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A survey of fruits and vegetables consumed in Ghanaian households and their micromineral content

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Fruits and vegetables are good sources of microminerals essential for life. However, they can be relatively expensive and may even be unavailable during off-season periods. Many people do not consume fruits and vegetables frequently due to their high cost. As a result, they rely more on cereals, leading to malnutrition. This study aimed to determine the extent of fruit and vegetable consumption by Ghanaian households and assess the concentrations of selected microminerals in the fruits and vegetables consumed. A household food survey was conducted in 14 administrative regions of Ghana using a structured questionnaire. Selected fruits and vegetables were analyzed for their concentrations of Fe, Zn, Cu, and Mn. The results revealed that Ghana has a variety of fruits and vegetables rich in microminerals, but their availability is not consistent throughout the year. The study also found that fruits and vegetables are abundant and cheaper during bumper seasons. Additionally, findings indicated regional variations in fruit consumption, with higher consumption occurring when fruits and vegetables are in season. Therefore, the country should establish storage and processing facilities to preserve excess fruits and vegetables during bumper seasons, ensuring a sustained supply during off-season periods.

Key words: Nutrition, fruits, vegetables, microminerals, health.

INTRODUCTION

The increase in liver, heart, kidney and cancer diseases is due to poor eating and lifestyle habits among people across the globe (Asrani et al., 2019). The best defense for everyone is a healthy lifestyle and a good immune system. This puts nutrition at the center stage of life. Several reports have shown that malnutrition, micromineral deficiency and polluted water affects the health, growth and development of humans (Shukla et al., 2018; Godswill et al., 2020; Arfi et al., 2022). There is therefore the need for stakeholders to support in finding a lasting solution to these global challenges. In view of this, the United Nations (UN) tried to address the problem by including nutrition and food security in its Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs). Though the platform tries to solve these problems, most of the global discussions and submissions on food security focus on macronutrient and calories intake and not nutritional security (Ritchie et al., 2018;

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Shiratori et al., 2023). This will have a negative impact on Ghana which has 41.38% of her population in rural communities, (Ghana Statistical Service, 2021).

Reports indicate that micromineral deficiencies are most common in regions where populations depend on monotonous diets (Biesalski, 2013; Sharma et al., 2017; Ceccanti et al., 2021). This issue is particularly prevalent in developing countries, where staple foods such as maize, rice, millet, sorghum, cassava, yam, and cocoyam lack sufficient microminerals (Goredema-Matongera et al., 2021). Micromineral deficiency is worse in developing countries because people are not able to diversify their diet with adequate amounts of fruits, vegetables or animal products to enhance nutrition due to poverty (Saravanakumar, 2020; Kumar et al., 2022). Countries with high micromineral deficiency end up with continued and sustained loss of productivity, permanent mental disability, blindness, low immune system function and increased infant and maternal mortality. The most affected in these conditions are pregnant women and children.

For proper growth and development of humans, nineteen vitamins and minerals are essential for physical and mental development, immune system functioning and various metabolic processes of the body (Godswill, 2020). Vitamin A, iron, copper, zinc and manganese are good for sight, immune system functioning and metabolic processes of the body (Biesalski, 2013: Godswill, 2020). Not having balanced diets could result in not having the required vitamins and minerals in food which affects nutrition and lead to micromineral deficiency.

Iron is a micromineral responsible for oxygen transport in the body to enhance efficient functioning of haemoglobin in the body. Aside other factors that causes anaemia in the body, a deficiency of iron results in anaemia and reduction of red blood cells in the body (Kennedy et al., 2003; Hoenemann et al., 2021). Therefore, diet diversification is critical for the enhancement of iron levels in the body. It is essential for diets to include iron rich foods such as meat, poultry and fish which have great bioactive iron needed for the metabolic activities of the body (Biesalski, 2013, 2016). It is also reported that ascorbic acid rich foods enhance iron absorption in the body (Kennedy et al., 2003; Basrowi and Dilantika, 2021; Piskin et al., 2022). It is therefore good to diversify one's food intake to include fruits and vegetables that will enhance the absorption of iron for the metabolic activities of the body especially during menstruation, pregnancy, breastfeeding and the initial growth period of an individual. This study was carried out to investigate the consumption of fruits and vegetables by Ghanaian households. It also investigates the concentration of microminerals (Fe, Zn, Cu and Mn) in some fruits and vegetables consumed by Ghanaian households.

MATERIALS AND METHODS

A total of 3521 households from fourteen administrative regions of Ghana were used for the study.

Sampling/Data collection technique

A household food survey and laboratory analysis was carried out to investigate the consumption of fruits and vegetables in Ghanaian households from November 2021 to March 2022. Ethical clearance (UCCIRB/EXT/2021/21) was obtained from the Institutional Review Board of the University of Cape Coast, Ghana to conduct this study. For the household food survey, structured questionnaires were used to elicit information on the frequency of consumption of fruits and vegetables in households. The country's administrative regions were taken as strata and each stratum was further stratified within the regions into urban, peri-urban and rural areas. The communities within these areas were further stratified considering the social class (lower income, middle income and higher income earner) of the people. The number of households interviewed per region is presented in Supplementary Table 1. Respondents were purposively selected for interview in the communities. All residents aged 18 years or more in each selected household were deemed eligible to respond to questions. This gave all residents of a household equal opportunity to be interviewed. The interviews were conducted in the local language of the people in the locality, where the surveys were carried out. The objectives of the research were made known to the respondents before they were included as subjects of the research. Respondents were assured of their anonymity and confidentiality of their responses to the questionnaires. The responses obtained were coded and entered into SPSS (IBM SPSS, version 20, Armonk, NY) for analysis.

Sampling of fruits and vegetables from the field

Sample of *Solanum torvum* (Kwahu nsusua), *Solanum lycopersicum* (tomatoes), *Solanum melongena* (garden eggs), *Tetrapleura tetraptera* (Prekese), *Brassica oleracea* var. *capitata* (cabbage), *Allium fistulosum* (spring onion), *Colocasia esculenta* leaves (cocoyam leaves), *Manihot esculenta* (cassava leaves), *Elaeis guineensis* (palm fruit), *Capsicum chinense* "Habanero Group" (pepper), *Capsicum annuum* var. *annuum* (green pepper), *Abelmoschus esculentus* (okro), *Phaseolus lunatus* (white beans), *Phaseolus vulgaris* (green beans), *Daucus carota* (carrots), *Corchorus olitorious* (ayoyo), *Amaranthus cruentus* (alefu) and *Roselle calyx* (Sobolo) from five different sources namely Mampong-Ashanti, Ejura, Kumasi, Ejisu and Nsuta markets in the Ashanti Region of Ghana were obtained for micromineral assessment. Fruits and vegetables from each of these sources were treated as replicate giving total of 5 replicates per sample.

