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Uncovering Household Dietary Iron Inadequacy in Nigeria: A Data Science Exploration for Advancing Sustainable Development Goals

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Abstract*—Iron inadequacy remains a silent driver of hidden hunger, yet traditional survey analyses often miss its complexity. We applied a data science framework that integrates large-scale household data cleaning, feature engineering, and predictive analytics to uncover dietary iron inadequacy patterns across Nigerian households. Using nationally representative data from the 2018/2019 Nigeria Living Standard Survey (NLSS), we examined the socioeconomic and demographic factors influencing household iron intake. We categorized households into Adequate and Inadequate Intake groups based on daily iron consumption per adult equivalent and used logistic regression analysis to identify significant predictors. While 78.92% of households achieved adequate iron intake, 21.08% experienced inadequacy, with 10.11% facing severe deficiency. Higher household income, greater food expenditure, marital status, and increased dietary diversity significantly reduced the odds of iron inadequacy. In contrast, male-headed households, larger household sizes, and certain older age groups showed elevated risks. Higher education levels were associated with greater odds of iron inadequacy, a finding that may reflect emerging urban dietary transitions. Our findings highlight the multidimensional drivers of iron inadequacy in Nigeria and emphasize the need for targeted interventions that promote dietary diversity, address urban dietary shifts, and support vulnerable populations.

Keywords*—Data Science, Dietary Diversity, Iron Inadequacy, Nigeria, Nutrition, Sustainable Development Goals.

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I. Introduction

Iron deficiency is the most prevalent micronutrient disorder globally, contributing significantly to the global burden of disease through its effects on maternal health, cognitive development, and economic productivity [1,2]. Often referred to as a form of "hidden hunger," it affects nearly one-quarter of the global population, with over 1.8 billion people experiencing some form of anaemia in 2019 [3,4]. In sub-Saharan Africa, approximately half of all anaemia cases are due to iron deficiency, with dire implications for labour productivity, education outcomes, and child survival [5].

In Nigeria, the burden is especially alarming. According to the 2018 Nigeria Demographic and Health Survey (NDHS), 68% of children under five, 58% of pregnant women, and 49% of non-pregnant women are anaemic, largely as a result of inadequate iron intake [6]. The prevalence is highest in poor households, rural settings, and regions with limited dietary diversity [7, 8]. Despite increased attention to food security and caloric sufficiency, micronutrient adequacy, particularly iron, remains under-measured and under-addressed in public health nutrition [9].

While most research focuses on individual-level assessments (particularly for children and women), a growing body of evidence suggests that analysing dietary iron intake at the household level offers deeper insight into food access, consumption equity, and nutrient sufficiency [10]. Household-level data provides a more realistic measure of dietary deprivation in communal food systems like Nigeria's, where intra-household food sharing is the norm. It also facilitates alignment with Household Consumption and Expenditure Surveys (HCES), which are widely used for nutrition-sensitive policy planning [11].

Moreover, household-level analysis allows for integrating economic variables (e.g., food expenditure per adult equivalent), geospatial patterns, and demographic drivers, enabling predictive analytics and scalable modelling across diverse settings. This approach supports a more equitable, system-wide view of nutritional access and is particularly suited for advancing the Sustainable Development Goals (SDGs) including SDG 2 (Zero Hunger), SDG 3 (Good Health), SDG 5 (Gender Equality), SDG 10 (Reduced Inequalities), and SDG 12 (Responsible Consumption and Production).

This study addresses these gaps by applying a data science-driven analytical pipeline to household dietary data from the nationally representative 2018/2019 Nigeria Living Standards Survey (NLSS). The pipeline includes systematic pre-processing, winsorization, adult male equivalent (AME) scaling, and logistic regression modelling. We construct derived variables such as dietary diversity scores (DDS) and per capita/Adult Equivalent (AE)-adjusted food expenditures to estimate iron intake and identify the key predictors of dietary inadequacy. The study also quantifies the prevalence and severity of household-level iron inadequacy, offering disaggregated insights across regions and income groups.

By combining rigorous data science methodology with public health nutrition principles, this research contributes to evidence-based interventions for tackling hidden hunger in Nigeria and supports the broader agenda of sustainable development.

