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Abstract

From 2013 to 2023, over 90% of the population in Tanzania fell below the WHO-recommended fruit and vegetable (FAV) intake of ≥5 servings/day. Variation between wet and dry seasons further influences dietary intake and stability, which has implications for nutritional adequacy and non-communicable disease (NCD) risk, especially in rural areas. However, evidence on seasonal FAV intake and its determinants in Northwestern Tanzania is limited. This study aimed to describe the adequacy and seasonality of FAV intake and examine associations with socio-demographic and health factors in Northwestern Tanzania. Data were collected from 2012-2013 as part of regular serological surveys in the Magu Health and Demographic Surveillance System (HDSS), including 7,620 participants. Three multinomial logistic regression models were used to assess associations between seasonal FAV intake and socio-demographic and health characteristics. Most participants (96.1%) reported inadequate intake in both seasons. FAV adequacy and intake measures were significantly higher in the wet season compared to the dry season. In adjusted analysis, females and overweight/obese individuals had a lower relative risk of inadequate intake, whereas rural residents and adults aged 50 years or older had a higher risk. These findings emphasize a need for further research and interventions incorporating seasonal variation on FAV intake, with a focus on vulnerable groups and improving year-round accessibility of culturally relevant, affordable FAV within local environmental contexts.

Keywords: fruit and vegetables, seasonality, healthy diet, Tanzania, Magu HDSS

1. Introduction

Tanzania, like many Sub-Saharan African (SSA) countries, is experiencing a rise in the burden of non-communicable diseases (NCDs).[1] Concurrently, the country faces a triple burden of malnutrition, characterized by persistent stunting, increasing rates of obesity, and widespread micronutrient deficiencies.[2,3] These health challenges are driven by multiple factors, including low dietary diversity, rapid population growth, urbanization, and shifts in physical activity patterns and food preferences.[4,5] As diet is a critical determinant of nutrition and disease outcomes, understanding patterns and inadequacies in food consumption is essential for improving population health and reducing disease burden.[2]

One key component of a healthy diet is fruit and vegetable (FAV) intake. Fruits and vegetables provide essential vitamins, minerals, phytonutrients, and dietary fiber, which support overall immune and metabolic health.[7-10] Furthermore, sufficient FAV intake is associated with reduced risk of many NCDs, including cardiovascular disease, type 2 diabetes, and hypertension, as well as all-cause mortality and micronutrient deficiencies.[8,11-15.] These benefits are maximized when individuals consume at least 5 servings, or approximately 400g, of fruits and vegetables daily.[12,6]

Despite these well-documented benefits, FAV intake remains inadequate worldwide. In 2021, approximately 2.6 million deaths were attributable to suboptimal FAV intake.[16.] Only 80% of adults in low- and middle-income countries (LMICs) consume >5 servings/day.[17] In Tanzania, over 90% of the population did not meet this standard in 2013 or 2023, as reported by the STEPwise approach to Surveillance (STEPS) surveys, which assess NCD risk factors at the population level.[18,19]

The Tanzanian government has recognized nutrition and dietary diversity as public health priorities. The National Multisectoral Nutrition Action Plan II for 2021–2026 outlines strategic actions to reduce malnutrition, including a target to lower the prevalence of inadequate FAV intake to 68% by 2025–2026.[2] Similarly, the National Strategic Plan for Prevention and Control of Non-Communicable Diseases (2021–2026) emphasizes dietary awareness and FAV intake.[1] Together, these documents reflect government commitment to FAV intake as an indicator of diet quality and population health, yet data suggest this priority has not translated into practice, as inadequate consumption remains widespread. FAV is a particularly relevant indicator in Tanzania, as it reflects diet quality and micronutrient adequacy, but is strongly constrained by affordability, availability, and seasonal agricultural cycles. Moreover, FAV intake is a globally recognized indicator, allowing comparability across countries and over time. Despite national-level monitoring, there remains a limited understanding of how FAV intake varies across socio-demographic groups and environmental conditions.

Dietary stability refers to the ability of individuals and households to maintain dietary adequacy over time despite environmental or economic fluctuations.[20] Dietary diversity, on the other hand, reflects the variety of foods consumed at a single point in time. Hence, individuals may have diverse diets in one season but still experience dietary instability. In Tanzania, seasonality is an important part of dietary stability, particularly in rural settings where livelihoods and food access are closely related to agricultural cycles.[21] Variations between wet and dry seasons affect the availability, variety, and cost of foods, especially for fruits and vegetables, leading to fluctuations in diet quality and a risk of micronutrient deficiencies.[22-24] Evidence from SSA suggests that rural diets are especially dynamic and that fruit consumption tends to decline during the dry season.[21,25] This dynamic is particularly pronounced in Tanzania, where approximately 80% of rural households primarily depend on home-grown FAV yields.[26,27]

Nutritional outcomes and FAV consumption are also shaped by a range of socio-demographic factors, including education, income, marital status, household size, and gender.[9,22,28,29] Diet and health are closely related, as adequate nutrition supports immune function and the management of chronic diseases, including HIV and hypertension.[30,31] This further stresses the importance of stable access to nutrient-rich foods, like fruits and vegetables, in the Tanzanian health context. Despite recognition that seasonality and other socio-demographic determinants influence dietary diversity and intake, few studies have empirically examined the stability of FAV intake across seasons in Northwestern Tanzania.[32,33]

In Northwestern Tanzania, household food access is shaped by local environmental conditions, making the area particularly relevant for examining dietary stability. The Kisesa ward in the Magu District of Northwestern Tanzania is largely rural, with most residents engaged in subsistence farming or small-scale trade.[34,35] The agricultural sector is particularly sensitive to climatic variability, as irregular rainfall and extended dry spells may undermine crop production and contribute to food insecurity.[36]

Rainfall in Northwestern Tanzania follows a bimodal pattern, with the Vuli (short rains) from October to December and the Masika (long rains) from March to May.[37] Most households cultivate staple crops, including maize, paddy, sorghum, cassava, sweet potatoes, and pulses.[35] Almost all households in Northwestern Tanzania grow food crops, but poorer households' harvests last only a few months, after which they rely on income from other economic activities to meet dietary needs.[38] Limited market access and transportation infrastructure in rural Tanzanian areas, like the Magu District, further restrict access to fruits and vegetables; as a result, fruit and vegetable intake in this setting is highly sensitive to seasonal and climatic fluctuations throughout the year.[39]

Although national surveys such as STEPS provide population-level estimates of FAV intake, they rely on cross-sectional assessments and do not capture seasonal variation at the individual level. Existing Tanzanian studies have examined dietary diversity, food security, or market dynamics rather than longitudinal intake patterns. There remains limited empirical evidence on how FAV intake fluctuates seasonally and which socio-demographic groups are most vulnerable to instability. This study aimed to describe FAV intake and its stability across wet and dry seasons in rural and semi-urban areas of Northwestern Tanzania and identify associated socio-demographic and health factors. Although this approach does not capture real-time intra-individual seasonal variation, it provides population-level insights into perceived seasonal differences in dietary intake, which are relevant in settings where longitudinal dietary data are unavailable.

2. Methodology

2.1 Study design and setting

The Magu Health and Demographic Surveillance System (Magu HDSS) was established in 1994 in a ward called Kisesa, Magu District, Mwanza Region, Northwestern Tanzania, as an open community cohort to study HIV epidemiology. Regular serosurveys have been conducted within the Magu HDSS, targeting all eligible individuals aged 15 years and older. Between 1994 and 2016, eight epidemiological surveys were carried out at roughly three-year intervals.[40]

During each survey round, a temporary clinic was established in each of seven villages. At these clinics, interviews were conducted to collect information on socio-demographic characteristics, birth history, sexual behavior, knowledge and attitudes towards HIV, experience with HIV counseling and treatment (HCT), and screening for other health issues.[41] Serosurvey data were collected electronically and linked to the other HDSS data through a unique household identifying number.

This cross-sectional secondary analysis used data from the seventh round of the Serosurveys, conducted in 2012/2013, which included 7,620 participants. Although the data were collected over a decade ago, they remain relevant because structural determinants of diet in Northwestern Tanzania, such as agricultural dependence and seasonal rainfall patterns, have remained largely consistent. Furthermore, more recent national surveys continue to report a high prevalence of inadequate FAV intake, suggesting that insufficient consumption persists as a public health concern.[18]

As this study represents a secondary analysis of the Sero 7 survey, which was primarily designed to monitor HIV epidemiology, only variables relevant to the current study objectives were extracted from the larger dataset, including FAV intake measures, socio-demographic characteristics, economic activity, HIV status and HCT uptake, self-reported diabetes and hypertension, and clinician-measured anthropometrics (height and weight). Other variables available in Sero 7 (e.g., sexual behavior, reproductive history, HIV knowledge) were not included because they were not pertinent to the research questions of this analysis.

