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Original Article

# Household Double Burden of Malnutrition and Associated Factors in Sokoto Metropolis, Northwestern Nigeria: A Cross-Sectional Study

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## ABSTRACT

**Background:** The double burden of malnutrition, the coexistence of undernutrition and overnutrition within the same household, is an escalating public health concern in nutrition-transitioning countries, yet household-level evidence from northwestern Nigeria remains limited. **Methods:** A community-based cross-sectional study was conducted among 246 households (659 individuals) across nine wards of Sokoto Metropolis, Nigeria, using multistage sampling. Adults were assessed by BMI and under-five children by Mid-Upper Arm Circumference (MUAC), a screening measure of acute malnutrition. A household was classified as double-burdened if it contained at least one wasted under-five child and one overweight/obese adult simultaneously. Food security, dietary patterns, income relative to the national minimum wage (NGN70,000), and intra-household food allocation were assessed by questionnaire. Associations were tested using Pearson chi-square, with Monte Carlo simulated p-values and odds ratios (95% CI). **Results:** The double burden of malnutrition affected 32.9% of households, 84.6% had at least one wasted child or overweight/obese adult. Among under-five children, 46.4% were wasted; 61.8% adults were overweight or obese. Household food security status ($p<0.001$) and ward of residence ($p=0.009$) were significantly associated with household nutritional status, whereas income relative to the minimum wage, dietary diversity, and maternal BMI were not. Sex was associated with individual nutritional status ($p<0.001$) but not with adult BMI ($p=0.408$). Food was reported as shared unequally in 75.6% of households, with fathers most often receiving the largest portion. **Conclusions:** One in three households experiences the double burden of malnutrition, associated with household food security and ward of residence, but not with income relative to the minimum wage or maternal BMI. Interventions should prioritize household food security alongside geographically targeted programming, and the role of food allocation should be tested in future studies.

# 1. INTRODUCTION

Malnutrition remains one of the leading public health challenges affecting both developed and developing countries, manifesting as undernutrition (stunting, wasting, and underweight), micronutrient deficiencies, overweight, and obesity [1]. While undernutrition has traditionally dominated public health concern in low- and middle-income countries, rapid changes in dietary habits, urbanization, and lifestyle have driven a simultaneous rise in overweight and obesity, giving rise to the double burden of malnutrition [2]. At the household level, this paradox commonly manifests as an overweight or obese adult member living alongside an undernourished child, or more broadly, any coexistence of undernutrition and overnutrition among household members [3].

Nigeria is undergoing a similar nutrition transition. Findings from the Nigeria Demographic and Health Survey indicate that a substantial proportion of children under five years remain stunted, wasted, or underweight, while overweight and obesity among adults, particularly women, continue to rise [4]. Several interconnected factors have been implicated in the double burden of malnutrition, including household food security, dietary diversity, income, intra-household food allocation, and geographic/community-level food environments [5, 6]. However, most available evidence on the household double burden in Nigeria has focused on national estimates or populations in southern Nigeria, leaving a gap in household-level evidence from northwestern Nigeria specifically.

Sokoto Metropolis, like many urban centers in Nigeria, has experienced considerable demographic, socioeconomic, and dietary change, yet the prevalence and correlates of the household double burden of malnutrition in this setting have not been empirically established.

This study therefore assessed the prevalence of the household double burden of malnutrition in Sokoto Metropolis and examined its association with socioeconomic characteristics, household income relative to the national minimum wage, food security status, dietary consumption patterns, and intra-household food allocation practices. As this is a descriptive cross-sectional study employing bivariate statistical tests, the factors examined are reported as associated factors rather than causal determinants.

# 2. MATERIALS AND METHODS

### 2.1 Study Design and Area

This study employed a community-based descriptive cross-sectional design conducted in Sokoto Metropolis, Sokoto State, Nigeria, spanning Sokoto North, Sokoto South, and Wamakko Local Government Areas.

### 2.2 Sample Size and Sampling Technique

The minimum sample size was determined using Cochran's formula for cross-sectional studies [7]: $n = Z^2p(1-p)/d^2$, where $Z=1.96$ (95% confidence level), $p=0.122$ (an anticipated household double-burden prevalence of 12.2%), and $d=0.05$ (margin of error). This yielded a base sample of $n\approx165$, which was inflated to 250 households to account for a design effect and anticipated non-response. A multistage sampling technique was used: Local Government Areas were selected, three wards were selected from each using simple random sampling (nine words in total), a household listing exercise was conducted in each ward, and households were selected by simple random sampling (approximately 28 households per ward)

Anthropometric measurements were obtained from all consenting resident household members present at the time of the visit. Of the 250 households sampled, 246 (98.4%) had complete and valid data and were retained for analysis, yielding 659 individuals (249 adults, 304 children under five years, and 106 children/adolescents aged 5–17 years). Only household members present at the time of the visit were measured, so on average 2.7 individuals per household (1.0 adults and 1.2 under-five children) were measured, fewer than the reported household size (Section 3.1).

