

The Volumetric Loophole: Why 'Less Sugar' Comparative Claims and Deceptive GDA Metrics on 500ml and 600ml Soft Drinks Exacerbate Population-Level Obesity and Dental Caries in Nigeria

Christopher Enasor Fregene

chrisfregene@gmail.com

NAFDAC <https://orcid.org/0009-0005-0126-6104>

Dike Bevis Ojji

UNIABUJA

Abimbola Opeyemi Adegboye

FUTM

Research Article

Keywords: Obesity, Dental caries, Nutrient comparative claims, Guideline Daily Amount, Free sugars, Soft drinks, NAFDAC, Nigeria

Posted Date: June 30th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10186848/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

The commercial food environment in urban Nigeria is driving a dual increase in diet-related non-communicable diseases (NCDs), particularly adult and early-onset childhood obesity, alongside severe dental caries. Beverage manufacturers are increasingly using front-of-pack nutrient comparative claims, such as "less sugar," alongside industry-led Guideline Daily Amount (GDA) panels to capture health-conscious demographics. While these labels are technically legal by achieving a relative 25% sugar reduction against outdated high-sugar baselines, this standard completely ignores the absolute sugar payload delivered by expanded 500ml and 600ml retail configurations.

Objective

To evaluate how commercial soft drinks in Nigeria carrying "less sugar" profiles (Coca-Cola, Pepsi, and 7-Up) align with or undermine the World Health Organization (WHO) guidelines for free sugar intake, and to model their direct contribution to the national burdens of obesity and dental caries.

Methods

A public health nutritional modeling and dietary intake assessment was conducted. The absolute free sugar masses for Coca-Cola (7.5 g/100ml), Pepsi (7.1 g/100ml), and 7-Up (6.9 g/100ml) were mapped across 500ml and 600ml bottles. These payloads were benchmarked against the WHO recommendation restricting free sugars to < 10% (strong recommendation) and < 5% (conditional recommendation) of daily energy intake for a standard 2,000 kcal/day adult profile (ceiling: 50 g/day) and a 1,500 kcal/day pediatric profile (ceiling: 37.5 g/day). Front-of-pack industry's 250ml GDA baseline was mathematically evaluated against WHO absolute thresholds to expose the scale of risk under-reporting.

Results

The evaluated soft drinks deliver absolute sugar payloads ranging from 34.5 g to 37.5 g per 500ml container, and 41.4 g to 45.0 g per 600ml container. A single 600ml bottle of 7-Up (6.9 g/100ml)—the lowest concentration evaluated—delivers 41.4 g of absolute sugar, instantly exhausting 82.8% of an adult's and 110.4% of a child's maximum daily allowance. For Coca-Cola, a single 600ml bottle delivers 45.0 g of sugar (90.0% of the adult and 120.0% of the pediatric daily limit). The industry's GDA label asserting that a 250ml serving contains 19g of sugar or "21% GDA" relies on an unscientific 90g daily denominator. This under-reports obesity and dental risks by more than double, as 19g actually consumes 38.0% of an adult's and 50.7% of a child's entire daily allowance.

Conclusion

Relative "less sugar" descriptors on large-volume containers mask dangerously large quantities of free sugars, creating a false sense of dietary safety that directly accelerates obesity and enamel

demineralization across Nigerian demographics. The National Agency for Food and Drug Administration and Control (NAFDAC) must prohibit relative nutrient comparative claims on large-volume packaging and replace confusing GDA panels with mandatory front-of-pack black octagonal warning labels.

1. Introduction

The West African sub-region, spearheaded by Nigeria, is undergoing an aggressive nutritional transition driven by rapid urbanization, shifting maternal labor dynamics, and the deep market penetration of fast-moving consumer goods (FMCG) corporations. This shift has fundamentally altered the national dietary risk profile, with highly processed, pre-packaged commodities largely supplanting traditional high-fiber dietary baselines [1]. Consequently, Nigeria is facing a profound public health crisis, where corporate-driven overnutrition and oral pathologies coexist within a strained health infrastructure. Specifically, obesity and dental caries have emerged as severe, interrelated national epidemics cutting across pediatric and adult populations.