The laboratory analysis was carried out by first washing the collected samples under running water for further processing and analysis in the laboratory. The samples were individually packaged in 200 g quantities and stored in a chest freezer (Samsung) at -21ºC until they were freeze dried using a Drawell Freeze drier (Shanghai Drawell Scientific Instrument Co., Ltd. Shanghai, China). The freeze-dried samples were then milled into fine powder using a blender (Kenwood Limited, Tokyo, Japan). The milled samples were assessed for their microminerals (Fe, Zn, Mn, Cu) in 5 replicates.

Analysis of microminerals in samples

Samples were digested using the sulphuric acid–hydrogen peroxide method (Allen et al., 1974; Lowther, 1980). An amount of 0.10 g of dried samples was placed into a 100 ml Kjeldahl flask. A volume of 4.4 ml of digestion reagent comprising of a mixture of 350 ml hydrogen peroxide, 0.42 g selenium powder, 14 g lithium sulphate

Table 1. Dependent variables for the frequency of consumption of fruits/vegetables.

How often do you eat fruits?	How often do you eat vegetables?
Daily (1)	Daily (1)
Weekly (2)	Weekly (2)
Monthly (3)	Monthly (3)
Rarely (4)	Rarely (4)
When in season (5)	When in season (5)
Sometimes (6)	Sometimes (6)

and 420 ml sulphuric acid was added and heated gently at 80-90°C with a gradual increase in temperature to 150-200°C and held for 2 hours until digest was clear. The samples were then left on the plate for another 30 min. to cool. The digest was topped up to 50 ml with distilled water for further analysis. The filtrate from the digestion was used for Fe, Zn, Mn and Cu analysis using a 200 series Atom Absorption Spectrophotometer (Agilent Technologies, Santa Clara, CA). The digestion and analysis were repeated five times per sample and the mean value used for statistical analysis.

Data processing and analysis

Data from the food survey was subjected to descriptive statistics (IBM SPSS version 20, Armonk, NY). Cross tabulations to determine the relationships between the data set were conducted. The data was also subjected to Bayesian Model analysis (R software). For this, two separate analyses were conducted with how often individuals eat fruits (Frequency of fruits) and how often vegetables are eaten (Frequency of vegetables) as the dependent/response variables in each analysis. Frequency of fruits was considered an ordinal variable with six levels (Table 1). Frequency of vegetables was also represented as an ordinal variable with six levels. How often Fruits/Vegetables were eaten is a sequential process because individual can move up (or drop down) to different levels based on the number of times fruits/vegetables are consumed. The nutritional data from the fruits and vegetables were compared using analysis of variance followed by Turkey's test where statistical differences were obtained (Minitab version 17; Minitab Inc., State College, PA).

RESULTS

Results from the survey showed that more than half of the respondents interviewed in all age groups eat fruit daily but very few respondents eat fruits monthly or rarely (Table 2). There were significant differences ($P < 0.001$) in the eating of vegetables among the respondents but those differences did not show very strong association among the respondents (Table 3). There was a very weak association between age and marital status (Cramér's V = 0.0598 and Cramér's V = 0.0805 respectively); while gender, type of community setting, level of education, household size and household income with the region showed the strongest association among them (Table 2).

There were significant differences in the frequency of eating fruit among all the demographic factors. Although there were significant differences among the demographic factors, the association between age and gender with regards to the eating of fruits and vegetables was weak (Tables 2 and 3). Moreover, the association between the vegetable eating pattern and level of education, household size, marital status, type of community and household income were stronger relative to age and gender (Table 3). The region showed a much stronger relationship than all the other demographic factors considered during the survey.

In terms of gender, more males were likely to eat fruits when in season than females. However, females were more likely to eat fruit weekly than male. It is worth noting that there was a small probability of both genders eating fruits sometimes. There was also equally small probability of both genders not remembering when they eating fruits or occasionally (Others) (Figure 1).

In terms of the Age of people who consume fruits, the reference category was individuals below the age of 17, hence the coefficients of the various levels of Age indicate the extent to which people of different age groups differ from people below 17 years on how often fruits are eaten. The estimated mean of all the levels of age was negative except those above 66 years. Hence the number of fruits eaten by the different age groups (except those 66 or more) appear to be lower than those eaten by individuals aged 17 or below. The 95%-CI of all the levels contain zero, this indicates that Age has no effect on the number of fruits eaten.

Marital Status had Single as the reference category. The estimated mean of all the other levels of Marital Status were negative, which is indicative of lower fruits eaten. The 95%-CI of all the levels of Marital Status contain zero, hence Marital Status has no effect on the number of fruits eaten. Marital status, Number of fruits eaten per day (No. per day) and house size had the 95%-CIs containing zero, hence they had no effect on the frequency of fruits eaten.

All estimates for levels of education were negative, indicating that the average frequency of eating fruits is lower across all educational levels compared to the reference category, 'No literacy'. The confidence intervals

Table 2. Frequency of eating fruits (n=3521).