II. Methodology and Analytical Framework

A. Study Design

We employed a cross-sectional, data science-driven analytical framework to examine dietary iron inadequacy among Nigerian households. Drawing from the nationally representative 2018/2019 NLSS, the data science pipeline (Figure 1) included:

- Data acquisition
- Data cleaning and pre-processing
- Nutrient scaling via Adult Male Equivalent (AME)
- Feature engineering (e.g., dietary diversity, income quantiles)
- Predictive modelling using logistic regression

This approach integrates nutritional epidemiology with applied data analytics to identify the socioeconomic, demographic, and dietary drivers of iron inadequacy. It aligns with SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being), SDG 5 (Gender Equality), SDG 10 (Reduced Inequality), and SDG 12 (Responsible Consumption and Production).

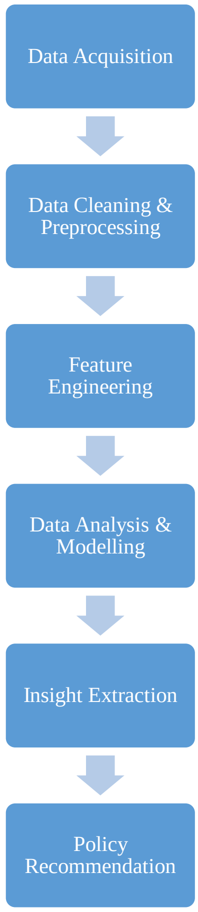

Figure 1: Data Science Analytical Pipeline illustrating the stages of uncovering household dietary iron inadequacy, from data acquisition to policy recommendations.

B. Data Source

We used secondary data from the 2018/2019 NLSS, administered by the National Bureau of Statistics (NBS). The survey covers food consumption, expenditure, education, health, and demographic information across Nigeria's six geopolitical zones and rural-urban sectors. The food consumption module documents the intake of over 100 food items over a seven-day recall period. After cleaning, we retained 22,117 households with valid food records for analysis.

C. Data Preprocessing and Nutrient Normalization

1) AME Scaling and Normalization

To account for variations in individual nutritional requirements within households, we calculated the AME size of each household, following the method outlined by [12]. This approach scales each household member's nutrient requirement relative to that of a healthy adult male aged 19–49 years, whose daily iron requirement is set as the reference (8 mg/day).

$$AME_i = \frac{\text{Iron requirement}_i}{8} \ldots\ldots\ldots\ldots\ldots (1)$$

Where:

Iron Requirement$_i$ is the WHO/FAO recommended daily iron intake (mg/day) for Individual *i*.

We computed total household AME by summing across all members.

2) AME Scaling and Normalization

We calculated total dietary iron intake from food consumption using standard nutrient conversion factors. Weekly intake for household h was computed as:

$$\text{Total Iron Intake}_{week} = \sum_{j-1}^{n} \text{Food Quantity}_j \times \text{Iron Content}_j \text{ .... (2)}$$

$$\text{Daily Iron Intake}_{HH} = \frac{\text{Total Iron Intake}_{week}}{7} \text{ .... (3)}$$

Where:

Food Quantity $_j$: Amount of food item j consumed in grams over 7 days

Iron Content $_j$: Iron concentration (mg/g) of food item

n: Total number of food items consumed

$$\text{Iron Intake per AME} = \frac{\text{Daily Iron Intake}_{HH}}{Household\ AME\ Size} \text{ ....(4)}$$

This normalization ensured comparability across households of varying sizes and compositions.