Epidemiological surveys in urban Nigerian centers indicate that the prevalence of overweight and obesity among adults has reached approximately 25% to 35% in metropolitan hubs, serving as a primary upstream driver for the 31.2% national prevalence of hypertension, type-2 diabetes, and cardiovascular complications [2–3]. Concurrently, dental caries remains the single most prevalent chronic oral disease in Nigeria. Local clinical audits reveal that up to 33.5% of children and a rapidly increasing proportion of working-age adults suffer from untreated enamel decay and severe dental pain [4]. This burden directly impairs systemic nutrition, productivity, and overall oral health-related quality of life.

The primary dietary factor driving both systemic adiposity and dental caries is the high consumption of free sugars, particularly in liquid form via carbonated soft drinks. In response to growing public health awareness and civil society advocacy, beverage manufacturers have shifted toward front-of-pack nutrient comparative claims, utilizing descriptor terms like "less sugar" or "reduced sugar". Under current guidelines from Codex Alimentarius and local frameworks managed by NAFDAC, a nutrient comparative claim is deemed compliant if the nutrient content between the compared foods differs by a relative margin of at least 25%.

Furthermore, these packaging layouts incorporate industry-designed Guideline Daily Amount (GDA) badges, claiming that a discrete 250ml portion of a beverage like Coca-Cola contains 19g of sugar, representing only "21% of an adult's GDA." However, the World Health Organization (WHO) explicitly advises reducing the intake of free sugars to less than 10% of total daily energy requirements (strong recommendation), with a further reduction below 5% (approximately 25g for adults and 18.75g for children) suggested for additional systemic and dental health benefits [5–6]. This paper evaluates the commercial reality of leading soft drink brands in urban Nigeria—including Coca-Cola (7.5 g/100ml), Pepsi (7.1 g/100ml), and 7-Up (6.9 g/100ml)—to demonstrate how relative nutrient comparative claims and GDA metrics mask absolute sugar loads, thereby accelerating obesity and dental caries.

2. Methods

2.1 Sample Profiling and Volumetric Parameters

The index matrices selected for this public health modeling were prominent commercial carbonated soft drink portfolios widely distributed across retail networks, open markets, and school-adjacent kiosks in Lagos and Abuja, Nigeria:

- **Coca-Cola Original (Reformulated/Less Sugar Blend):** 7.5 g of free sugar per 100ml.
- **Pepsi Cola:** 7.1 g of free sugar per 100ml.
- **7-Up:** 6.9 g of free sugar per 100ml.

The primary retail units audited were standard 500ml and 600ml polyethylene terephthalate (PET) bottles, which are highly favored for daily consumption due to competitive market pricing.

2.2 Dietary Intake Modeling and Demographic Caloric Baselines

Dietary intake calculations converted relative sugar concentrations into the absolute cumulative mass ingested per individual single-serve retail container. The absolute payload was calculated using the formula:

$$\text{Absolute Sugar Payload (g)} = (\text{Sugar Density (g)} \div 100 \text{ ml}) \times \text{Total Packaging Volume (ml)}$$

To capture the specific health risks to different populations, the resulting absolute masses were benchmarked against the WHO guidelines for free sugars modeled across two distinct demographic energy profiles [7]:

1. **Standard Adult Baseline (2,000 kcal/day):** The WHO 10% strong recommendation restricts total free sugars to ≤ 50 g/day, while the 5% conditional health and dental protective threshold restricts free sugars to ≤ 25 g/day.
2. **Standard Pediatric Baseline (1,500 kcal/day):** The WHO 10% strong recommendation restricts total free sugars to ≤ 37.5 g/day, while the 5% conditional dental protective threshold restricts free sugars to ≤ 18.75 g/day.

2.3 GDA Mathematical Audit

The industry front-of-pack GDA statement—which asserts that a 250ml serving containing 19g of sugar contributes 21% of the daily limit—was back-calculated to expose its hidden mathematical reference base [8]. This reference base was then directly contrasted against the absolute WHO adult and pediatric metrics to map out the exact scale of consumer misdirection regarding systemic health risks.

