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Bertha Lilian Mkandawire and Ken Miura

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Faculty/Graduate School of AGRICULTURE KYOTO UNIVERSITY

Division of Natural Resource Economics
Kitashirakawa Oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan

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Bertha Lilian Mkandawire, Kyoto University/FANRPAN
Ken Miura, Kyoto University

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Abstract

The seasonal nature of agriculture poses significant challenges to rural women in sub-Saharan Africa, affecting their ability to manage their health and balance farm and domestic work across periods. However, empirical evidence on these issues remains limited despite their importance. This study investigates seasonal variations in time use, anthropometric measures, and food security among female caregivers in 300 farm households in rural Malawi using panel data collected at four points during the 2022/2023 agricultural season. The results reveal that women's work hours increase during the lean season, reducing leisure time, whereas time spent on household chores remains consistent. Seasonal fluctuations in food security correspond to deteriorating women's nutritional outcomes, as measured by mid-upper arm circumference. Seasonal variations in women's body weight suggest additional influences beyond time use, disease, and food security. These findings underscore the ongoing threat of seasonality to female Malawian farmers.

Keywords: seasonality, gender, agricultural labor, food security, Malawi

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Contact information: bmunthali@fanrpan.org (Mkandawire) and miura.ken.3e@kyoto-u.ac.jp (Miura).

1. Introduction

Agriculture is an important sector in most developing economies and plays a multifaceted role in rural household livelihoods. Globally, agri-food systems employ many women, and in several nations, women rely more on these industries for their livelihoods than men do (FAO, 2023). The substantial role of women in agriculture has motivated empirical studies focusing on gender to design future policies aimed at improving women's development outcomes (e.g., Melaku et al., 2024).

In rural African settings, women bear the primary responsibility for their families' health and face challenges in managing nutrition and balancing workloads between on-farm and domestic activities during the farming season (Johnston et al., 2018). Agricultural labor demand varies across seasons and genders, affecting household labor supply decisions and gender roles (Skoufias, 1993; Wodon & Beegle, 2006). In addition, intense farming periods from the production perspective correspond to the "hunger season" from the consumption side, with heightened food insecurity caused by seasonal food scarcity further complicating the link between work, nutrition, and health (Orr et al., 2009; Anderson et al., 2018). Cross-sectional data miss these critical variations; therefore, the complex link between work, nutrition, and health emphasizes the need for a holistic approach to investigate seasonal variations in factors relevant to women's welfare by collecting data between the onset and end of agricultural production. Despite the significance of seasonality and its consequences as a fundamental challenge in rural Africa, even descriptive evidence remains scarce, as Johnston et al. (2018) highlighted in their review. This scarcity is primarily due to the high data requirements of frequent panel surveys across periods.

This study uses new household panel data collected four times within the same farming season from rural Malawi to investigate the seasonal variations in women's time-use patterns, household food security, and health outcomes among Malawian agricultural households. As a unique feature of this study, female representatives (i.e., the spouses of the head or female household heads) aged 18 to 49 years were interviewed in the sampled households to focus on women's welfare. During the 2022/2023 agricultural season, 300 randomly selected households from 20 villages were visited and interviewed four times: November 2022, January 2023, March 2023, and June 2023. Each survey collected detailed information on demographics, each member's health status, food security, and women's time use. We also measured body weight and left mid-upper arm circumference (MUAC) in female representatives to capture acute malnutrition in the short term.

Our empirical results indicate that women's work hours are inversely related to leisure time, with a notable decrease in leisure time during periods of increased farm labor demands between November and January. However, the average time spent on household chores remains consistent across seasons, reflecting the traditional responsibility of women in domestic work. We find that seasonal health shocks, particularly during the cropping season from November to February, with an average of three sick days per month conditional on being sick, reduce women's domestic work hours, even after controlling for seasonal dummies. In contrast, we observed a marginally significant positive association between illness and farm production work hours. A possible explanation for this counterintuitive positive correlation is low labor productivity due to illness. If the work must be completed on time and alternative labor is difficult to find, the sick should also work. However, when sick, women have lower labor productivity and take longer to complete farm work than usual. The pressure of labor demand for farm work and workforce shortages can drive women to remain committed to work despite their ill health.