D. Feature Engineering

1) Dietary Diversity Score (DDS)

We calculated DDS based on the consumption of 12 FAO-recommended food groups: Cereals, Roots and Tubers, Vegetables, Fruits, Meat, Eggs, Fish and Seafood, Legumes, Nuts and Seeds, Milk and Milk Products, Oils and Fats, Sweets, and Spices/Condiments/Beverages. Each household received a score of 1 for each food group consumed at least once in the past seven days. The total DDS ranged from 0 to 12. Based on score distribution:

- Low DDS: < 5
- Moderate DDS: 5–8
- High DDS: > 8

2) Income Quantiles

We proxied household income using total annual real expenditure per adult equivalent. Expenditure was adjusted using NLSS deflators and grouped into income terciles:

- Low-income: Bottom 33%
- Middle-income: 34%–66%
- High-income: Top 33%

E. Outcome Variable Construction

We defined the binary dependent variable, Iron Inadequacy, as:

1 (Inadequate): If iron intake per AME < 8 mg/day

0 (Adequate): If iron intake per AME ⩾ 8 mg/day

This classification aligns with the WHO minimum requirement for adult males and enabled logistic regression analysis.

F. Analytical Strategy and Model Specification

1) Descriptive Statistics

We summarized dietary iron inadequacy prevalence by sector and income group. Group differences were tested using chi-square tests (categorical variables) and t-tests (continuous variables).

2) Logistic Regression Model

We estimated a binary logistic regression to assess the likelihood of iron inadequacy based on dietary, demographic, and economic predictors. The model is specified as:

$$\log\left(\frac{\text{P(Iron Inadequate=1)}}{1-\text{P(Iron Inadequate=1)}}\right) = \beta_0 + \sum_{k=1}^{n} \beta_k X_k + \varepsilon \text{ .... (5)}$$

Where:

- P(Iron Inadequate) is the probability that a household is iron inadequate,
- X_k are the explanatory variables (e.g., DDS, income category, education)
- β_k are the estimated coefficients,
- ϵ: Error term

We report odds ratios and 95% confidence intervals for interpretability. The model was estimated in Stata 16.0.

III. Results Interpretation and Discussion

A. Summary Statistics and Rural-Urban Disparities

Descriptive statistics and mean comparisons across urban and rural households are presented in Table I. The combined statistics in Table I show that the average Nigerian household head is 48.35 years old (SD = 15.75), oversees a household of about 5.22 persons (SD = 3.18), and consumes an average of 6.90 mg of iron per adult equivalent per day (SD = 4.32). This value falls below the 8 mg/day adequacy threshold, suggesting a widespread risk of iron deficiency nationally. The average dietary diversity score (DDS) is 8.92, indicating moderate food variety across Nigerian households. However, average iron intake per AE remains high at 15.66 mg, likely driven by a subset of high-consuming households.

Table I: Descriptive Statistics of Key Household Variables by Residence Type

Variable	Urban Mean (SD)	Rural Mean (SD)	Combined Mean (SD)	t-value	p-value
Age of Household Head (years)	48.48 (15.53)	48.30 (15.84)	48.35 (15.75)	0.797	0.425
Household Size (persons)	4.72 (2.91)	5.45 (3.27)	5.22 (3.18)	-15.69	<0.001
Iron Intake (mg/day, AE-scaled)	6.32 (4.01)	7.16 (4.42)	6.90 (4.32)	-13.39	<0.001
Dietary Diversity Score	9.37 (1.34)	8.73 (1.60)	8.92 (1.55)	29	<0.001
Real Total Expenditure (₦/AE/year)	242,898 (271,402)	152,916 (139,112)	180,624 (194,416)	32.52	<0.001
Real Food Expenditure (₦/AE/year)	131,932 (114,857)	96,484 (87,285)	107,399 (97,991)	25.18	<0.001
Iron Intake per AE	14.57 (9.53)	16.15 (10.47)	15.66 (10.22)	-10.66	<0.001

Source: Author's computation using NLSS 2018/2019 dataset.

When disaggregated by location, clear disparities emerge. Rural households have higher average iron intake (7.16 mg vs. 6.32 mg; $p < 0.001$) despite lower food and total expenditure, aligning with earlier research by [13] and [14], which noted that rural diets in Nigeria often contain more traditional, nutrient-rich staples like leafy vegetables and legumes. Conversely, urban households exhibit higher dietary diversity (9.37 vs. 8.73; $p < 0.001$), but this does not translate to greater iron adequacy, possibly reflecting a shift toward energy-dense, micronutrient-poor processed foods in urban diets [14, 15].

