

Evaluating the Nutrition Transition in Sub-Saharan and North Africa: Balancing Saturated Fatty Acid (SFA) Caps Against Micronutrient Deficiencies and Food Security

Christopher Enasor Fregene

chrisfregene@gmail.com

University of Abuja <https://orcid.org/0009-0005-0126-6104>

Dike Bevis Ojji

University of Abuja

Abimbola Opeyemi

Federal University of Technology

Research Article

Keywords:

Posted Date: July 21st, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10405906/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: Global dietary strategies increasingly target saturated fatty acids (SFAs) to curb cardiovascular diseases (CVD). While global guidelines associate tropical oils (TOs) with cardiovascular risk via LDL-C elevation, raw and minimally processed African Red Palm Oil (RPO) retains cardioprotective tocotrienols and carotenoids. In lower- and middle-income countries (LMICs), TOs—specifically refined palm olein containing up to 50 g of SFAs per 100 g—serve as crucial, low-cost caloric vehicles. Sweeping global restrictions risk exacerbating Vitamin A deficiency while spiking household food expenditures, threatening food security and necessitating a stratified regulatory approach.

Objective: This paper models the public health and nutritional trade-offs of implementing a strict World Health Organization (WHO) 10% SFA energy cap across six structurally diverse LMICs (Nigeria, Kenya, Ghana, South Africa, Egypt, and Morocco) compared to High-Income Countries (HICs).

Methodology: Using national food consumption surveys, we executed an intake assessment and dietary risk reduction simulation modeling. The model simulated a mandatory 50% substitution of palm olein with high-polyunsaturated fatty acid (PUFA) oils, tracking impacts on total SFA intake, cardiovascular risk metrics (LDL-C/HDL-C ratio), household food expenditures, and Vitamin A intake.

Results: In HICs, the simulation successfully reduced SFA intake below the 10% threshold with minimal economic disruption. In contrast, LMICs exhibited severe friction points. In Nigeria and Ghana, the substitution triggered a 15–22% spike in household food costs and a precipitous 30% drop in dietary Vitamin A access. In Egypt and South Africa, the model predicted moderate CVD risk reduction but high vulnerability to international oil supply shocks.

Conclusion: A singular, flat SFA mandate creates a public health paradox in lipid-dependent LMICs.

Policy Recommendations: Global health bodies must transition from blanket nutrient caps to "Contextual Nutrition Frameworks" that differentiate industrial processing from domestic food security vehicles, subsidize regional soft-oil value chains and safeguard micronutrient status.

1. Background

The paradigm of global nutritional governance relies heavily on nutrient-specific thresholds to address the global burden of non-communicable diseases (NCDs). The World Health Organization's (WHO) guideline restricting saturated fatty acid (SFA) intake to less than 10% of total daily energy represents a milestone in cardiovascular disease (CVD) prevention [1]. However, the operationalization of this guideline presents a severe epidemiological and socioeconomic paradox when applied to lower- and middle-income countries (LMICs).

At the center of this tension is refined palm olein. Industrially and domestically ubiquitous across sub-Saharan Africa and North Africa, palm olein is an exceptionally stable, affordable, and high-yielding lipid

source. Structurally, it contains up to 50 g of SFAs per 100 g of oil, alongside approximately 40 g of monounsaturated fatty acids (MUFAs) and 10 g of polyunsaturated fatty acids (PUFAs) [2–4].

In High-Income Countries (HICs), palm olein primarily enters the food supply invisibly through ultra-processed foods (UPFs), making SFA reduction a matter of industrial reformulation [5–6]. Conversely, in LMICs like Nigeria, Ghana and Kenya, palm olein is a primary cooking staple and a foundational vector for caloric delivery and fat-soluble vitamin absorption [7–8].

Unilateral policy enforcement of SFA caps without localized risk-benefit modeling risks destabilizing fragile food systems. This perspective paper utilizes advanced intake assessments and risk reduction simulations to evaluate the divergent impacts of global SFA mandates across six key LMICs vs. HICs, aiming to provide international development agencies (WHO, UNICEF, SUN, GAIN) with an empirical roadmap for equitable nutrition policy.

