

Assessing Differences in Hypertensive Status, Cascade of Care, and Fruit and Vegetable Consumption Between Rural and Urban Populations in Northwestern Tanzania.

by

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Defense Date: March 24, 2025

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Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in the Duke Global Health Institute in the Graduate School of Duke University
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ABSTRACT

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Abstract

Hypertension (HTN) remains a major contributor to preventable cardiovascular deaths in Tanzania, with its prevalence influenced by rapid urbanization, dietary shifts, and healthcare disparities. This cross-sectional study assessed differences in uncontrolled HTN, the care cascade, and dietary patterns between rural and urban communities across 12 districts in Northwestern Tanzania.

Among 6,957 participants (59% urban, 61% female, median age 42 years), key findings revealed that 30% consumed alcohol, 6.1% were smokers, 21% had diabetes, and 78% earned less than 100,000 TZN. HTN prevalence was higher in rural areas (32%) compared to urban areas (29%), with urban residents having lower odds of HTN (0.866). Notably, only 26% had ever undergone blood pressure screening, and no significant differences emerged in HTN management between rural and urban settings, apart from a higher past HTN diagnosis in rural areas (45% vs. 39%). Dietary trends showed no significant differences in fruit consumption, but vegetable intake was higher at medium levels (1.12) yet lower at high levels (0.684) in urban areas.

Despite urban areas having better healthcare infrastructure, gaps in early HTN detection remain the primary barrier in both settings. The findings underscore the need for targeted interventions to enhance screening, diagnosis, and dietary awareness, particularly in rural communities where the HTN burden is higher.

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1. Introduction

Hypertension (HTN) is the leading cause of preventable cardiovascular-related deaths worldwide, accounting for approximately 10.8 million deaths annually (Dai et al., 2021; Murray et al., 2020; Yusuf et al., 2020). It is the most essential modifiable risk factor for cardiovascular diseases and is often referred to as a "silent killer" due to its asymptomatic nature (Fatima & Mahmood, 2021; Nguyen & Chow, 2021). Nearly half of individuals with HTN are unaware of their condition (*Cardiovascular Diseases (CVDs)*, n.d.), increasing the risk of severe complications such as stroke, heart failure, and other cardiometabolic diseases (Fuchs & Whelton, 2020).

Global trends indicate significant disparities in HTN prevalence and management between high-income and low- and middle-income countries (LMICs). High-income countries have successfully implemented policies and culturally tailored interventions, resulting in a decline in HTN prevalence by 2.6% between 2000 and 2010 (Abdalla et al., 2023; NCD Risk Factor Collaboration (NCD-RisC), 2017). Also, HTN awareness rates increased from 58.2% to 67.0%, treatment rates rose from 44.5% to 55.6%, and blood pressure control improved from 17.9% to 28.4% (Mills et al., 2016). In contrast, LMICs have seen a 7.7% increase in prevalence, with only one in three individuals aware of their condition and limited access to treatment and control measures (Murray et al., 2020). Recent epidemiological transitions have shifted the global disease burden from infectious diseases to non-communicable diseases (NCDs), leading to a significant rise in HTN rates (Gouda et al., 2019). In 2010, an estimated 1.4 billion people had HTN, a number projected

to exceed 1.6 billion by 2025, with sub-Saharan Africa expected to maintain the highest prevalence rates (Mills et al., 2016).

Tanzania exhibits one of the highest HTN prevalence rates in Sub-Saharan Africa, ranging from 19% in rural areas to 35% in urban areas, with older adults bearing the greatest burden (NCD Risk Factor Collaboration (NCD-RisC), 2017). Northwestern Tanzania reflects similar trends and is undergoing rapid socio-economic and demographic developments influenced by population growth, globalization of food markets, and urbanization (Casari et al., 2022; Liu & Peng, 2023). These developments influence lifestyle behaviors, increasing exposure to sedentary habits, unhealthy diets, and unhealthy habits which are risk factors for HTN (Demographic Trends and Urbanization, n.d.; Kimeu, 2022).

Despite these challenges, limited research exists on current HTN rates and associated factors in Northwestern Tanzania, particularly regarding rural-urban disparities linked to socio-demographic and economic developments.

Moreover, effective HTN management relies on a structured care cascade encompassing early identification, diagnosis, treatment, adherence, and long-term control (NCD Risk Factor Collaboration (NCD-RisC), 2017). However, inadequate healthcare access, medication shortages, and financial barriers contribute to poor HTN control in Tanzania, with complications of HTN like stroke and heart failure being the leading causes of adult hospitalization and mortality (Mills et al., 2016). Identifying the bottlenecks within the HTN care cascade between rural and urban Northwestern Tanzania will be essential for improving patient outcomes and reducing mortality.

Dietary patterns, particularly fruit and vegetable (F&V) consumption, also play a crucial role in NCD prevention and management. While increased F&V intake is linked to lower risks of NCDs, improved nutritional status, and better health outcomes (Diet, Nutrition and the Prevention of Chronic Diseases, n.d.), Northwestern Tanzania is experiencing a shift toward higher consumption of processed, high-fat foods (Keding et al., 2011; Maletnlema, 2002). Urban areas are experiencing a growing demand for nontraditional, high-fat foods, while rural areas are beginning to follow similar trends (Pallangyo et al., 2020a). Sociodemographic and socioeconomic factors, such as income levels, market availability, and cultural preferences, significantly influence dietary choices. These factors may affect F&V consumption across rural and urban Northwestern Tanzania amid ongoing social and economic developments.

Therefore, this study aims to assess differences in HTN prevalence, care cascade effectiveness, and F&V consumption between rural and urban areas in Northwestern Tanzania. By identifying key factors influencing HTN status, management, and dietary habits, the findings will inform targeted interventions to reduce disparities, enhance HTN control, and support broader public health strategies in the region.

2. Methodology

2.1 Study Design and Setting

Data analyzed for this study were collected as a baseline survey for an electronic database of a rural-urban cohort established in November 2019 by Bugando Medical Centre in collaboration with the Catholic University of Health and Allied Sciences (CUHAS). The survey was conducted to assess the burden of NCDs, specifically HTN and Diabetes (DM), with this paper focusing on HTN only. We used a multistage sampling technique, which involved two stages of sampling. The first stage involved dividing Northwestern Tanzania into six main zones using the 2012 Tanzania demographic census. The second stage involved systematically sampling [JE1] [JK2] at the district level, where two districts were selected from each of the six regions, specifically one urban and one rural district. This sampling technique resulted in the team selecting 12 study districts.

Northwestern Tanzania is an agriculturally rich region primarily characterized by a rural population and a rapidly growing youth demographic (*Tanzania | Culture, Religion, Population, Language, & People | Britannica*, n.d.). Rural and Urban areas were classified using demographic characteristics, population size, and classifications from the 2012 Tanzania census (*2012_Tanzania_in_Figure_English.Pdf*, n.d.). The selected rural areas included Geita, Bukoba Vijijini, Bunda, Busega, Sengerema, and Shinyanga, while the selected urban areas included Chato, Muleba, Serengeti, Bariadi, Misungwi, and Kishapu. A medical screening exercise was then conducted in each of the 12 districts.

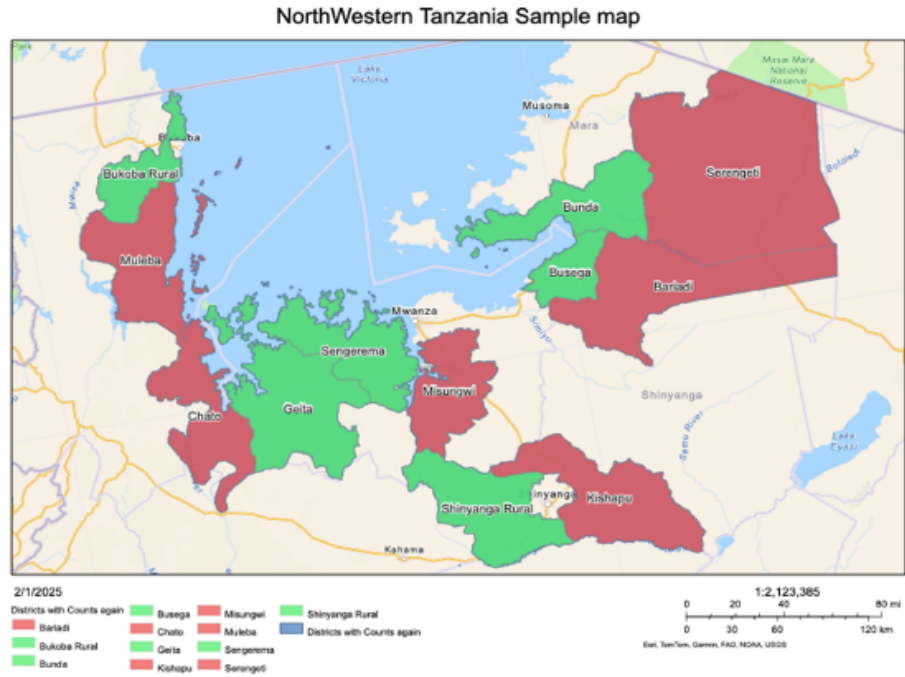


Figure 1: Map of Selected Sites for Medical Screening Exercise

2.2 Study Participants

Eligible study participants included all adults residing in selected 12 districts in Northwestern Tanzania who were 18 years and above on the screening day and excluded all persons who were severely ill or mentally challenged. Study participants were identified through community and health facility announcements for NCD screening in each district.