3. Results

3.1 Absolute Ingestion Payload and Daily Value Calculations

Nutritional modeling reveals that despite meeting the relative "less sugar" designation, the absolute payload delivered by these 500ml and 600ml containers is structurally excessive. A single 500ml container delivers between 34.5 g and 37.5 g of absolute free sugar, while a 600ml container delivers an extreme payload of 41.4 g to 45.0 g of highly bioavailable liquid sugar (Table 1).

Table 1
Comparative Breakdown of True Sugar Contributions vs. WHO Daily Allowances

Brand Product Profile	Sugar Concentration	Total Bottle Volume	Absolute Sugar Mass	% Adult WHO 10% Limit (50g Max)	% Adult WHO 5% Dental Limit (25g Max)	% Child WHO 10% Limit (37.5g Max)
7-Up	6.9 g / 100ml	500 ml	34.5 g	69.0%	138.0%	92.0%
		600 ml	41.4 g	82.8%	165.6%	110.4%
Pepsi Cola	7.1 g / 100ml	500 ml	35.5 g	71.0%	142.0%	94.7%
		600 ml	42.6 g	85.2%	170.4%	113.6%
Coca-Cola	7.5 g / 100ml	500 ml	37.5 g	75.0%	150.0%	100.0%
		600 ml	45.0 g	90.0%	180.0%	120.0%

3.2 GDA Deconstruction and Public Health Distortion

The mathematical audit of the front-of-pack GDA icon reveals a deliberate dilution of nutritional risk metrics. By declaring that 19g of sugar in a 250ml serving of Coca-Cola equals "21% GDA," the industry relies on an unscientific adult denominator baseline of **90 grams of sugar per day**.

When this same 19g portion is benchmarked against evidence-based public health indicators, its true risk configuration more than doubles, obscuring the severe physiological danger it poses to human metabolism and dentition (Table 2).

Table 2
Mathematical Disconnect Between Industry GDA and WHO Health Metrics for a 250ml Portion (19g Sugar)

Evaluation Standard	Implied Daily Denominator	Calculated % Contribution of a Single 250ml Portion	Public Health Policy Ingestion Risk Status
Industry Front-of-Pack GDA	90.0 g / day	21.0%	Framed as a minor, low-risk carbohydrate allocation
WHO Adult 10% Upper Limit	50.0 g / day	38.0%	High-risk boundary (Accelerates risk of metabolic syndrome)
WHO Adult 5% Health Target	25.0 g / day	76.0%	Severe boundary (Exhausts three-quarters of daily allowance)
WHO Pediatric 10% Ceiling	37.5 g / day	50.7%	Extreme metabolic stressor (Exhausts half of a child's daily allowance)

4. Pathophysiological Mechanisms: Driving Obesity and Dental Caries

To understand why the "less sugar" nutrient comparative claim is structurally deceptive, the relative chemical reduction must be evaluated against the direct physiological damage these absolute sugar volumes cause.

4.1 Hepatic Glucose Loading and Obesity Pathways

Because these beverages are ultra-processed liquid matrices entirely devoid of dietary fiber, consumption bypasses the oral mastication signals that trigger satiety. When an individual drinks a 500ml or 600ml container, an absolute load of 34.5g to 45.0g of free sugar enters the duodenum within minutes, causing a massive, rapid spike in blood glucose. This sudden influx triggers an immediate hyperinsulinemic response from the pancreas to prevent acute systemic toxicity.

The liver is forced to process this extreme concentration of simple monosaccharides. Once hepatic glycogen stores are filled, the excess sugar undergoes rapid **hepatic de novo lipogenesis (DNL)**, converting directly into triglycerides. These lipids are subsequently deposited into visceral adipocytes, accelerating systemic fat accumulation and driving clinical obesity across age brackets. Furthermore, this frequent metabolic flooding promotes peripheral insulin resistance, establishing a direct path toward type-2 diabetes and metabolic syndrome [9]. The "less sugar" label acts as a dangerous behavioral catalyst by reducing psychological friction, encouraging frequent purchases, and fostering consumer habits that lock individuals into long-term positive energy balances [10].