We also observed pronounced seasonal fluctuations in household food security and dietary quality. Households experience food insecurity and poor dietary diversity during the lean season from planting to harvesting. With a significant decrease in nutrient-dense foods, households rely on simple diets consisting primarily of staples (*Nsima*, a thick porridge made from maize flour) and vegetables. The Household Dietary Diversity Score (HDDS) reveals that households typically consume three or four food groups during the lean season. These seasonal variations observed in the descriptive analysis hold after controlling for household-fixed effects and household-specific health shocks in a regression analysis.

Finally, the data reveal that anthropometric outcomes (i.e., body weight and MUAC) also deteriorate during the lean seasons but revert after harvest in June. The extensive amount of time women dedicate to tilling the land, managing farm-related tasks, and harvesting crops restricts their ability to maintain good health. This, coupled with a poor diet, may result in poor health outcomes. Our regression analysis tests these conjectures and shows that seasonal changes in household-level food security lead to deteriorating nutritional outcomes, as measured by MUAC. Thus, acute malnutrition proxied by MUAC occurs seasonally, mainly because of limited access to food. In contrast, seasonal variations in women's body weight suggest additional influences beyond time use, illness, and household food security.

This study contributes to the literature by providing empirical evidence that seasonality remains a threat to rural households in general and women in particular (Waswa et al., 2021; De Janvry et al., 2022; Hasan et al., 2023). The study closest to ours is that of De Janvry et al. (2022), who investigated the empirical characterization of the seasonality of rural labor calendars in Malawi by connecting the labor requirements of crops to the labor supply reported by households.[1] Their

[1] Other related studies are Waswa et al. (2021) and Hasan et al. (2023), which examine how seasonal variations in food availability and access contribute to inadequate nutrient intake among women and their children and the association between household food insecurity and child undernutrition. Unlike these studies, we explicitly incorporate seasonal change in labor demand as a source of seasonal variations and associate them with health and nutritional outcomes by collecting time-use data.

household-level analysis also examined the depth of the associations between seasonal labor calendars, employment opportunities, and low consumption. Given that family members respond differently to the effects of seasonality as far as their welfare indicators are connected, we instead conducted an individual-level analysis by focusing on women, the family's most vulnerable members regarding nutritional outcomes. In addition to those of children, the nutritional outcomes of women are a measure of household socioeconomic well-being. Thus, we extend the work of De Janvry et al. (2022) by using anthropometric measures as welfare indicators and describing the impact of agricultural seasonality on women's welfare in rural economies. In addition, this study examined the channels through which nutritional outcomes fluctuate across seasons by discussing the relative importance of time allocation, illness, household food security, and dietary quality. Our approach provides evidence from a new perspective on seasonality research.

The remainder of this paper is organized as follows. Section 2 details the choice of the study site and discusses the importance of studying seasonal variations in women's time use in this setting, followed by a description of the household survey conducted in Malawi's Mchinji district. Section 3 provides descriptive evidence for important empirical variables. Section 4 presents a regression analysis that examines the welfare implications of seasonality. Finally, Section 5 concludes the paper by discussing policy implications and future research directions.

2. Setting

2.1. Study Site

This study uses data from agricultural households in Mchinji district in the central region of Malawi. We selected Mchinji district as our survey area for three primary reasons. First, Mchinji district is located approximately 100 km northwest of Lilongwe. The proximity to the urban center in Lilongwe adds interesting variations in the time-use patterns of women, depending on how frequently men leave the village in search of seasonal employment in the city. Because Mchinji district also borders Zambia and Mozambique, the Zambia border district of Chipata (also the capital of the Eastern province of Zambia) and the Mozambique district bordering Mchinji offer seasonal labor for men and women from Mchinji district. In addition, a high movement of goods occurs between Lilongwe and Chipata and between Mchinji and the border district of Mozambique, offering residents of Mchinji district more opportunities such as access to food and markets, compared to non-border districts in the central region. This geographic feature generates another essential factor to consider in distilling variations in women's time-use when their husbands leave home in search of opportunities across these borders.