2. Methodology

2.1 Data Sources and Population Subgroups

Dietary intake baselines were reconstructed using harmonized national food consumption data, including the Nigeria National Micronutrient Survey, Kenya National Micronutrient Survey, Ghana Living Standards Survey, and South African National Health and Nutrition Examination Survey (SANHANES), alongside food balance sheets for Egypt and Morocco. Comparative HIC baselines were drawn from the US NHANES and European EFSA dietary databases [9–15]. The target simulation demographic was restricted to women of reproductive age (15–49 years) and children under 5, representing populations most vulnerable to both malnutrition and food price volatility.

2.2 Intake Assessment & Composition Modeling

Refined palm olein was modeled with a standardized profile of:

- Saturated Fatty Acids (SFAs): 50 g / 100 g
- Monounsaturated Fatty Acids (MUFAs): 40 g / 100 g
- Polyunsaturated Fatty Acids (PUFAs): 10 g / 100 g

Baseline daily lipid profiles, total energy intake (kcal), and associated Vitamin A intakes (accounting for fortification levels where applicable) were established for each country.

2.3 Risk Reduction Simulation Modeling

We built a deterministic substitution model simulating a policy-enforced **50% reduction in dietary palm olein**, systematically replaced on an equal-isocaloric basis with a high-PUFA alternative (e.g., sunflower or soybean oil, containing ~ 10–12 g SFA per 100 g).

Three primary target outcomes were simulated:

1. **Cardiovascular Risk Alteration:** Calculated via changes in the Total Cholesterol to HDL-Cholesterol (TC/HDL-C) ratio using standard linear metabolic equations [16–17].
2. **Economic Friction Score:** Modeled by mapping local market cost differentials between palm olein and imported or locally produced soft oils against average household income percentiles [18].
3. **Micronutrient Disruption Index:** Measuring the percentage change in daily Vitamin A intake resulting from the displacement of fortified or native carotenoid-rich palm oil products [19–20].

2.4 Physiological Impact Model

To model the physiological impact of replacing 50% of dietary palm olein with high-PUFA alternatives (e.g., soybean or sunflower oil), we utilize a modified Mensink predictive equation. This estimates changes in serum Low-Density Lipoprotein Cholesterol (Δ LDL-C) and High-Density Lipoprotein Cholesterol (Δ HDL-C) based on the percentage of total daily energy intake (Δ E) shifted between fatty acid classes [16–17].

$$\Delta \text{ LDL-C (mmol/L)} = 0.032 \times \Delta E_{\text{SFA}} - 0.006 \times \Delta E_{\text{MUFA}} - 0.014 \times \Delta E_{\text{PUFA}}$$

$$\Delta \text{ HDL-C (mmol/L)} = 0.012 \times \Delta E_{\text{SFA}} + 0.009 \times \Delta E_{\text{MUFA}} + 0.007 \times \Delta E_{\text{PUFA}}$$

Where:

- ΔE_{SFA} = Change in energy percentage from SFA (decreased by the substitution).
- ΔE_{PUFA} = Change in energy percentage from PUFA (increased by the substitution).

Cardiovascular Risk Metric

The target outcome is the change in the Total Cholesterol to HDL-C ratio (Δ TC/HDL-C), where a decrease signifies minimized cardiovascular risk

$$\Delta \text{ TC} = 0.041 \times \Delta E_{\text{SFA}} - 0.004 \times \Delta E_{\text{MUFA}} - 0.017 \times \Delta E_{\text{PUFA}}$$

2.4 Economic Friction and Regressive Expenditure Elasticity Model

The economic strain placed on vulnerable households by a mandatory oil substitution policy is modeled using a modified Foster-Greer-Thorbecke (FGT) poverty index variant. It maps the local market price differential against household income percentiles (Y_i) [18]:

$$\text{Economic Friction Score (EFS)} = \sum_{i=1}^n ((z_i - Y_i) \div z_i)^{\alpha} \times [Q_{\text{oil}} \times (P_{\text{soft}} - P_{\text{olein}})]$$

Where:

- z_i = National poverty line threshold for household i .

- Q_{oil} = Average daily household volumetric consumption of cooking oil.
- P_{soft} = Local retail market price per liter of imported/alternative soft oil (e.g., sunflower/soy).
- P_{olein} = Local retail market price per liter of refined palm olein.
- α = Poverty aversion parameter ($\alpha = 1$ for friction severity, $\alpha = 2$ for friction inequality).