2.3 Data Collection

Data were collected from study participants using the WHO Step survey (*Standard STEPS Instrument*, n.d.) transcribed into Kiwi Swahili. Data collection was between March and August 2019. A team of trained research staff accompanied by each district’s public

health officer conducted the health screening exercise. Data were collected using a paper-based approach, after which it was recorded electronically for analysis.

2.4 Health Screening

On the first day of screening in each district, study participants were individually introduced to the study, after which their concerns were addressed, and written informed consent was obtained. Participants who provided consent had their vital signs and anthropometric measurements taken after resting for at least 30 minutes. This included three blood pressure measurements at a 3-minute interval, blood glucose level, height, weight, and waist circumference. Subsequently, participants were asked to fill out the translated WHO STEPS instrument. Participants who were unable to read or write received assistance from the study team in completing the survey, and all questions raised by the participants were answered carefully. Each survey took approximately 30 to 45 minutes to complete. Participants identified by the study team at the screening centers to have hypotension defined by a systolic blood pressure of less than 90mmHg and a diastolic blood pressure of less than 60mmHg (*Low Blood Pressure - When Blood Pressure Is Too Low*, n.d.) or hypertensive urgencies also defined by a systolic blood pressure measurement of 180mmHg and above and a diastolic blood pressure measurement of 110mmHg and above (Patel et al., 2016), or other health emergencies were quickly referred to the nearest health facility mostly situated within a kilometer from the study site. The team also took the opportunity to educate study participants on NCDs after completing their vitals, anthropometric measurements, and blood pressure measurements.

2.5 Definition of Key Variables

2.5.1 Blood Pressure Measurement.

Two trained general nurses measured blood pressure using a standardized digital blood pressure machine (Omron Digital HEM-907, Tokyo, Japan). Measurements were taken on the left upper arm while participants were seated in a comfortable position, with the pressure cuff properly fitted to ensure accuracy. The average of the three blood pressure readings was used to classify participants as having uncontrolled HTN, being pre-hypertensive, or normotensive. Participants identified to have an average systolic blood pressure reading greater or equal to 140mmHg or a diastolic reading greater or equal to 90mmHg were classified as having uncontrolled HTN. Those with systolic blood pressure readings within ranges above or equal to 120mmHg to less than 140mmHg and diastolic blood pressure readings above or equal to 80mmHg to less than 90mmHg and not part of the uncontrolled hypertensive group were classified as having pre-uncontrolled blood pressure (pre-hypertensive). Finally, those having a systolic blood pressure below 120mmHg and a diastolic below 80mmHg were classified as normotensive (Ramzy', n.d.).

2.5.2 Measurement for Cascade of Care

Past Blood Pressure Measurements were obtained by asking study participants if they had ever at any point in their lives had their blood pressure measured by a medical professional, which included a nurse, doctor, or community health worker. We then continued to identify participants with Previous Diagnoses of HTN. Here we asked Patients who have ever had their blood pressure measured at any point in their lives by health personnel whether they have ever been diagnosed with HTN in a health facility by a doctor or a clinical officer. Afterward, we identified Participants with Access to

Antihypertensives by asking Participants previously diagnosed with HTN by a doctor or clinical officer if they had access to their antihypertensive medications within the past two weeks. Finally, we identified Participants with Blood Pressure Control among study participants who were on antihypertensive medication and had access to their prescribed medication within the two weeks preceding the study. Their blood pressure was measured at three different time intervals to determine whether their readings fell within the controlled blood pressure range (normotensive) on the day of screening. Controlled blood pressure was defined as a systolic blood pressure of less than 140 mmHg and a diastolic blood pressure of less than 90 mmHg (2020_Tanzania_in_Figure_English.Pdf, n.d.).

2.5.3 Fruit and Vegetable Measurement

The recommended daily intake of F&V by the WHO is at least 400 g (5 – 6 servings daily) (*Increasing Fruit and Vegetable Consumption to Reduce the Risk of Noncommunicable Diseases*, n.d.). Daily F&V intake was calculated from the number of servings of F&V consumed per day in a typical week. Participants were asked how many days in a week they consume at least five servings of F&V with a vivid explanation of what servings mean in the local context as validated by WHO (*Standard STEPS Instrument*, n.d.). Inadequate F&V consumption was defined as less than five servings a day. This was used to calculate the number of days per week one consumed more than five servings of fruit and another for vegetables. F&V consumption was self-reported by study participants. The number of days participants reported consuming adequate F&V was categorized as follows: 0–1 day was classified as low consumption, 2–3 days as medium consumption, and 4-7 days as high consumption (Wolfson & Bleich, 2015; Zhang et al., 2024).

2.5.4 Participant Monthly Earning Measurement

Participants were asked to select from a category of average monthly earning bracket within which they fell. These brackets included those who earned less than 20000 TSH, ranged from 20,000-100000 TSH, ranged from 100000-500000 TSH, and greater than 500,000 TSH.

2.5.5 Level of Education Measurement

Participants were asked about their highest level of education with 7 different categories to select from.

2.6 Statistical Analysis

The data were processed and summarized using the R software, version 4.4.0. Continuous variables were characterized using their median and interquartile ranges, while categorical variables were summarized using frequency and percentages. Demographic characteristics and prevalence of uncontrolled HTN based on rural-urban residency status were compared using the Wald test (Alexander, 2016) accounting for the multistage sampling technique used. To assess differences in continuous variables based on rural/urban residence, we also used the Cluster-Robust t-test (Colin Cameron & Miller, 2015) and accounted for the “District” variable since the first stage of the sampling was representative of Northwestern Tanzania. Binomial logistic regression was employed to estimate the effect of rural/urban residency on having uncontrolled HTN while accounting for factors influencing the association between where one lives and one’s HTN status at a 5% significance level. For the analyses of cascade of care for HTN, each level factored into the other, from ever having one’s blood pressure measured to getting diagnosed with the disease to having access to medication, and finally to having blood pressure control on the

day of screening. Then, a multinomial logistic regression was used to estimate the effect of rural/urban residence on F&V consumption. Two separate models were established: one for fruit intake and another for vegetable intake.

2.6.1 Model for Fruit Intake

We employed a multinomial regression model to compare three different levels of the outcome variable (Fruit Consumption). The first comparison involved the intake of no to one day of fruits per week (fruits= (0-1)) to the intake of two to three days of fruits per week (fruits= (2-3)). The second comparison involved the intake of no to one day of fruit intake per week (fruits= (0-1)) to the intake of four to seven days of fruits per week (fruits= (4-7)), making taking no to one day of fruits per week (fruits= (0-1)) as our reference fruit intake relative to the other two fruit consumption levels.

2.6.2 Model for Vegetable Intake

We used a multinomial regression model to compare three different levels of the outcome variable (Vegetable Consumption). The comparison involved the intake of no to one day of vegetables per week (vegetable= (0-1)) with the intake of two to three days of vegetables per week (vegetable = (2-3)). The second comparison involved no to one day of vegetable intake per week (vegetable = (0-1)) to the intake of four to seven days of vegetables per week (vegetable= (4-7)), making taking no to one day of vegetables per week (vegetable= (0-1)) as our reference vegetable intake relative to the other two vegetable consumption levels.

2.7 Theoretical Framework

To explore the differences between rural and urban settings regarding various outcome variables (such as HTN status and F & V consumption), we selected all variables in our dataset that were associated with the independent variable (urban residency) and were either risk factors or contributing factors to the outcome variables. This approach allowed us to not only identify the differences in the outcome variables between rural and urban settings reduce confounding of the urban/rural association with the outcome and but also to identify factors that were associated with the outcome variable within Northwestern Tanzania. This process guided the selection of variables included in our final model to define rural-urban differences for each outcome. Variables that were statistically significant at the 5% level demonstrated a meaningful relationship with the outcome variables.

3. Result

3.1 Characteristics of Study Participants

A total of 6857 participants were screened and completed the survey with their characteristics represented in Table 1. A greater proportion of participants resided in urban settings (4134, 59.4%) compared to rural settings (2823, 40.6%) and participants consisted of more females (4244, 61%) relative to males (2713, 39%). The overall median (interquartile range (IQR)) age (years) of participants was (42, 30-56) and the median age was slightly higher for those residing in rural settings (45, 32-57.5) as compared to those residing in urban areas (41, 28-55). Most participants were married (4,867 participants, 70%), engaged in daily physical activity for at least 10 minutes (4,656 participants, 67%), and had a normal BMI range of 18.5–25 (4,052, 58%). Most participants were self-employed (4,538 65%) reflective across both urban (2,191, 53%) and rural (1,376, 49%) areas and earned below 100000 TSH (5442, 78%). Only 6.1% of participants were current smokers and 30% were current consumers of alcohol with a greater proportion found in rural areas. (1435, 21%) of participants were aware of the risk factors of HTN with the majority residing in urban areas and 179 (21%) of participants had a history of diabetes.