Second, Mchinji is an active tobacco-growing area in Malawi, along with Kasungu, Lilongwe, and Dowa. Because tobacco is a resource-intensive crop with high demands for labor and time, comparing women's time use and its influence on the household economy between households performing *ganyu* in tobacco and non-tobacco households is intriguing. Although tobacco farms are commercial units owned by commercial farmers, local farmers in Mchinji district are often employed on them as *ganyu* seasonal laborers. *Ganyu* is a common source of casual wage labor in many parts of Malawi, often providing short-term relief by bridging seasonal access to food and income for rural households, albeit often insufficient to supplement seasonal food deficits (Bouwman et al., 2021; Gono et al., 2023). *Ganyu* is more prevalent in the rainy season than in the dry season, and payment for *ganyu* is either in cash or in kind (Dimova et al., 2010). De Janvry et al. (2022) demonstrated that low household consumption in rural areas is critically associated with a lack of work opportunities, indicating that *ganyu* is a key activity in nourishment and consumption smoothing for rural households in Malawi. With that important aspect of *ganyu*, understanding women's time use as laborers on their farms and seasonal laborers on those of others has important implications for this study. Another interesting aspect of *ganyu* is that smallholder farmers may need to bargain between receiving short-term relief from food insecurity through *ganyu* earnings and risking future agricultural productivity gains from their farms, as they make time tradeoffs between working as *ganyu* workers for other farms and committing to timely crop management on their own. Thus, *ganyu* labor has implications for a vicious circle of poverty, whereas previous studies have not found any empirical support for seasonal poverty traps due to *ganyu* (Dimova et al., 2010; Orr et al., 2009).

Third, the prevalence of malnutrition is salient in Mchinji district. According to the fifth Malawi Integrated Household Survey (IHS) report in 2020, malnutrition levels are persistently high in the central region, where Mchinji district is located, followed by the southern and northern regions (MNSO, 2020). Among the nine districts in the central region, Mchinji has the second highest malnutrition rate, with stunting at 18% and underweight at 9%. Food shortages are a common issue. The IHS 2020 food shortage data describing seasonal food availability show that Mchinji was among the top 10 out of 32 districts in Malawi, where food stock shortages persisted in most months that year (MNSO, 2020). This evidence appears to contradict the ability of Mchinji district to access food easily from neighboring districts in other countries. This observation suggests that the issue is affordability rather than accessibility.

[Figure 1]

Among the seven traditional authorities (TA) in Mchinji district, we selected TA Mkanda and Sub-chief (SC) Mavwere as the study sites to capture interesting contrasts in female labor demand. Figure 1 shows the locations of these two sites. TA Mkanda is adjacent to Chipata in Zambia and has a livelihood system influenced by the two countries' socioeconomic activities. In contrast, SC Mavwere is on the international border with Mozambique and is close to the Lilongwe urban center. Although TA Mkanda and SC Mavwere share similar agricultural production and demographic characteristics, women's livelihoods and time use could show remarkable differences because of variations in exposure to international borders and Malawi's capital city. These differences make the comparison meaningful.

The main agricultural season at the study site is the rainy season, which spans from November to March. At the time of this study, the primary crop in the survey area was maize (the staple food), followed by legumes, such as soybeans and groundnuts. Both men and women participated in maize production, with women dedicating comparable amounts of time to its cultivation.

2.2. Data

This study uses panel data from 300 households. For survey sampling, we obtained the latest list of households and villages in the district prepared by the planning division of the Mchinji district office in August 2022. The list includes approximately 7500 households in 47 villages in TA Mkanda and 20000 households in 161 villages in SC Mavwere. From the list, we randomly selected 12 villages from TA Mkanda and eight villages from SC Mavwere.[2] We replaced villages that were too small for us to cover a sufficient number of households or those that were not found in the field. We then randomly selected 15 households from each sampled village for a total of 300 sampled households.