Any participant aged 15+ who completed the Sero 7 Survey was included. Participants were excluded if they had missing data, showed discrepancies in their responses (e.g., indicating 'yes' to having received formal education but reporting zero years of schooling), or answered 'don't know' to any question. All excluded participants were recorded and counted. The final analytical sample, including participants with and without HCT data, was 7,226 individuals.

2.2 Measures

2.2.1 Fruit and vegetable intake

FAV intake was measured using participant responses to the food section of the questionnaire. Illustrated cards were used to show common fruits and vegetables and their average portion sizes; these cards helped participants recall their intake and reduce errors in estimating standard portion sizes. In the Tanzanian context, fruits and vegetables are often consumed as part of mixed dishes (e.g., stews and sauces), which may complicate accurate estimation of portion sizes. Although illustrated portion cards were used to aid recall, some degree of misclassification or measurement error in FAV intake is likely.

Participants were asked whether they consumed fruits or vegetables during the wet and dry seasons, the frequency of consumption in a typical week during that season, and the number of portions typically consumed on days when fruits or vegetables were eaten. The average servings per day of combined fruit and vegetables in the dry versus wet season were the main outcome variables. These measures were calculated using the equation $\left[\frac{(\frac{days\ consumed\ FAV}{week}) \times (\frac{portions\ of\ FAV}{day})}{7}\right]$. Previous studies have also relied on self-reported dietary assessment methods, including food-frequency based approaches, which supports the comparability of findings.[18]

Participants who consumed <5 servings of fruits and/or vegetables per day were categorized as having "inadequate intake," and those who consumed ≥5 servings per day were categorized as having "adequate intake" during either season. This classification is based on the WHO recommendation of ≥5 servings per day and has previously been applied in Tanzania.[9]

To capture the seasonal stability of FAV intake, a four-category FAV stability variable was constructed:

1. Stable adequate: consumed ≥5 servings per day in both wet and dry seasons
2. Wet intake: consumed ≥5 servings per day in the wet season but <5 servings per day in the dry season
3. Dry intake: consumed <5 servings per day in the wet season but ≥5 servings per day in the dry season
4. Stable inadequate: consumed <5 servings per day in both wet and dry seasons

This variable reflects the adequacy and seasonal stability of FAV intake, enabling the

identification of individuals who maintain sufficient intake year-round versus those vulnerable to seasonal declines. The wet and dry intake categories are particularly relevant in policy and health programming as they specify the seasonality of inadequate intake, as opposed to a measure of non-specified directional change.

Because the Sero 7 questionnaire was not designed as a full dietary assessment tool, only a restricted set of diet-related variables was available. Key food groups typically required to analyze complete dietary patterns, as in other Tanzanian studies, were not collected; therefore, this analysis focuses solely on seasonal variation in FAV intake.[21,25]

2.2.2 Socio-demographic characteristics

Participants were interviewed to obtain sociodemographic and health-related characteristics, including age (years), sex (male/female), height (cm), weight (kg), village of residence, educational attainment, marital status, HIV status, use of health services, self-reported presence of diabetes and hypertension, and participation in income-generating activities.

Villages were categorized as semi-urban (Kanyama, Kisesa) or rural (Igekemaja, Kitumba, Isangijo, Ihayabuyaga, Welamasonga). Age was grouped into 15–24, 25–49, and 50+ years. Marital status was categorized as never married, married (monogamous or polygamous), or divorced/widowed/separated. Body mass index (BMI) was calculated using the formula [weight (kg) / (height (m))^2] and categorized as underweight (<18.5), normal (18.5–24.9), or overweight/obese (≥25.0), according to WHO guidelines.[42] Educational status was categorized as no formal education, primary education (completion of primary schooling), or secondary education (secondary school, college, or university). Participants were asked whether they engaged in any income-generating activity (Yes/No). For those reporting participation, the primary income-generating activity was categorized as farming, skilled labor (e.g., driving, professional, skilled labor), or unskilled labor/other (e.g., business, unskilled labor, other).

2.2.3 Health characteristics

HIV status was determined based on clinic HIV test results (positive/negative). HCT uptake was measured using responses to the question: "How many times have you had HIV counseling and testing?", in either a voluntary or provider-initiated context. Participants reporting zero times were categorized as having no HCT uptake, while those reporting one or more tests were categorized as having HCT uptake. HCT uptake was analyzed as a binary variable (any previous HCT/none). This operationalization aligns with approaches used in previous studies examining HIV testing behaviors using binary outcomes.[43,44]

Self-reported diabetes and hypertension status were measured using the response to the questions, "Have you ever been told by a doctor or other health worker that you have raised blood sugar or diabetes?" and "Have you ever been told by a doctor or other health worker that you have high blood pressure or hypertension?", respectively. Both variables were coded as binary outcomes (Yes/No). Although clinical measurements were not collected in Sero 7, self-reported diabetes and hypertension have been used as proxy indicators in similar population-based studies.[45] Diabetes and hypertension were self-reported and not clinically verified, which may result in underreporting and misclassification; this limitation is considered in interpretation of results.

2.3 Statistical analysis

Descriptive statistics were calculated to summarize participant sociodemographic and health characteristics in the 7,226 individual sample. Continuous variables were reported with median

and IQR, while categorical variables were presented with counts and percentages. Continuous FAV intake (servings/day) between the wet and dry seasons was compared using a paired t-test for normally distributed data, with non-parametric Wilcoxon signed-rank tests conducted as a non-parametric sensitivity analysis. Changes in adequacy of intake (<5 vs. ≥5 servings/day) between seasons were assessed using McNemar's test. Associations between dietary stability and socio-demographic factors were examined using multinomial logistic regression. Bivariate models were first fitted for each predictor separately to estimate relative risk ratios (RRR) and 95% confidence intervals. All variables showing marginally significant associations ($p<0.10$) in bivariate analysis were included in the multivariable model to obtain adjusted RRRs. Stable adequate served as the reference category for all models. When expected cell counts were below 5 in certain subgroups, indicating potential data sparsity and risk of unstable model estimates, the categories were collapsed into two groups: stable intake (stable adequate + stable inadequate) and changed intake (wet + dry); these binary analyses focused on whether participants' intake changed across seasons rather than on season-specific adequacy. This collapse required analysis using binary logistic regression and limited the ability to distinguish between improvements and declines in adequacy across seasons.

Complete-case analysis was used for all variables with low missingness (5%). Because HCT had substantial missingness (16.3%), it was excluded from 2 of the multivariable models to prevent major reductions in sample size. Instead, HCT was examined separately using descriptive and bivariate analyses and an additional limited multivariable model. These findings were interpreted cautiously, with no imputation methods being applied. Figure 1 provides a summary of participant inclusion, including missing data. Associations were considered significant at $p < 0.05$. All analyses were conducted using STATA/BE 19.5F and RStudio (version 2023.12.1+402).

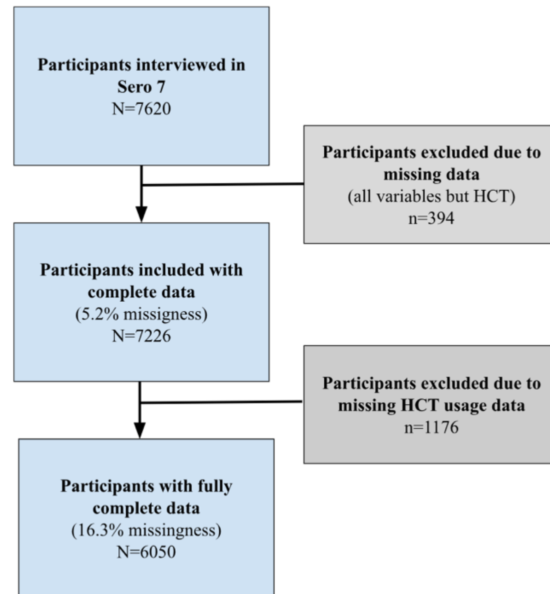

Figure 1. Participant inclusion flow chart.

3. Results

3.1 Population description

Table 1 provides a detailed summary of the sociodemographic, health, and dietary characteristics of the study population. The final analytical sample, including participants with and without HCT data, was comprised of 7,226 individuals, the majority of whom were female (62.65%). Participants were predominantly between 25 and 49 years of age (41.63%), with smaller proportions in the 15–24 (37.14%) and 50+ (21.23%) age groups. Most respondents resided in rural areas (66.04%), while the remaining third lived in semi-urban settings.

With respect to nutritional status, most participants had a normal BMI (69.62%), whereas 20.19% were underweight and 10.19% were overweight or obese. More than half of the participants were married (52.89%), while only 14.99% were widowed, divorced, or separated, and

one-third had never been married. The majority identified as ethnically Sukuma (94.33%). Two-thirds of the population (64.81%) reported participating in an income-generating activity, most frequently farming (78.05%); smaller proportions reported skilled (4.53%) and unskilled labor/other activities (17.42%) (Table 1).

HIV prevalence in the sample was 6.95%. Self-reported diabetes and hypertension were uncommon, reported by 0.43% and 2.68% of participants, respectively (Table 1). Of the 6,050 respondents with responses for the HIV counseling and testing question, uptake was 43.02%.