Respondents' characteristics	Daily (%)	Weekly (%)	Monthly (%)	Rarely (%)	When in season (%)	Other (%)	Inferential statistics
Age (years)							$\chi^2_{(25, 3521)} = 61.77$; $P < 0.001$
Up to 25	58	16	2	5	7	13	Cramér's V = 0.0598
26-35	62	12	2	2	7	14	
36-45	60	15	1	3	8	12	
46-55	59	13	2	4	8	15	
56-65	58	12	2	2	17	9	
Greater than 65	54	14	4	2	12	14	
Gender							$\chi^2_{(5, 3521)} = 52.14$; $P < 0.001$
Male	57	13	2	5	13	10	Cramér's V = 0.1217
Female	60	14	2	3	6	14	
Level of education							$\chi^2_{(20, 3521)} = 289.49$; $P < 0.001$
No literacy	54	12	1	4	21	8	Cramér's V = 0.1434
Non-formal	53	10	3	4	18	11	
Basic education/middle school	59	14	2	3	4	17	
Secondary/Technical	64	15	1	2	3	15	
Tertiary	64	15	2	5	8	6	
Household size (people)							$\chi^2_{(20,3521)} = 348.39$; $P < 0.001$
1-5	60	15	2	3	5	16	Cramér's V = 0.1576
5-10	64	13	1	4	10	9	
11-15	45	13	3	7	24	8	
16-20	30	13	2	9	44	2	
More than 20	9	14	5	0	64	9	
Marital status							$\chi^2_{(15, 3521)} = 68.45$; $P < 0.001$
Single	57	15	3	3	7	15	Cramér's V = 0.0805
Married	59	14	2	3	10	12	
Divorced	66	8	3	4	3	16	
Widower/Widow	80	11	0	2	0	7	
Household income (GH**)**							$\chi^2_{(25, 3521)} = 358.31$; $P < 0.001$
Less or equal 100	40	18	2	5	19	16	Cramér's V = 0.1543
101-500	54	16	3	3	5	20	
501-1000	71	12	2	3	5	7	
1001-1500	73	12	4	4	3	5	
1501-2000	84	8	0	2	2	4	
Greater than 2000	88	5	1	3	1	2	
Region							$\chi^2_{(45, 3521)} = 2.7 \times 10^3$; $P < 0.001$
Greater Accra	**61**	**19**	**2**	**10**	**2**	**6**	**Cramér's V = 0.3887**
Ashanti	83	8	2	1	2	4	
Eastern	7	22	5	0	0	65	
Central	88	6	0	1	0	4	
Upper West	9	11	0	7	68	4	
Upper East	58	35	1	2	3	1	
Volta	17	21	5	6	17	34	
Brong Ahafo	69	20	2	2	2	5	
Northern	49	12	1	8	26	5	
Western	80	9	1	3	1	6	

Table 2. Contd.

Community type							$X^2_{(15, 3521)} = 168.56$; P < 0.001
Urban	68	15	1	5	4	7	Cramér's V = 0.1263
Peri urban	61	13	2	3	4	17	
Rural	55	13	3	3	13	13	

Table 3. Frequency of eating vegetables (n=3521).

Respondents' characteristics	Daily (%)	Weekly (%)	Monthly (%)	Rarely (%)	When in season (%)	Other (%)	Inferential Statistics
Age (years)							$X^2_{(25, 3521)} = 120.71$; P < 0.001
Up to 25	27.57	24.88	1.87	7.83	20.68	17.17	Cramér's V = 0.0836
26-35	25.46	21.49	1.38	7.01	25.92	18.73	
36-45	22.17	21.88	1.74	7.39	32.17	14.64	
46-55	18.07	15.66	1.93	9.16	33.73	21.45	
56-65	17.32	15.15	2.16	5.63	45.89	13.85	
Greater than 65	13.19	15.38	2.2	11.54	38.46	19.23	
Gender							$X^2_{(5, 3521)} = 12.67$; P = 0.027
Male	21.83	21.42	1.83	8.73	31.57	14.62	Cramér's V = 0.0600
Female	23.7	20.7	1.77	7.33	27.92	18.57	
Level of education							$X^2_{(20, 3521)} = 505.52$; P < 0.001
No literacy	11.85	16.91	0.72	6.65	54.19	9.68	Cramér's V = 0.1895
Non-formal	16.89	25.68	3.38	17.57	29.05	7.43	
Basic Education/middle school	19.36	21.41	2.17	7.41	26.01	23.64	
Secondary/ technical	29.82	22.2	1.46	8.1	17.34	21.07	
Tertiary	44.49	21.84	2	6.81	17.43	7.41	
Household size (people)							$X^2_{(20, 3521)} = 212.57$; P < 0.001
1-5	24.33	21.18	2.06	7.5	22.47	22.47	Cramér's V = 0.1231
5-10	23.96	21.19	1.12	8.13	35.29	10.29	
11-15	12.15	17.13	3.31	8.84	48.07	10.5	
16-20	11.11	9.26	0	7.41	61.11	11.11	
More than 20	0	18.18	0	0	77.27	4.55	
Marital status							$X^2_{(15, 3521)} = 112.43$; P < 0.001
Single	27.73	22.7	2.39	7.17	18.94	21.08	Cramér's V = 0.1032
Married	20.39	20	1.56	7.78	34.08	16.19	
Divorced	22.6	20.34	1.13	6.21	33.9	15.82	
Widower/Widow	26.77	19.69	0.79	14.17	31.5	7.09	
Household income (GH**)**							$X^2_{(25, 3521)} = 421.77$; P < 0.001
less or equal 100	10.16	12.6	1.02	7.52	47.97	20.73	Cramér's V = 0.1674
101-500	17.17	21.06	2.19	6.57	26.22	26.78	
501-1000	27.84	25.57	2.27	9.08	25.26	9.98	
1001-1500	45.24	14.29	3.57	7.74	22.62	6.55	
1501-2000	53.21	12.84	3.67	4.59	22.02	3.67	
Greater than 2000	46.06	21.82	0.61	4.85	22.42	4.24	
Region							$X^2_{(45, 3521)} = 2.5 \times 10^3$; P < 0.001
Greater Accra	53.74	23.36	3.27	10.28	4.67	4.67	Cramér's V = 0.3779
Ashanti	26.95	16.47	1.2	5.54	44.31	5.54	
Eastern	2.37	10.51	3.39	0.34	1.02	82.37	

Table 3. Contd.

Central	49.35	25.32	2.59	10.91	9.61	2.22	
Upper West	4.61	6.58	0.66	4.61	80.26	3.29	
Upper East	4.67	3.33	0.67	3.33	86.67	1.33	
Volta	3.83	10.2	2.3	9.44	22.96	51.28	
Brong Ahafo	32.51	39.01	1.86	6.81	16.41	3.41	
Northern	15.2	20.18	0.29	10.82	43.57	9.94	
Western	13.74	35.59	1.35	10.14	25.68	13.51	
Community type							$\chi^2_{(15, 3521)} = 322.07$; $P < 0.001$
Urban	42.95	17.79	1.76	6.57	17.63	13.30	Cramér's V = 0.1746
Peri urban	23.79	24.47	1.28	6.14	21.31	23.02	
Rural	15.61	19.6	2.12	9.23	38.23	15.21	