The survey team comprised four graduates from national universities in Malawi and the first author. A unique feature of the survey was that female household representatives were interviewed. In most cases, the survey team interviewed the spouses of the household heads or the female household heads. In the first survey, we visited the first 15 households in each village's household list. We set the following three inclusion conditions for households: (1) they had been in the village for the past two years consistently, (2) the female representative's age was verified to be between 18 and 49 years, and (3) they had child(ren) under the age of five years. If they met these criteria, they were selected and included in the survey; otherwise, the next assigned household was selected until 15 households were reached in each village.

[Figure 2]

Each household was interviewed four times during the main agricultural season using structured questionnaires. Figure 2 illustrates the timeline of the interviews throughout the survey, with the typical agricultural practices of maize production for each period. We conducted the first survey in early November 2022 to collect information on land preparation from 300 households. The second

[2] We assigned more weights to TA Mkanda than SC Mavwere because, according to the list prepared by World Agroforestry (ICRAF), SC Mavwere has 400 villages and TA Mkanda has 603. Villages may be heterogeneous; thus, the number of villages is not necessarily proportional to population. However, we speculate that the list from the district office may likely be incomplete. The ICRAF's list is available at http://landscapeportal.org/layers/geonode:villagesgeo.

survey was conducted with 290 households in mid-late January 2023 to follow up with the respondents and capture the time used for planting activities and fertilizer applications. This period corresponded to the first weeding season. We then conducted the third survey in mid-late March with 291 households and the fourth in mid-June with 271 households to collect information on harvesting activities.[3] Thus, the data are unbalanced panel. In addition to details on agricultural activities, each survey collected the following basic information: family rosters, the health status of each member, participation in seasonal *ganyu* labor, household assets, food security, and the social groups in which the household participates.

We restricted the analysis sample by dropping 35 observations that failed to interview female representatives or collect outcome variables (3.0%, 35/1152). Thus, the total number of observations in the analysis sample is 1117, with 298 observations from November 2022, 281 from January 2023, 278 from March 2023, and 260 from June 2023. The attrition rate between November 2022 and June 2023 is 12.8% ((298-268)/298).

3. Descriptive Analysis

3.1. Time Use by Women

For each survey, female respondents were asked about their time-use patterns in the last 24 hours. Given that task synchronization is common in the local context, the time-use module allowed for multitasking and up to two simultaneous activities to be reported in the same timeframe. Based on the respondents' answers, we grouped the reported activities into three broad categories: work, household chores, and leisure.[4]

[Figure 3]

Figure 3 illustrates how women spend their time on each activity during the active period of agricultural production, from the beginning of the season (November) to the end (June), emphasizing their roles and ability to adjust to the farming cycle. Thus, Figure 3 shows the flexibility with which women manage their time. Of particular note is how work and leisure interact. In November and January, which have more work hours than in other months, and in March, which is marked by reduced farm labor demands, women devote fewer hours to work and more to leisure, with this pattern persisting in June. Therefore, work hours and leisure time are inversely related.

[3] The data collection in TA Mkanda covering 12 villages took 6–8 days on average, depending on the presence of social events like festivals and funerals. The survey took 4–6 days on average in SC Mavwere with eight villages.

[4] The "Work" category aggregates the following seven subcategories: "work as employed," "own business work," "food crop farming," "cash crop farming," "livestock raising," "fishing/fishpond culture," and "commuting (to/from work)." The "Household chores" category aggregates the following seven subcategories: "shopping/getting services," "weaving and sowing," "cooking," "domestic work (e.g., fetching water and firewood)," "caring for children," "caring for adults (elderly and sick), and "traveling (not for work)." The "Leisure" category aggregates the following seven subcategories: "sleep and resting," "eating and drinking," "personal care," "watching TV/listening to the radio," "exercising," "social activities and hobbies," and "religious activities."

This important empirical regularity can be linked to the role of men and other family members in sharing workloads, especially in agriculture, which could account for changes in working hours across seasons. While different agricultural activities may demand disproportionate hours from other family members based on comparative advantage, Figure 3 illustrates women's consistent engagements in farming in the cropping season.