2.5 Micronutrient Disruption and Retinol Equivalent (RE) Deficit Model

The impact on population-wide Vitamin A intake via fortified palm olein or traditional red palm oil is modeled by calculating the daily Retinol Equivalent Availability (REA_j) for population subgroup j [19–20]:

$$\Delta REA_j = [C_{base} \times V_{fort} \times (1 - \Omega)] \times \Delta Q_{olein}$$

Where:

- C_{base} = Native or legally mandated fortification concentration of Vitamin A in palm olein (e.g., Nigeria's mandate of 30 mg/kg or 100,000 IU/kg of Vitamin A as retinyl palmitate).
- V_{fort} = Fortification compliance coefficient of local mills ($0.0 \leq V_{fort} \leq 1.0$).
- Ω = Thermal degradation factor of Vitamin A during standard domestic cooking/frying practices (typically 0.30 to 0.55).
- ΔQ_{olein} = The volumetric reduction in palm olein intake driven by the 50% restriction policy.

3. Results and Discussion

3.1 Comparative Analysis: LMICs vs. HICs

The simulation model revealed a stark divergence between economic archetypes. In HICs, the 50% reduction in palm olein seamlessly lowered average SFA intake closer to the < 10% energy target [1] without altering baseline food security or micronutrient status, as palm olein was replaced by alternative fats during commercial manufacturing.

However, across the six LMICs, the outcomes split along geographic and socioeconomic lines:

- **The West African Cluster (Nigeria & Ghana):** These nations experienced severe negative externalities. Because palm olein represents a massive share of the daily lipid profile, a 50% substitution stripped away up to 30% of baseline Vitamin A access for low-income households. Economically, because local soft-oil supply chains are underdeveloped, substituting palm olein with imported alternatives triggered a 15% (Ghana) and 22% (Nigeria) surge in household oil expenditures, severely threatening food security [21–25].

- **The East African Cluster (Kenya):** Kenya showed moderate economic friction (12% cost increase). The nutritional impact was characterized by a distinct calorie gap, as low-income consumers in informal settlements simply reduced total fat purchases rather than buying more expensive soft oils, risking a drop in total daily energy intake [26–28].
- **The Industrialized LMIC Cluster (South Africa, Egypt, Morocco):** These countries displayed a different risk profile. The substitution successfully reduced population-wide SFA intake and lowered simulated CVD biomarkers. However, because Egypt and Morocco rely intensely on imported vegetable oils, the model highlighted a dangerous exposure to global supply chain shocks and currency devaluations [29–31].

3.2 The Policy Conflict for Global Stakeholders

For organizations like **UNICEF** and the **Scaling Up Nutrition (SUN) Movement**, these results reveal a structural conflict. A policy designed by the **WHO** to combat long-term cardiovascular mortality could accidentally trigger an immediate spike in wasting (acute malnutrition) and hidden hunger (Vitamin A deficiency) in West and East Africa.

Furthermore, **GAIN (Global Alliance for Improved Nutrition)** models highlight that palm olein is one of the most cost-effective vehicles for national industrial vitamin fortification programs. Forcing food industries in Nigeria or Ghana away from palm olein undermines decades of public health infrastructure built to eliminate childhood blindness.

4. Conclusion and Policy Recommendations

4.1 Conclusion

A uniform, single-threshold approach to SFA consumption fails to account for the structural realities of food systems in LMICs. Refined palm olein containing 50 g of SFA per 100 g cannot be treated simply as an unhealthy additive; it is a foundational caloric and micronutrient anchor for millions. Imposing rigid caps without local mitigation strategies creates an unacceptable trade-off between chronic cardiovascular risk management and immediate food security.

4.2 Strategic Policy Recommendations

1. **Adopt Contextual Nutrition Frameworks (CNFs):** The WHO should replace flat nutrient mandates with stratified guidelines that differentiate between palm olein used as a hidden ingredient in industrial ultra-processed foods (UPFs) and palm olein used as a primary, direct-to-consumer cooking oil in LMICs.
2. **Implement Dual-Purpose Fortification Mandates:** Where palm olein restrictions are deemed medically necessary, UNICEF and GAIN must co-fund the immediate transfer of fortification

infrastructure to local soft-oil alternatives (soy, groundnut) to prevent catastrophic drops in Vitamin A delivery.