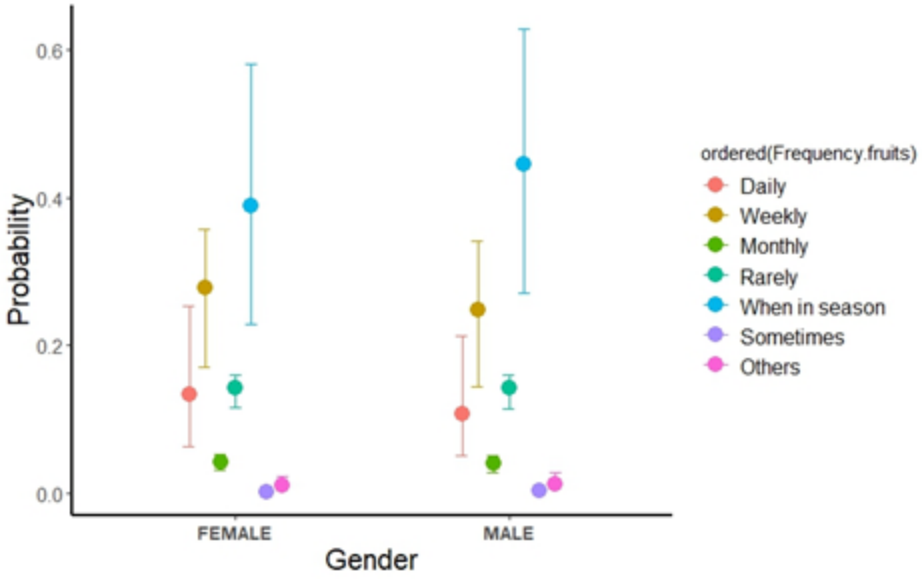

Figure 1. Marginal effects of gender on frequency of eating fruits. Points indicate the posterior mean estimates of the probability of frequency of eating fruits (indicated by color) for each gender. Error bars indicate 95% Credible Intervals. Others = do not remember, occasionally.

Figure 2 displays the estimated probabilities of the six response categories for the five levels of education groups. The probability of people with tertiary education when in season was relatively lower than those with 'No literacy' 'non-formal', 'Basic education/middle school' and 'secondary/technical'. However, people with tertiary education ate fruits weekly than people with 'No literacy' 'non-formal', 'basic education/middle school' and 'secondary/technical'. There was a relatively low probability of people at all educational level to eat fruits rarely, monthly and sometimes (Figure 2).

From Figure 3, the frequency of eating fruits 'When in season' had the highest probability. The second highest probability of eating fruits was 'Weekly'. The frequency of eating fruits 'rarely', 'Sometimes' and occasionally (others) had the lowest probability.

Figure 4 showed that among all the eleven levels of occupation, farmers, seamstress/tailors, unemployed and apprentices had the highest probability of eating fruits when in season. 'Police/fire service' officers had the highest probability of eating fruits daily. Traders, self-employed, hair dressers, teachers/ nurses, 'Police/Fire Service', students, doctors, lawyers, accountants and lectures had a similar probability of eating fruits weekly. Respondents in all categories of occupation had a low probability of eating fruits monthly. Most especially people who did not remember or occasionally ate fruits (others) were among those with the lowest probability.

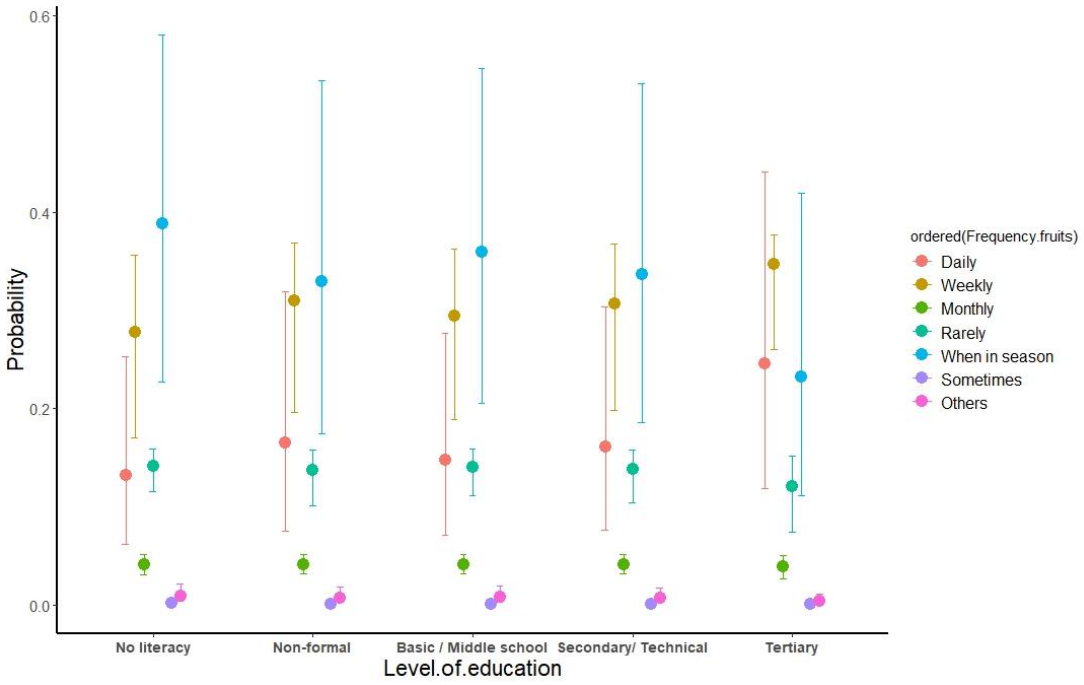

Figure 2. Marginal effects of education on frequency of eating fruits. Others = do not remember, occasionally.