On the contrary, the average time spent on household chores was stable across all periods. Women commit the same amount of time to chores, irrespective of the time within the agricultural season. As primary agricultural contributors, women often balance their agricultural responsibilities with other essential household tasks, including childcare and cooking (Slavchevska et al., 2016). As Wodon and Beegle (2006) have also shown with time-use data over a 13-month period in Malawi, in the local context, household chores are a woman's responsibility. When other family members support women's workloads, women's time use in such households can be more flexible and vary across the production season. For example, flexibility in time use for chores would be introduced if men were involved in domestic work. The extent to which the leading female household member receives support in domestic work from other family members may be heterogeneous. We will explore this heterogeneity across households in the regression analysis.

3.2. Women Health Status

[Figure 4]

Health shocks are an essential determinant of seasonal time use. Additionally, the health problems that rural Malawian women face may exhibit seasonal features. Figure 4 shows the frequency of illness and number of sick days in each season. Notably, the proportion of women with illness is higher in the cropping season between November and February than between March and May, albeit not significantly. Figure 4 also shows that the average number of sick days was highest in January and February. The increase in illness among these women may explain the slight decline in average work hours from January to March (Figure 3), food insecurity, and limited dietary variety between January and March, as discussed below. Given women's important roles in agricultural and household production, seasonal illness may limit their capacity to spend time working and sourcing food.

The consequences of seasonal illness can appear in anthropometric measurements. The survey also collected anthropometric data for women between 18 and 49 years of age. The survey team used a tape measure to record women's left arm MUAC. MUAC is used to determine short-term acute malnutrition due to undernutrition or disease. Women's weights were recorded using a digital scale. Changes in body weight also reflect short-term health status.

[Figure 5]

Figure 5 shows the physical health of the sampled women in rural Malawi based on weight and MUAC outcomes, highlighting the impact of seasonal changes in food security on their physical state. Compared with the beginning of the rainy season, these health outcomes deteriorated during more demanding seasons, primarily when farmers engaged in planting and other agricultural activities. The period between January and March, which had the poorest health outcomes, also coincided with the lean season, characterized by food scarcity. By June, weight and MUAC measurements returned to the levels recorded in November. In June, food is abundant after harvest and agricultural activities are reduced. Based on these considerations, seasonal changes in health outcomes can be explained by household-level food security. Our discussion now turns to the food security indicators on the consumption side at the household level.

3.3. Household Food Security

[Figure 6]

Figure 6 depicts the seasonal fluctuations in family food security in the rural Malawian context by showing the distribution of answers to questions related to food security for each survey. Each panel in Figure 6 represents a different facet of food security: food availability (FS1), household consumption capacity (FS2), dietary diversity (FS3), and food choice (FS4). One indicator of access to food is how people perceive what might or might not have been available for consumption. For example, the FS1 panel captures food availability by reporting the number of days out of the last 30 when respondents worried that their household would not have sufficient food. The distribution shows that household-level concerns about running out of food were most intense in January. January corresponds to the lean period between planting and harvesting seasons, commonly known as the "hunger season," when the foods are not available and accessible, making individuals more susceptible to the adverse effects of illness (Matchado, 2019). To a lesser extent, food concerns were also intense for most households in November, indicating that food insecurity had already begun at the onset of the rainy season. Although early harvests mitigated food concerns for some households in March (Anderson et al., 2018), most faced food security concerns until the primary harvesting season.

The FS2 panel represents consumption capacity by reporting the number of days the respondent could not eat foods they preferred in the last 30 days. The FS3 panel captures dietary diversity by reporting the number of days the respondent had to eat a limited variety of foods in the last 30 days. These panels illustrate a greater capacity to eat favored foods and a more varied diet (adding legumes and fish, as discussed in more detail in the next subsection) in the post-harvest season compared to other months when only food staples and vegetables are consumed. Conversely, these indicators showed discernible decreases throughout the pre-harvest period. This pattern also indicates the "lean season," when food supplies run low, and families frequently turn to less preferred meal choices. In addition to highlighting the problem of food availability, the decline in dietary diversity during this period raises questions about nutritional sufficiency and its potential health effects.