**2.3 Data Collection**

Data were collected using a structured, interviewer-administered questionnaire covering household socio-demographic characteristics, monthly income, dietary consumption frequency, household food security, intra-household food allocation practices, and anthropometric measurements.

**2.4 Anthropometric Assessment and Classification**

Adult nutritional status was assessed using BMI (weight in kilograms divided by height in meters squared), classified per WHO criteria [8] as underweight (<18.5 kg/m²), normal (18.5–24.9 kg/m²), overweight (25.0–29.9 kg/m²), or obese (≥30.0 kg/m²). Under-five children were assessed using Mid-Upper Arm Circumference (MUAC) only, classified using standard colour-band cut-offs as wasted (<11.5 cm, the severe acute malnutrition range), at risk (11.5–<12.5 cm, the moderate acute malnutrition range), or normal (≥12.5 cm). Throughout this paper, "wasted" refers to MUAC <11.5 cm; children in the at-risk band were not counted as wasted, so the household classification below uses the stricter threshold. [Authors to state the age range of children measured (MUAC is valid from 6 months), the measurement protocol and enumerator training.] MUAC was selected as a rapid, low-cost, field-validated screening measure of acute wasting; however, because length/height and weight were not converted into height-for-age (stunting) or weight-for-age (underweight) z-scores in this analysis, this study captures only the wasting dimension of child undernutrition, and stunting and underweight prevalence could not be assessed. This is an explicit scope restriction of the present analysis, not an indication that stunting and underweight are less important, and is addressed further under limitations.

A household was classified as experiencing the double burden of malnutrition if it contained at least one wasted under-five child and at least one overweight/obese adult simultaneously; households with only a wasted child were classified as "undernutrition only," households with only an overweight/obese adult as "overnutrition only," and all others as "normal." Adults with underweight BMI (<18.5 kg/m²) and children in the at-risk MUAC band were not counted as undernourished in this classification, so a household could be labelled "normal" or "overnutrition only" while containing an underweight adult or an at-risk child; in this paper a "malnourished member" therefore means a wasted child (MUAC <11.5 cm) or an overweight/obese adult.

Children and adolescents aged 5–17 years (n=106) had weight and height recorded, but their nutritional classification requires BMI-for-age z-scores derived from an age- and sex-specific growth reference (WHO AnthroPlus), which had not been completed at the time of this analysis; this age group was therefore excluded from the double-burden classification. To assess whether this exclusion could have produced spuriously "normal" household classifications, we checked whether any household's classification depended solely on unclassified 5–17-year-olds: no such household was identified: every one

of the 246 analyzed households had at least one classifiable adult and/or under-five member, so no household was misclassified as "normal" purely because its only measured members fell in the unclassified age band. Ninety of the 250 sampled households (36.0%) had at least one member aged 5–17 years. Nonetheless, because a wasted or overweight adolescent could add an additional undernourished or overnourished member to a household already classified from its adults/under-fives, the double-burden prevalence reported here should still be regarded as a conservative (potentially underestimated) figure pending completion of this age group's classification.

### 2.5 Income Categorization

Household monthly income was categorized relative to the prevailing National Minimum Wage of NGN70,000: households earning below this threshold were classified as "below minimum wage," and those earning NGN70,000 or above as "at/above minimum wage."

### 2.6 Household Food Security Assessment

Household food security was assessed using a study-specific, two-item food-insecurity experience screen conceptually adapted from established approaches such as the Household Food Insecurity Access Scale and the Food Insecurity Experience Scale [6], rather than the full validated instrument itself. Respondents reported the frequency, in the preceding 30 days, with which the household (i) worried about not having enough food and (ii) reduced meal size or skipped meals due to a lack of food or money. Responses to these two items were combined to classify households as Secure, occasionally insecure, or frequently insecure. This abbreviated screen has not been independently validated for the Sokoto or wider Nigerian context, and this is acknowledged as a limitation; results based on this measure should be interpreted with this in mind.

### 2.7 Dietary Diversity

Household dietary consumption was assessed via a food-frequency approach across five food groups (animal protein, fruits, vegetables, processed foods, sugar-sweetened beverages). For analytical purposes, a simplified dietary diversity proxy was derived from three nutrient-dense food groups only (animal protein, fruits, vegetables), each scored 0 (Never) to 4 (Daily) and summed (range 0–12), with households grouped into tertiles of low, medium, and high diversity. This proxy is not equivalent to, and is considerably narrower than, the standard Food and Agriculture Organization Household Dietary Diversity Score, which captures 12 food groups via 24-hour recall; it was adopted here as a pragmatic, lower-burden alternative focused on the food groups most relevant to the double burden of malnutrition, and its non-standard nature is acknowledged as a limitation.