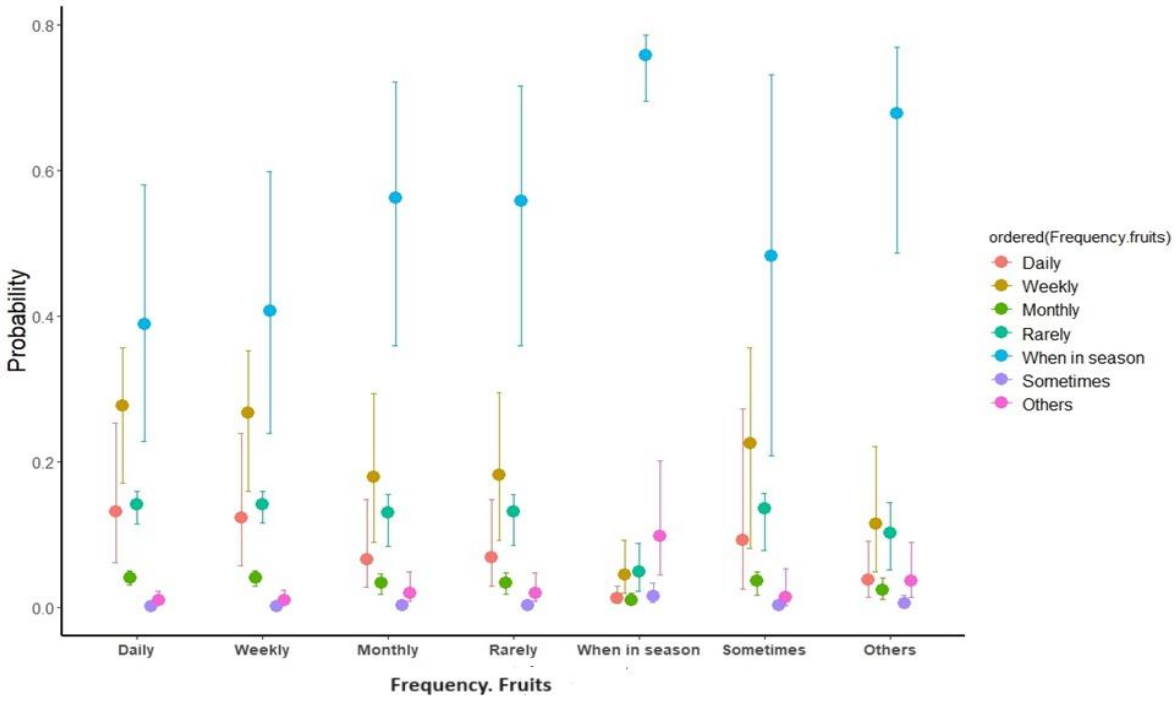

Figure 3. Marginal effects of frequency of eating vegetables. Others = do not remember, occasionally.

(95%-CIs) for 'Non-formal' and 'Basic Education/Middle school' include zero, suggesting that they have no significant effect on fruit consumption frequency. Conversely, the 95%-CIs for 'Secondary/Technical' and 'Tertiary' education do not include zero, indicating with at least 95% confidence that respondents with 'Secondary/

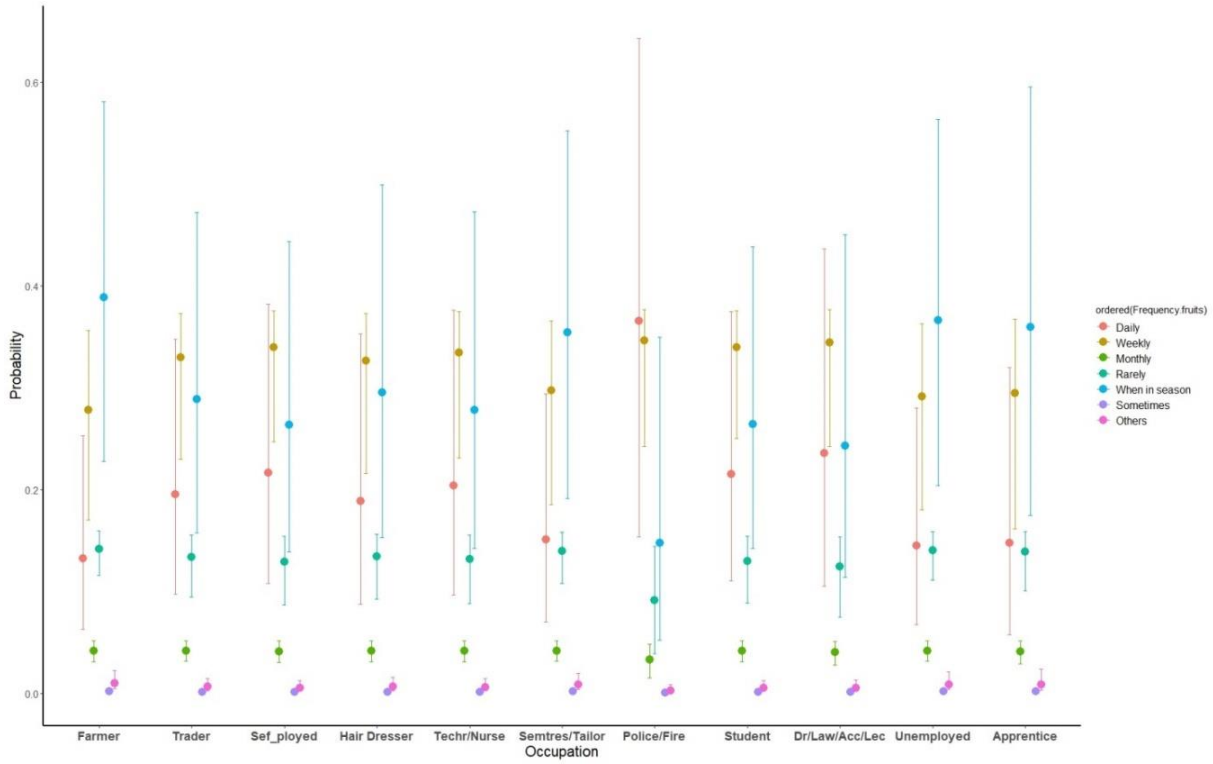

Figure 4. Marginal effects of occupation on frequency of eating fruits. Sef_ployed = Self-employed; Techr = Teacher; Semtres = Seamstress; Fire = Fire service; Dr = Medical Doctor; Law = Lawyer; Acc = Accountant; Lec = Lecturer. Others = do not remember, occasionally.

Technical' or 'Tertiary' education, on average, consume fewer fruits than those with 'No literacy'.

Figure 2 displays the estimated probabilities of the six response categories for the five levels of education groups. The probability of people with tertiary education when in season is relativity lower than those with 'No literacy' 'Non-formal', 'Basic Education/Middle school' and 'Secondary/Technical'. However, people with tertiary education to eat fruits weekly than people with 'No literacy' 'Non-formal', 'Basic Education/Middle school' and 'Secondary/Technical'. There is a relatively low probability of people at all educational level to eat fruits rarely, monthly and sometimes (Figure 2).

From figure 3, the frequency of eating fruits 'When in season' has the highest probability. The second highest probability of eating fruits was 'Weekly'. The frequency of eating fruits 'rarely', 'Sometimes' and occasionally (others) had the lowest probability.

