbitrary percentage reduction strategies like a 30% flat reduction—presents a highly effective, scalable structural mechanism to lower cardiovascular disease burdens. However, policies must carefully navigate industrial cost pressures and regional trade dynamics within West Africa to ensure long-term sustainability.

Background

Non-communicable diseases (NCDs), particularly cardiovascular diseases (CVDs), are accelerating rapidly across Sub-Saharan Africa [1]. In Nigeria, hypertension affects over 30% of the adult population, driven heavily by rapid urbanization and transitioning dietary profiles [2]. Elevated dietary sodium intake

is directly tied to elevated blood pressure, stroke, and arterial stiffness [3]. The World Health Organization recommends an absolute daily restriction of less than 2,000 mg of sodium (5g of salt) per adult, and a further reduced limit scaled down proportionally based on energy requirements for children (typically capped around 1,200 mg/day for young children) [4].

While discretionary table salt has historically been blamed for high sodium consumption in Africa, the rapid commercialization of the food supply chain has shifted the burden toward hidden sodium in processed foods [5]. In urban Nigeria, bread has transitioned from a luxury item to an indispensable, highly accessible staple food consumed daily across all socio-economic strata [6]. Because bread is eaten regularly and in large portions, it serves as a major, silent driver of population-wide chronic sodium exposure, threatening not only adults but also establishing early-onset cardiovascular risks in children.

To address this, the WHO introduced Global Sodium Benchmarks, setting a threshold of 370 mg/100g specifically for leavened bread [7]. Additionally, the WHO Regional Nutrient Profile Models (NPM) established a stricter ceiling of 250 mg/100g (0.25g/100g) to govern marketing and advertising to children [8]. This paper provides a case perspective evaluating the current sodium architecture of commercially available bread in Nigeria, models age-stratified exposure risks, and critiques the viability of relative percentage reductions. Furthermore, it outlines the trade, economic, and industrial implications of these proposed regulatory shifts, contrasting the local landscape with active interventions in other Low- and Middle-Income Countries (LMICs).

Methodology

Data Sources and Sample Profiling

Nutritional profile data from 11 prominent bread brands widely distributed in Nigerian retail markets were compiled. Table 1 shows the dataset that includes a diverse mix of classic white loaves, premium butter formulations, and whole-wheat alternatives:

Table 1
Sodium content of bread in Lagos, Nigeria

S/N	Brand name	Sodium content (g per 100 g)
1	Fluffy dough white bread	0.5
2	English oven 100% whole wheat bread	0.9
3	Butterburst wheat bread	0.132
4	Sosoft classic white bread	0.9
5	Butterburst premium bread	0.9
6	Bokku	0.5
7	Remsil soft white bread	0.5
8	Classic cream	0.41
9	Top taste	0.5
10	Butter rich bread	0.435
11	SP Royal super loaf	0.9

Age-Stratified Intake Assessment and Risk Modeling

All values were converted from grams to milligrams (mg) per 100g of product. To accurately reflect different life-stage vulnerabilities, the risk model implements an age-stratified dietary tracking framework based on West African urban baseline consumption metrics [9–10]:

- **Adult Cohort Intake**: Fixed at a baseline of **150g** of bread per individual per day.
- **Child Cohort Intake**: Fixed at a baseline of **75g** of bread per individual per day (representing a typical portion size for pediatric populations aged 2–10 years).

The age-stratified daily sodium contribution from bread was calculated using the equation:

Daily Sodium Intake (mg) = ((Mean Sodium Content (mg/100g) ÷ 100) × Portion Size (g))

Risk Reduction Simulation Framework

Two independent, policy-driven simulation models were built to evaluate the impact of mandatory reformulation across both demographics:

- **Scenario 1 (WHO Global Benchmark Compliance)**: Outliers exceeding the WHO limit were mathematically capped at exactly 370 mg/100g. Brands already below this threshold remained unchanged.