Urban households also report significantly higher annual food and total expenditure per AE (₦131,932 and ₦242,898, respectively), yet these financial advantages do not close the nutritional gap. These results challenge the assumption that higher income or expenditure always equates to better dietary outcomes and support calls for nutrition-sensitive, not just food-security-driven, interventions [17].

The findings reinforce the importance of targeting dietary quality and iron-rich food access in both rural and urban areas, but through tailored strategies. For urban populations, policies should address dietary transitions and promote iron fortification or supplementation. For rural households, preserving and enhancing access to traditional iron-rich foods remains essential.

Table II presents the socioeconomic and demographic profile of Nigerian households. Nationally, 82.08% of households are headed by males, and 75.08% of all households are headed by married individuals. Most household heads are above 40 years, with 41.09% over the age of 50. Education indicators reveal concerning disparities: 15.28% of all household heads have no formal education, and only 18.6% attained tertiary education. While the majority of households (66.06%) achieved high dietary diversity (DDS > 8), about one-third fell below this threshold, indicating potential vulnerability to micronutrient inadequacy. Income is evenly split across terciles due to the construction method, but notable disparities emerge when disaggregated.

Urban–rural disaggregation reveals plain differences. Gender dynamics show that 83.75% of rural households were headed by males compared to 78.33% in urban areas ($\chi^2 = 93.86$, $p < 0.001$). This male dominance may reflect patriarchal norms and labor division, but also has implications for dietary decisions and household nutrition priorities.

Household head age group distributions also differed significantly by sector ($\chi^2 = 35.36$, $p < 0.001$), with rural households having slightly older heads, potentially influencing conservative food choices and lower DDS scores.

Marital status was significantly associated with sector ($\chi^2 = 85.6$, $p < 0.001$), with rural households more likely to be headed by married individuals. Marital status often correlates with household stability and food security, although its direct impact on iron intake is nuanced and may vary with household dynamics.

Education level showed the most striking disparity ($\chi^2 =$ 1300+, $p < 0.001$), with nearly 20% of rural household heads having no formal education compared to only 6.4% in urban areas. Education is a key driver of dietary knowledge and nutrient-adequate food choices, and this gap likely contributes to observed inequalities in diet quality.

Similarly, dietary diversity showed a strong urban advantage. While 78% of urban households reported high DDS (>8), only 60.73% of rural households did so ($\chi^2 = 629.83$, $p < 0.001$). This divergence emphasizes the need for tailored nutrition education and food system interventions in rural regions.

Table II: Household Socioeconomic Profile

Variable	Category	Urban (%)	Rural (%)	Total (%)	Chi²	p-value
Gender of Household Head	Male	78.33	83.75	82.08	93.86	<0.001
	Female	21.67	16.25	17.92		
Household Head Age Group	≤30 years	8.57	10.67	10.01	35.36	<0.001
	31–40 years	26.85	24.9	25.51		
	41–50 years	24.57	22.85	23.39		
	>50 years	40.01	41.58	41.09		
Marital Status	Not Married	28.95	23.12	24.92	85.6	<0.001
	Married	71.05	76.88	75.08		
Education Level	No Formal Education	6.38	19.84	15.28	1300+	<0.001
	Primary	21	31.62	28.02		
	Secondary	42.93	35.62	38.09		
	Tertiary	29.69	12.92	18.6		
Dietary Diversity	Low (DDS < 5)	0.72	1.57	1.31	629.83	<0.001
	Medium (5–8)	21.25	37.7	32.64		
	High (>8)	78.03	60.73	66.06		
Income Group	Low Income	14.49	41.72	33.33	2000+	<0.001
	Middle Income	33.99	33.04	33.33		
	High Income	51.52	25.24	33.33		

Source: Author's computation using NLSS 2018/2019 dataset.

Income group analysis confirms economic disparities: 41.72% of rural households were in the lowest income tercile compared to only 14.49% of urban households ($\chi^2 =$ 2000+, $p < 0.001$). These differences highlight the double burden of poverty and poor diet diversity faced by rural populations, reinforcing the need for integrated social protection and nutrition-sensitive agricultural policies.