The high proportion of rural residents and farming households is particularly relevant given the study's focus on seasonal dietary stability, as these groups are more directly impacted by agricultural cycles and rainfall variability.

3.2 Patterns of fruit and vegetable consumption

Overall, fruit and vegetable consumption was low among participants. Median combined FAV intake was 1.71 servings per day (IQR: 1.29–2.36) (Table 1). Intake varied by season, with higher consumption during the wet season. Median daily FAV intake during the wet season was 2.29 servings (IQR: 1.71–3.29), compared with 1.00 servings in the dry season (IQR: 0.57–1.71).

When fruit and vegetable intake were examined separately, participants reported slightly higher fruit consumption than vegetable consumption in both seasons. Median daily fruit intake was 0.93 servings (IQR: 0.57–1.36), while median vegetable intake was 0.79 servings per day (IQR: 0.50–1.14). Both fruits and vegetables were consumed a median of 3.50 days/week throughout the year.

Figure 2 presents mean daily FAV intake in the wet and dry seasons across sociodemographic, socioeconomic, and health-related subgroups. Although the magnitude of difference varied by subgroup, the consistent pattern indicates higher FAV consumption during the wet season across the entire study population.

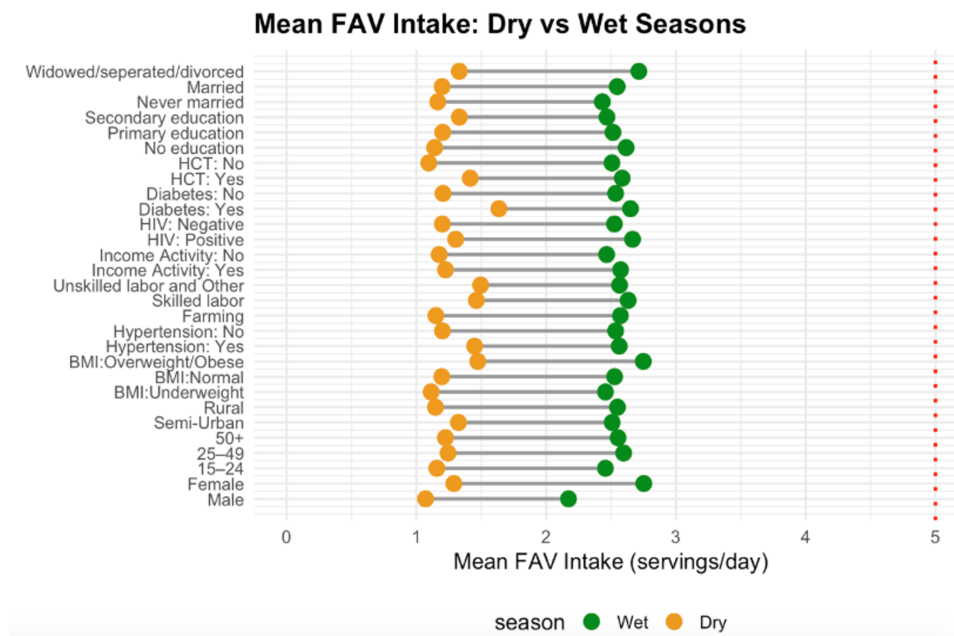

Figure 2. Mean FAV intake for wet and dry seasons by sociodemographic and health characteristics.

3.3 Seasonal differences in fruit and vegetable intake

Table 2 presents the cross-tabulation of FAV intake adequacy across the wet and dry seasons. Overall, only a small proportion of participants met adequate FAV intake in either season. During the wet season, 261 participants (3.61%) achieved adequate FAV intake, while 6,965 (96.39%) did not. In the dry season, adequacy further declined: only 42 participants (0.58%) met adequate intake, while 7,184 (99.42%) were inadequate.

Across seasons, only 23 participants (0.32%) achieved adequate intake in both the wet and dry seasons. An additional 238 (3.29%) had adequate intake in the wet season but not the dry season, while 19 (0.29%) improved from inadequate in the wet season to adequate in the dry season. The majority, 6,946 participants (96.12%), reported inadequate intake in both seasons.

There was a statistically significant difference in FAV intake between the wet and dry seasons. On average, participants consumed substantially more FAV during the wet season, with a mean increase of 1.33 servings per day (95% CI: 1.30–1.35; $t = 68.41$, $p < 0.01$). The Wilcoxon signed-rank test confirmed this difference ($Z = 68.58$; $p < 0.01$), indicating a consistent seasonal shift in intake.

The odds of achieving adequate intake were also markedly higher in the wet season. Participants had 12.53 times higher odds of meeting recommended intake levels in the wet season compared with the dry season (95% CI: 7.85-21.18; $\chi^2 = 186.62$; $p < 0.01$). Detailed results are presented in Table 3.

3.4 Bivariate regression

Table 4 summarizes the bivariate logistic regression results comparing three FAV stability categories (Wet Intake, Dry Intake, and Stable Inadequate) relative to the reference group (Stable Adequate). These findings should be interpreted cautiously due to small cell counts for some variables and resulting wide confidence intervals.

Females had a significantly lower relative risk of Stable Inadequate intake (RRR = 0.07; 95% CI: 0.01–0.55; $p = 0.01$) compared with males. Rural residence was associated with a higher relative risk across all three FAV stability categories compared with semi-urban residents: Wet Intake (RRR = 10.52; 95% CI: 4.16–26.62; $p < 0.01$), Dry Intake (RRR = 4.06; 95% CI: 1.11–14.81; $p= 0.03$), and Stable Inadequate (RRR = 3.56; 95% CI: 1.51-8.40; $p<0.01$). Overweight or obese participants had a significantly lower risk of Wet Intake (RRR = 0.27; 95% CI: 0.14–0.71; $p < 0.01$) and Stable Inadequate intake (RRR = 0.23; 95% CI: 0.10-0.57; $p < 0.01$) relative to those with normal BMI.

Of those economically-active participants, those who worked Unskilled/other labor had a lower relative risk of Wet Intake compared to those who farmed as their main activity (RRR = 0.42; 95% CI: 0.08–0.57; $p<0.01$).

Of those limited participants with responses for HCT usage, uptake was associated with lower relative risk. Individuals who had ever used HCT services were significantly less likely to experience Wet Intake (RRR = 0.26; 95% CI: 0.09–0.73; $p = 0.01$) and less likely have Stable Inadequate intake (RRR = 0.22; 95% CI: 0.08–0.60; $p < 0.01$), compared with those who had never used HCT services.

No other sociodemographic, economic, or health variables were significantly associated with FAV stability categories, but the 50+ age group and income-generating participation were both marginally associated with Dry Intake and Stable Inadequate, respectively. Due to low cell counts, self-reported diabetes and education results were unstable; a corresponding binary analysis for both variables is presented in the Appendix, with no statistically significant findings.

3.5 Multivariable regression

Table 5 presents the adjusted multinomial logistic regression results comparing the three FAV stability categories (Wet Intake, Dry Intake, and Stable Inadequate) with the reference group, Stable Adequate intake. Analyses were conducted in three samples based on data availability. Results for the full analytic sample are presented first. Of the 7,620 participants in the Sero 7 survey, 7,226 were included in this analysis after excluding those with missing values on key variables. This sample represents the broadest available dataset for examining FAV stability categories and serves as the primary reference for comparisons with the two subsamples presented subsequently.

3.5.1 Full analytic sample (N=7,226)

Females had a lower relative risk of Stable Inadequate intake compared to males (RRR = 0.10; 95% CI: 0.01–0.72; p=0.02). Those aged 50 years or older had a significantly higher relative risk of Wet Intake (RRR = 10.86; 95% CI: 1.26–93.69; p=0.03) and Dry Intake (RRR = 15.41; 95% CI: 1.33–178.61; p=0.03), compared to those aged 15-24. Compared with semi-urban residents, rural participants had a significantly higher relative risk of experiencing Wet Intake (RRR = 10.86; 95% CI: 3.85–26.62; p<0.01) and Stable Inadequate intake (RRR = 2.98; 95% CI: 1.21–7.30; p=0.02). Overweight or obese participants had a 63% lower relative risk of Stable Inadequate intake (RRR = 0.37; 95% CI: 0.15–0.93; p = 0.04) compared with those with normal BMI. Income-generating activity participation showed no statistically significant association with any FAV stability category after adjustment.

3.5.2 Subsample of economically active participants (N= 4,683)

Among economically active participants, only resident area and BMI factors had significant associations. Rural residence had a higher relative risk of Wet Intake (RRR = 9.99; 95% CI: 3.11-32.10; p<0.01) and Dry Intake (RRR = 6.47; 95% CI: 1.11-37.65; p=0.04), compared to semi-urban participants. Overweight or obese participants had a significantly lower risk of Stable Inadequate intake (RRR = 0.36; 95% CI: 0.13–0.95; p=0.04) relative to those with normal BMI.