### 2.8 Intra-Household Food Allocation

Intra-household food allocation was assessed using respondent perception rather than objectively measured or weighed food portions. Respondents were asked a single yes/no question ("Are all household members usually given equal portion sizes?"); households answering "no" were classified as having unequal food sharing. Two follow-up categorical questions then asked respondents to identify, from a fixed list of household roles (e.g., father/husband, mother/wife, children, elderly members), who typically received the largest portion, and who was most likely to reduce their portion first when food was insufficient. As a perception-based, single-respondent measure, these findings reflect the reporting household member's perspective and may be subject to recall or social-desirability bias; they do not reflect independently measured portion weights.

### 2.9 Statistical Analysis

Data were analyzed using Python (pandas, NumPy, SciPy). Descriptive statistics (frequencies, percentages, means and standard deviations) summarized household and individual characteristics.

Household-level analyses examined the associations of income category, food security status, dietary diversity and ward of residence with household nutritional status, classified into four mutually exclusive categories (double burden, overnutrition only, undernutrition only, and normal; **Table 1**). These analyses were conducted separately from the individual-level analyses, which comprised: (i) sex versus adult BMI classification (n = 249 adults); (ii) sex versus pooled individual nutritional status (n= 553; 249 adults classified by BMI plus 304 under-five children classified by MUAC); and (iii) maternal BMI versus child nutritional status (mother–child pairs).

Associations between categorical variables were tested with the Pearson chi-square ($\chi^2$) test of independence, with statistical significance set at $p < 0.05$. Expected cell frequencies were examined for every test. Where more than 20 % of cells had an expected frequency below 5 (as occurred for the nine-ward analysis), the asymptotic *p*-value was corroborated by a Monte Carlo simulation-based *p*-value (20 000 resamples under the null hypothesis of independence with fixed row totals). Effect sizes were quantified with Cramér's V for all chi-square tests. Odds ratios with 95 % confidence intervals (Wald method) were additionally computed for two pre-specified binary comparisons: food security status (frequently insecure versus secure) in relation to double-burden versus all other households, and sex in relation to overnourished versus other nutritional status in the pooled individual analysis.

No adjustment was made for multiple testing, and the chi-square tests did not account for clustering of households within wards; *p*-values are therefore interpreted with appropriate caution.

# 3. RESULTS

### 3.1 Socio-Demographic and Household Characteristics

A total of 246 households comprising 659 individuals were included in the analysis. Households were distributed across Sokoto North (39.4%), Sokoto South (30.9%), and Wamakko (29.7%), and were predominantly male-headed (95.1%), with a mean reported household size of 5.1 ± 3.6 persons of whom on average 2.7 per household were present and measured. Business enterprise (53.3%) was the leading source of household income.

### 3.2 Household Income, Food Security, and Dietary Patterns

About half of the households (50.4%) earned a monthly income below the NGN70,000 national minimum wage. Household food insecurity affected 47.6% of households (30.5% frequently insecure, 17.1% occasionally insecure; **Figure 1**). Diets were dominated by rice and tuwo (a traditional thick, dough-like side eaten with soup), with frequent vegetable consumption (77.6% at least 3–4 times weekly) but comparatively infrequent animal protein and fruit intake, alongside notable frequencies of processed food and sugar-sweetened beverage consumption.