3. **Subsidize Regional Soft-Oil Value Chains:** To mitigate the economic friction identified in Nigeria and Kenya, national agricultural policies must incentivize domestic cultivation of high-PUFA/MUFA crops (such as groundnuts and soybeans). There should be investment in the local production of low-SFA alternatives, such as groundnut (peanut) oil or soybean oil to swift the market away from increased reliance on expensive imports.
4. **Enforce Fractional Standards in Industrial Sourcing:** Regional regulatory bodies (e.g., NAFDAC in Nigeria) should mandate that industrial food processors utilize specialized palm oil fractions with lower SFA content (e.g., double-fractionated liquid palm olein) while preserving traditional, unrefined red palm oil variants for local culinary use.
5. **Mandatory National Processing Standards:** Regional mill upgrades should be funded to reduce the formation of harmful oxidized free fatty acids during processing, preserving the native health benefits of local oils.
6. **Enforce Targeted Labeling:** Front-of-pack labels that limit processed industrial SFAs should be implemented while educating consumers on proper portion controls for traditional cooking practices.
7. **Advance mass-balance blending formulations:** Optimized 43:57 palm olein-to-soybean oil protocol.

Declarations

5.1 Acknowledgments

This work was conceptualized to align with the strategic objectives of the WHO, UNICEF, SUN, and GAIN toward equitable global nutrition standards.

5.2 Competing Interests

The authors declare no competing financial or institutional interests.

5.3 Funding

This simulation study did not receive external funding; it represents an independent academic perspective framework.

5.3 Clinical Participation and Ethics

Not applicable.

References

1. World Health Organization. Saturated fatty acid and trans-fatty acid intake for adults and children: WHO guideline. Geneva: World Health Organization; 2023. Available from: [who.int](https://www.who.int).

2. Malaysian Palm Oil Council. Emerging markets: Evaluating Sub-Saharan Africa for palm oil potential. *MPOC Market Insights*. 2020.
3. World Economic Forum. How African palm oil can boost livelihoods and protect forests. *WEF Platforms*. 2022.
4. Mancini A, Imperlini E, Nigro E, Montagnese C, Daniele A, Orrù S, Buono P. Biological and nutritional properties of palm oil and palmitic acid: Effects on health. *Molecules*. 2015;20(9):17339-17361.
5. Baker P, Machado P, Santos T, Sievert K, Backholer K, Hadjidakou M, et al. Ultra-processed foods and the nutrition transition: Global, regional and national trends, food systems transformations and market drivers. *Obesity Reviews*. 2020;21(12):e13126.
6. Onyia CU, Bello AA. Optimizing fatty acid composition and nutritional profile of crude and refined palm oil, sunflower oil, groundnut oil, and their blends. *Food Analytical Methods*. 2025;18(3):412-425.
7. Malaysian Palm Oil Board. Red palm oil: A natural food-based strategy to combat vitamin A deficiency and enhance carotenoid bioavailability. Kuala Lumpur: MPOB Technical Bulletin; 2025.
8. Ritz L, Gelli A, Aberman NL. Hidden hunger in Sub-Saharan Africa: Mapping the food sources of micro- and macro-nutrients across twelve countries. *AgEcon Search Working Papers*. 2026.
9. UNICEF, GAIN, Federal Ministry of Health Nigeria. Nourishing Nigeria: Highlights and Key Findings from the 2021 National Food Consumption and Micronutrient Survey (NFCMS). Abuja: UNICEF; 2024.
10. Ministry of Health, Republic of Kenya. The Kenya National Micronutrient Survey 2011: Baseline assessment of nutritional status and dietary intake patterns. Nairobi: MoH Kenya; 2011.
11. Ghana Statistical Service. Ghana Living Standards Survey Round 7 (GLSS7): Main report on household expenditure, consumption, and living conditions. Accra: GSS; 2019.
12. Shisana O, Labadarios D, Rehle T, Simbayi L, Zuma K, Dhansay A, et al. South African National Health and Nutrition Examination Survey (SANHANES-1). Cape Town: HSRC Press; 2014.
13. Food and Agriculture Organization. FAOSTAT Food Balance Sheets: Country lipid and vegetable oil supply profiles for Egypt and Morocco. Rome: FAO United Nations; 2023.
14. Centers for Disease Control and Prevention (CDC). National Health and Nutrition Examination Survey (NHANES) Dietary Data Files. Hyattsville, MD: U.S. Department of Health and Human Services; 2022.
15. European Food Safety Authority. The EFSA Comprehensive European Food Consumption Database: Nutrient and fatty acid intake mapping. *EFSA Journal*. 2021;19(4):e06500.
16. Mensink RP, Zock PL, Kester AD, Katan MB. Effects of dietary fatty acids and carbohydrates on the ratio of serum total to HDL cholesterol and on serum lipids and apolipoproteins: a meta-analysis of 60 controlled trials. *Am J Clin Nutr*. 2003;77(5):1146-1155.
17. Mensink RP. Effects of saturated fatty acids on serum lipids and lipoproteins: a systematic review and regression analysis. Geneva: World Health Organization; 2016.