These findings are consistent with earlier reports from the 2018 NDHS [6] and studies by [18], [19], and [20], which noted education and income as key determinants of dietary diversity. The urban advantage in education and income reinforces disparities in dietary outcomes. Male-dominant household leadership, especially in rural regions, may reflect cultural norms and influence nutrition decision-making.

These disparities call for differentiated interventions. Nutrition programs must be gender- and education-sensitive. Targeting male household heads with tailored nutrition awareness campaigns could improve household-level decisions. Additionally, expanding rural education and market access policies could narrow the inequality gap in dietary diversity and iron adequacy.

B. Prevalence and Severity of Iron Inadequacy among Nigerian Households

As shown in Table III, the analysis revealed that 21% of Nigerian households are iron inadequate, consuming below the 8 mg/day threshold per adult equivalent. This finding is alarming, as it implies that one in every five households is at risk of iron deficiency, a key driver of hidden hunger. The iron intake among adequate households averaged 18.3 mg/day, while inadequate households consumed just 5.79 mg/day, resulting in a mean difference of 12.51 mg — a gap that is both statistically significant (t = 85.76, p < 0.001) and clinically meaningful.

The data show that while many households may consume more than adequate iron, those facing inadequacy fall dangerously short, with an average iron gap of 2.21 mg/day. This magnitude of deficiency is particularly concerning because it represents a structural nutrition gap, not just daily fluctuation. The narrow standard deviation within the inadequate group (SD = 1.56) further confirms that the majority of these households are persistently low in iron intake, and not just marginally deficient.

This highlights a stark inequality in dietary iron access and the urgent need for targeted interventions such as iron-fortified foods, nutrition education, and social safety nets that prioritize low-income and nutritionally vulnerable households.

Table III: Difference in Average Daily Iron Intake Between Adequate and Inadequate Households

Group	Mean (mg/AE/day)	Std. Dev.
Iron Inadequacy (%)	**0.21**	**0.002**
Adequate Households	18.3	9.93
Inadequate Households	5.79	1.56
Mean Difference	**12.51**	—
t-statistic	**85.76**	—
p-value	**<0.001**	—
Gap iron	**2.21**	1.56

Source: Author's computation using NLSS 2018/2019 dataset.

C. *Distribution of Household Iron Inadequacy by Sector, Income Group, and Dietary Diversity in Nigeria*

The results in Table IV show important disparities in household iron adequacy across residence type, income levels, and dietary diversity categories in Nigeria.

- Sectoral Variation

Although both rural and urban households have relatively high rates of iron adequacy, rural households showed a slightly higher adequacy rate (79.53%) than urban households (77.56%). This difference, though modest, is statistically significant ($\chi^2 = 11.06$, $p = 0.001$), indicating structural or dietary factors unique to rural settings that might support higher iron adequacy, possibly linked to subsistence farming or local access to traditional iron-rich foods

- Income-Based Disparities

The association between income and iron adequacy is striking. While only 63.86% of low-income households meet the adequacy threshold, the proportion rises to 90.47% among high-income households. The gradient is strongly significant ($\chi^2 > 1600$, $p < 0.001$), suggesting that financial access to diverse and nutrient-dense foods plays a central role in combating iron deficiency. This aligns with SDG 1 and SDG 10 on poverty reduction and reducing inequalities, reinforcing the need for economic empowerment as a nutrition-sensitive intervention strategy.

- Dietary Diversity

Iron adequacy also varies dramatically with dietary diversity. Only 43.94% of households with low dietary diversity (DDS < 5) are iron adequate, compared to 82.52% for those with high dietary diversity (DDS > 8). The difference is not only statistically significant (p < 0.001) but also large in magnitude. This underscores the role of diet quality, beyond food quantity, in achieving micronutrient adequacy. The results strongly support investments in nutrition education, agricultural diversification, and food system reforms to promote consumption of iron-rich and bioavailable foods, aligning with SDG 2 (Zero Hunger), SDG 3 (Good Health), and SDG 12 (Responsible Consumption).