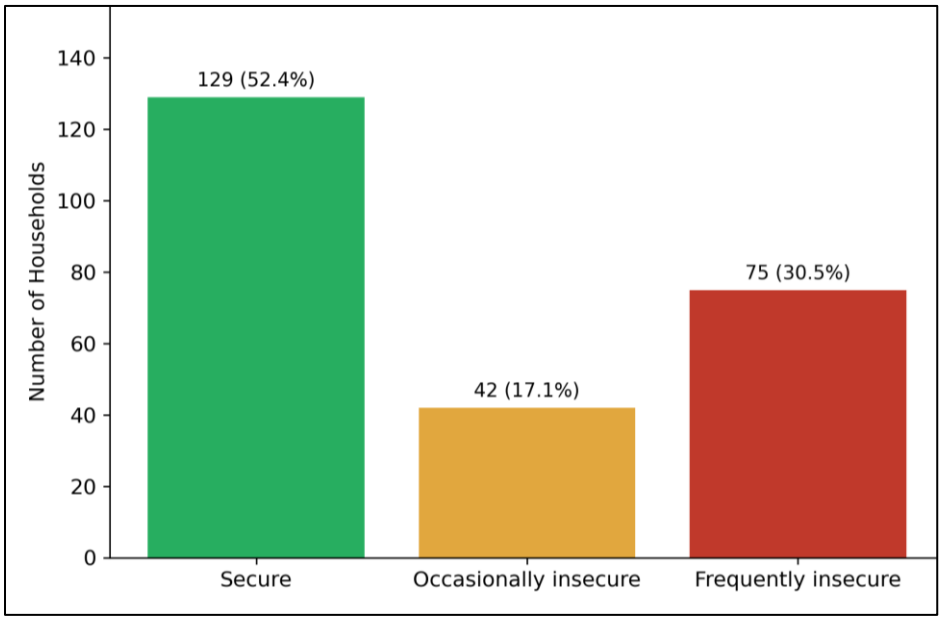



**Figure 1.** Household food security status of the study population (n=246).

### 3.3 Nutritional Status of Household Members

Among under-five children (n=304), 46.4% were wasted (MUAC <11.5 cm) and 25.0% were at risk (MUAC 11.5–<12.5 cm); only 28.6% were of normal nutritional status (**Figure 2**).

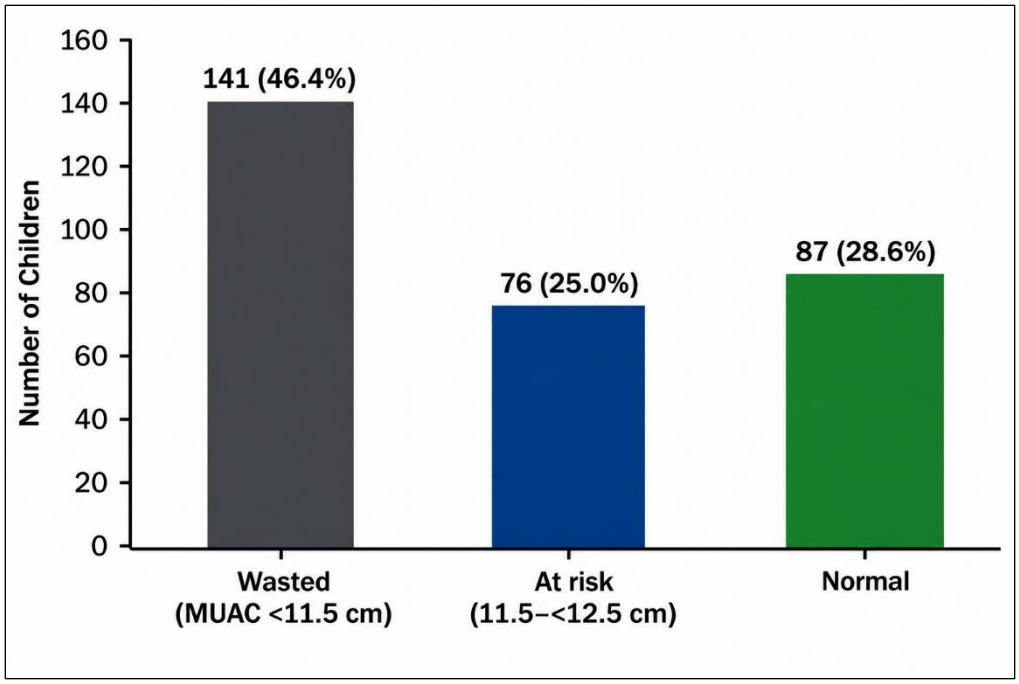



**Figure 2.** Mid-Upper Arm Circumference (MUAC)-based wasting status of children under five years (n=304). Wasted = MUAC <11.5 cm; at risk = 11.5–<12.5 cm.

Among adults (n=249), 61.8% were overweight or obese (49.4% overweight, 12.4% obese), while 30.1% had normal BMI and 8.0% were underweight (**Figure 3**).