3.5.3 Subsample of participants with HIV counselling and testing usage data (N= 6,050)

Of those participants with a response to HCT usage, females had a lower relative risk of Stable Inadequate intake compared to males (RRR = 0.10, 95% CI: 0.01–0.76; p=0.03). In line with the other models' findings, rural residents had a higher relative risk of Wet Intake (RRR = 7.36; 95% CI: 2.63-20.63; p<0.01), compared to semi-urban participants. HCT uptake had a lower relative risk of Stable Inadequate intake (RRR = 0.37, 95% CI: 0.13–1.07), although this association was insignificant (p = 0.07). No other independent variable showed statistically significant associations with any FAV intake category.

4. Discussion

Overall, FAV intake in this rural/semi-urban Tanzanian population was low, with a median intake of 1.71 servings/day. Only 3.56% of individuals achieved adequate intake in at least one season, with less than 1% meeting recommended intake in both seasons. FAV intake showed strong seasonal variation, with significantly higher intake in the wet season compared with the dry season. Wet-season intake exceeded dry-season intake by 1.33 servings per day on average (95% CI: 1.30–1.45), with a 12.53-fold increase in the odds of adequate consumption.

Multivariable analyses identified several significant associations, although some estimates were imprecise due to wide confidence intervals and small cell counts. In adjusted models, female sex and

being overweight/obese were associated with a lower risk of inadequate intake, whereas rural residence and being aged 50+ were associated with a higher risk of inadequate or seasonally unstable intake. Associations with income-generating activity and HCT uptake attenuated after adjustment.

The low overall intake observed aligns with national findings from the Tanzania STEPS surveys, which similarly report average daily FAV intake of 1.5–2.5 servings.[18,19] Comparable patterns of inadequate consumption have been documented across SSA studies and STEP surveys.[16,17,46,47] This pattern likely reflects broader structural barriers such as limited storage capacity, low purchasing power, competing food priorities, limited nutritional knowledge, as well as shifting diets.[48,49] Data from high-income settings also supports low-intake, illustrating the scoping inadequacies of diets worldwide.[50]

Seasonal variation in FAV availability and intake is also well-established, with dry/post-harvest periods consistently associated with decreased dietary diversity and reduced access to fresh produce.[23,25,48,51] Considering the high prevalence of farming as an income-generating activity, FAV intake is likely to be influenced by seasonality, as agricultural cycles affect food availability, access, utilization, and supply stability in Tanzania.[25] Diets are often more diverse in the rainy season, especially with respect to intake of FAV, such as vitamin A-rich dark leafy greens and fruits.[51] This further highlights the nutritional impact of fluctuating diets, as individuals' intakes of beneficial nutrients vary throughout the year, reducing the optimization of FAV benefits.

In line with this study, Msambichaka et al. (2018) found that women had a lower risk for inadequate intake.[9] While this pattern was not statistically significant across all literature, a pattern of higher FAV intake among women is consistently observed in STEPS findings.[18,19] This finding could be a result of women's central role in preparing and managing food resources in Tanzanian households, as well as greater reported awareness of healthy diets and seeking nutritional guidance.[51] Furthermore, men consume their meals out of the home more often than women, which may impact their access and consumption of FAV.[52,53]

The observed associations between rural residence and FAV stability differ in some literature, suggesting that rural households may have greater access to FAV due to proximity to agricultural production; however, they are consistent with studies that incorporate seasonal analyses, which more effectively capture dietary variation.[7,48] Rural regions often face shortages post-harvest, limited storage capacity, reduced market access, and lower financial resources to buffer seasonal price increases.[18,21,25] Affordability is a well-documented barrier to the intake of adequate diets for rural households.[33,51,54] Furthermore, to meet the recommended FAV intake, the increase in food expenditure would be more significant in rural areas than urban ones.[49] Notably, rural residence remained a significant predictor across adjusted models, strengthening confidence in this association.

The observed inadequate intake among adults aged 50 years or older is supported by evidence from SSA showing that most elderly adults have limited dietary adequacy.[55,56] FAV intake decreases with age, although some Tanzanian findings suggest the opposite, indicating possible regional or cohort differences.[9,48,55] Older adults may face barriers to adequate FAV intake due to reduced income, physical limitations affecting food production, reliance on others for food procurement, and prioritization of staple foods over fruits and vegetables.[57] In rural settings, older adults may be disproportionately affected by seasonal food shortages due to limited mobility and resources. Furthermore, few interventions have focused on the nutritional status of this population, since women of

reproductive age, infants, and children are often prioritized due to their specific needs.[55,56]

Groups identified with a higher risk of inadequate FAV intake in this study, including rural residents, older adults, and men, are also shown to have a higher prevalence of hypertension in Tanzania.[58] As prevalence for related NCDs is rising, this link suggests that seasonal dietary inadequacy may contribute to existing NCD vulnerabilities.[1]

Limited literature exists on BMI and FAV, making direct comparisons difficult; however broader dietary diversity and food insecurity research highlights various pathways. Korir et al. (2024) found a positive association between dietary diversity and BMI, suggesting that more varied food intake may be linked to overweight/obese BMI categories.[59] While FAV has a positive impact on an individual's diet, its association to higher BMI may be diminished by unhealthy eating patterns like high-calorie or high-fat diets. Dietary diversity does not necessarily equate to nutritional adequacy, so this relationship should be considered critically and further studied. Food security may also be a mediating factor, as food-secure women were found to have higher median BMI values.[27,60] Seasonal fluctuations in FAV availability may have a smaller impact among food-secure individuals, which could support the lower risk of inadequate intake observed among overweight/obese participants.[27]

The positive, though not statistically significant, association between HCT uptake and adequate intake is consistent with Msambichaka et al. (2018) linking health-seeking behaviors to higher FAV intake, although evidence remains preliminary.[9] Another study identified that increased preventative health care usage was associated with healthy behaviors; even though FAV intake was not significantly associated, it supports a potential pathway for understanding the direction of association.[61] This positive but non-significant association may represent a preliminary pathway, but requires further exploration.

4.1 Strengths and limitations

This is among the few studies in Tanzania that focus specifically on FAV intake. The Sero 7 dataset offered a large sample size, which was important given the low incidence of adequate intake, and ensured socio-demographic attributes were represented in the sample. Considering the changing nutritional and epidemiological landscape of Tanzania, this study supports previously identified patterns of FAV intake and highlights a need for additional, more current research.

This study was based on a secondary analysis of cross-sectional data, which limits the ability to infer causal relationships between FAV stability and health or socio-demographic factors. The data were collected in 2012–2013; thus, findings may not fully reflect recent dietary patterns. In addition, self-reported information on FAV intake and disease diagnoses for hypertension and diabetes may be subject to recall bias. The use of a single dietary indicator may not capture the full complexity of dietary diversity, total nutrient intake, or intra-seasonal fluctuations in intake. Furthermore, the Sero 7 questionnaire did not distinguish between staple crops and other vegetables. No imputation methods were used; complete-case analysis was applied because missingness was minimal for most variables. Despite low missingness, excluding participants with incomplete responses may have introduced selection bias if missingness was not random. Individuals with lower literacy or education may be more likely to provide incomplete responses and may also be more vulnerable to inadequate FAV intake, potentially leading to underestimation of the true magnitude of dietary inadequacy. Missingness in the HCT variable was higher and was addressed analytically by separating HCT in the analysis. Furthermore, no information about other potential modifiers, such as an awareness of the components

of a healthy diet, purchasing power, and accessibility, was collected. Finally, because the data come from one geographic region in Northwestern Tanzania, generalizability to other populations is limited.

4.2 Recommendations

This study provides evidence of significant seasonality in FAV intake in Northwestern Tanzania and associated determinants. These findings highlight the need for season-conscious interventions that stabilize year-round access and consumption of FAV. Future studies should consider more frequent and longitudinal dietary assessments, such as those employed in initiatives like the CGIAR-led Fruit and Vegetables for Sustainable Healthy Diets Initiative, which utilize repeated measurements to better capture seasonal dietary variation.

Research exploring the specific cultural, environmental, and economic mechanisms that shape intake is essential to illuminating why such associations exist. Given the epidemiological transition in Tanzania, studies should also explore seasonal dietary inadequacy as a specific risk factor for NCDs. Furthermore, evaluative studies on interventions like community gardens, improved storage and processing infrastructure, and subsidies for FAV during the dry season would provide evidence for practice.

While current national action plans acknowledge the importance of improving FAV intake, such reporting lacks a seasonal dimension. Future policies should emphasize education on the importance of FAV intake and strengthening the food system to reduce potential barriers like affordability. Studies have shown that improving knowledge through education is not enough to improve diets in Tanzania and that structural interventions are also necessary.[48] Furthermore, specific populations, like rural residents, males, and older adults, who were associated with inadequate intake, should be targeted as well.