Table IV: Household Iron Inadequacy by Sector, Income Group, and Dietary Diversity in Nigeria

Variable	Category	Iron Adequate (%)	Iron Inadequate (%)	Chi²	p-value
Sector	Urban	77.56%	22.44%	11.06	<0.001
	Rural	79.53%	20.47%		
Income Group	Low Income	63.86%	36.14%	1600+	<0.001
	Middle Income	82.43%	17.57%		
	High Income	90.47%	9.53%		
Dietary Diversity	Low (DDS < 5)	43.94%	56.06%	477.39	<0.001
	Medium (DDS 5–8)	73.02%	26.98%		
	High (DDS > 8)	82.52%	17.48%		

Source: Author's computation using NLSS 2018/2019 dataset.

D. *Logistic Regression Model of Iron Inadequacy*

The binary logistic regression model estimated the odds of a household being iron inadequate based on key demographic, socioeconomic, and dietary variables. As shown in Table 5, several predictors were statistically significant, offering insights into household-level iron adequacy dynamics in Nigeria.

The results reveal significant relationships between socioeconomic, demographic, and dietary factors and the odds of household iron inadequacy.

Real food expenditure per adult equivalent was negatively associated with iron inadequacy. Although the odds ratio was close to one (OR = 0.999987), the effect was statistically significant (p < 0.001), indicating that even small increases in food expenditure considerably reduce the likelihood of iron deficiency.

Households in the middle- and high-income groups were 53% and 56% less likely, respectively, to experience iron inadequacy compared to their low-income counterparts. Similarly, households headed by married individuals showed a 38% reduction in the odds of iron inadequacy compared to unmarried household heads

Table V: Logistic Regression Predicting Household Iron Inadequacy (Odds Ratios)

Variables	Odds Ratio	Std. Err.	z-value	p-value
Real food expenditure per AE	0.999987	1.00E-06	-17.25	0
Income category				
Middle income	0.471	0.0269	-13.2	0
High income	0.436	0.0394	-9.18	0
Married household head	0.615	0.0494	-6.05	0
Education level				
Primary education	4.406	0.342	19.11	0
Secondary education	5.517	0.427	22.05	0
Tertiary education	5.411	0.471	19.4	0
Dietary diversity group				
Medium DDS	0.069	0.015	-12.32	0
High DDS	0.049	0.0106	-13.98	0
Sector (Rural = 2)	0.54	0.0254	-13.11	0.00
Household size (AE)	1.013	0.0061	2.17	0.03
Household head age group				
31–40 years	1.156	0.0954	1.76	0.079
41–50 years	1.269	0.108	2.81	0.005
>50 years	1.137	0.0958	1.52	0.129
Male household head	1.224	0.106	2.33	0.02
Constant	15.042	3.91	10.43	0

Source: Author's analysis using NLSS 2018/2019 dataset. Note: Reference category for income = low income; reference category for dietary diversity = low diversity (<5 groups); education reference is no formal education; urban is 1 while rural is 2; age category <31 is reference for age group

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Unexpectedly, higher educational attainment was associated with increased odds of iron inadequacy. Households where the head had primary, secondary, or tertiary education were about 4 to 5 times more likely to experience iron inadequacy compared to those with no formal education.

Dietary diversity emerged as a critical protective factor: households with medium and high dietary diversity scores had 93% and 95% lower odds, respectively, of iron inadequacy compared to those with low diversity.

Rural households showed a 46% lower risk of iron inadequacy compared to urban households, suggesting possible advantages of rural dietary patterns.

Regarding household composition, an increase in the number of adult equivalents slightly but significantly increased the risk of iron inadequacy.

For household head age groups, those aged 41–50 years were significantly more likely to have iron inadequacy (OR = 1.27, $p < 0.01$) compared to heads younger than 31 years. Although heads aged 31–40 and above 50 showed higher odds, these associations were not statistically significant at the 5% level.

Lastly, male-headed households were 22% more likely to experience iron inadequacy compared to female-headed households.

The logistic regression findings underscore the complex interactions between economic capacity, dietary habits, and demographic factors in determining household nutritional outcomes. The protective role of higher income and food expenditure aligns with previous studies such as [18], [21]–[25] who reported that increased household resources positively affect dietary quality and micronutrient intake in Nigeria.