[Figure 7]

Figure 7 illustrates the severity and human cost of food insecurity in rural Malawi, particularly in extreme forms. The data reveal the essential characteristics of food insecurity, including the frequency of eating meals smaller than what is needed (FS5), the occurrence of days without food (FS6), and the frequency of going to bed hungry (FS7). Figure 7 highlights the seasonal changes in these more direct food insecurity markers, showing lower frequencies in seasons with abundant food, typically following harvest. All three occurred more frequently when food supplies were low before the main harvest, indicating a considerable change in food access and availability. These findings suggest that food scarcity is sufficiently severe to lead to hunger and missed meals in some households during the lean season. Such empirical evidence indicates that seasonal food availability is an important determinant of food security because it directly affects the quality and quantity of food accessible to communities, as highlighted in a study conducted in Ethiopia by Aweke et al. (2022).

While each measure is interesting, aggregating them into a summary index would benefit further analysis. Therefore, we created a food security index by applying principal component analysis (PCA) to the above seven questions on household food security. We then used the first principal component to determine the weighting factors for each answer to gauge food insecurity and define the index. By definition, a higher score implies greater food insecurity.

[Figure 8]

Figure 8 illustrates the seasonal changes in the aggregate food insecurity measure. The score was highest in January 2023, consistent with our previous observations for each disaggregated question. Combined with the observations from Figures 6 and 7, Figure 8 illustrates how food security is a dynamic state strongly influenced by the seasonal agricultural cycle. The upward trends in the graph show that the post-harvest season is when households typically experience a phase of relative food abundance. This pattern demonstrates the direct relationship between crop production and food security. The previous subsection showed a similar trend of seasonal fluctuations in women's weight and MUAC measurements. Thus, the figures in this subsection suggest the cyclical nature of food security at the household level as a potential pathway behind women's health indicators in rural Malawi. The following subsection discusses seasonal dietary diversity in more detail by reporting the descriptive statistics.

3.4. Household Dietary Quality

Nutritional outcomes depend not only on food quantity but also on dietary diversity and micronutrient intake (Korir et al., 2023). Time constraints imposed by agricultural activities during the peak season have ripple effects on dietary choices and food consumption patterns. Women are deeply involved in land preparation, planting, and crop tending during this time. Increased labor demands can limit the time available for food preparation, potentially leading to less diverse and nutritious household diets and contributing to deficiencies in essential vitamins and minerals (Vemireddy & Pingali, 2021; Marivoet & Ulimwengu, 2022). While we confirmed constant domestic work hours throughout the periods on average (Figure 3), this unfavorable scenario regarding dietary choices may happen for specific households.

National food-based dietary guidelines for each country recommend the intake of safe, nutritious, and diverse foods after computing the nutritional needs of the average population to determine adequacy. The HDDS is commonly used to gauge dietary diversity at the household level. The HDDS, defined as the total number of food groups consumed in a specific reference period, provides a household-level indicator for assessing the ability to access diverse food.[5] The literature has also validated the HDDS as a proxy for socioeconomic status.[6]

In this study, each survey recorded what the household had consumed in the previous 24 hours as the recall period. This study categorized food into the following 12 groups[7]: 1) cereals; 2) roots and tubers; 3) milk and milk products; 4) vegetables and tubers; 5) fruits; 6) meats; 7) eggs; 8) fish; 9) legumes, nuts, and seeds; 10) oils and fats; 11) sweets; and 12) spices, condiments, and beverages. We counted the number of food groups as the HDDS and used it in our analysis. Thus, our defined HDDS ranges from 0 to 12.

[Figure 9]

[5] A similar definition can be used to construct individual-level diversity scores. Individual-level dietary diversity indicators (e.g., Minimum Dietary Diversity for Women) can serve as proxies for diet quality because previous work has shown their association with nutrient adequacy.

[6] However, this indicator has not been validated as a proxy for the adequacy of specific macro- and micro-nutrients, and the minimum cutoff point for a sufficiently diverse diet has not been established in the literature. Refer to Data4Diets (2023) for a comprehensive introduction to the HDDS and other food security indicators.