5. Conclusion

This study confirms low FAV intake in this rural and semi-urban Tanzanian population and demonstrates an association between seasonal inadequacy with socio-demographic and health factors. Adequate intake was uncommon year-round and even rarer in the dry season. The significant seasonal fluctuation highlights the role of environmental conditions and socio-demographic determinants in shaping dietary patterns. Rural residence and older age were associated with a higher risk of inadequate consumption in both individual seasons and over the combined period. Women and individuals who were overweight/obese had a lower risk for inadequate intake year-round. These findings emphasize the need for additional research on dietary patterns, with a focus on FAV and seasonality. Future interventions should emphasize stability, affordability, and accessibility of FAV throughout the year. Tailored strategies for higher-risk populations are particularly important. As Tanzania's population and nutritional landscapes change, addressing FAV fluctuations and adequacy is consequential.

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References

1. MOHCDGEC. (2021). *National Strategic Plan for Prevention and Control of Non-Communicable Diseases 2021-2026. Ministry of Health, Community Development, Gender, Elderly, and Children.* https://tzdpg.or.tz/wp-content/uploads/2022/04/NCD-ACTION-PLAN-2021-2026.pdf
2. PMO. (2021). *National Multisectoral Nutrition Action Plan II 2021/22-2025/26*. United Republic of Tanzania's Prime Minister's Office. https://www.pmo.go.tz/uploads/documents/sw-1646121553-NMNAP.pdf
3. Steyn, N. P., & McHiza, Z. J. (2014). Obesity and the nutrition transition in Sub-Saharan Africa. *Annals of the New York Academy of Sciences*, 1311, 88–101. https://doi.org/10.1111/nyas.12433
4. Amunga, D. A., Hess, S. Y., Grant, F. K. E., Kinabo, J., & Olney, D. K. (2024). Diets, Fruit and Vegetable Intake and Nutritional Status in Tanzania: Scoping Review. *Maternal & Child Nutrition*, e13785. https://doi.org/10.1111/mcn.13785
5. Bosu, W. K. (2015). An overview of the nutrition transition in West Africa: Implications for non-communicable diseases. *The Proceedings of the Nutrition Society*, 74(4), 466–477. https://doi.org/10.1017/S0029665114001669
6. WHO. (n.da). *Healthy diet*. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/healthy-diet
7. Mensah, D. O., Nunes, A. R., Bockarie, T., Lillywhite, R., & Oyebode, O. (2021). Meat, fruit, and vegetable consumption in sub-Saharan Africa: A systematic review and meta-regression analysis. *Nutrition Reviews*, 79(6), 651–692. https://doi.org/10.1093/nutrit/nuaa032
8. Wallace, T. C., Bailey, R. L., Blumberg, J. B., Burton-Freeman, B., Chen, C. O., Crowe-White, K. M., Drewnowski, A., Hooshmand, S., Johnson, E., Lewis, R., Murray, R., Shapses, S. A., & Wang, D. D. (2020). Fruits, vegetables, and health: A comprehensive narrative, umbrella review of the science and recommendations for enhanced public policy to improve intake. *Critical Reviews in Food Science and Nutrition*, 60(13), 2174–2211. https://doi.org/10.1080/10408398.2019.1632258
9. Msambichaka, B., Eze, I. C., Abdul, R., Abdulla, S., Klatser, P., Tanner, M., Kaushik, R., Geubbels, E., & Probst-Hensch, N. (2018). Insufficient Fruit and Vegetable Intake in a Low- and Middle-Income Setting: A Population-Based Survey in Semi-Urban Tanzania. *Nutrients*, 10(2), 222. https://doi.org/10.3390/nu10020222
10. Liu, R. H. (2013). Health-promoting components of fruits and vegetables in the diet. *Advances in Nutrition*, 4(3), 384S-92S. https://doi.org/10.3945/an.112.003517
11. Aune, D., Giovannucci, E., Boffetta, P., Fadnes, L. T., Keum, N., Norat, T., Greenwood, D. C., Riboli, E., Vatten, L. J., & Tonstad, S. (2017). Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality—A systematic review and dose-response meta-analysis of prospective studies. *International Journal of Epidemiology*, 46(3), 1029–1056. https://doi.org/10.1093/ije/dyw319
12. Wang, X., Ouyang, Y., Liu, J., Zhu, M., Zhao, G., Bao, W., & Hu, F. B. (2014). Fruit and vegetable consumption and mortality from all causes, cardiovascular disease, and cancer: Systematic review and dose-response meta-analysis of prospective cohort studies. *BMJ*, 349, g4490. https://doi.org/10.1136/bmj.g4490
13. Boeing, H., Bechthold, A., Bub, A., Ellinger, S., Haller, D., Kroke, A., Leschik-Bonnet, E., Müller, M. J., Oberritter, H., Schulze, M., Stehle, P., & Watzl, B. (2012). Critical review: Vegetables and fruit in the prevention of chronic diseases. *European Journal of Nutrition*, 51(6), 637–663. https://doi.org/10.1007/s00394-012-0380-y
14. Siegel, K. R. (2019). Insufficient Consumption of Fruits and Vegetables among Individuals 15 Years and Older in 28 Low- and Middle-Income Countries: What Can Be Done? The Journal of

Nutrition, 149(7), 1105–1106. https://doi.org/10.1093/jn/nxz123

15. Springmann, M., Mozaffarian, D., Rosenzweig, C., & Micha, R. (2022). 2021 Global Nutrition Report Chapter 2: What we eat matters: Health and environmental impacts of diets worldwide. Development Initiatives. https://globalnutritionreport.org/reports/2021-global-nutrition-report/
16. Xu, X., Yan, P., Chen, W., Wei, W., Thomson, B., Ruan, S., Cao, Z., Ou, C., Geldsetzer, P., Han, T., Wang, J., Chen, S., & Li, J. (2025). The global burden of disease attributable to suboptimal fruit and vegetable intake, 1990–2021: A systematic analysis of the global burden of disease study. *BMC Medicine*, 23, 456. https://doi.org/10.1186/s12916-025-04275-9
17. Frank, S. M., Webster, J., McKenzie, B., Geldsetzer, P., Manne-Goehler, J., Andall-Brereton, G., Houehanou, C., Houinato, D., Gurung, M. S., Bicaba, B. W., McClure, R. W., Supiyev, A., Zhumadilov, Z., Stokes, A., Labadarios, D., Sibai, A. M., Norov, B., Aryal, K. K., Karki, K. B., … Jaacks, L. M. (2019). Consumption of Fruits and Vegetables Among Individuals 15 Years and Older in 28 Low- and Middle-Income Countries. *The Journal of Nutrition*, 149(7), 1252–1259. https://doi.org/10.1093/jn/nxz040
18. MOHTZ, NIMR, and OCGS. (2023). *Non-Communicable Disease Risk Factors (STEPS) Survey 2023*. Ministry of Health Mainland Tanzania and Zanzibar. https://cdn.who.int/media/docs/default-source/2021-dha-docs/2023-steps-country-report-united-republic-of-tanzania.pdf?sfvrsn=2d22c772_1
19. Mayige, M. (2013). *Tanzania STEPS Survey Report*. National Institute for Medical Research. https://www.researchgate.net/profile/Gibson-Kagaruki/publication/311065616_TANZANIA_STEPS_SURVEY_REPORT/links/583c978a08ae502a85e3e9bd/TANZANIA-STEPS-SURVEY-REPORT.pdf
20. Mtingele, A., & O'Connor, D. (2019). Seasonality, food prices and dietary choices of vulnerable households: A case study of nutritional resilience in Tanzania – African Journal of Agricultural and Resource Economics. Seasonality, Food Prices and Dietary Choices of Vulnerable Households: A Case Study of Nutritional Resilience in Tanzania, *African Journal of Agricultural and Resource Economics,* 14(3), 202–218.
21. Paulo, L. S., Lenters, V. C., Chillo, P., Wanjohi, M., Piedade, G. J., Mende, D. R., Harris, V., Kamuhabwa, A., Kwesigabo, G., Asselbergs, F. W., & Klipstein-Grobusch, K. (2025). Dietary patterns in Tanzania's transitioning rural and urban areas. *Journal of Health, Population, and Nutrition*, 44, 71. https://doi.org/10.1186/s41043-025-00774-w
22. Stadlmayr, B., Trübswasser, U., McMullin, S., Karanja, A., Wurzinger, M., Hundscheid, L., Riefler, P., Lemke, S., Brouwer, I. D., & Sommer, I. (2023). Factors affecting fruit and vegetable consumption and purchase behavior of adults in sub-Saharan Africa:A rapid review. *Frontiers in Nutrition*, 10. https://doi.org/10.3389/fnut.2023.1113013
23. Waswa, L. M., Jordan, I., Krawinkel, M. B., & Keding, G. B. (2021). Seasonal Variations in Dietary Diversity and Nutrient Intakes of Women and Their Children (6-23 Months) in Western Kenya. *Frontiers in Nutrition*, 8, 636872. https://doi.org/10.3389/fnut.2021.636872
24. Vaitla, B., Devereux, S., & Swan, S. H. (2009). Seasonal Hunger: A Neglected Problem with Proven Solutions. *PLOS Medicine*, 6(6), https://doi.org/10.1371/journal.pmed.1000101
25. Ntwenya, J. E., Kinabo, J., Msuya, J., Mamiro, P., & Majili, Z. S. (2015). Dietary Patterns and Household Food Insecurity in Rural Populations of Kilosa District, Tanzania. *PLoS ONE*, 10(5), e0126038. https://doi.org/10.1371/journal.pone.0126038
26. Minja, E. G., Swai, J. K., Mponzi, W., Ngowo, H., Okumu, F., Gerber, M., Pühse, U., Long, K. Z., Utzinger, J., Lang, C., Beckmann, J., & Finda, M.