4.2 Acidogenesis, Biofilms, and Dental Caries Pathways

The oral cavity serves as the immediate site of injury for these large-volume beverages. Every consumption event of a 500ml or 600ml bottle exposes the dentition to a highly concentrated sucrose and fructose environment. Highly acidogenic oral bacteria, primarily *Streptococcus mutans* and *Lactobacillus* species, rapidly ferment these free sugars within the local oral biofilm. This fermentation process generates organic acid waste products—predominantly lactic acid—directly on the tooth surfaces [11].

The rapid production of acid drives the local interdental pH far below the critical threshold of **5.5**. At this acidic level, hydrogen ions actively dissolve the mineralized hydroxyapatite matrix of the tooth enamel, causing **enamel demineralization** [12]. While healthy saliva acts as a natural buffer to wash away acids and remineralize enamel, this protective mechanism requires hours of undisturbed recovery.

Because consumers typically consume 500ml or 600ml bottles through multiple sips over extended periods (e.g., throughout a workday or school day), the oral cavity remains in a state of prolonged, continuous acid exposure (Figure 1). This constant acid bath prevents saliva from buffering the oral environment, causing unchecked enamel erosion that leads to cavitated lesions, deep pulpitis, and severe dental caries.

5. Empirical Reasons to Prohibit the "Less Sugar" Descriptor and GDA Panels

To safeguard public health and ensure regulatory transparency, NAFDAC must immediately ban the "less sugar" nutrient comparative claim and GDA panels on 500ml and 600ml product lines. The specific, empirical reasons for this prohibition include:

5.1 Exploitation of the "Health Halo" to Drive Volumetric Overconsumption

The "less sugar" descriptor exploits consumer psychology through a "health halo" effect [13]. Consumers routinely interpret comparative text as a certificate of safety, assuming a 25% reduction makes the product suitable for regular, uninhibited consumption. This cognitive distortion removes the psychological friction associated with drinking soft drinks, encouraging parents to include them in daily school lunchboxes or adults to consume them as benign refreshments. When paired with 500ml and 600ml bottles, the claim encourages overconsumption, as consumers remain unaware that the expanded package volume completely negates any relative reduction in sugar density.

5.2 Systematic Deception via the Relative Reference Baseline

The 25% relative reduction rule is inherently flawed because it relies on arbitrary, historically high baseline reference products (which exceeded 11g to 13g of sugar per 100ml). If a standard beverage formulation is exceptionally hazardous, a secondary formulation that is 25% less dense remains

dangerous. Maintaining a sugar density of 6.9g to 7.5g per 100ml means these beverages are still highly concentrated sugar solutions. Allowing a brand to claim a nutrition/health benefit based on a high baseline reference encourages an industry-wide race to the bottom, where sweet products compete for health credentials without achieving absolute public safety thresholds.

5.3 Deliberate Misdirection via Unscientific GDA Denominators

GDA panels undermine public health literacy by utilizing an unscientific reference baseline of 90g of total sugar per day. This denominator confuses consumers by blending intrinsic sugars (found in whole fruits and milk) with free, added liquid sugars. By applying this inflated 90g adult ceiling to products consumed by children and adults alike, front-of-pack labels obscure the reality that a single 250ml glass of cola actually consumes half of a child's and nearly 40% of an adult's daily safety allowance, creating a false sense of dietary safety.