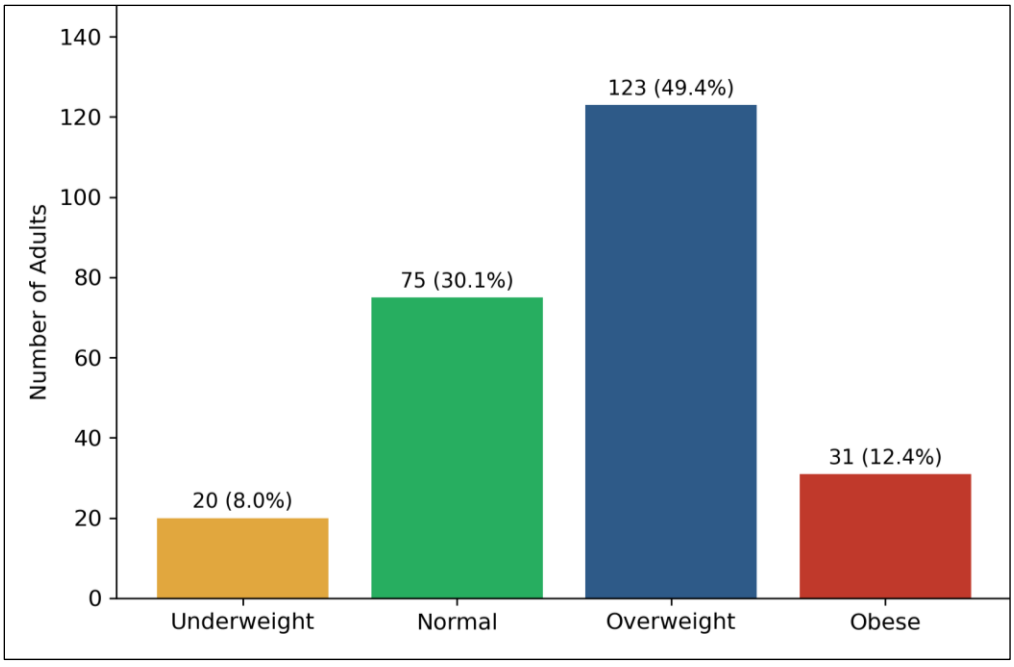



**Figure 3.** BMI-based nutritional classification of adult household members (n=249).

### 3.4 Prevalence and Factors Associated with the Household Double Burden of Malnutrition

Overall, 81 households (32.9%) exhibited the double burden of malnutrition, 67 (27.2%) had overnutrition only, 60 (24.4%) had undernutrition only, and 38 (15.4%) were classified as normal (**Table 1**). Prevalence varied markedly by ward, from 8.3% in Wajage to 48.0% in Arkilla (**Figure 4**). Thus 208 households (84.6%) had at least one wasted child or overweight/obese adult (all categories other than normal).

**Table 1.** Household nutritional status distribution (n = 246).

| Nutritional status category | Frequency (n) | Percentage (%) |
|---|---|---|
| Double burden | 81 | 32.9 |
| Overnutrition only | 67 | 27.2 |
| Undernutrition only | 60 | 24.4 |
| Normal | 38 | 15.5 |

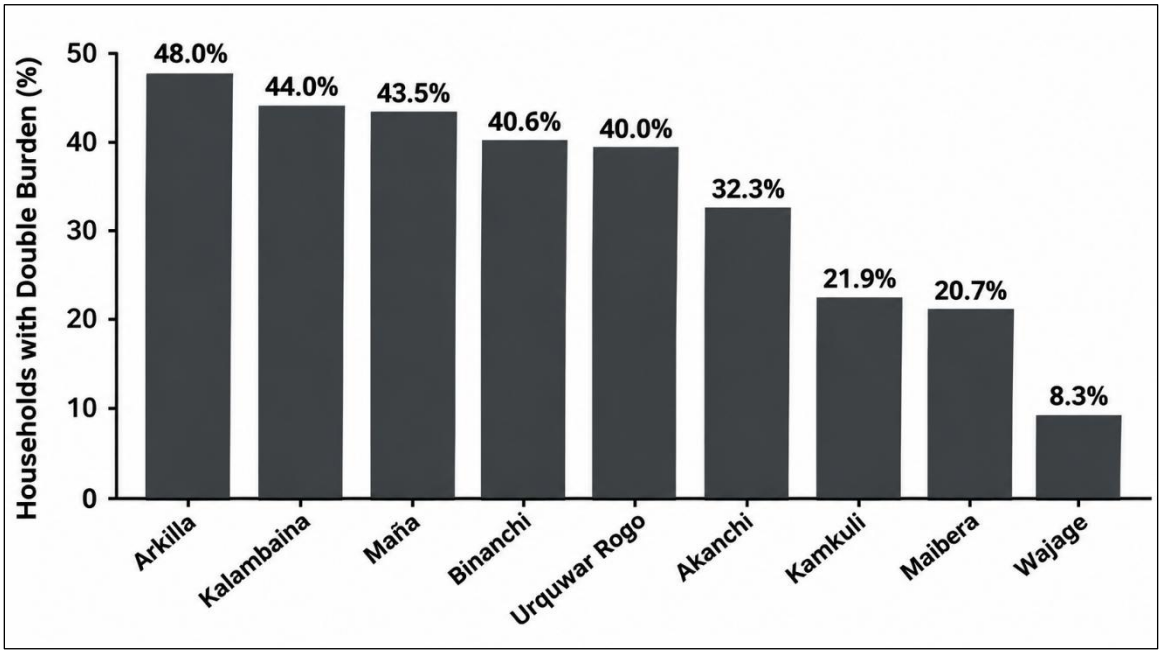



**Figure 4.** Prevalence of the household double burden of malnutrition by ward of residence. Percentages are of households within each ward.