Table 1: Characteristics of Study Participants

Variable.	Overall N = 6957	Rural 2823,40.6%	Urban 4134, 59.4%
Sex			
Male	2713(39%)	1086(38%)	1627(39%)
Female	4244(61%)	1737(62%)	2507(61%)
Age	42(30-56)	45(32-57.5)	41(28-55)
Married	4867(70%)	2083(74%)	2784(67%)
BMI	23.3(20.93-26.78)	23.24(20.76-26.72)	23.36(20.96-26.78)
BMI ranges			
<18.5	456(6.6%)	234(8.3%)	222(5.4%)
18.5 - (<25)	4052(58%)	1593(56%0	2459(59%)
25 - (30)	1547(22%)	601(21%)	946(23%)
>30	902(13%)	395 (14%)	507 (12%)
Smoking	425 (6.1%)	228(8.1%)	197(4.8%)
Alcohol	2068(30%)	959(34%)	1109(27%)
Aware of risk factors of HTN	1435(21%)	523(19%)	912(22%)
History of Diabetes	179 (21%)	90 (23%)	89 (20%)
Physical activity	4656(67%)	2053(73%)	2603(63%)
Average household monthly earnings (TSH)			
<20000	2705(40%)	1238(44%)	1557(38%)
20,000-100000	2647(38%)	1014(36%)	1633(40%)
100000-500000	1258(18%)	492(17%)	766(19%)
>500000	257(3.7%)	79(2.8%)	178(4.3%)

3.2 Differences in HTN Status across rural and urban Northwestern Tanzania

3.2.1 Blood Pressure Measurements

The distribution of blood pressure ranges among study participants is summarized in Table 2. Overall, (2011, 29%) of participants had uncontrolled HTN, with a higher prevalence in rural areas (910, 32%) compared to urban areas (1101, 27%). [JE1] [JK2] Most participants were pre-hypertensive (3002, 43%), with similar pre-hypertensive prevalence rates across rural (1185, 42%) and urban (1817, 44%) Northwestern Tanzania. Only (1944, 28%) of participants had normal blood pressure, with a lower percentage in rural areas (728, 26%) compared to urban areas (1216, 29%). This data is also presented in Figure 2.

Table 2: Classification of Blood Pressure Measurements between Rural and Urban Northwestern Tanzania.

Blood Pressure classification	Overall (n, %)	Rural	Urban
Uncontrolled HTN	2011, 0.29	910, 0.32	1101, 0.27
Pre hypertensive	3,002, 0.43	1185, 0.42	1817, 0.44
Normal blood pressure	1944, 0.28	728, 0.26	1216, 0.29



Figure 2: Classification by Proportion of Various Blood Pressure Statuses between Rural and Urban Northwestern Tanzania

3.2.2 Differences in Odds of Uncontrolled HTN Status between Rural and Urban Northwestern Tanzania.

In a bivariate analysis, residence was significantly associated with [JE1] [JK2] the odds of uncontrolled HTN status ($p < 0.001$). Urban residents had lower odds of having uncontrolled HTN than rural residents (OR = 0.79, 95% CI: 0.70, 0.88).

In a multivariable analysis, we accounted for smoking, alcohol consumption, salt intake, physical activity, Body Mass Index (BMI), age, and sex. Residency, age, alcohol consumption, physical activity, and BMI were significantly associated with HTN at a 5% significance level. Urban residents had lower odds of uncontrolled HTN compared to rural residents (OR = 0.87, 95% CI: 0.77–0.97). Additionally, each one-year increase in age raised the odds of having uncontrolled HTN by 4% (OR = 1.04, 95% CI: 1.04–1.05), holding other variables constant. Alcohol consumption was associated with a 35% increase in the odds of uncontrolled HTN (OR = 1.35, 95% CI: 1.19–1.53). Participants who engaged in daily walking or cycling for at least 10 minutes had lower odds of uncontrolled HTN (OR = 0.84, 95% CI: 0.75–0.95) than those who did not. Furthermore, a unit increase in BMI raised the odds of uncontrolled HTN by 2% (OR = 1.02, 95% CI: 1.01–1.02). This is represented in Table 3 below.

Table 3: Relative Odds of Uncontrolled HTN Status between Rural and Urban Northwestern Tanzania.

Uncontrolled BP status	Odds Ratio	Standard error	P value	Confidence interval
Bivariable				
Urban	0.79	0.06	<0.001	0.71 - 0.88
Multivariable				
Urban	0.87	0.06	0.01	0.77 - 0.97
Age	1.04	0.01	<0.001	1.04 - 1.05
Male	1.08	0.06	0.19	0.96 - 1.22
smoke_tobacco	0.79	0.12	0.05	0.63 - 0.99
meduim_salt_intake	0.87	0.10	0.17	0.71 - 1.06
high_salt_intake	1.10	0.11	0.39	0.89 - 1.37
alcohol_consume	1.35	0.06	<0.001	1.19 - 1.53
walksorbikesforatleast10minutes	0.84	0.06	<0.001	0.75 - 0.95
BMI	1.02	0.003	<0.001	1.01 - 1.02

3.3 Differences in Cascade of Care for HTN across Rural and Urban Northwestern Tanzania

Table 4 summarizes the cascade of care for HTN across rural and urban Northwestern Tanzania. Overall, only 26% of study participants have ever had their blood pressure measured at some point in their lives by a health worker. However, there was no significant difference ($P = 0.09$) between study participants in rural Northwestern Tanzania who had ever had their blood pressure measured by a healthcare worker (28%) compared to those in urban Northwestern Tanzania (24%). Among individuals who have had their blood pressure checked at least once in their lifetime, 42% had a prior history of HTN diagnosed by a doctor or clinical officer. This prevalence was higher in rural areas (45%) compared to urban areas (39%).

Of those with a previous diagnosis of HTN by a doctor or clinical officer, about half (51%) had access to antihypertensives in the past two weeks, with no significant difference between rural (53%) and urban (48%) areas ($p=0.19$). Finally, among study participants on antihypertensives, 64% had controlled HTN, with no significant difference between rural (64%) and urban (64%) areas ($p=0.64$). This treatment cascade is visually represented in Figure 3.

Table 4: Differences in Cascade of Care for HTN between Rural and Urban Northwestern Tanzania

Variable	Overall (n, N) %	Rural	Urban	P value
Number of participants who have had their blood pressure checked	1777/6957, (26%)	789/2823, (28%)	988/4134, (24%)	0.09
Number of participants with previous diagnosis of HTN	743/1777, (42%)	358/789, (45%)	385/988, (39%)	0.001
Number of participants who are on medication	399/743, (53%)	202/368, (56%)	197/385, (51%)	0.19
Number of participants with blood pressure under control	255/399, (64%)	131/205, (64%)	124/194, (64%)	0.64

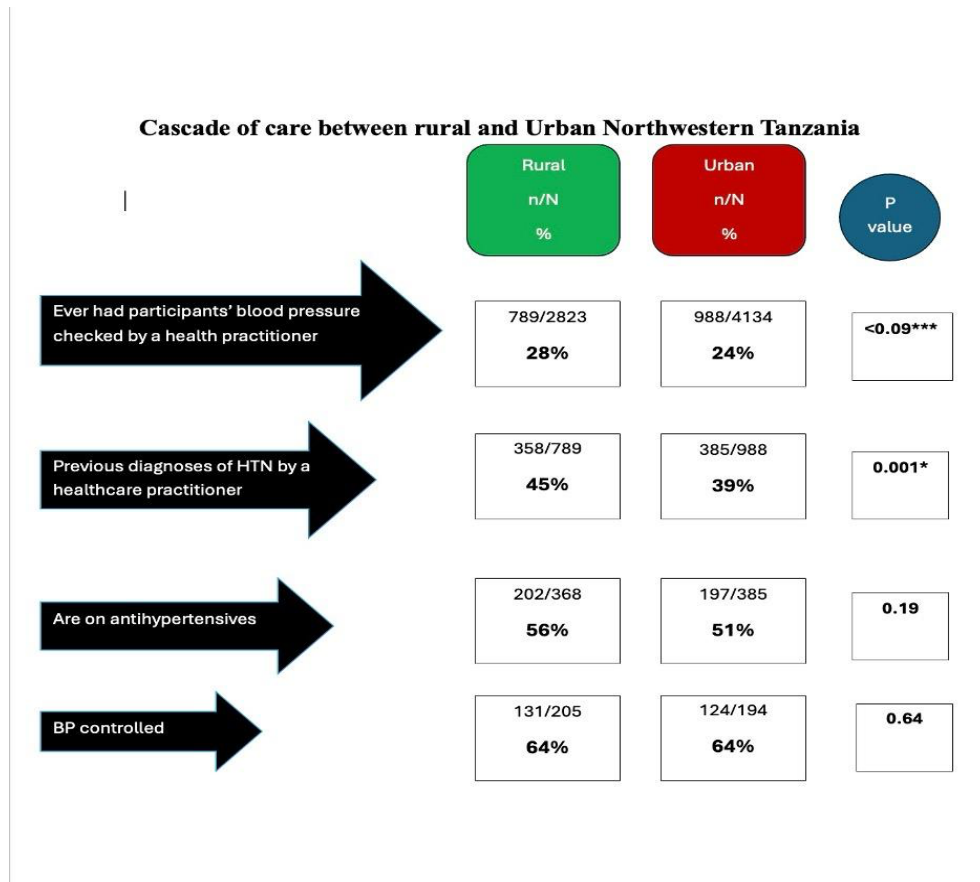


Figure 3: Comparison of the Cascade of Care for HTN between Rural and Urban Northwestern Tanzania