[7] The survey asked questions on 16 more fine-grained categories. In calculating the HDDS, 1) vitamin A rich vegetables and tubers, 2) dark green leafy vegetables, and 3) other vegetables are aggregated into vegetables. 1) Vitamin A rich fruits (e.g., mangos) and 2) other fruits (e.g., bananas) are aggregated into fruits. Finally, 1) organ meats and 2) fresh meats are aggregated into meats.

Figure 9 shows the distribution of the HDDS by survey period to illustrate how rural Malawian families' eating patterns and nutritional adequacies changed across seasons. Our data show seasonal variations in dietary diversity, as reflected by the HDDS. The HDDS for the first two survey months was concentrated on three food groups. The distribution then became slightly flatter in March, possibly because most field crops are maturing by this month, increasing household access to green maize and some field vegetables. However, as we will discuss, these early harvests do not translate into dietary diversity because maize and vegetables are already part of the standard diet in January. Thus, the average HDDS remained low: 3.52 in November 2022, 3.23 in January 2023, and 3.21 in March 2023. Combining the observations regarding health outcomes from Figures 4 and 5, the months with the lowest performance for women's health indicators coincide with periods when the HDDS is low.

Figure 9 shows a much flatter HDDS distribution during the harvest season, as some households transition towards more than five food groups. This improvement is also related to household income stream, as farmers can sell their produce after harvest and use the proceeds to supplement their diets in addition to their yield. However, despite the observed improvement, the average HDDS remained below the recommended minimum of five food groups at 4.20.

[Figure 10]

To further analyze seasonal variations in nutritional diversity in rural Malawian households, Figure 10 presents the fraction of food categories households consume within the last 24 hours by survey period. Figure 10 represents the detailed consumption landscape by showing how the surveyed households' food plates changed seasonally. Figure 10 shows a decrease in the number of nutrient-dense foods (e.g., meats, fish, and milk) high in protein and micronutrients as a striking feature of the lean season: Diets during the season are primarily composed of vegetables and staples (*Nsima*) with salt, resulting in an average HDDS of 3.[8] The data also show a minor increase in a few food groups (e.g., roots, fish, legumes, and oil) in the post-harvest period, although dietary diversity remains poorly represented. This seasonal contrast emphasizes guaranteeing food diversity and availability by considering seasonal variations that significantly influence dietary decisions. Figure 10 draws attention to the necessity of policies and programs that enhance the amount, type, and diversity of food that these populations have access to throughout the year.

4. Econometric Analysis

4.1. Empirical Specifications

[8] While salt is not nutritionally categorized as a food group, it is recognized for its fortified iodine content, a micronutrient of public health importance.

While the descriptive evidence presented in Section 3 underscores seasonal variations in women's work patterns and health outcomes, the associations between the factors determining women's welfare are complex. This study focused on women's anthropometric outcomes (i.e., body weight and MUAC) as welfare indicators. This section disentangles the complicated links among labor supply, food security, illness, and health by using a regression framework to examine the determinants of seasonal fluctuations in women's anthropometric outcomes.

[Figure 11]

Building on previous literature (e.g., Higgins & Alderman, 1997; Johnston et al., 2018), we hypothesized a chain of effects relevant to seasonality to guide the empirical analysis. Figure 11 illustrates this using a directed acyclic graph. For example, seasonality affects women's time use through two pathways. First, seasons directly determine time-use patterns, reflecting the seasonal labor demand for agricultural activities. Second, we assume that sickness mediates the influence of seasonal factors on work hours.

Seasonality affects body weight as a welfare indicator through channels other than time use, illness, and food security. Other potential mechanisms include biological responses and seasonal price movements. The directed acyclic graph incorporates these possibilities by allowing seasonality to affect body weight directly.