The strong protective influence of dietary diversity confirms similar results from [26]–[29]. They emphasize that diversified diets rich in fruits, vegetables, and animal-source foods are critical for preventing micronutrient deficiencies.

The positive association between higher education levels and iron inadequacy contrasts with earlier findings that generally link education with better nutrition outcomes [29]. This contradiction could reflect urbanization effects among educated populations, where dietary patterns may shift towards processed, iron-poor foods despite increased knowledge. Studies such as [15], [30], and [31] have documented this shift across Low- and Middle-Income countries (LMICs). It may also reflect occupational and time-use trade-offs—educated individuals may consume more convenience foods and fewer traditional iron-rich staples.

The significantly higher odds of iron inadequacy among rural households reinforce the structural disadvantages they face—poor infrastructure, low market access, and limited food variety. Addressing rural food deserts and improving supply chains is crucial.

The increased risk among male-headed households and larger households suggests the need for more nuanced household-targeted nutrition interventions. Male-headed households may prioritize expenditures differently, and larger families may dilute available resources, consistent with the observations of [32,33] in related Nigerian contexts.

Overall, the study highlights the urgent need for interventions promoting dietary diversity, addressing urban dietary transitions, and targeting vulnerable subgroups such as low-income, male-headed, and large households to effectively tackle iron inadequacy at the community level.

Future research could explore the role of education, specifically maternal education, in improving dietary diversity and iron intake at the household level.

Our findings underscore the importance of addressing not only the quantity of food consumed but also the quality, with an emphasis on increasing the intake of iron-rich foods and improving dietary diversity.

IV. Conclusion and Policy Recommendations

Conclusion

This study uncovered a significant burden of household-level dietary iron inadequacy in Nigeria, with approximately 21.1% of households falling below the recommended daily iron intake per adult equivalent. Using nationally representative data and a data science pipeline, this research provides novel, evidence-based insights into the socioeconomic and dietary predictors of iron inadequacy across urban and rural sectors.

Key findings indicate that higher dietary diversity, greater food expenditure, and higher income levels were significantly associated with reduced odds of iron inadequacy. In contrast, households with low education, larger household age group sizes, and residence in rural areas were more vulnerable to inadequate iron intake. Importantly, the regression model also highlighted that despite education being conventionally protective, lower educational attainment was paradoxically associated with higher odds of inadequacy, likely due to structural dietary inequalities rather than knowledge alone.

The findings of this study present clear implications for nutrition-sensitive policy and program design in Nigeria. Given that dietary iron inadequacy continues to affect a substantial share of households, targeted interventions are urgently required to improve dietary quality and address micronutrient gaps across diverse population groups.

First, there is a strong need to strengthen community-level nutrition programs with a deliberate focus on enhancing dietary diversity and increasing access to iron-rich foods. These programs should be prioritized in low-income and rural areas where vulnerability is highest. Local governments, primary health care agencies, and NGOs can work together to deliver tailored interventions that are both culturally appropriate and scalable.

Secondly, the results call for the development of gender-sensitive, household-centered nutrition education campaigns. Current approaches tend to focus predominantly on women and children. However, this study shows that male-headed households are also vulnerable. Nutrition messaging must therefore emphasize iron-rich diets for all household members — men, women, adolescents, and the elderly — and should be delivered through schools, mass media, and community leaders in local languages for maximum impact.

In addition, rural food systems must be strengthened to close the gap in dietary quality between rural and urban households. Expanding rural infrastructure, market access, and the availability of fortified foods can enhance food diversity and resilience. This supports SDG 10 on reducing inequalities and SDG 12 on sustainable consumption by ensuring that nutritious food is accessible and affordable in underserved areas.

Finally, to ensure that interventions are timely and well-targeted, there is an urgent need to institutionalize data-driven nutrition monitoring. Tools from data science should be integrated into national nutrition surveillance systems to support real-time tracking, geospatial targeting of high-risk zones, and dynamic policy design. This aligns with SDG 17, emphasizing the role of partnerships and innovation in strengthening data systems for sustainable development.

Together, these recommendations support a multi-dimensional strategy to address hidden hunger and promote inclusive, evidence-based progress toward the Sustainable Development Goals in Nigeria.

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