(2021). Dietary diversity among households living in Kilombero district, in Morogoro region, South-Eastern Tanzania. *Journal of Agriculture and Food Research,* 5, 100171. https://doi.org/10.1016/j.jafr.2021.100171

27. Leyna, G. H., Mmbaga, E. J., Mnyika, K. S., Hussain, A., & Klepp, K.-I. (2010). Food insecurity is associated with food consumption patterns and anthropometric measures but not serum micronutrient levels in adults in rural Tanzania. *Public Health Nutrition*, 13(9), 1438–1444. https://doi.org/10.1017/S1368980010000327
28. Gebre, G. G., & Rahut, D. B. (2021). Prevalence of household food insecurity in East Africa: Linking food access with climate vulnerability. *Climate Risk Management*, 33, 100333. https://doi.org/10.1016/j.crm.2021.100333
29. Kamphuis, C. B. M., Giskes, K., de Bruijn, G.-J., Wendel-Vos, W., Brug, J., & van Lenthe, F. J. (2006). Environmental determinants of fruit and vegetable consumption among adults: Asystematic review. *The British Journal of Nutrition*, 96(4), 620–635.
30. Obeagu, E. I., Obeagu, G. U., & Okwuanaso, C. (2024). Optimizing Immune Health in HIV Patients through Nutrition: A Review. *Elite Journal of Immunology*, 2(1). https://www.researchgate.net/publication/378684472_Optimizing_Immune_Health_in_HIV_Patients_through_Nutrition_A_Review
31. Nitin, P., Shashidara, R., Hedge, U., Jaishanka, H., & Sreeshyla, H. (2023). JCDR - Immune System and Malnutrition: The Inseparable Duo in Managing HIV: A Narrative Review. *Journal of Clinical and Diagnostic Research*, 17(10), CE01–CE05. doi.org/10.7860/JCDR/2023/65524.18533
32. Bai, Y., Naumova, E. N., & Masters, W. A. (2020). Seasonality of diet costs reveals food system performance in East Africa. Science Advances, 6(49), eabc2162. https://doi.org/10.1126/sciadv.abc2162
33. Hirvonen, K., Taffesse, A. S., & Worku Hassen, I. (2015). Seasonality and household diets in Ethiopia. *Public Health Nutrition*, 19(10), 1723–1730. https://doi.org/10.1017/S1368980015003237
34. Gourlay, A., Wringe, A., Birdthistle, I., Mshana, G., Michael, D., & Urassa, M. (2014). “It is like that, we didn’t understand each other”: Exploring the influence of patient-provider interactions on prevention of mother-to-child transmission of HIV service use in rural Tanzania. *PloS One*, 9(9), e106325. https://doi.org/10.1371/journal.pone.0106325
35. Katunzi, W. R. (2013). The Impacts of Climate Change on Food Security and Community Base Adaptation options: The Case of Magu District in Mwanza, Tanzania.*The Open University of Tanzania.* https://repository.out.ac.tz/922/
36. Magang, D., Ojara, M., & Lou, Y. (2024). Dry spells and probability of rainfall occurrence over Tanzania, East Africa. In Review. https://doi.org/10.21203/rs.3.rs-3873481/v1
37. Suleiman, R. (2018). Local and regional variations in conditions for agriculture and food security in Tanzania: A review (No. 10; AgriFoSe2030). Department of Food Technology, Nutrition and Consumer Sciences, College of Agriculture, Sokoine University of Agriculture. https://pub.epsilon.slu.se/16577/1/suleiman_r_200116.pdf
38. FEWS NET. (2008). *Preliminary Rural Livelihood Zoning: Tanzania*. Famine Early Warning Systems Network. https://fews.net/east-africa/tanzania/livelihood-description/september-2008/print
39. Ameye, H. (2023). Dietary quality in rural areas, secondary towns, and cities: Insights from Tanzania. *Food Security*, 15, 1563–1584.
40. Urassa, M., Marston, M., Mangya, C., Materu, J., Elsabe, D., Safari, K., Kagoye, S., Todd, J., & Boerma, T. (2024). Cohort Profile Update: Magu Health and Demographic Surveillance System, Tanzania. *International Journal of Epidemiology*, 53(3), dyae058. https://doi.org/10.1093/ije/dyae058
41. Kishamawe, C., Isingo, R., Mtenga, B., Zaba, B., Todd, J., Clark, B., Changalucha, J., & Urassa, M.

(2015). Health & Demographic Surveillance System Profile: The Magu Health and Demographic Surveillance System (Magu HDSS). *International Journal of Epidemiology*, 44(6), 1851–1861. https://doi.org/10.1093/ije/dyv188
42. WHO. (n.db). *Body mass index (BMI).* https://www.who.int/data/gho/data/themes/topics/topic-details/GHO/body-mass-index
43. Ren, X.-L., Wu, Z.-Y., Mi, G.-D., McGoogan, J. M., Rou, K.-M., Zhao, Y., & Zhang, N. (2017). HIV care-seeking behaviour after HIV self-testing among men who have sex with men in Beijing, China: A cross-sectional study. *Infectious Diseases of Poverty,* 6(1), 112. https://doi.org/10.1186/s40249-017-0326-y
44. Asingwire, J. M., Isiko, I., Rombe, K. F., Mwesigwa, A., Ikwara, E. A., Olot, H., Okoro, L. N., Izunwanne, M. J. P., Agunwa, B. O., Bwana, A. A., Kalemba, W. Y., & Anyamene, E. L. (2025). Prevalence and determinants of HIV testing-seeking behaviors among women of reproductive age in Tanzania: Analysis of the 2022 Demographic and health survey. *AIDS Research and Therapy,* 22(1), 14. https://doi.org/10.1186/s12981-025-00710-2
45. Smith, L., López Sánchez, G. F., Veronese, N., Soysal, P., Oh, H., Barnett, Y., Keyes, H., Butler, L., Allen, P., Kostev, K., Jacob, L., Shin, J. I., & Koyanagi, A. (2022). Fruit and Vegetable Intake and Non-Communicable Diseases among Adults Aged ≥50 Years in Low- and Middle-Income Countries. *The Journal of Nutrition, Health & Aging*, 26(11), 1003–1009. https://doi.org/10.1007/s12603-022-1855-z
46. Keding, G. B., Msuya, J. M., Maass, B. L., & Krawinkel, M. B. (2012). Relating dietary diversity and food variety scores to vegetable production and socio-economic status of women in rural Tanzania. *Food Security,* 4(1), 129–140. https://doi.org/10.1007/s12571-011-0163-y
47. Padrão, P., Laszczyńska, O., Silva-Matos, C., Damasceno, A., & Lunet, N. (2012). Low fruit and vegetable consumption in Mozambique: Results from a WHO STEPwise approach to chronic disease risk factor surveillance. *British Journal of Nutrition,* 107(3), 428–435. https://doi.org/10.1017/S0007114511003023
48. Kaur, S. (2023). Barriers to consumption of fruits and vegetables and strategies to overcome them in low- and middle-income countries: A narrative review. *Nutrition Research Reviews,* 36(2), 420–447. https://doi.org/10.1017/S0954422422000166
49. Miller, V., Yusuf, S., Chow, C. K., Dehghan, M., Corsi, D. J., Lock, K., Popkin, B., Rangarajan, S., Khatib, R., Lear, S. A., Mony, P., Kaur, M., Mohan, V., Vijayakumar, K., Gupta, R., Kruger, A., Tsolekile, L., Mohammadifard, N., Rahman, O., … Mente, A. (2016). Availability, affordability, and consumption of fruits and vegetables in 18 countries across income levels: Findings from the Prospective Urban Rural Epidemiology (PURE) study. *The Lancet Global Health*, 4(10), e695-703. https://doi.org/10.1016/S2214-109X(16)30186-3
50. Xu, X., Yan, P., Chen, W., Wei, W., Thomson, B., Ruan, S., Cao, Z., Ou, C., Geldsetzer, P., Han, T., Wang, J., Chen, S., & Li, J. (2025). The global burden of disease attributable to suboptimal fruit and vegetable intake, 1990–2021: A systematic analysis of the global burden of disease study. *BMC Medicine*, 23(1), 456. https://doi.org/10.1186/s12916-025-04275-9
51. Abizari, A.-R., Azupogo, F., Nagasu, M., Creemers, N., & Brouwer, I. D. (2017). Seasonality affects dietary diversity of school-age children in northern Ghana. *PLOS ONE*, 12(8), e0183206. https://doi.org/10.1371/journal.pone.0183206
52. Macha, D. E., Chegere, M. J., & Munuo, A. (2025). *Gendered Pathways to Nutrition in Tanzania: The Interplay of Household Dynamics, Food Affordability and Adaptive Strategies.* African Economic Research Consortium. https://publication.aercafricalibrary.org/handle/123456789/4013
53. Ambikapathi, R., Irema, I., Lyatuu, I., Caswell, B., Mosha, D., Nyamsangia, S., Galvin, L., Mangara, A., Boncyk, M., Froese, S. L., Verissimo, C. K.,