3.4 Difference in Fruit and Vegetable Consumption across Rural and Urban Northwestern Tanzania.

3.4.1 Fruit Consumption

The distribution of F&V consumption among study participants is summarized in Table 5. For fruit consumption, only (1%) of study participants consumed five and above servings of fruit for 5 days and above per week. Most participants (79%) reported consuming the WHO-required number of fruits 2 to 3 days per week, with a similar pattern across rural (80%) and urban (79%) areas. Additionally, 12% of participants consumed fruits 4 to 7 days a week, with identical rates between urban (13%) and rural (12%) areas. A smaller proportion, 8.2%, consumed fruits for just one day or none during the week, with a slightly higher rate in urban areas (8.5%) compared to rural areas (7.8%). These data are visually represented in Figure 4.

In a bivariable regression, there was no statistical difference in the odds of fruit consumption between urban and rural areas at medium-level fruit consumption (2-3 days per week) and high-level fruit consumption (4-7 days per week).

For multivariable analyses, we accounted for residency, consumption of processed food, education, average monthly earnings, age, and BMI. At medium-level fruit consumption (2-3 days per week), there was no statistical difference in fruit consumption between rural and urban Northwestern Tanzania ($P = 0.83$). Average monthly earnings and consumption of processed food were statistically significant with fruit consumption. Those who consumed a high amount of processed food had lower odds (0.65) of consuming fruits as compared to those who consumed a low amount of processed food. Also, those who

earned a high average monthly income had a higher odd of consuming fruit (1.33) compared to those who earned a low average monthly income, and those who had some level of education had a higher odd (1.98) of consuming Fruit compared to those who do not have any level is education (P = 0.001).

At high levels of fruit consumption (4-7 days per week), there was also no significant difference between those who reside in rural Northwestern Tanzania and those in urban areas. Those with some level of education had a higher level of fruit consumption (2.44) relative to those who didn't (P = 0.001). Those who earned high average monthly salaries had higher odds of consuming fruits (2.66) relative to those who earned low average monthly salaries. Lastly, every one-year increase in age increases the odds of fruit consumption by 1.02(P = 0.001). The distribution of the odds of uncontrolled HTN status between rural and urban Northwestern Tanzania is summarized in Table 6.

Table 5: Distribution of Fruit and Vegetable Consumption between Rural and Urban Northwestern Tanzania using a Wald Test.

	Fruit Consumption				Vegetable consumption			
Levels	All N=6957	Rural N=2823	Urban N=4134	P valu e 0.5	All N=6957	Rural N=2823	Urban N=4134	P Valu e <0.001
Low (0-1 day/w eek)	569 (8.2%)	219 (7.8%)	350 (8.5%)		1296 (19%)	547 (19%)	749 (18%)	
Mediu m (2-3 days/ week)	528 (79%)	2261 (80%)	3267 (79%)		5483 (79%)	2181 (77%)	3302 (80%)	
High (4-7 days/ week)	860 (12%)	343 (12%)	517 (13%)		178 (2.6%)	95 (3.4%)	83 (2.0%)	

Table 6: Odds of fruit consumption between rural and urban Northwestern Tanzania

Fruit Consumption	Odds Ratio	Std. Error	P value	Lower CI	Upper CI
Bivariable					
Medium					
Urban	0.90	0.09	0.27	0.08	1.08
High					
Urban	0.94	0.11	0.60	0.08	1.17
Multivariable					
Medium					
Urban	0.98	0.09	0.83	0.82	1.18
highprocessedfood	0.65	0.15	0.00	0.49	0.86
some_edu	0.51	0.11	0.06	0.41	0.63
highearning_average	1.33	0.10	0.01	1.09	1.63
Age	1.00	0.00	0.54	1.00	1.01
BMI	0.99	0.00	0.26	0.99	1.00
High					
urban	1.07	0.11	0.56	0.85	1.34
highprocessedfood	1.10	0.18	0.60	0.78	1.55
some_edu	2.44	0.16	0.00	1.80	3.32
highearning_average	2.66	0.15	0.00	2.00	3.55
Age	1.02	0.00	0.00	1.00	1.02
BMI	0.98	0.01	0.10	0.97	1.00

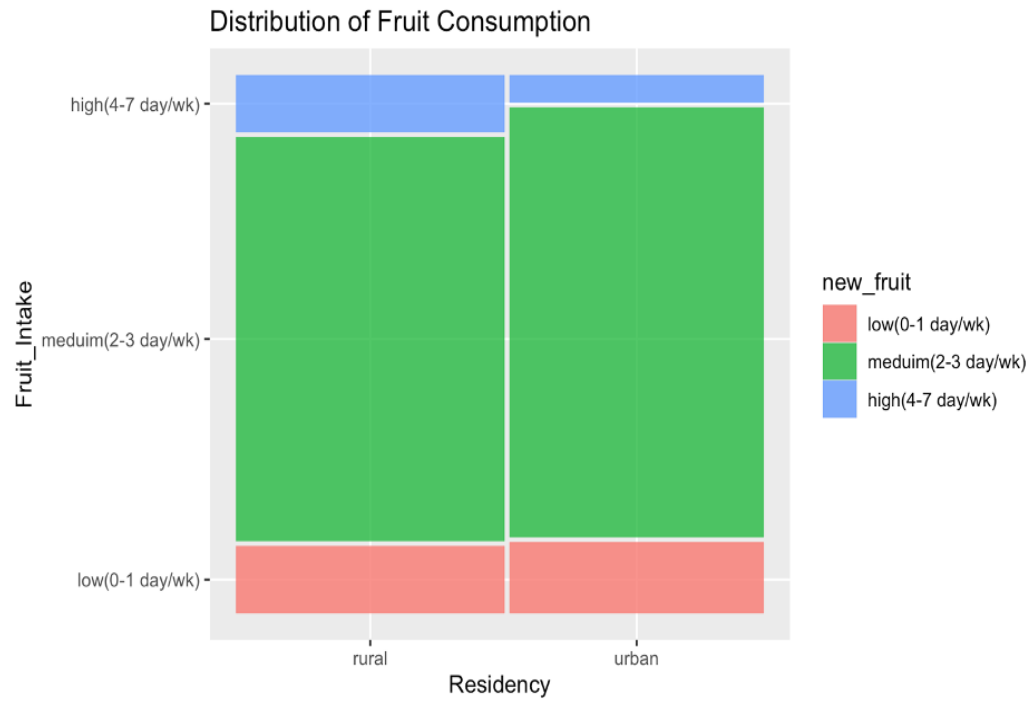


Figure 4: Proportion of Fruit Consumption across Rural and Urban Northwestern Tanzania

3.4.2 Vegetable Consumption

For vegetable consumption, only 1% of study participants consumed 5 and above servings of vegetables for 5 days and above per week. (79%) of participants consumed vegetables 2 to 3 days a week, with a slightly higher percentage in urban areas (80%) compared to rural areas (77%). 19% consumed vegetables only 1 day or not at all per week, with similar rates across rural (19%) and urban (18%) settings. A smaller group (2.6%) consumed vegetables 4 to 7 days a week, with a lower rate in urban areas (2%) compared to rural areas (3.2%). Vegetable consumption is illustrated in Figure 5.

In a bivariable multinomial regression, there was no statistical difference between the odds of urban and rural vegetable consumption (OR = 1.10, 95% CI: 0.98, 1.25, P = 0.11) at medium-level fruit consumption (2-3 days per week). However, at high-level vegetable consumption (4 to 7 days per week), people residing in urban areas had lower odds of vegetable consumption relative to those in rural areas (OR = 0.64, 95% CI: 0.47, 0.87, P = 0.005).

In a multivariable multinomial regression, at medium-level vegetable consumption (2-3 days per week), those who reside in urban settings had higher odds of consuming vegetables (1.14) compared to those who reside in rural areas (P = 0.04). Also, study participants who had some education had higher odds of vegetable consumption (1.41) relative to those who did not have any education (P = 0.00). Those who had high average monthly earnings had higher odds of vegetable consumption (1.41) than those who had low monthly earnings (P = 0.00).

At high levels of vegetable consumption (4-7 days per week), those in urban areas had lower odds of consumption (0.69) relative to those in urban areas ($P=0.02$), and those who earned high average monthly salaries had higher (1.27) odds of consumption of vegetables relative to those who earned low average monthly salaries. All other variables were not significant. This is represented in Table 7 below.