Figure 4 shows that among all the eleven levels of occupation, farmers, semstres/ tailors, unemployed and apprentices have the highest probability of eating fruits when in season. 'Police/Fire Service' officers have the highest probability of eating fruits daily. Traders, self-employed, hair dressers, teachers/ nurses, 'Police/Fire Service', students, doctors, lawyers, accountants and lectures had a similar probability of eating fruits weekly. Respondents in all categories of occupation had a low probability of eating fruits monthly. Most especially people who did not remember or occasionally ate fruits (others) were among those with the lowest probability.

Community setting, towns and village had significant effect on consumption of fruits and vegetables. This implies that the level of consumption varies with the community settings (Supplementary Table 2). This means that the level of consumption varies with the same amount across levels of community setting. From the model, the fixed effect is Region and Community setting, with the reference categories being Greater Accra region and urban community respectively. The means consumption for Ashanti, Eastern, Upper West, Upper East, Volta, Northern and Western Regions indicate that there was a strong effect of these regions on the frequency at which respondents eat fruits. The other regions, Central, Oti, Bono, Bono East, Savanna and Western North had no significant effect on respondents' consumption of fruits (Supplementary Table 2).

It can be seen from Figure 5 that Central region had the highest probability for the daily consumption of fruits, followed closely by the Bono East. Greater Accra and Bono regions have the third and fourth highest probability respectively. Respondents in the Upper West, Northern and Upper East regions have the highest probability

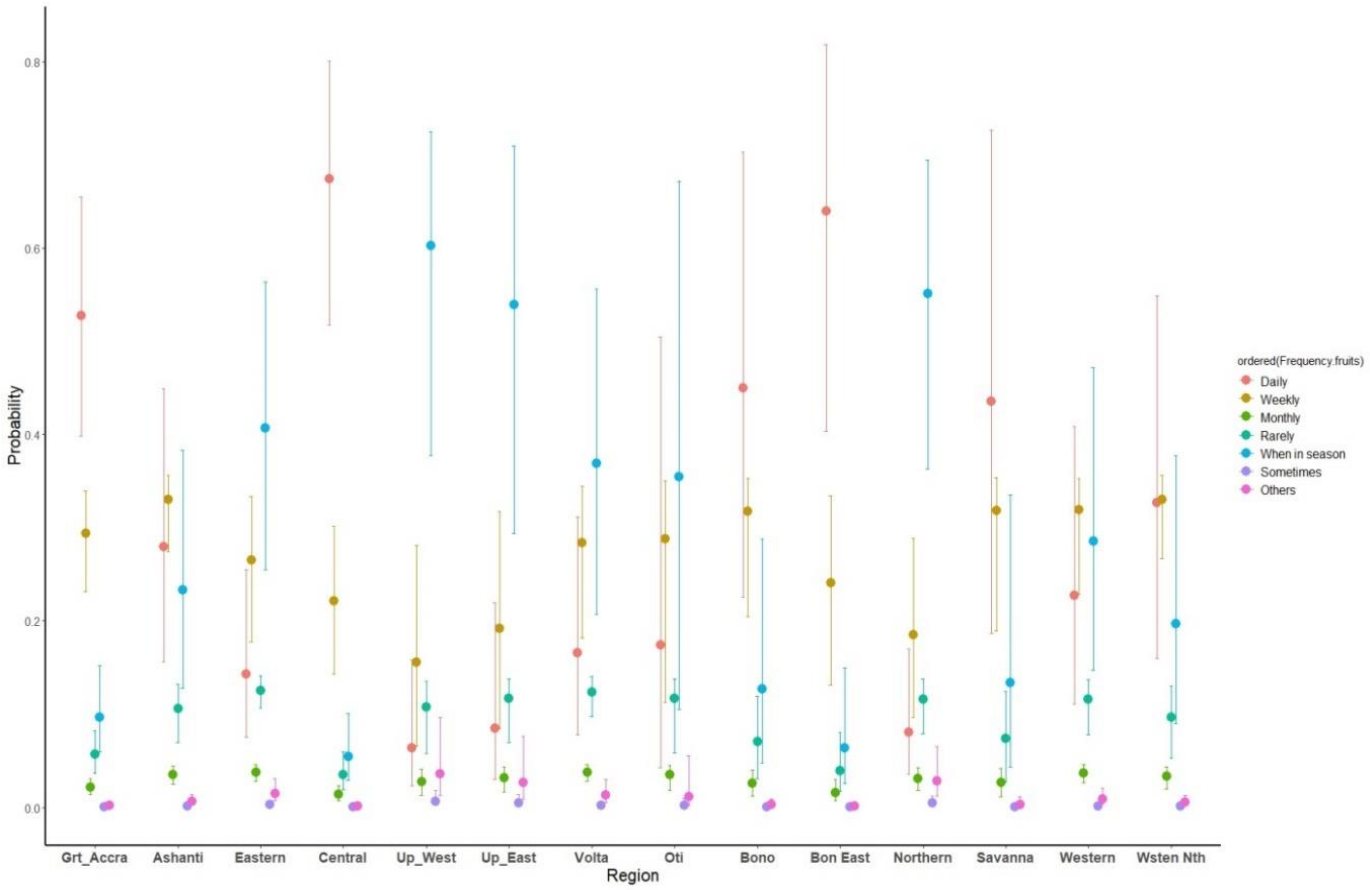

Figure 5. Marginal effects of region on frequency of eating fruits. Grt_Accra = Greater Accra; Up_West = Upper West; Up_East = Upper East; Bon East = Bono East; Wsten Nth = Western North. Others = do not remember, occasionally.

among those who frequently eat fruits 'When in season'. Eastern region had the fourth highest probability for 'When in season' whilse Volta region was fourth (Figure 5).

For Community setting, the regression coefficients for peri-urban and rural were both positive. This indicates that the average consumption of fruits for respondents in Peri-urban and Rural communities were higher than those in urban communities.

From figure 6, respondents in urban communities had the highest probability of eating fruits 'Daily', whiles those in peri-urban areas had the second highest probability with those in rural communities having the least probability of eating fruits 'Daily'. Rural communities however had the highest probability among those who consume fruits frequently 'When in season'. Peri-urban communities had the second highest probability, with those in urban communities having the lowest probability for eating fruits 'When in season'.