Itatiro, J., Kariathi, V., Kazonda, P., Wandella, M., Fawzi, W., Killewo, J., Mwanyika-Sando, M., PrayGod, G., … Gunaratna, N. S. (2022). Gender and Age Differences in Meal Structures, Food Away from Home, Chrono-Nutrition, and Nutrition Intakes among Adults and Children in Tanzania Using a Newly Developed Tablet-Based 24-Hour Recall Tool. *Current Developments in Nutrition,* 6(3), nzac015. https://doi.org/10.1093/cdn/nzac015
54. Krige, S. M., Mahomoodally, F. M., Subratty, A. H., & Ramasawmy, D. (2012). Relationship between Socio-Demographic Factors and Eating Practices in a Multicultural Society. *Food and Nutrition Sciences*, 3(3), 286–295. https://doi.org/10.4236/fns.2012.33042
55. Mbwana, H. A., Kinabo, J., Lambert, C., & Biesalski, H. K. (2016). Determinants of household dietary practices in rural Tanzania: Implications for nutrition interventions. *Cogent Food & Agriculture,* 2(1), 1224046. https://doi.org/10.1080/23311932.2016.1224046
56. Peltzer, K., & Phaswana-Mafuya, N. (2012). Fruit and vegetable intake and associated factors in older adults in South Africa. *Global Health Action*, 5, 10.3402/gha.v5i0.18668. https://doi.org/10.3402/gha.v5i0.18668
57. Kimokoti, R. W., & Hamer, D. H. (2008). Nutrition, health, and aging in sub-Saharan Africa. *Nutrition Reviews*, 66(11), 611–623. https://doi.org/10.1111/j.1753-4887.2008.00113.x
58. Kilume, U., Luoga, P., Nyangi, E., & Nyamuhanga, T. (2025). "It is just that we are alive but we are suffering": Experience of food insecurity among elderly in Morogoro, Tanzania—a qualitative study. *Discover Public Health*, 22(1), 299. https://doi.org/10.1186/s12982-025-00699-z
59. Kavishe, B., Biraro, S., Baisley, K., Vanobberghen, F., Kapiga, S., Munderi, P., Smeeth, L., Peck, R., Mghamba, J., Mutungi, G., Ikoona, E., Levin, J., Bou Monclús, M. A., Katende, D., Kisanga, E., Hayes, R., & Grosskurth, H. (2015). High prevalence of hypertension and of risk factors for non-communicable diseases (NCDs): A population based cross-sectional survey of NCDS and HIV infection in Northwestern Tanzania and Southern Uganda. *BMC Medicine,* 13, 126. https://doi.org/10.1186/s12916-015-0357-9
60. Korir, L., Ehiakpor, D. S., Danso-Abbeam, G., Djokoto, J. G., Rizov, M. (2024). Balanced Choices: Examining the Impact of Dietary Diversity on BMI, Health Risks, and Rising Rates of Obesity in Kenya. *Obesities*, 4(4), 509–523. https://doi.org/10.3390/obesities4040040
61. Walton, C., Taylor, J., Ogada, I., Agon, N., & Raynor, L. (2020). Associations among food security, BMI, diet diversity and food consumption patterns of women in rural Kenya. *African Journal of Food, Agriculture, Nutrition and Development*, 20(5), 16290–16308.
62. Lee, I.-C., Chang, C.-S., & Du, P.-L. (2017). Do healthier lifestyles lead to less utilization of healthcare resources? *BMC Health Services Research*, 17(1), 243. https://doi.org/10.1186/s12913-017-2185-4

Table 1. Sociodemographic, health, and dietary characteristics of study participants

Variable	Groups	N=7226	Females	Males
		n (%)	n (%)	n (%)
All			4527 (62.65)	2699 (37.35)
Age Group	15-24	2684 (37.14)	1453 (54.14)	1231 (45.86)
	25-49	3008 (41.63)	2087 (69.38)	921 (30.62)
	50+	1534 (21.23)	987 (64.34)	547 (36.66)
Resident Area	Semi-Urban	2454 (33.96)	1683 (68.58)	771 (31.42)
	Rural	4772 (66.04)	2844 (59.60)	1928 (40.40)
BMI	Underweight	1459 (20.19)	760 (52.09)	699 (47.91)
	Normal	5031 (69.62)	3164 (62.89)	1867 (37.11)
	Overweight/Obese	736 (10.19)	603 (81.93)	133 (18.07)
Marital Status	Never married	2321 (32.12)	1003 (43.21)	1218 (56.79)
	Married	3822 (52.89)	2550 (66.72)	1272 (33.28)
	Widowed/Separated/Divorced	1083 (14.99)	974 (89.94)	109 (10.06)
Ethnicity	Sukuma	6816 (94.33)	4244 (62.27)	2572 (37.73)
	Other	410 (5.67)	283 (69.02)	127 (30.98)
Income-Generating	Yes	4683 (64.81)	2943 (62.84)	1740 (37.16)
	No	2543 (35.19)	1584 (62.29)	959 (37.71)
Economic activity n= 4683	Farming	3655 (78.05)	2277 (62.30)	1378 (37.70)
	Skilled labor	212 (4.53)	93 (43.87)	119 (56.13)
	Unskilled labor/other	816 (17.42)	573 (70.22)	243 (29.78)
HCT uptake n= 6050	Yes	2603 (43.02)	1614 (62.01)	989 (37.99)
	No	3447 (56.98)	2035 (59.04)	1412 (40.96)
HIV Status	Positive	502 (6.95)	357 (71.12)	145 (28.88)
	Negative	6724 (93.05)	4170 (62.02)	1554 (37.98)
Diabetes	Yes	31 (0.43)	18 (58.06)	13 (41.94)
	No	7195 (99.57)	4509 (62.67)	2686 (37.33)

Hypertension	Yes	194 (2.68)	166 (85.57)	28 (14.43)
	No	7032 (97.32)	4361 (62.02)	2671 (37.98)
Education	No education	2059 (28.49)	1616 (78.48)	443 (21.52)
	Primary	3912 (54.14)	2380 (60.84)	1532 (39.16)
	Secondary	1255 (17.37)	532 (42.31)	724 (57.69)
	Median	**Interquartile Range**		
Age	31	20-46		
BMI	20.71	18.92-22.68		
FAV intake combined seasons	1.71	1.29-2.36		
FAV intake wet season	2.29	1.71-3.29		
FAV intake dry season	1.00	0.57-1.71		
Fruit intake combined seasons	0.93	0.57-1.36		
Vegetable intake combined seasons	0.79	0.50-1.14		
Average days per week fruit	3.50	2.50-4.50		
Average days per week vegetables	3.50	2.50-4.50		

Intake measured in servings/day.

Table 2. Adequacy of FAV intake by season

	Dry Season		
Wet Season	Adequate	Not Adequate	**Total**
Adequate	23	238	261
Not Adequate	19	6946	6965
Total	42	7184	7226

Table 3. Comparison of FAV intake between wet and dry seasons - continuous and binary analyses

Outcome type	**Test**	**Measure**	**Estimate (Wet-Dry)**	**95% CI**	**Test Statistic**	**P-value**
Continuous Outcome (servings/day)	Paired t-test	Mean difference	1.33	(1.30, 1.35)*	68.41	<0.01
	Wilcoxon Signed Rank				68.58	<0.01
Binary Outcome (Adequate vs. Inadequate intake)	McNemar's Chi Square	OR	12.53	(7.85, 21.18) *	186.62	<0.01

Table 4. Bivariate multinomial logistic regression results for FAV stability categories