Table 7: Differences in Odds of Vegetable Consumption between Rural and Urban Northwestern Tanzania

Fruit Consumption	Odds Ratio	Std. Error	P value	Lower CI	Upper CI
Bivariate					
Medium					
Urban	1.06	0.63	0.11	0.98	1.25
High					
Urban	0.64	0.16	0.01	0.47	0.87
Multivariate					
Medium					
Urban	1.14	0.06	0.04	1.01	1.30
highprocessedfoodconsumption	0.99	0.12	0.90	1.78	1.24
some_edu	1.41	0.08	0.00	1.20	1.67
highearning_average	1.34	0.07	0.06	1.16	1.56
Age	1.00	0.00	0.10	1.00	1.01
BMI	0.99	0.00	0.10	0.99	1.00
High					
Urban	0.69	0.16	0.02	0.50	0.95
highprocessedfoodconsumption	4.65	0.20	0.06	3.14	6.88
some_edu	2.76	0.30	0.10	1.54	4.97
highearning_average	1.27	0.20	0.02	0.85	1.89
Age	1.01	0.00	0.11	1.00	1.02
BMI	1.00	0.01	0.76	0.99	1.01

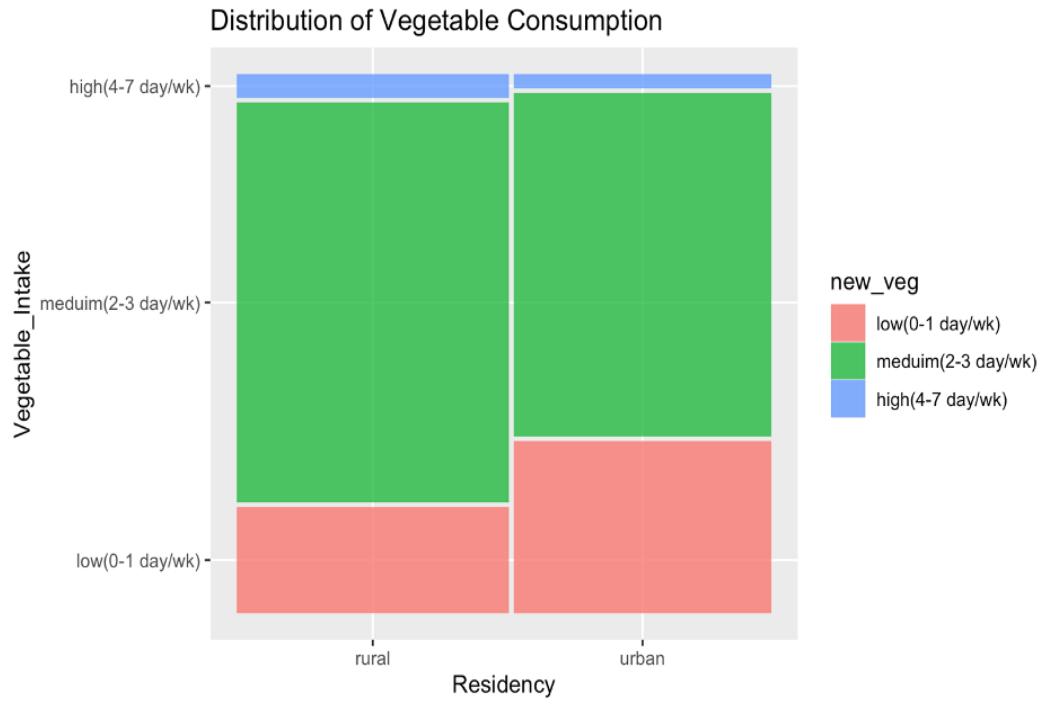


Figure 5: Proportion of Vegetable Consumption across Rural and Urban Northwestern Tanzania

4. Discussion

4.1 Differences in HTN Status between Rural and Urban Northwestern Tanzania

From the above analysis, the overall prevalence of uncontrolled HTN in Northwestern Tanzania was found to be similar to findings from previous studies in Tanzania (Mosha et al., 2017). Edward et al. reported in a systematic review that HTN prevalence ranged from 19% to 35%, with lower percentages in rural settings and higher percentages in urban areas (Edwards et al., 2000)¹¹. Interestingly, our study found a higher prevalence of uncontrolled HTN in rural Northwestern Tanzania compared to urban areas, contrary to previous studies (Ranzani et al., 2022; Sani et al., 2024) though our sampling method, which we purposefully sampled rural and urban areas in each region as described in the methods section is different from random sampling method used in other studies. These shifting trends suggest ongoing socio-demographic developments that influence lifestyle patterns across the region.

The study found that alcohol consumption significantly increased the odds of uncontrolled HTN in the region. In Northwestern Tanzania, a larger portion of the alcohol supply comes from locally brewed beverages, primarily in rural areas. This contributes to easier access and also a lower cost, leading to higher alcohol consumption [JE5] [JK6] and an increased risk of HTN in rural Northwestern Tanzania compared to urban areas (Madundo et al., 2024). Rural Northwestern Tanzania also faces a lack of regulation, with the strength of most alcoholic beverages not known (Madundo et al., 2024). In contrast, urban areas experience an influx of foreign alcoholic beverages, which are more expensive and subject to some level of regulatory enforcement (Staton et al.,

2020). These differences in alcohol availability and affordability contribute to the higher odds of uncontrolled HTN in rural areas compared to urban Northwestern Tanzania contributing to the increased odds of uncontrolled HTN observed in the rural areas.

Physical activity was associated with reduced odds of uncontrolled HTN.

Traditionally, rural areas had higher levels of physical activity due to Indigenous farming practices and manual transportation methods, such as walking and cycling (Kohl et al., 2012). However, these trends are evolving (Guwatudde et al., 2016). While farming remains the primary occupation in rural Northwestern Tanzania, modernized practices, such as machine-assisted farming and chemical use, are reducing the need for strenuous labor (Guwatudde et al., 2016). Additionally, motorbikes are increasingly replacing walking and cycling, further contributing to declining physical activity levels (GBD 2015 Risk Factors Collaborators, 2016). The World Health Organization (WHO) has reported an overall decline in physical activity across the African continent, meaning that both urban and rural areas are now at increased risk of uncontrolled HTN due to reduced physical activity levels as compared to the past when physical activity levels were higher in rural areas relative to urban areas (Physical Activity in Low and Middle-Income Countries, n.d.).

Higher BMI was significantly associated with increased odds of uncontrolled HTN, aligning with findings from previous studies in Tanzania (Msollo et al., 2024; Pallangyo et al., 2020a). BMI is largely influenced by nutritional habits, which are undergoing noticeable changes in both rural and urban areas (Pallangyo et al., 2020a). Traditionally, urban residents were more exposed to dietary factors contributing to high BMI, such as processed foods, meat, and dairy products (Drewnowski, 2000). However,

rural areas are now experiencing similar trends, with an increased consumption of cheap vegetable oils (e.g., palm and sunflower oils) and highly concentrated sugary beverages (Drewnowski, 2000). These dietary changes are contributing to rising BMI levels in both rural and urban areas, thereby increasing uncontrolled HTN risk across the region relative to past studies where this was only seen as a significant issue in urban Northwestern Tanzania (Pallangyo et al., 2020b).

4.2 Differences in Cascade of Care for HTN between Rural and Urban Northwestern Tanzania

Among study participants, less than one-third have ever had their blood pressure measured by a healthcare professional. Given that the median age of participants was 42 years (interquartile range: 30–56 years), it is concerning that only a few study participants have ever had a blood pressure check by a healthcare professional. This finding aligns with the generally low awareness of HTN status in LMICs (Mosha et al., 2017). As highlighted earlier, HTN is a "silent killer" that requires regular screening both in communities and healthcare facilities to enable early detection, effective management, and prevention of life-threatening complications (Fatima & Mahmood, 2021). Therefore, the low percentage of participants ever having their blood pressure checked is concerning.

There was no significant difference in the proportion of study participants who have ever had their blood pressure checked between rural and urban areas in Northwestern Tanzania. Tanzania's healthcare system operates in a multi-tiered structure, where individuals are referred from primary care facilities to more specialized centers as needed. However, this system faces challenges, including inefficient communication and referral

pathways (Kwesigabo et al., 2012). Rural areas suffer from a shortage of trained healthcare workers, many of whom are often absent due to poor working conditions (Munga & Mæstad, 2009). In contrast, urban areas have more healthcare professionals with broader responsibilities and better-equipped facilities (Kwesigabo et al., 2012; Munga & Mæstad, 2009). Additionally, rural communities face greater barriers to healthcare access, including long travel distances, limited health education and screening programs, and lower literacy levels compared to urban areas (Levira & Todd, 2017; Mbutia et al., 2022).

Interestingly, despite urban areas having a more robust healthcare system, this advantage did not significantly translate into a higher proportion of study participants ever having their blood pressure checked compared to rural areas. Since early identification of HTN is the first step in the effective management of HTN, targeted interventions should integrate screening methods into both community-based and health facility systems. Strengthening referral pathways and expanding screening programs in both rural and urban Northwestern Tanzania is essential, given the overall low rates of blood pressure measurement observed in this study.