There were variable amounts of microminerals in the various fruits and vegetables (Table 4). Concentration of microminerals typically ranged from 0.0 – 0.081 mg/Kg (Table 4).

DISCUSSION

In Ghana, people consume fruits and vegetables daily or weekly, with a notable increase during bumper periods when these items are abundant. The frequency of fruit and vegetable consumption was influenced by gender, community setting, educational level, income, and geographical location. Regional differences particularly impact consumption patterns. Professions also play a role, as individuals in lower-paid jobs tend to consume more fruits and vegetables during bumper seasons, whereas those with higher-paid jobs and higher education ate them regularly throughout the week. This discrepancy may stem from the affordability of fruits and vegetables to households, aligning with findings from Saravanakumar (2020) and Kumar et al. (2022) indicating higher micromineral deficiency risks among those with less dietary diversity. Additionally, the socioeconomic status of households directly affects their nutritional quality. Lower-income families may struggle to afford daily or weekly purchases of fruits and vegetables due to cost, whereas those in higher-paid positions can afford them more regularly. Individuals with higher education

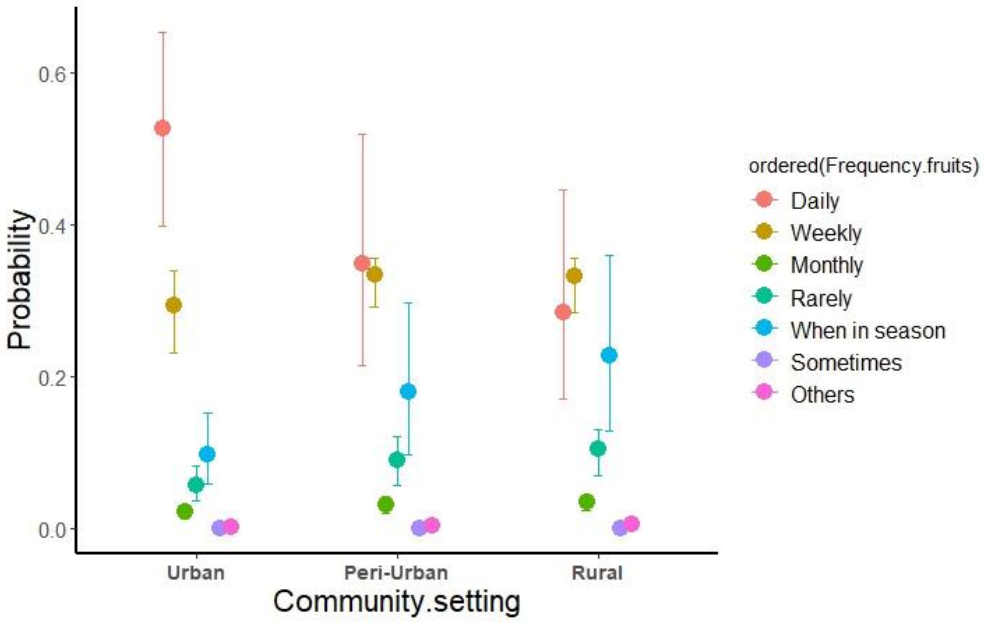

Figure 6. Marginal effects of region on frequency of eating fruits.

levels tend to prioritize healthier eating habits, consistent with insights from Frank et al. (2019). This trend reflects an understanding among literate individuals, especially those with advanced education, of the nutritional benefits of fruits and vegetables and the importance of incorporating them into daily diets.

Depending on the regional location, some respondents did not have an all-year supply of some fruits and vegetables as expected in an ideal condition but only access them during the bumper season where they are available and have the lowest selling price. The northern sector for instance has one season of rain followed by a long drought and so the availability of fruits and vegetables are not regular. Additionally, there were inadequate storage facilities for such fruits and vegetables to be preserved. Aside the non-availability of storage facilities, there were not enough industries with people who had the requisite skill and technology to process farm produce for later use. It was observed at the regional level that some of the respondents did not have access to some fruits and vegetables because they were not cultivated in those regions. This had an influence on consumption of those fruits and vegetables. At the peak of harvest, most traders can supply the fruits and vegetables to areas where the produce were rarely eaten and sell them at an affordable price.

Consequently, perishable fruits and vegetables become scares and expensive during the lean season. This has a great influence on the achievement of goals 2 and 3 of the SDG. This subsequently threatens nutritional quality and food security and needs to be addressed to prevent hidden hunger. Hidden hunger caused by over dependence on cereals (such as, maize, rice, millet) and tubers (such as, cassava, yam) (Noack and Pouw, 2015; Zikankuba et al., 2019; Hossain et al., 2021) can be avoided if Ghanaians consume the diverse fruits and vegetables available to them in the correct proportions. It is therefore important for stakeholders and governments to find means of storing or processing excess fruits and vegetables for future use.

Though there are reports that suggest that rural folks eat nutrient-deficient food (Govender et al., 2017; Geng et al., 2022; Huse et al., 2022), findings from this study indicate that people in rural communities in Ghana use more local green vegetables such as *C. esculenta* leaves (cocoyam leaves), *C. olitorious* (ayoyo) and *A. cruentus* (aleefi) in the preparation of their meals whiles urban dwellers eat a lot of fast food such as, fried rice with chicken and “banku” with tilapia and very little pepper source. This implies that the rural people in Ghana have a higher chance of overcoming micromineral deficiency than those in the urban communities. Even financially endowed people living in urban communities eat some micronutrient-deficient food such as fried rice due to their lifestyle, modernization and urbanization. These have a potentially negative impact on their nutritional quality and micromineral deficiency. Unfortunately, the urban folks regard the local foods rich in native leafy vegetables to be out of fashion and tasteless.

Most families and households are compelled to depend on calories and energy rich foods to satisfy hunger instead of quality diet due to high cost of feeding. However, many of the energy-rich food items are micronutrient deficient (Kennedy et al., 2003; Beal et al.,

Table 4. Concentration (mg/kg) of micro and macronutrients present in selected vegetables.