- **Scenario 2 (WHO Child-Centric NPM Compliance)**: Outliers exceeding the marketing restriction limit were capped at exactly 250 mg/100g. Brands below this ceiling remained unchanged.

Results and Discussion

Baseline Analytical Assessment

The descriptive statistical breakdown shows that the vast majority of commercial bread options in Lagos, Nigeria contain highly elevated sodium levels:

Parameter	Value
Mean Sodium Content	597.91 mg/100g
Median Sodium Content	500.00 mg/100g
Minimum Sodium Content	132.00 mg/100g (*Butterburst wheat*)
Maximum Sodium Content	900.00 mg/100g (*Multiple Brands*)
Proportion Exceeding WHO Benchmark (370 mg/100g)	**90.91%** (10/11 brands)
Proportion Exceeding WHO NPM Ceiling (250 mg/100g)	**90.91%** (10/11 brands)

Four major brands (*English oven 100% whole wheat, Sosoft classic white, Butterburst premium, and SP Royal super loaf*) exhibit a sodium density of 900 mg/100g. This is nearly 2.5 times higher than the maximum global recommendation. Only one specialty brand (*Butterburst wheat bread*) currently complies with both international standards.

Age-Stratified Simulation Model Outcomes

The risk reduction simulation models show that proactive structural changes would significantly lower population-wide sodium exposure, yielding equivalent relative protection to both adults and pediatric populations:

========== **ADULT PORTION MODEL (150g)** ==========
Baseline Profile: 597.91 mg/100g

[==========] **Daily Load: 896.86 mg**

Scenario 1 (WHO Benchmark Cap: 370 mg/100g)

[==========] **Daily Load: 522.55 mg (-41.7% Reduction)**

Scenario 2 (WHO NPM Cap: 250 mg/100g)

[==========] **Daily Load: 358.91 mg (-60.0% Reduction)**

========== **CHILD PORTION MODEL (75g)**==========

Baseline Profile: 597.91 mg/100g

[==========] **Daily Load: 448.43 mg**

Scenario 1 (WHO Benchmark Cap: 370 mg/100g)

[==========] **Daily Load: 261.27 mg (-41.7% Reduction)**

Scenario 2 (WHO NPM Cap: 250 mg/100g)

[==========] **Daily Load: 179.45 mg (-60.0% Reduction)**

Demographic Impact Analysis

1. Adult Demographic Impact (150g Daily Consumption):

- **Baseline Exposure**: At current composition levels, eating a standard adult portion generates a hidden sodium load of **896.86 mg**, consuming **44.8%** of an adult's entire daily healthy allowance.
- **Impact of Scenario 1**: Enforcing the WHO benchmark lowers the mean sodium concentration across these brands to 348.36 mg/100g. This change drops the daily adult sodium load down to **522.55 mg**, preventing **374.32 mg** of unnecessary sodium intake every day (**41.7%** reduction).
- **Impact of Scenario 2**: Applying the stricter child protection standard creates a highly safe nutritional footprint, bringing the mean down to 239.27 mg/100g. The adult daily sodium load drops to **358.91 mg**, achieving a **60.0%** reduction (**537.95 mg** saved daily) compared to baseline.

2. Child Demographic Impact (75g Daily Consumption):

- **Baseline Exposure**: Pediatric ingestion of a smaller 75g daily baseline portion still yields a dangerous sodium burden of **448.43 mg**. Given a child's lower safe physiological limit (~ 1,200 mg/day), this singular, ordinary food item claims **37.4%** of their entire daily allowance. This early exposure heavily patterns gustatory preferences for high salt and increases the risk of early-onset juvenile hypertension.
- **Impact of Scenario 1**: Implementing the WHO benchmark reduces daily pediatric intake to **261.27 mg**. This eliminates **187.16 mg** of unneeded sodium exposure every day (**41.7%** reduction), preserving precious margins for other essential foods.
- **Impact of Scenario 2**: Adhering strictly to the marketing constraint limit provides optimal pediatric protection. The child daily load drops to a safe level of **179.45 mg**, a massive **60.0%** structural reduction that completely reshapes the nutritional safety of school-age diets.