18. Foster J, Greer J, Thorbecke E. A class of decomposable poverty measures. *Econometrica*. 1984;52(3):761-766.
19. Global Alliance for Improved Nutrition (GAIN). Fortification assessment coverage toolkit (FACT) survey: Assessing large-scale food fortification programs for vegetable oils and staples. Geneva: GAIN; 2022.
20. Klemm RD, West KP, Palmer AC, Johnson Q, Randall P, Wiradnyani L, et al. Vitamin A fortification of wheat flour as a public health strategy in low- and middle-income countries: a systematic review. *Nutr Rev*. 2010;68(2):65-81.
21. TechnoServe. Closing Nigeria's Edible Oil Fortification Gap. Abuja: TechnoServe Nigeria Reports; 2026. Available from: technoserve.org.
22. Global Alliance for Improved Nutrition (GAIN). Large Scale Food Fortification Compliance in Nigeria: State of the Nation Report 2022. Geneva: GAIN; 2022. Available from: gainhealth.org.
23. Ministry of Food and Agriculture (MoFA). Medium-Term Expenditure Framework (MTEF) 2025-2028: Tree Crops Diversification Project (GTCDP). Accra: Republic of Ghana; 2025.
24. Ghana Statistical Service (GSS). Informal Cross Border Trade Report: Food Price Volatility and Accessibility to Healthy Diets in Ghana. Accra: GSS; 2026.
25. TechnoServe, Bill & Melinda Gates Foundation. Edible Oil Study: The Opportunity for Oil Fortification with the Sustainable Alliance for Large-Scale Food Fortification (SAPFF). Lagos: TechnoServe; 2022. Available from: technoserve.org.
26. Kenya National Bureau of Statistics (KNBS). Kenya Continuous Household Survey Programme (KCHS) 2022: Household Consumption Expenditure and Poverty Dynamics. Nairobi: KNBS; 2024.
27. Global Alliance for Improved Nutrition (GAIN). Urban Food Environments in Low- and Middle-Income Countries: Policy Brief on Food Purchasing Practices in Nairobi Slums. Geneva: GAIN; 2021.
28. Kimani-Murage EW, Schofield L, Wekesah F, Mohamed S, Mberu B, Ettarh R, et al. Vulnerability to food insecurity and malnutrition in urban slums in Nairobi, Kenya. *J Urban Health*. 2014;91(6):1096-1113.
29. International Monetary Fund (IMF). Regional Economic Outlook: Middle East and Central Asia – Navigating Asymmetric Shocks. Washington, DC: IMF; 2026 [cited 2026 Jul 18]. Available from: imf.org
30. Kaldas T. Egypt on the frontline of regional war's economic disruption: Currency depreciation and import strains. *African Business*. 2026 Apr 28 [cited 2026 Jul 18].
31. Ministry of Supply and Internal Trade. National Strategy for Edible Oil Logistics: Expanding Storage Terminals at the Port of Alexandria to Mitigate Global Supply Shocks. Cairo: Arab Republic of Egypt; 2025.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [ComparativeMatrix.docx](#)