Household-level associations with nutritional status (four categories: double burden, overnutrition only, undernutrition only, and normal) are summarized in **Table 2**. Ward of residence was significantly associated with household nutritional status ($\chi^2 = 43.20$, df = 24, $p = 0.009$; Monte Carlo simulated $p = 0.008$; Cramér's V = 0.24). Household food security status showed a strong association ($\chi^2 = 193.27$, df = 6, $p < 0.001$; Cramér's V = 0.63). The corresponding odds ratio comparing frequently insecure with food-secure households for double-burden versus all other categories was exceptionally large (OR

= 745.5, 95 % CI 162.2–3425.6) and is likely unstable because of near-complete separation; this estimate should therefore be interpreted with caution pending cell counts and, preferably, an exact or Firth-corrected analysis.

In contrast, neither income category relative to the national minimum wage ($\chi^2 = 0.28$, df = 3, $p = 0.964$; Cramér's V = 0.03) nor dietary diversity tertiles ($\chi^2 = 1.26$, df = 6, $p = 0.537$; Cramér's V = 0.05) were associated with household nutritional status. Income category was also unrelated to food security status itself ($\chi^2 = 0.45$, df = 2, $p = 0.799$), confirming that the observed food-security association was not merely a proxy for income.

These findings indicate that, in this setting, household food security and fine-scale geographic location (ward) are the principal correlates of the household double burden of malnutrition, whereas income relative to the minimum wage and a simplified dietary-diversity proxy are not.

**Table 2.** Household-level chi-square tests of association with household nutritional status (four categories).

| Variables Tested | $\chi^2$ | df | p-value | Cramér's V | OR (95% CI) | Decision |
|---|---|---|---|---|---|---|
| Ward/area (9 categories) | 43.20 | 24 | 0.009* | 0.24 | — | Significant |
| Food security status | 193.27 | 6 | <0.001 | 0.63 | 745.5 (162.2–3425.6)† | Significant |
| Income category (vs. minimum wage) | 0.28 | 3 | 0.964 | 0.03 | — | Not significant |
| Dietary diversity (tertiles) | 1.26 | 6 | 0.537 | 0.05 | — | Not significant |
| Income category vs. food security status (shown for context; not tested against household status) | 0.45 | 2 | 0.799 | 0.04 | — | Not significant |

*Monte Carlo simulated p = 0.008 (see text). †Odds ratio for Frequently insecure vs. Secure households comparing double-burden status versus all other households; the exceptionally large magnitude of this estimate is discussed in Section 4.3. The estimate is likely unstable (near-complete separation is possible).

Individual-level associations are presented in **Table 3**. Sex was not associated with adult BMI classification ($\chi^2 = 2.90$, df = 3, p = 0.408; n = 249). In contrast, sex was significantly associated with pooled individual nutritional status ($\chi^2 = 54.71$, df = 2, p < 0.001; Cramér's V = 0.29; n = 553), with females having higher odds of overnutrition (OR = 6.12, 95% CI 3.43–10.92). Because this pooled analysis combines adults classified by BMI and under-five children classified by MUAC, the finding is not interpreted as evidence of excess overnutrition among adult women. Maternal BMI classification was not associated with child nutritional status ($\chi^2 = 2.70$, df = 6, p = 0.845).

**Table 3.** Individual-level chi-square tests of association.

| Variables Tested | $\chi^2$ | df | p-value | Cramér's V | OR (95% CI) | Decision |
|---|---|---|---|---|---|---|
| Sex vs. adult BMI classification (n= 249) | 2.90 | 3 | 0.408 | 0.11 | — | Not significant |
| Sex vs. individual nutritional status (n= 553) | 54.71 | 2 | <0.001 | 0.29 | 6.12 (3.43–10.92) * | Significant |
| Maternal BMI vs. child nutritional status (mother–child pairs) | 2.70 | 6 | 0.845 | 0.06 | — | Not significant |

*Odds ratio for female versus male for overnourished versus other nutritional status. The analysis pools adults (BMI) and under-five children (MUAC); N = 553 (249 adults + 304 under-fives).

### 3.5 Intra-Household Food Allocation

Based on respondent perception (Section 2.8), food was reported as shared unequally in 186 of 246 households (75.6%). Among all households, fathers/husbands were most frequently identified as receiving the largest portion (183/246; 74.4%). When food was insufficient, elderly members were the group most often reported to reduce their portions first (121/246; 49.2%), followed by mothers (43/246; 17.5%). The remaining responses were distributed across other household members (children, other adults, or no clear hierarchy). These findings reflect the perception of a single respondent per household and were not formally tested against household nutritional status.