		Wet Intake		Dry Intake		Stable Inadequate	
Variable		**RRR (95% CI)**	**p-value**	**RRR (95% CI)**	**p-value**	**RRR (95% CI)**	**p-value**
Sex	Male	(ref)	-	(ref)	-	(ref)	-
	Female	0.18 (0.02, 1.37)	0.10	0.10 (0.01, 0.91)	0.04	0.07 (0.01, 0.55)*	0.01
Age Group	15-24	(ref)	-	(ref)	-	(ref)	-
	25-49	0.98 (0.38, 2.53)	0.97	0.75 (0.18, 3.13)	0.69	0.51 (0.21, 1.25)	0.14
	50+	5.62 (0.67, 47.26)	0.11	8.40 (0.76, 93.34)	0.08	3.96 (0.49, 32.24)	0.20
Resident Area	Semi-Urban	(ref)	-	(ref)	-	(ref)	-
	Rural	10.52 (4.16, 26.62)*	<0.01	4.06 (1.11, 14.81) *	0.03	3.56 (1.51, 8.40)*	<0.01
BMI	Normal	(ref)	-	(ref)	-	(ref)	-
	Underweight	1.58 (0.34, 7.26)	0.56	0.93 (0.11, 7.59)	0.95	1.90 (0.43, 8.43)	0.40
	Overweight/Obese	0.27 (0.10, 0.71)*	<0.01	0.35 (0.08, 1.60)	0.18	0.23 (0.10, 0.57)*	<0.01
Income-Generating	Yes	(ref)	-	(ref)	-	(ref)	-
	No	1.78 (0.59, 5.44)	0.31	2.19 (0.51, 9.33)	0.29	2.62 (0.89, 7.70)	0.08
Economic activity n=4683	Farming	(ref)	-	(ref)	-	(ref)	-
	Skilled labor	0.67 (0.08, 5.80)	0.71	1.13 (0.06, 21.09)	0.93	0.51 (0.06, 4.08)	0.53
	Unskilled labor/Other	0.21 (0.08, 0.57)*	<0.01	0.50 (0.11, 2.27)	0.37	0.22 (0.09, 0.56)*	<0.01
HCT uptake n=6050	No	(ref)	-	(ref)	-	(ref)	-
	Yes	0.26 (0.09, 0.73)*	0.01	0.37 (0.08, 1.39)	0.13	0.22 (0.08, 0.60)*	<0.01

HIV Status	Negative	(ref)	-	(ref)	-	(ref)	-
	Positive	1.00 (0.28, 3.56)	0.99	1.25 (0.22, 7.05)	0.80	0.48 (0.14, 1.62)	0.24
Diabetes	Yes						
	No			***			
Hypertension	No	(ref)	-	(ref)	-	(ref)	-
	Yes	0.96 (0.12, 7.89)	0.97	1.22 (0.07, 20.94)	0.89	0.59 (0.8, 4.42)	0.61
Education	No education						
	Primary						
	Secondary			***			
Marital Status	Never married	(ref)	-	(ref)	-	(ref)	-
	Married	1.30 (0.49, 3.46)	0.60	1.40 (0.35, 5.67)	0.64	0.95 (0.37, 2.42)	0.92
	Widowed/Separated/Divorced	1.54 (0.43, 5.56)	0.51	0.70 (0.09, 5.53)	0.73	0.80 (0.23, 2.73)	0.72

ref= Reference category: Stable Adequate. Results presented as Relative Risk Ratios (RRR) with 95% Confidence Intervals. RRR values >1 indicate increased relative risk of being in the comparison category vs. Stable Adequate; RRR <1 indicates decreased risk. *Indicates $p < 0.05$. ***Indicates model instability due to low cell counts; corresponding binary analysis presented in Appendix.

Table 5. Adjusted multinomial logistic regression results for FAV stability categories

Variable		Wet Intake		Dry Intake		Stable Inadequate	
		RRR (95% CI)	p-value	RRR (95% CI)	p-value	RRR (95% CI)	p-value
A. Full participant population (N = 7,226)							
Sex	Male	(ref)	-	(ref)	-	(ref)	-
	Female	0.24 (0.03, 1.82)	0.17	0.12 (0.01, 1.10)	0.06	0.10 (0.01, 0.72)*	0.02
Age Group	15-24	(ref)	-	(ref)	-	(ref)	-
	25-49	2.14 (0.76, 6.09)	0.15	1.58 (0.33, 7.67)	0.57	1.21 (0.45, 3.25)	0.7
	50+	10.86 (1.26, 93.69)*	0.03	15.41 (1.33, 178.61)*	0.03	7.68 (0.92, 64.03)	0.06
Resident Area	Semi-Urban	(ref)	-	(ref)	-	(ref)	-
	Rural	10.13 (3.85, 26.62)*	<0.01	3.93 (1.02, 15.07)	0.05	2.98 (1.21, 7.30)*	0.02
BMI	Normal	(ref)	-	(ref)	-	(ref)	-
	Underweight	1.29 (0.27, 6.04)	0.75	0.65 (0.08, 5.45)	0.69	1.29 (0.29, 5.81)	0.74
	Overweight/Obese	0.47 (0.17, 1.28)	0.14	0.53 (0.10, 2.59)	0.43	0.37 (0.15, 0.93)*	0.04
Income-generating	Yes	(ref)	-	(ref)	-	(ref)	-
	No	2.38 (0.70, 8.03)	0.16	2.71 (0.55, 13.23)	0.22	2.58 (0.80, 8.36)	0.11
B. Subsample: participants engaged in income-generating activities (N = 4,683)							
Sex	Male	(ref)	-	(ref)	-	(ref)	-
	Female	0.38 (0.05, 3.01)	0.36	0.13 (0.01, 1.36)	0.09	0.13 (0.02, 1.02)	0.05
Age Group	15-24	(ref)	-	(ref)	-	(ref)	-
	25-49	1.63 (0.43, 6.23)	0.48	1.34 (0.18, 10.06)	0.77	0.79 (0.22, 2.80)	0.71
	50+	5.71 (0.54, 60.24)	0.14	7.55 (0.40, 140.88)	0.18	3.82 (0.38, 37.87)	0.25

Resident Area	Semi-Urban	(ref)	-	(ref)	-	(ref)	-
	Rural	9.99 (3.11, 32.10)*	<0.01	6.47 (1.11, 37.65)*	0.04	2.56 (0.87, 7.52)	0.08
BMI	Normal	(ref)	-	(ref)	-	(ref)	-
	Underweight	1.72 (0.21, 14.19)	0.61	0.89 (0.05, 16.53)	0.94	1.59 (0.20, 12.49)	0.66
	Overweight/Obese	0.44 (0.15, 1.31)	0.14	0.45 (0.07, 2.93)	0.41	0.36 (0.13, 0.95)*	0.04
Economic activity	Farming	(ref)	-	(ref)	-	(ref)	-
	Skilled labor	1.58 (0.17, 14.52)	0.69	1.95 (0.10, 34.45)	0.66	0.68 (0.08, 5.70)	0.73
	Unskilled labor/ Other	0.59 (0.20, 1.78)	0.35	1.39 (0.27, 7.11)	0.69	0.47 (0.17, 1.30)	0.15
C. Subsample: participants with HCT usage responses (N = 6,050)							
Sex	Male	(ref)	-	(ref)	-	(ref)	-
	Female	0.24 (0.03, 1.91)	0.18	0.18 (0.02, 1.86)	0.15	0.10 (0.01, 0.76)*	0.03
Age Group	15-24	(ref)	-	(ref)	-	(ref)	-
	25-49	2.18 (0.75, 6.34)	0.15	1.66 (0.30, 9.11)	0.56	1.41 (0.52, 3.84)	0.50
	50+	8.85 (1.00, 78.04)	0.05	10.64 (0.81, 140.09)	0.07	6.14 (0.73, 51.76)	0.10
Resident Area	Semi-Urban	(ref)	-	(ref)	-	(ref)	-
	Rural	7.36 (2.63, 20.63)*	<0.01	2.76 (0.64, 11.90)	0.17	2.09 (0.80, 5.46)	0.13
BMI	Normal	(ref)	-	(ref)	-	(ref)	-
	Underweight	0.99 (0.21, 4.76)	0.99	0.94 (0.10, 8.16)	0.95	1.08 (0.24, 4.89)	0.93
	Overweight/Obese	0.47 (0.17, 1.32)	0.15	0.63 (0.122, 3.24)	0.58	0.38 (0.15, 0.98)	0.05
	Yes	(ref)	-	(ref)	-	(ref)	-

Income-generating	No	1.96 (0.56, 6.83)	0.29	1.77 (0.31, 10.23)	0.52	2.00 (0.61, 6.62)	0.25
HCT uptake	No	(ref)	-	(ref)	-	(ref)	-
	Yes	0.47 (0.15, 1.40)	0.17	0.54 (0.12, 2.45)	0.42	0.37 (0.13, 1.07)	0.07

ref=Reference category: Stable Adequate. Results presented as Relative Risk Ratios (RRR) with 95% Confidence Intervals. RRR values >1 indicate increased relative risk of being in the comparison category vs. Stable Adequate; RRR <1 indicates decreased risk. Models were adjusted for sex, residence area, BMI category, and marital status (and for income-generating activity and HCT uptake in the subsamples). *Indicates p < 0.05.

Table 6. Supplementary Binary Regression Analysis for Diabetes and Education

		Change/No Change	
Variable		**RR (95% CI)**	**p-value**
Diabetes	No	(ref)	-
	Yes	0.91 (0.13, 6.26)	0.92
Education	No education	(ref)	-
	Primary	0.79 (0.61, 1.04)	0.09
	Secondary	0.85 (0.59, 1.21)	0.37

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