6. Discussion and Policy Recommendations

The findings of this analysis demonstrate a dangerous misalignment between relative food labeling metrics and the absolute realities of public health nutrition. Regulatory frameworks that allow nutrient comparative claims and GDA panels without placing caps on the total package volume enable manufacturers to market massive absolute loads of liquid sugar under a wellness-oriented banner. To protect consumers and mitigate the rising national burden of obesity and dental caries, Nigeria's regulatory framework must implement a structural pivot:

1. **Abolish Relative Percentage Qualifications for Nutrition Claims:** NAFDAC must amend its *Food Products Advertisement Regulations 2021 and Pre-Packaged Food (Labelling) Regulations 2022* [14–15]. Nutrient comparative claims should not be granted based solely on a relative 25% difference. Instead, a product must also remain under a strict, absolute maximum ceiling (e.g., ≤ 4.0 g of sugar per 100ml, and an absolute cap of ≤ 15 g of total sugar per retail unit packaging) to qualify for any descriptive front-of-pack text.
2. **Prohibit Industry-Led GDA Labeling:** GDA panels must be legally banned from carbonated soft drink configurations due to their unscientific reference baselines. They should be replaced with mandatory, high-contrast Front-of-Pack Warning Labels (FOPL)—such as black octagonal stop signs—stating "**HIGH SUGAR**" for any individual product container that delivers more than 10% of the daily sugar value across its full volume.
3. **Establish Pack-Size Caps and Tiered Taxes:** The Federal Ministry of Finance should transition the current flat ₦10 per litre sugar tax into a tiered excise framework that penalizes large-volume containers (500ml and 600ml) [16]. This will encourage manufacturers to reduce absolute package sizes to 330ml or lower, capping the maximum absolute sugar load available in the market.

Declarations

Ethics Approval and Consent to Participate

Not applicable. This research evaluates public nutritional data and product labeling parameters; no human subjects or animal clinical models were utilized.

Availability of Data and Materials

The mathematical calculations and nutritional modeling matrices analyzed during this study are fully disclosed within this manuscript.

Competing Interests

The authors declare that they have no competing financial or non-financial interests.

References

1. Okop KJ, Nnyepi MS, Tiffin N, et al. The Processed food revolution in African food systems and the double burden of malnutrition. *Global Food Security*. 2020.
2. Ramalan MA, et al. Prevalence and trends of adult overweight and obesity in Nigeria - A systematic review and meta-analysis. *PubMed*. 2023.
3. World Health Organization. *Nigeria collaborates with WHO to curb hypertension, introduces control initiative*. Brazzaville: WHO Regional Office for Africa. 2020.
4. Folayan MO, et al. Prevalence of Dental Caries Among 6–11-Year-Olds in Nigeria: A Systematic Review and Meta-Analysis. *MDPI Children*. 2024.
5. Codex Alimentarius Commission. Guidelines on nutrition labelling: CAC/GL 2–1985. Rome: FAO/WHO; 1985.
6. Fregene C. Dietary intake assessment of sugar in several pack sizes of carbonated soft drinks in Nigeria. *Nutri Food Sci Int J*. 2026;8(4):000693.
7. World Health Organization. Guideline: Sugars intake for adults and children. Geneva: World Health Organization; 2015.
8. Interpretive front-of-pack nutrition labels vs. guideline daily amounts (GDAs): a systematic analysis of consumer cognitive biases and misdirection. *Food Policy*. 2023;115:102410.
9. Stanhope KL. Sugar consumption, metabolic dysregulation, and cardiometabolic risk: an updated review of the evidence. *Nutrients*. 2016;8(1):34.
10. Chandon P, Wansink B. Is food marketing making us fat? A review of marketing-induced overeating. *Nutr Rev*. 2012;70(10):571–9.
11. Pitts NB, Zero DT, Marsh PD, Ekstrand K, Weintraub JA, Ramos-Gomez F, et al. Dental caries. *Nat Rev Dis Primers*. 2017;3(1):17030.
12. Lemos JA, Palmer SR, Zeng L, Wen ZT, Sorsa TV, Han MD, et al. The biology of *Streptococcus mutans*. *Microbiol Spectr*. 2019;7(1):7-1.

13. The health halo effect of reduced-sugar claims on carbonated beverages: consumer perception vs. metabolic reality. Public Health Nutr. 2025;28(3):204-215.

14. National Agency for Food and Drug Administration and Control (NAFDAC). Food Products Advertisement Regulations 2021. Abuja: Federal Ministry of Health.