## 4. DISCUSSION

### 4.1 Key Findings

This study found that approximately one in three households in Sokoto Metropolis (32.9%) experiences the double burden of malnutrition, a prevalence higher than estimates from other African urban settings [9, 5]. This high prevalence, combined with the finding that 84.6% of households had at least one wasted child or overweight/obese adult, underscores the scale of nutrition transition already under way in this northwestern Nigerian setting [10]. As this figure is based on wasting (not stunting or underweight) among children, and excludes the 5–17-year age group, it should be interpreted as a conservative, wasting-specific estimate rather than a comprehensive measure of all forms of child undernutrition (Section 2.4).

Contrary to expectation, household income relative to the national minimum wage was not significantly associated with the double burden of malnutrition, consistent with the observation that the relationship between socioeconomic status and obesity is often non-linear in transitioning economies [11]. Instead, household food security status showed a statistically significant association with household nutritional status (the magnitude should be treated cautiously; Section 4.3), aligning with the argument that food security, rather than income alone, more directly shapes household dietary adequacy and nutritional risk [6].

The ward-level variation observed (8.3% to 48.0%) echoes prior findings that the double burden is highly context-dependent even within small geographic areas [5]; notably, this pattern held at the fine-grained ward level but not when wards were

aggregated to their parent Local Government Areas, suggesting that hyper-local food environments and livelihoods, rather than broad administrative geography, may be more relevant to double-burden risk. Sex was significantly associated with pooled individual nutritional status (OR=6.12, 95% CI 3.43–10.92 for overnutrition in females) but not with BMI classification among adults alone (p=0.408); because the pooled analysis combines adults and children, this association is not interpreted as evidence of a female excess of overnutrition among adults.

Notably, maternal BMI classification did not significantly predict child nutritional status, diverging from the "overweight-mother/undernourished-child" pathway frequently emphasized in the literature [3,13]. This suggests that, in this population, the double burden may be more closely related to household-wide food security than to a direct maternal-to-child pathway. Food was perceived as shared unequally in three-quarters of households, with fathers favored and the elderly most often identified as reducing their portions [14]; because this was not tested against household nutritional status, it is consistent with, but does not demonstrate, a food-allocation mechanism.

**4.2 Comparison with Existing Studies**

The 32.9% household double-burden prevalence reported here exceeds the 20–30% range reported among urban poor South African households [9] and is at the upper end of estimates synthesized across low-income settings [5], suggesting Sokoto Metropolis may represent a comparatively advanced stage of nutrition transition, albeit measured here on a narrower (wasting-only) basis than some comparator studies that include stunting and underweight. The null association between maternal BMI and child nutritional status contrasts with the dual-burden household pathway described in earlier reviews [3,13], indicating that household-wide rather than purely maternal-to-child mechanisms may be more relevant associated factors in this setting.

The household double-burden prevalence of 32.9 % observed in Sokoto Metropolis is higher than estimates previously reported from urban poor settings in South Africa (approximately 20–30 %) [9] and higher than the national estimate of 12.2 % derived from the most recent analysis of Nigeria Demographic and Health Survey mother–child dyads [15]. It also exceeds the pooled prevalence of approximately 6 % for the classic stunted-child/overweight-mother phenotype across 22 sub-Saharan African countries [16]. The figure is, however, comparable to the 37.4 % prevalence recently documented among mother–child pairs in selected Nigerian urban and semi-urban centers [17]. Direct comparison remains limited because the present study classified child undernutrition solely on the basis of acute wasting (MUAC < 11.5 cm), whereas most earlier studies incorporated stunting or underweight [3,5,9].

The strong association with household food security is consistent with the broader literature that positions food security as a more proximal determinant of household nutritional risk than income alone [6,15,18]. The absence of an association with income relative to the national minimum wage aligns with evidence that the socioeconomic patterning of overweight and obesity becomes non-linear or even reverses during advanced stages of the nutrition transition in lower-middle-income settings [11,19,20].

Finally, the null association between maternal BMI and child nutritional status diverges from the classic "overweight mother–undernourished child" pathway emphasized in earlier reviews [3,13] and in several recent multi-country analyses

[16]. This discrepancy suggests that, in the present northwestern Nigerian urban context, household-level factors (particularly food security and fine-scale geographic location) may be more salient than a purely maternal–child pathway.