Scientific name	Local name	Crop type	Mean concentration of micronutrients (mg/kg)			
			Fe	Zn	Mn	Cu
Corchorus olitorious	Ayoyo	Leafy vegetable	0.064±0.01	0.0072±0	0.0125±0	0.002±0
Amaranthus cruentus	Aleefu	Leafy vegetable	0.0805±0.06	0.0075±0.01	0.0115±0.01	0.00
Roselle calyx	Sobolo	Dried hibiscus flowers	0.051±0	0.0064±0	0.0455±0	0.003±0
Manihot esculenta	Capevars leaves	Leafy vegetable	0.036±0	0.0074±0	0.0395±0	0.00
Colocasia esculenta	Kontomire	Leafy vegetable	0.0255±0	0.00	0.0225±0	0.00
Capsicum annuum Group	Green pepper	Fruity vegetable	0.0055±0	0.0053±0	0.009±0	0.0055±0
Phaseolus vulgaris	Green beans	Fruity vegetable	0.00	0.0072±0	0.012±0	0.005±0
Brassica oleracea var. *capitata*	Cabbage	Leafy vegetable	0.00	0.00705±0	0.0285±0	0.005±0
Solanum melongena (L)	Garden eggs	Fruity vegetable	0.011±0	0.0061±0	0.01±0	0.006±0
Daucus carota L.	Carrot	Root vegetable	0.0155±0	0.0077±0	0.018±0	0.007±0
Abelmoschus esculentus	Fresh okro	Fruity vegetable	0.00	0.00705±0.01	0.018±0.01	0.007±0
Abelmoschus esculentus	Dried okro	Fruity vegetable	0.0225±0	0.0103±0	0.0175±0	0.008±0
Phaseolus lunatus L.	Beans (Bush Lima)	Fruity vegetable	0.0275±0.02	0.00805±0	0.01±0	0.0085±0
Elaeis guineensis Jacq.	Palm fruit	Fruity vegetable	0.028±0	0.0057±0	0.0095±0	0.0095±0
Capsicum chinense Habanero Group	Pepper	Fruity vegetable	0.023±0	0.00645±0	0.011±0	0.01±0
Solanum lycopersicum	Tomato	Fruity vegetable	0.02±0	0.00335±0	0.0085±0	0.01±0
Tetrapleura tetraptera	Prekese	Fruity vegetable	0.06±0	0.00645±0	0.013±0	0.0095±0
Solanum torvum	Kwawu nsusua	Fruity vegetable	0.048±0.007	0.01032±0.005	0.011167±0.0004	0.002±0.00026

Therefore, micronutrient deficiency is much higher than energy deficiency (Kennedy et al., 2003) because energy-rich foods are much cheaper than micronutrient-rich foods. Even in developed countries, people who are poor turn to depend more on starchy cereals and tubers because they are cheaper than fruits and vegetables which are rich in micronutrient (Nanbol, 2019; Akeem et al., 2019).

Findings from this study also showed that where respondents lived (community setting) influenced the consumption of fruits and vegetables. Indeed, people living in rural areas where fruits and vegetables are cultivated have readily access to such food items than some people in urban areas. Therefore, where one lives likely influences their access and frequency of eating fruits and vegetables and this varies across towns and villages in the various regions. Fruits and vegetables are known to contain important minerals including Fe, Zn, Mn and Cu which are important for growth and development. It is therefore important that Ghanaians eat micronutrient-rich fruits and vegetables to develop good mental health, eyesight and prevent stunting. This can be achieved through education, improvement of household per capital income to enable the family to have the financial ability to add vegetables and fruits to their diet and the use of postharvest technology to process, store and preserve fruits and vegetables produced by farmers for future use.

Conclusion

This study demonstrates that majority of Ghanaians incorporate vegetables and fruits into their meals, with increased consumption during bumper seasons. The research further highlights that locality and socioeconomic factors significantly influence people's habits regarding fruit and vegetable intake. Ghana boasts a wide variety of fruits and vegetables rich in essential microminerals such as Fe, Zn, Mn, and Cu. Leveraging these nutritious options could effectively combat micromineral deficiencies and improve overall nutrition. It is recommended that individuals prioritize locally available fruits and vegetables to contribute to achieving Sustainable

Development Goal 2 (zero hunger) and Goal 3 (good health and well-being). Government intervention is crucial, including initiatives to establish more storage and processing facilities nationwide.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Supplementary Table 1. Number of household interview per region.

Region	Number of households
Greater Accra	214
Bono East	200
Northern Region	147
Savanna Region	195
Western	244
Western North Region	200
Ashanti	668
Eastern	295
Central	541
Upper West	150
Upper East	150
Volta Region	243
Oti Region	149
Bono Region	125
Total	3521

Supplementary Table 2. Multivariate Bayesian ordinal logistic regression of Contextual factors for frequency of fruits.

Multilevel Hyperparameter	Estimate	Est. Error	l-95%CI	u-95%CI	Rhat	Bulk ESS	Tail ESS
District (Number of levels: 91) sd (Intercept)	0.84	0.12	0.62	1.09	1.00	3662	5868
Town/Village (No. of levels: 199) sd (Intercept)	0.52	0.09	0.35	0.71	1.00	3255	5906
Regression coefficients							
Intercept[1]	0.17	0.30	-0.41	0.76	1.00	4516	6860
Intercept[2]	1.66	0.30	1.09	2.25	1.00	4535	6483
Intercept[3]	1.83	0.30	1.25	2.42	1.00	4537	6642
Intercept[4]	2.40	0.30	1.83	2.99	1.00	4547	6564
Intercept[5]	8.26	0.39	7.50	9.04	1.00	6633	7641
Region							
Greater Accra (reference) Ashanti	1.05	0.50	0.05	2.02	1.00	3535	5641
Eastern	1.97	0.49	0.98	2.92	1.00	3434	5239
Central	-0.74	0.46	-1.66	0.17	1.00	3157	5528
Upper West	2.97	0.65	1.70	4.23	1.00	5338	7174
Upper East	2.86	0.69	1.55	4.21	1.00	4952	6821
Volta	1.74	0.55	0.66	2.83	1.00	4128	6463
Oti	1.53	0.92	-0.26	3.34	1.00	6287	7865
Bono	0.11	0.64	-1.17	1.34	1.00	4105	6533
Bono East	-0.65	0.59	-1.82	0.49	1.00	3853	6153
Northern	2.92	0.56	1.81	4.02	1.00	4496	7216
Savanna	0.23	0.72	-1.21	1.64	1.00	4852	6401
Western	1.20	0.56	0.10	2.31	1.00	4080	5889
Western North	0.26	0.60	-0.93	1.41	1.00	4172	5682
Community setting							
Urban (reference) Peri-Urban	0.95	0.29	0.38	1.52	1.00	3750	5879
Rural	1.29	0.29	0.71	1.86	1.00	3954	6054