15. National Agency for Food and Drug Administration and Control (NAFDAC). Pre-Packaged Food (Labelling) Regulations 2022. Abuja: Federal Ministry of Health.

16. Fagbule OF, Amafah J, Sarumi AT, Ibitoye OO. Sugar-sweetened beverage tax: a crucial component of a multisectoral approach to combating non-communicable diseases in Nigeria. Niger J Med. 2024;32(5):461–7.

Figures

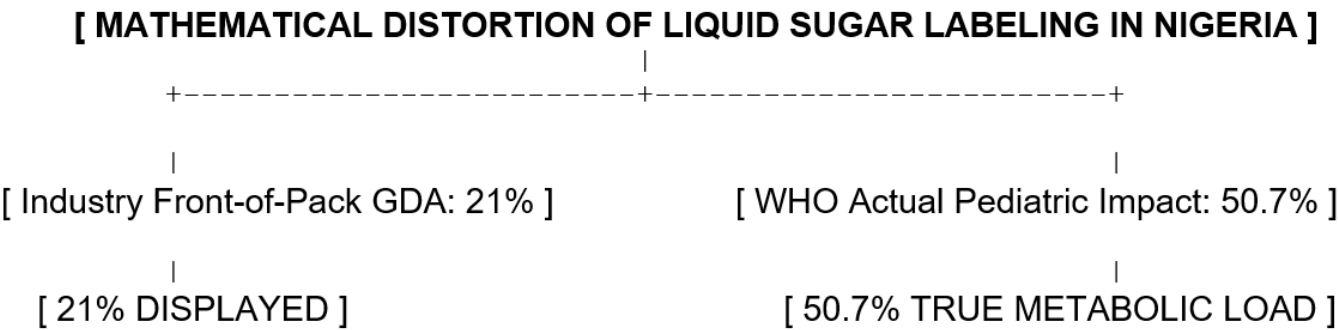


Figure 1

Visual mapping of the structural under-reporting gap between GDA claims and WHO pediatric baselines.

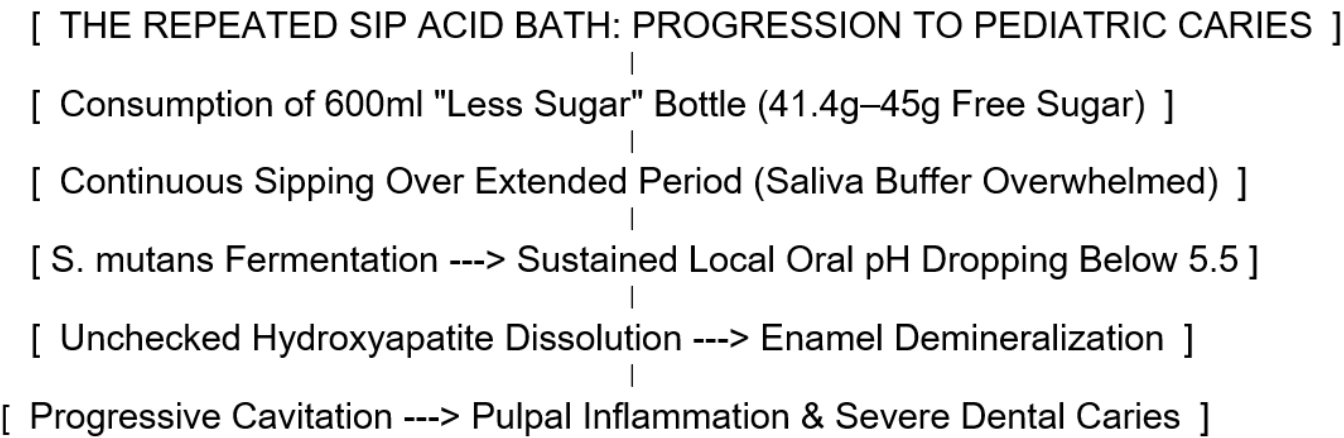


Figure 2

Figure 1: Flowchart detailing the cariogenic pathway of extended large-volume soft drink consumption.