### 4.3 Methodological Considerations

Several measurement choices in this study warrant explicit discussion. First, because under-five nutritional status was assessed by MUAC alone, this study captures wasting but not stunting or underweight; the true burden of child undernutrition, and consequently the true household double-burden prevalence, is likely higher than reported here. Second, the food security screen used was a study-specific two-item measure conceptually related to, but distinct from, validated instruments and has not itself been validated in this population; the very large odds ratio observed between food security and double-burden status (OR=745.5, 95% CI 162.2–3425.6) is far larger than typically reported in the food security literature and should be interpreted cautiously it may reflect a genuine, strong local relationship, but could also partly reflect shared measurement variance between how food security and household nutritional status were operationalized in this dataset. We recommend that this association be re-examined using a validated food security instrument (e.g., the Household Food Insecurity Access Scale) in future work before its magnitude is treated as a precise effect estimate. Third, the dietary diversity proxy used (three food groups) is narrower than the standard 12-group Household Dietary Diversity Score, which may explain the null association observed. Fourth, intra-household food allocation was assessed via respondent perception rather than measured portions, and may not fully reflect actual distribution. In addition, the proportion of children with MUAC <11.5 cm (46.4%) is higher than would typically be expected from population surveys, so measurement quality and the sampling of children should be considered when interpreting prevalence; the stricter threshold (<11.5 cm) also means that households with children in the 11.5–<12.5 cm band were not classified as having a wasted child. Pooling adults (BMI) and children (MUAC) in the sex analysis limits its interpretability, and the chi-square tests did not account for the clustering of households within wards or for multiple testing. Finally, because this is a cross-sectional study using bivariate chi-square tests without multivariable adjustment, the associations reported cannot be interpreted as causal determinants, and we have accordingly used the terms “associated factors” and “correlates” throughout.

### 4.4 Strengths and Limitations

This study's strengths include a household sample of 246 (659 individuals), multistage sampling across nine wards, simultaneous assessment of household food security, dietary patterns, income, and intra-household food allocation alongside anthropometry, and the use of assumption-checking (expected cell frequencies, Monte Carlo confirmation), effect sizes (Cramér's V), and odds ratios with 95% confidence intervals alongside p-values. Limitations include: the cross-sectional design, which precludes causal inference; restriction of child undernutrition assessment to wasting (MUAC) only, excluding stunting and underweight; exclusion of children/adolescents aged 5–17 years (n=106) from double-burden classification pending WHO AnthroPlus BMI-for-age z-score processing, which likely makes the reported prevalence a conservative underestimate; use of a non-validated, study-specific food security screen; a narrower-than-standard three-food-group dietary diversity proxy; a perception-based, single-respondent measure of intra-household food allocation rather than

objectively measured portions; and unadjusted bivariate tests that did not account for clustering within wards or multiple testing, with adults and children pooled in the sex analysis.

### 4.5 Future Research Directions

Future studies should complete BMI-for-age z-score classification for children and adolescents aged 5–17 years to refine double-burden prevalence estimates; assess stunting and underweight alongside wasting using full anthropometric indices; employ a validated food security instrument and a full twelve-food-group dietary diversity score; objectively measure intra-household food allocation (e.g., weighed plate studies); and adopt longitudinal, multivariable, or mixed-methods designs to clarify the causal pathways linking household food security and intra-household food allocation to the double burden of malnutrition.

## 5. CONCLUSIONS

The household double burden of malnutrition is a substantial public health concern in Sokoto Metropolis, affecting approximately one in three households and associated with household food security status and ward of residence, but not with income relative to the minimum wage or maternal nutritional status. Given the descriptive, bivariate nature of this cross-sectional analysis, these findings should be understood as associated factors rather than proven causal determinants. Nutrition interventions in this setting should prioritize household food security programming, with geographically targeted delivery in high-burden wards, alongside further research to test the role of intra-household food allocation, to validate the food security and dietary diversity measures used and to complete the nutritional classification of children and adolescents aged 5–17 years.

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## CONFLICT OF INTEREST

The authors have no conflicts of interest.

## AUTHOR CONTRIBUTION

**Khadijah Abdullahi Bagudu:** Conceptualization, methodology, formal analysis, writing original draft, review and editing. **Murtala Sambo:** Investigation, formal analysis, review and editing. **Aisha Sahalu S/pawa:** Methodology, investigation, data collection. **Fatima Yusuf:** Methodology, investigation, data collection. **Maryam Muhammad:** Investigation, data collection, validation and writing. **Ahmad Ibrahim Maihaja:** Investigation, data collection, validation and writing.

## ETHICAL CONSIDERATION

Ethical approval was obtained from the Sokoto State Ministry of Health Research Ethics Committee (Ref. No. SKHREC/1580/V. IV) prior to data collection, in accordance with the Declaration of Helsinki. Written informed consent was obtained from all adult participants and from the parents/guardians of children [authors to confirm], and confidentiality was maintained throughout the study.

## AVAILABILITY OF DATA AND MATERIAL

The data that support the findings of this study are available in the article. Further details may be obtained from the corresponding author upon request.

## DECLARATION OF AI USE

During the preparation of this manuscript, the authors used Claude (Anthropic), an artificial intelligence language model, to assist with statistical computation on the study dataset, and structuring of the manuscript text, and formatting to journal guidelines. All AI-assisted content, including statistical outputs and tables, was reviewed, verified against the source dataset, and edited by the authors, who take full responsibility for the accuracy, integrity, and originality of the manuscript. No figures, tables, or graphs were generated by AI.

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