Critical Evaluation: Why a 30% Reduction Standard Will Not Work

A common alternative regulatory strategy relies on a flat, across-the-board percentage reduction framework (e.g., requiring all manufacturers to cut existing sodium levels by 30%). While visually simple, this relative approach is scientifically and operationally flawed for bread:

1. **Failure to Stabilize Ultra-High Outliers**: For heavily salted products like *English oven 100% whole wheat*, *Sosoft classic white*, *Butterburst premium*, and *SP Royal super loaf* (all sitting at 900 mg/100g), a relative 30% reduction only reduces their final content to **630 mg/100g**. This modified value remains dangerously high, exceeding the WHO global maximum threshold (370 mg/100g) by over 70%. It falls short of providing meaningful protection for high-volume consumers.
2. **Penalizing Healthy Reformulation Leaders**: A blanket relative percentage target discriminates against socially responsible companies that have already invested capital into low-sodium profiles. For example, *Butterburst wheat bread* operates at an excellent baseline of 132 mg/100g. Forcing a further mandatory 30% cut on this brand would drag its level down to **92.4 mg/100g**. At this extremely low level, the dough loses the technical ionic strength required for cross-linking gluten structures, disrupting yeast fermentation kinetics and rendering the loaf commercially unbakable.
3. **Institutionalizing Market Inequities**: A relative target fails to create a flat, standardized playing field. Instead, it rewards bad actors. Manufacturers that have historically over-salted their loaves retain an artificial, highly addictive flavor advantage over premium, health-conscious alternatives. Establishing fixed, absolute metric ceilings (maximum mg of sodium per 100g of bread) remains the only scientifically viable path to shift a population food environment safely.

Economic Impact and Trade Implications

ECONOMIC & TRADE REFORMULATION ACCORD	
INDUSTRIAL COST IMPLICATIONS	**REGIONAL TRADE DYNAMICS (AfCFTA)**
• Yeast/Leavening Adjustments	• Standard Harmonization Barriers
• Extended Proofing Cycle Times	• ECOWAS Porous Border Leakage
• Shelf-Life Preservative Swaps	• Protectionist Informal Imports
POPULATION HEALTHCARE RETURN ON INVESTMENT	
• Slashed Stroke & Hypertension Costs	
• Protected Macroeconomic Productivity	

Industrial Cost and Operational Realities

In industrial baking, sodium chloride (salt) serves as a multi-functional ingredient rather than just a flavor enhancer. It controls yeast fermentation rates, strengthens gluten matrices to trap carbon dioxide, and

lowers water activity to inhibit mold growth [11].

- **Production Adjustments**: Forcing a sudden drop in sodium levels requires manufacturers to extend their dough-proofing times to avoid structural collapse. This lengthens production cycles and lowers daily factory output volumes.
- **Preservative Costs**: To offset the lost shelf-life protection from lower salt levels, bakeries must substitute sodium with more expensive chemical alternatives, such as calcium propionate.
- **Equipment Upgrades**: Smaller, informal local bakeries lack automated micro-dosing machinery. This makes precision sodium management highly difficult, introducing a financial barrier that could squeeze out smaller operators and consolidate market power toward larger industrial conglomerates.

Trade Dynamics and AfCFTA Alignment

As a leading economic force within the Economic Community of West African States (ECOWAS) and a key participant in the African Continental Free Trade Area (AfCFTA), Nigeria's food regulations have major cross-border trade implications [12–13]:

- **Porous Border Leakage**: If Nigeria unilaterally enforces strict, mandatory sodium targets without broad regional agreements, it risks creating an unlevel playing field. Neighboring nations with looser guidelines could flood Nigerian border towns with cheaper, high-sodium informal imports.
- **Export Barriers**: Conversely, if Nigerian industrial bakeries modify their products to meet local low-sodium targets, they may struggle to export those goods to regional markets where consumers still prefer traditional, higher-salt flavor profiles.
- **The Need for Regional Harmonization**: To avoid creating hidden trade barriers, NAFDAC must coordinate with the ECOWAS Standards Harmonization Model (ECOSHAM). Aligning these targets ensures that food safety standards support, rather than hinder, continental trade growth.