Among those who have ever had their blood pressure measured, nearly half had been diagnosed with HTN by a doctor or clinical officer. This is consistent with the high prevalence of uncontrolled blood pressure readings observed in this study. Previous research has also reported a high HTN prevalence in Northwestern Tanzania (Edwards et al., 2000). We observed a significant difference in the proportion of participants with a prior HTN diagnosis between rural and urban areas, with rural areas exhibiting a higher prevalence in this study. This suggests that contributing factors to HTN are evolving

differently across these regions, largely influenced by alcohol consumption, physical inactivity, and unhealthy dietary habits, as seen in the early chapter of this study.

Efforts to reduce HTN prevalence must target both urban and rural areas, taking into account the distinct risk factors contributing to higher prevalence in rural Northwestern Tanzania. Additionally, only about half of those previously diagnosed with HTN had access to medication, with no significant difference between rural and urban areas. This highlights persistent challenges in medication access despite the relatively better healthcare infrastructure and higher socioeconomic status in urban areas (Levira & Todd, 2017).

Finally, nearly two-thirds of those with access to antihypertensive medication had their blood pressure under control. Blood pressure control among HTN patients is influenced by lifestyle choices and medication adherence (Ojangba et al., 2023). The high rate of blood pressure control among those with access to antihypertensive drugs suggests good adherence to lifestyle changes or both among study participants who had access to medication. Furthermore, there was no significant difference in blood pressure control between rural and urban areas among study participants who had access to antihypertensives, suggestive of similar adherence or healthy behavioral patterns among individuals receiving treatment across both regions.

4.3 Difference in Fruit and Vegetable Consumption across Rural and Urban Northwestern Tanzania

4.3.1 Fruit Consumption

Overall, fruit consumption among study participants was low, measuring with the World Health Organization (WHO) recommendation of at least five servings per day (*Healthy Diet*, n.d.). Most participants met this recommended intake for only 2 to 3 days per week. This aligns with findings from previous studies in Tanzania (Msambichaka et al., 2018). A scoping review by Amuga et al. reported fruit consumption rates across different parts of Tanzania ranging between 6% and 61%, with most regions falling within the lower end of this range (Amunga et al., 2024) and over 90% of Tanzanians not meeting the minimum daily fruit uptake target (*Tanzania Sets New Targets to Boost Fruit and Vegetable Consumption*, 2024). Fruits generally consumed in Northwestern Tanzania include bananas, mangoes, oranges, pineapples, and watermelons (*Tanzania Fruits and Vegetables Market Size* | *Mordor Intelligence*, n.d.).

Several factors influence fruit consumption in Tanzania, including access, cost, and awareness (Beaudreault, 2019; Ignowski et al., 2023). In this study, while there was no significant difference in odds of fruit consumption between rural and urban Northwestern Tanzania, average monthly earnings, education level, and processed food consumption were significantly associated with fruit intake.

This trend reflects shifting dietary patterns in Tanzania, where fruit consumption remains low while processed food intake is high (Sauer et al., 2021). Approximately 70% of the total food consumed by rural Tanzanian households, including meals eaten outside

the home, is processed food. In urban households, this figure increases to 78% (*Africa | Economic Research Service*, n.d.).

Interestingly, past studies indicate that many Tanzanians prefer indigenous fruits due to their taste and availability (Msuya et al., 2010). However, cost and accessibility remain significant barriers to frequent fruit consumption (Seifu et al., 2024). In Northwestern Tanzania, fruits are generally more expensive than other food groups, including vegetables (*Food Prices in Tanzania*, n.d.). Higher-income individuals were more likely to consume fruits at both medium and high levels, highlighting the role of affordability.

Another key determinant of fruit consumption is awareness of its health benefits (Rakhshanderou et al., 2014). In this study, education was positively associated with fruit consumption, as individuals with higher education levels were more likely to consume fruits regularly.

While rural areas generally have better access to locally grown fruits (Miller et al., 2016), education levels are lower in these regions, potentially limiting awareness of the benefits of fruit consumption. Conversely, urban areas tend to have a higher proportion of educated individuals, which could increase awareness. However, higher fruit prices in urban areas, due to limited local production, may offset this advantage, contributing to the lack of a significant difference in fruit consumption rates between urban and rural areas.

Additionally, the increased availability of processed foods in both urban and rural regions, driven by globalization, was associated with lower fruit consumption odds. This

suggests that without policy and individual-level interventions, the growing exposure to processed foods may further reduce F&V intake in Tanzania increasing NCD risk in the region.

4.3.2 Vegetable Consumption

A similarly low vegetable consumption rate was observed in this study. Most participants met the WHO-recommended vegetable intake of at least five servings per day for only 2 to 3 days per week. This trend aligns with previous studies of low vegetable consumption in Tanzania (Msambichaka et al., 2018). Vegetables largely consumed within the region include beans, cabbage, tomatoes, onions, chilies, and peppers (*Tanzania Fruits and Vegetables Market Size | Mordor Intelligence, n.d.*).

At medium vegetable consumption levels (2-3 days per week), urban participants had higher odds of vegetable consumption compared to rural participants. However, at high vegetable consumption levels (4-7 days per week), the trend reversed, with rural participants having higher odds of vegetable consumption than urban participants.

Two main factors, education level, and average monthly earnings, were significantly associated with vegetable consumption. These factors likely explain the rural-urban differences in Northwestern Tanzania.

Vegetables tend to be less expensive than other food groups, including fruits, and are commonly included in most Tanzanian diets (Bioversity International et al., 2007). At medium consumption levels, urban residents can afford vegetables at a rate similar to rural residents. Additionally, higher education levels and monthly earnings in urban areas likely

contribute to increased awareness of the benefits of vegetable consumption and affordability, leading to higher intake at medium levels.

However, at high vegetable consumption levels (4-7 days per week), cost and availability play a crucial role in both rural and urban settings. Rural areas typically have greater access to locally grown vegetables at lower prices, making high-frequency consumption more feasible. In contrast, urban areas face higher vegetable prices due to limited accessibility, which may restrict consumption despite higher average earnings. While urban residents earn more than their rural counterparts, income alone does not offset the cost barrier, explaining the higher odds of vegetable consumption in rural areas.

These findings are consistent with other studies in Tanzania, which suggest that low awareness of the relevance of vegetable consumption is a major challenge in rural areas, whereas cost remains the primary barrier to high vegetable intake in urban areas (Msambichaka et al., 2018). This study reinforces these trends, as education was significantly associated with vegetable consumption, while income level played a key role in high-level vegetable consumption

4.4 Limitations of the study

A key limitation of this study is the reliance on self-reported data, which may have led to recall bias, as some participants may have misidentified medications or inaccurately reported their F&V consumption. This could result in either overestimating or underestimating treatment rates and dietary intake. Additionally, social desirability bias may have influenced responses, particularly for behavioral questions, as participants may have provided answers they perceived as more favorable rather than entirely accurate. Additionally, since this is a cross-sectional observational study, the identified associations do not imply causality, and caution should be exercised when interpreting the results for policy decisions as this introduces temporal bias. Further longitudinal studies tracking an enrolled cohort over time would help strengthen these estimates. Lastly, recruiting participants through health screenings may have introduced selection bias, as individuals more concerned about their health or at higher risk for hypertension may have been more likely to participate. This could have overestimated prevalence estimates and limited the generalizability of the findings. Additionally, because we purposively sampled rural and urban areas in each of the six regions in Northwestern Tanzania using a multistage sampling technique, there is a potential for selection bias, meaning the participants may not fully represent the broader population of Northwestern Tanzania, further limiting the study's generalizability.

5. Conclusion

The burden of uncontrolled HTN and pre-hypertension remains alarmingly high in both rural and urban Northwestern Tanzania, with rural populations facing significantly higher odds of uncontrolled HTN. This study shows the urgent need for targeted interventions beyond the conventional focus on urban areas. Rather than concentrating solely on urban populations, strategies to reduce HTN prevalence and improve its management must prioritize increasing physical activity levels across both regions. Additionally, given the widespread consumption of locally produced, unregulated alcohol in rural areas, systemic measures to reduce alcohol intake should be a public health priority with a higher focus on rural areas.

A critical gap identified in this study is the lack of early HTN detection, with a substantial proportion of participants having never had their blood pressure measured. Since early identification is the cornerstone of effective HTN management, this gap directly contributes to poor control rates and heightened HTN-related complications. Encouragingly, among those with access to antihypertensive medication, blood pressure control rates were relatively high. This finding highlights the potential for improved HTN outcomes if regular and efficient screening programs are integrated into both healthcare facilities and community settings, coupled with strengthened medication access. Therefore, policy-level and community-level initiatives must focus on routine blood pressure screening, increased medication availability, and early HTN detection efforts in both regions. Furthermore, urban healthcare infrastructure should be leveraged to enhance early

identification, while rural healthcare systems must be reinforced to meet the growing HTN burden.