Macroeconomic Healthcare Return on Investment

The initial compliance and reformulation costs absorbed by the private sector are heavily outweighed by broad public sector healthcare savings [14]:

- **Slashed Treatment Costs**: Treating chronic hypertension, kidney failure, and stroke drains billions of Naira annually from both household budgets and public healthcare systems.
- **Protected Productivity**: Because dietary risks disproportionately trigger cardiovascular events during an individual's peak working years, lowering population-wide sodium intake directly preserves national human capital and macroeconomic productivity.

Comparative LMIC Regulatory Landscape

Nigeria's current loose regulatory framework stands in stark contrast to several forward-thinking LMICs that have successfully integrated mandatory processed food caps into law:

- **South Africa**: A pioneer in African food policy, South Africa passed mandatory sodium reduction regulations (R.242) targeting staples like bread. The country systematically lowered permissible limits in bread from 400 mg/100g down to 380 mg/100g. This mandate yielded measurable, population-wide drops in blood pressure and saved millions in public healthcare stroke treatments [15].
- **Argentina & Chile**: Argentina implemented a comprehensive law (Law 26.905) setting strict maximum steps for sodium in bread alongside mandatory front-of-package warning labels. Chile's famous "Stop Sign" black warning labels apply directly to any product exceeding 400 mg of sodium per 100g, forcing widespread corporate reformulation to preserve sales [16].
- **Brazil**: Brazil relies on a highly successful voluntary partnership model with national food industry associations. Through synchronized, multi-year targets, they have systematically removed thousands of tons of sodium from commercial bread lines without triggering consumer pushback regarding taste [17].

Conclusion and Policy Recommendation

The current formulation profiles of commercial bread in Lagos, Nigeria represent a significant, unaddressed threat to public health nutrition across multiple generations. With over 90% of sampled brands far exceeding international health guidelines, both adults and young children are unknowingly consuming dangerous levels of sodium daily through an ordinary staple food. Relative percentage-based reduction targets are inadequate for high-sodium outliers and penalize healthier brands. The simulation models confirm that implementing basic absolute mandatory caps would immediately eliminate a massive portion of excess population-wide sodium exposure, yielding protective health margins across all demographics.

Strategic Policy Recommendations

1. **Enact Mandatory Absolute National Targets**: NAFDAC should phase in a clear, statutory sodium ceiling for leavened bread, targeted at ≤ 370 mg/100g, completely avoiding flawed percentage-reduction frameworks.
2. **Launch "Silent Reformulation" Subsidies**: Provide temporary fiscal relief or tax incentives on alternative dough conditioners (e.g., calcium propionate, potassium chloride) to offset industrial cost increases for small-and-medium enterprise bakeries.
3. **Advocate for ECOWAS Standards Harmonization**: Nigeria should lead regional trade policy discussions within ECOSHAM to create uniform West African sodium limits, preventing cross-border smuggling of non-compliant baked goods.
4. **Implement Front-of-Package Labeling (FOPL)**: Nigeria should implement distinct front-of-pack warning icons for foods high in sodium. This empowers consumers to make informed choices and

encourages manufacturers to reformulate their products to avoid warning labels.

5. **Enforce Marketing Restrictions and Pediatric Protection**: Protect younger populations by aligning policies with the WHO NPM guidelines. This includes banning high-sodium bread products (> 250 mg/100g) from school feeding initiatives and restricting their commercial advertisement to children.

Declarations

- **Ethics Approval:** Not applicable. This study utilizes public, secondary nutritional data and does not involve human subjects or animal tissue.
- **Consent for Publication:** Not applicable.
- **Availability of Data and Materials:** All data analyzed during this study are included within this published article.
- **Competing Interests:** The author declares no competing financial or institutional interests.
- **Funding:** This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.
- **Authors' Contributions:** Single-authored work. The author performed data extraction, statistical calculations, simulation modeling, and drafted the manuscript.