Beyond HTN management, this study also reveals medium level F&V consumption in Northwestern Tanzania, with socioeconomic factors, such as education, income levels, and processed food consumption, strongly influencing fruit intake. While there is no significant disparity in fruit consumption between rural and urban areas, the above key determinants hinder adequate fruit intake. To promote fruit consumption, interventions must address affordability through economic empowerment and education initiatives while curbing the growing reliance on processed foods, which negatively impact dietary habits. Vegetable consumption trends differed between rural and urban populations, with income and education playing a significant role. In rural areas, awareness campaigns should emphasize the health benefits of increased vegetable consumption, whereas in urban areas, efforts should focus on promoting homegrown vegetables and improving accessibility to reduce costs.

This study highlights the need for tailored interventions to address the specific challenges associated with HTN management and dietary habits in Northwestern Tanzania. With the launch of Tanzania's 2024 National Multi-Sectoral Nutrition Action Plan, addressing these disparities in F&V consumption presents a timely opportunity to support the country's broader goals of reducing NCDs. By implementing region-specific strategies that enhance HTN screening, treatment access, and healthier dietary practices, Tanzania can take a significant step toward reducing HTN-related morbidity and mortality while improving overall public health outcomes.

References

- 2020_Tanzania_in_Figure_English.pdf*. (n.d.). Retrieved December 13, 2024, from https://www.nbs.go.tz/nbs/takwimu/references/2020_Tanzania_in_Figure_English.pdf
- Abdalla, M., Bolen, S. D., Brettler, J., Egan, B. M., Ferdinand, K. C., Ford, C. D., Lackland, D. T., Wall, H. K., & Shimbo, D. (2023). Implementation Strategies to Improve Blood Pressure Control in the United States: A Scientific Statement From the American Heart Association and American Medical Association. *Hypertension (Dallas, Tex. : 1979)*, *80*(10), e143–e157. <https://doi.org/10.1161/HYP.000000000000232>
- Africa | Economic Research Service*. (n.d.). Retrieved March 7, 2025, from <https://www.ers.usda.gov/topics/international-markets-us-trade/countries-regions/africa>
- Alexander. (2016, September 19). *Wald Test: Definition, Examples, Running the Test*. Statistics How To. <https://www.statisticshowto.com/wald-test/>
- 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>
- Beaudreault, A. R. (2019). *Growing Tanzania's Nutrition Knowledge*. <https://www.csis.org/analysis/growing-tanzanias-nutrition-knowledge>
- Bioversity International, Smith, F. I., & Eyzaguirre, P. (2007). African Leafy Vegetables: Their Role in the World Health Organization's Global Fruit and Vegetables Initiative. *African Journal of Food, Agriculture, Nutrition and Development*, *7*(14), 01–17. <https://doi.org/10.18697/ajfand.14.IPGRI1-1>
- Cardiovascular diseases (CVDs)*. (n.d.). Retrieved December 12, 2024, from [https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-\(cvds\)](https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds))
- Colin Cameron, A., & Miller, D. L. (2015). A Practitioner's Guide to Cluster-Robust Inference. *Journal of Human Resources*, *50*(2), 317–372. <https://doi.org/10.3368/jhr.50.2.317>
- Dai, H., Bragazzi, N. L., Younis, A., Zhong, W., Liu, X., Wu, J., & Grossman, E. (2021). Worldwide Trends in Prevalence, Mortality, and Disability-Adjusted Life Years for Hypertensive Heart Disease From 1990 to 2017. *Hypertension (Dallas, Tex.: 1979)*, *77*(4), 1223–1233. <https://doi.org/10.1161/HYPERTENSIONAHA.120.16483>

- Drewnowski, A. (2000). Nutrition transition and global dietary trends. *Nutrition (Burbank, Los Angeles County, Calif.)*, 16(7–8), 486–487. [https://doi.org/10.1016/s0899-9007\(00\)00295-1](https://doi.org/10.1016/s0899-9007(00)00295-1)
- Edwards, R., Unwin, N., Mugusi, F., Whiting, D., Rashid, S., Kissima, J., Aspray, T. J., & Alberti, K. G. (2000). Hypertension prevalence and care in an urban and rural area of Tanzania. *Journal of Hypertension*, 18(2), 145–152. <https://doi.org/10.1097/00004872-200018020-00003>
- Fatima, S., & Mahmood, S. (2021). Combatting a silent killer – the importance of self-screening of blood pressure from an early age. *EXCLI Journal*, 20, 1326–1327. <https://doi.org/10.17179/excli2021-4140>
- Food Prices in Tanzania*. (n.d.). Retrieved March 7, 2025, from https://www.numbeo.com/food-prices/country_result.jsp?country=Tanzania
- Fuchs, F. D., & Whelton, P. K. (2020). HIGH BLOOD PRESSURE AND CARDIOVASCULAR DISEASE. *Hypertension (Dallas, Tex. : 1979)*, 75(2), 285–292. <https://doi.org/10.1161/HYPERTENSIONAHA.119.14240>
- GBD 2015 Risk Factors Collaborators. (2016). Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990-2015: A systematic analysis for the Global Burden of Disease Study 2015. *Lancet (London, England)*, 388(10053), 1659–1724. [https://doi.org/10.1016/S0140-6736\(16\)31679-8](https://doi.org/10.1016/S0140-6736(16)31679-8)
- Guwatudde, D., Kirunda, B. E., Wesonga, R., Mutungi, G., Kajjura, R., Kasule, H., Muwonge, J., & Bahendeka, S. K. (2016). Physical Activity Levels Among Adults in Uganda: Findings From a Countrywide Cross-Sectional Survey. *Journal of Physical Activity & Health*, 13(9), 938–945. <https://doi.org/10.1123/jpah.2015-0631>
- Ignowski, L., Belton, B., Tran, N., & Ameye, H. (2023). Dietary inadequacy in Tanzania is linked to the rising cost of nutritious foods and consumption of food-away-from-home. *Global Food Security*, 37, 100679. <https://doi.org/10.1016/j.gfs.2023.100679>
- Increasing fruit and vegetable consumption to reduce the risk of noncommunicable diseases*. (n.d.). Retrieved December 13, 2024, from <https://www.who.int/tools/elena/interventions/fruit-vegetables-ncds>
- Kohl, H. W., Craig, C. L., Lambert, E. V., Inoue, S., Alkandari, J. R., Leetongin, G., Kahlmeier, S., & Lancet Physical Activity Series Working Group. (2012). The pandemic of physical inactivity: Global action for public health. *Lancet (London, England)*, 380(9838), 294–305. [https://doi.org/10.1016/S0140-6736\(12\)60898-8](https://doi.org/10.1016/S0140-6736(12)60898-8)

- Kwesigabo, G., Mwangi, M. A., Kakoko, D. C., Warriner, I., Mkony, C. A., Killewo, J., Macfarlane, S. B., Kaaya, E. E., & Freeman, P. (2012). Tanzania's health system and workforce crisis. *Journal of Public Health Policy, 33 Suppl 1*, S35-44. <https://doi.org/10.1057/jphp.2012.55>
- Levira, F., & Todd, G. (2017). Urban Health in Tanzania: Questioning the Urban Advantage. *Journal of Urban Health: Bulletin of the New York Academy of Medicine, 94*(3), 437–449. <https://doi.org/10.1007/s11524-017-0137-2>
- Low Blood Pressure—When Blood Pressure Is Too Low.* (n.d.). www.heart.org. Retrieved March 2, 2025, from <https://www.heart.org/en/health-topics/high-blood-pressure/the-facts-about-high-blood-pressure/low-blood-pressure-when-blood-pressure-is-too-low>
- Madundo, K., Hudda, A., Seekles, M. L., Mmbaga, B., & Obasi, A. (2024). The landscape and level of alcohol policy enforcement in Tanzania. *PLOS Global Public Health, 4*(12), e0003203. <https://doi.org/10.1371/journal.pgph.0003203>
- Mbuthia, G. W., Magutah, K., & Pellowski, J. (2022). Approaches and outcomes of community health worker's interventions for hypertension management and control in low-income and middle-income countries: Systematic review. *BMJ Open, 12*(4), e053455. <https://doi.org/10.1136/bmjopen-2021-053455>
- 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., ... Mentz, 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](https://doi.org/10.1016/S2214-109X(16)30186-3)
- Mills, K. T., Bundy, J. D., Kelly, T. N., Reed, J. E., Kearney, P. M., Reynolds, K., Chen, J., & He, J. (2016). Global Disparities of Hypertension Prevalence and Control: A Systematic Analysis of Population-Based Studies From 90 Countries. *Circulation, 134*(6), 441–450. <https://doi.org/10.1161/CIRCULATIONAHA.115.018912>
- Mosha, N. R., Mahande, M., Juma, A., Mboya, I., Peck, R., Urassa, M., Michael, D., & Todd, J. (2017). Prevalence, awareness and factors associated with hypertension in North West Tanzania. *Global Health Action, 10*(1), 1321279. <https://doi.org/10.1080/16549716.2017.1321279>
- 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), Article 2. <https://doi.org/10.3390/nu10020222>