References

1. World Health Organization Regional Office for Africa. Deaths from noncommunicable diseases on the rise in Africa. Brazzaville: World Health Organization (2022) Available from: https://www.afro.who.int/news/deaths-noncommunicable-diseases-rise-africa
2. Nwankwo T et al (2026) Prevalence of hypertension among adults in Nigeria: a systematic review and meta-analysis. PubMed/NIH Repository
3. Farquhar WB, Edwards DG, Jurkovitz CT, Satoskar AA (2015) Dietary Sodium and Health: More Than Just Blood Pressure. J Am Coll Cardiol 65(10):1042–1050. 10.1016/j.jacc.2014.12.039
4. World Health Organization (2012) Guideline: Sodium intake for adults and children. World Health Organization, Geneva. Report No.: WHO/NMH/NHD/13.2
5. Gouda HN, Charlson F, Sorsdahl K et al (2019) Burden of non-communicable diseases in sub-Saharan Africa, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet Glob Health 7(10):e1375–e1387. 10.1016/S2214-109X(19)30366-0
6. Nexdigm (2024) *Nigeria Bakery Products Market Outlook to 2035: Rapid Urbanization and Shifting Consumer Habits Support Packaged Food Demand*. Mumbai: Nexdigm Market Research Store; Available from: https://www.nexdigm.com/market-research/report-store/nigeria-bakery-products-market/

7. World Health Organization. WHO global sodium benchmarks for different food categories, 2nd ed. Geneva: World Health Organization (2024) Available from: https://www.who.int/publications/i/item/9789240092013
8. World Health Organization Regional Office for Africa (2019) Nutrient Profile Model for the WHO African Region: A tool to protect children from the marketing of unhealthy foods and non-alcoholic beverages. World Health Organization Regional Office for Africa, Brazzaville
9. Alawode OA et al (2025) Availability, healthiness and sodium content of packaged and processed foods in Nigerian retail markets: a cross-sectional benchmarking study. BMC Public Health 10(1186):s41043
10. Sanusi RA et al (2024) Portion and Serving Sizes of Commonly Consumed Foods, in Household Measures, in Nigeria. Afr J Biomedical Res 27(2):145–152
11. Belz MC, Ryan LA, Arendt EK (2012) Salt reduction in baked products: Strategies and constraints. Trends Food Sci Technol 26(2):98–112. 10.1016/j.tifs.2012.01.001
12. Munich Personal RePEc Archive (2025) Impact of Tariff and Non-Tariff Barriers on Food Security in the ECOWAS Region. MPRA Paper 123114(1):15–28
13. Joint Research Framework. The impacts of the African Continental Free Trade Area on the Nigerian economy: an agri-food focus. ResearchGate / MAGNET & DEMETRA Joint Research Framework (2024) ;09:383681927
14. Basese M et al (2013) Salt reduction as a population-based intervention for the prevention of cardiovascular diseases: an economic assessment. Lancet 382(1):S7. 10.1016/S0140-6736(13)62605-7
15. South African National Department of Health (2013) Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act 54 of 1972): Regulations relating to the reduction of sodium in certain foodstuffs and related matters (Regulation R.214). Government Gaz. ;36274(Government Notice No. R.214). [Amended via Gazette 41164, Notice 1071].
16. Allemandi L et al (2019) Progress and challenges in the implementation of sodium reduction policies in Argentina and Chile: a comparative evaluation. Health Policy Plan 34(4):290–298. 10.1093/heapol/czz031
17. Nilson EA, Jaime PC, Resende DO (2017) Sodium Reduction in Processed Foods in Brazil: Analysis of Food Categories and Voluntary Targets from 2011 to 2017. Nutrients 9(7):740. 10.3390/nu9070740