- Msollo, S. S., Shausi, G. L., & Mwanri, A. W. (2024). Prevalence, knowledge and practices on prevention and management of overweight and obesity among adults in Dodoma City, Tanzania. *PLOS ONE*, *19*(1), e0297665. <https://doi.org/10.1371/journal.pone.0297665>
- Msuya, T. S., Kideghesho, J. R., & Mosha, T. C. E. (2010). Availability, preference, and consumption of indigenous forest foods in the Eastern Arc Mountains, Tanzania. *Ecology of Food and Nutrition*, *49*(3), 208–227. <https://doi.org/10.1080/03670241003766048>
- Munga, M. A., & Mæstad, O. (2009). Measuring inequalities in the distribution of health workers: The case of Tanzania. *Human Resources for Health*, *7*(1), 4. <https://doi.org/10.1186/1478-4491-7-4>
- Murray, C. J. L., Aravkin, A. Y., Zheng, P., Abbafati, C., Abbas, K. M., Abbasi-Kangevari, M., Abd-Allah, F., Abdelalim, A., Abdollahi, M., Abdollahpour, I., Abegaz, K. H., Abolhassani, H., Aboyans, V., Abreu, L. G., Abrigo, M. R. M., Abualhasan, A., Abu-Raddad, L. J., Abushouk, A. I., Adabi, M., ... Lim, S. S. (2020). Global burden of 87 risk factors in 204 countries and territories, 1990–2019: A systematic analysis for the Global Burden of Disease Study 2019. *The Lancet*, *396*(10258), 1223–1249. [https://doi.org/10.1016/S0140-6736\(20\)30752-2](https://doi.org/10.1016/S0140-6736(20)30752-2)
- NCD Risk Factor Collaboration (NCD-RisC). (2017). Worldwide trends in blood pressure from 1975 to 2015: A pooled analysis of 1479 population-based measurement studies with 19·1 million participants. *Lancet (London, England)*, *389*(10064), 37–55. [https://doi.org/10.1016/S0140-6736\(16\)31919-5](https://doi.org/10.1016/S0140-6736(16)31919-5)
- Nguyen, T. N., & Chow, C. K. (2021). Global and national high blood pressure burden and control. *Lancet (London, England)*, *398*(10304), 932–933. [https://doi.org/10.1016/S0140-6736\(21\)01688-3](https://doi.org/10.1016/S0140-6736(21)01688-3)
- Ojangba, T., Boamah, S., Miao, Y., Guo, X., Fen, Y., Agboyibor, C., Yuan, J., & Dong, W. (2023). Comprehensive effects of lifestyle reform, adherence, and related factors on hypertension control: A review. *The Journal of Clinical Hypertension*, *25*(6), 509–520. <https://doi.org/10.1111/jch.14653>
- Pallangyo, P., Mkojera, Z. S., Hemed, N. R., Swai, H. J., Misidai, N., Mgopa, L., Bhalia, S., Millinga, J., Mushi, T. L., Kabeya, L., Omar, A., Kaijage, A., Mulashani, R., Mosha, S., Mwapinga, F., & Janabi, M. (2020a). Obesity epidemic in urban Tanzania: A public health calamity in an already overwhelmed and fragmented health system. *BMC Endocrine Disorders*, *20*(1), 147. <https://doi.org/10.1186/s12902-020-00631-3>
- Pallangyo, P., Mkojera, Z. S., Hemed, N. R., Swai, H. J., Misidai, N., Mgopa, L., Bhalia, S., Millinga, J., Mushi, T. L., Kabeya, L., Omar, A., Kaijage, A., Mulashani, R., Mosha, S., Mwapinga, F., & Janabi, M. (2020b). Obesity epidemic in urban

Tanzania: A public health calamity in an already overwhelmed and fragmented health system. *BMC Endocrine Disorders*, 20(1), 147.
<https://doi.org/10.1186/s12902-020-00631-3>

Patel, K. K., Young, L., Howell, E. H., Hu, B., Rutecki, G., Thomas, G., & Rothberg, M. B. (2016). Characteristics and Outcomes of Patients Presenting With Hypertensive Urgency in the Office Setting. *JAMA Internal Medicine*, 176(7), 981–988. <https://doi.org/10.1001/jamainternmed.2016.1509>

Physical Activity in Low and Middle Income Countries. (n.d.). Physiopedia. Retrieved March 2, 2025, from https://www.physio-pedia.com/Physical_Activity_in_Low_and_Middle_Income_Countries

Rakhshanderou, S., Ramezankhani, A., Mehrabi, Y., & Ghaffari, M. (2014). Determinants of fruit and vegetable consumption among Tehranian adolescents: A qualitative research. *Journal of Research in Medical Sciences : The Official Journal of Isfahan University of Medical Sciences*, 19(6), 482–489.

Ramzy', 'Ihab. (n.d.). *Definition of hypertension and pressure goals during treatment (ESC-ESH Guidelines 2018)*. Retrieved December 24, 2024, from <https://www.escardio.org/Journals/E-Journal-of-Cardiology-Practice/Volume-17/definition-of-hypertension-and-pressure-goals-during-treatment-esc-esh-guidelin>

Ranzani, O. T., Kalra, A., Di Girolamo, C., Curto, A., Valerio, F., Halonen, J. I., Basagaña, X., & Tonne, C. (2022). Urban-rural differences in hypertension prevalence in low-income and middle-income countries, 1990-2020: A systematic review and meta-analysis. *PLoS Medicine*, 19(8), e1004079.
<https://doi.org/10.1371/journal.pmed.1004079>

Sani, R. N., Connelly, P. J., Toft, M., Rowa-Dewar, N., Delles, C., Gasevic, D., & Karaye, K. M. (2024). Rural-urban difference in the prevalence of hypertension in West Africa: A systematic review and meta-analysis. *Journal of Human Hypertension*, 38(4), 352–364. <https://doi.org/10.1038/s41371-022-00688-8>

Sauer, C. M., Reardon, T., Tschirley, D., Liverpool-Tasie, S., Awokuse, T., Alphonse, R., Ndyetabula, D., & Waized, B. (2021). Consumption of processed food & food away from home in big cities, small towns, and rural areas of Tanzania. *Agricultural Economics*, 52(5), 749–770. <https://doi.org/10.1111/agec.12652>

Seifu, B. L., Fente, B. M., Asmare, Z. A., Asnake, A. A., Bezie, M. M., Asebe, H. A., Melkam, M., & Negussie, Y. M. (2024). Factors associated with zero vegetable and fruit consumption among Tanzanian children. *BMC Public Health*, 24, 3039. <https://doi.org/10.1186/s12889-024-20472-2>

- Standard STEPS instrument*. (n.d.). Retrieved December 13, 2024, from <https://www.who.int/publications/m/item/standard-steps-instrument>
- Staton, C. A., Zhao, D., Ginalis, E. E., Hirshon, J. M., Sakita, F., Swahn, M. H., Mmbaga, B. T., & Vissoci, J. R. N. (2020). Alcohol Availability, Cost, Age of First Drink and Association with At-Risk Alcohol Use in Moshi, Tanzania. *Alcoholism, Clinical and Experimental Research*, *44*(11), 2266–2274. <https://doi.org/10.1111/acer.14457>
- Tanzania | Culture, Religion, Population, Language, & People | Britannica*. (n.d.). Retrieved December 13, 2024, from <https://www.britannica.com/place/Tanzania>
- Tanzania Fruits and Vegetables Market Size | Mordor Intelligence*. (n.d.). Retrieved January 3, 2025, from <https://www.mordorintelligence.com/industry-reports/fruits-and-vegetables-industry-in-tanzania-industry>
- Tanzania sets new targets to boost fruit and vegetable consumption*. (2024, August 27). The Citizen. <https://www.thecitizen.co.tz/tanzania/news/national/tanzania-sets-new-targets-to-boost-fruit-and-vegetable-consumption-4741000>
- Wolfson, J. A., & Bleich, S. N. (2015). Fruit and vegetable consumption and food values: National patterns in the United States by Supplemental Nutrition Assistance Program eligibility and cooking frequency. *Preventive Medicine*, *76*, 1–7. <https://doi.org/10.1016/j.ypmed.2015.03.019>
- Yusuf, S., Joseph, P., Rangarajan, S., Islam, S., Mente, A., Hystad, P., Brauer, M., Kutty, V. R., Gupta, R., Wielgosz, A., AlHabib, K. F., Dans, A., Lopez-Jaramillo, P., Avezum, A., Lanas, F., Oguz, A., Kruger, I. M., Diaz, R., Yusoff, K., ... Dagenais, G. (2020). Modifiable risk factors, cardiovascular disease, and mortality in 155 722 individuals from 21 high-income, middle-income, and low-income countries (PURE): A prospective cohort study. *Lancet (London, England)*, *395*(10226), 795–808. [https://doi.org/10.1016/S0140-6736\(19\)32008-2](https://doi.org/10.1016/S0140-6736(19)32008-2)
- Zhang, X., Lai, J., Jin, Z., Wu, Y., & Zhao, K. (2024). Daily consumption of specific categories of fruit and vegetables negatively correlated with frailty: Findings from the US National Health and Nutrition Examination Survey. *Nutrition Research and Practice*, *18*(6), 829–844. <https://doi.org/10.4162/nrp.2024.18.6.829>