Based on the assumed relationship depicted in Figure 11, we specify the fixed-effects model for women's time use as follows:

$$TimeUse_{ijt}^{k} = \beta_0 + \beta_1 Sick_{ijt} + \beta_2 Sick_{-ijt} + \beta_X X_{jt} + \alpha_i + \alpha_t + \varepsilon_{ijt} \quad (1)$$

where $TimeUse_{ijt}^{k}$ represents the hours spent on activity k by main female respondent i from household j at time t. We define two types of health shocks. $Sick_{ijt}$ is a dummy that equals one if main female respondent i became ill between the last survey time $t\text{-}1$ and the current survey time t. During the same reference period, $Sick_{-ijt}$ counted the number of family members, except for the main female respondent, who became ill. X_{jt} represents household-level controls including household size. To control for day-of-week lifestyle differences, X_{jt} includes six dummies for the day of the week to which the time use measured by the survey at time t refers. α_i is an individual fixed-effect for main female respondent i. α_t is a time fixed-effect for survey time t to capture the direct effect of seasonality. November 2022 is the reference category. Finally, ε_{ijt} is an error term.

Using similar notations, we model household-level food security as follows:

$$FoodInsecurity_{jt} = \gamma_0 + \gamma_1 Sick_{ijt} + \gamma_2 Sick_{-ijt} + \gamma_3 X_{jt} + \mu_j + \mu_t + \epsilon_{ijt} \quad (2)$$

where $FoodInsecurity_{jt}$ is a food insecurity measure for household j at time t. The aggregated food insecurity index based on PCA and HDDS separately is used as the outcome variable. μ_j is a household fixed-effect, and μ_t is a time fixed-effect for survey time t. ϵ_{ijt} is a random error term.

The probability of becoming ill is high when food intake is insufficient; therefore, sickness variables can be endogenous because of potential reverse causality. Although incomplete, this study used sickness variables measured in the last two months to circumvent endogeneity concerns.

Finally, we use women's anthropometric measures as welfare indicators and specify their determinants as follows:

$$Y_{ijt} = \delta_0 + \delta_T TimeUse_{ijt}^k + \delta_F FoodInsecurity_{ijt} + \delta_1 Sick_{ijt} + \delta_2 Sick_{-ijt} + \gamma_3 X_{jt} + \theta_i + \theta_t + u_{ijt} \quad (3)$$

where Y_{ijt} is the anthropometric outcome (either body weight or MUAC) of main female respondent i from household j measured at time t. θ_i is a fixed-effect for main female respondent i, and θ_t is a time fixed-effect for survey time t. Finally, u_{ijt} is an error term.

4.2. Regression Results

[Table 1]

Table 1 presents the factors influencing women's time by reporting OLS regression results for Equation (1). The results show that one's own illness has a statistically positive association with time spent on work (Column 1). If the illness is seasonal, this variable may capture seasonal factors, thereby creating spurious correlations. After considering seasonality, the significance is lost but remains marginally significant (Column 2). One explanation for the unexpected positive correlation between work hours and illness is low labor productivity due to sickness. If the workload must be completed on time and alternative labor is difficult to find, those who are ill should also work. However, women's labor productivity would be lower than normal, and farm work would take longer. These positive associations indicate that even when women experience illness, the demanding work in farm production leaves them no option but to prioritize work. This reflects the lack of labor alternatives for farming households.[9] The pressure of labor demand for farm work and workforce shortages can drive women to remain committed to work despite their ill health.

Columns (3) and (4) show that an increase in work hours in response to illness correlates with a decrease in domestic work hours. This contrast may indicate greater flexibility in household chores

[9] Sinha (2010) made a similar observation by highlighting the working conditions of farmers in India. He found that many agricultural workers remain engaged in agricultural practices despite hunger, pregnancy, and unpleasant health states.

than in farm work.[10] Additionally, the negative sign of the estimated coefficient on family size, albeit insignificant, is consistent with the conjecture that the primary female household member can receive support in domestic work from other family members more in a larger household. Regarding the consequences of illness in leisure time, the sign of the estimated coefficient is not statistically significant at any conventional level (Columns 5 and 6). The coefficients of the number of sick family members are insignificant across the specifications, providing no evidence of the consequences of health externalities on time use, at least in our dataset.

Finally, the time dummies capture seasonality in time use. Women's time-use patterns remained comparable between November 2022 and January 2023. The results also show that women devoted less time to work and household chores in March 2023. This pattern can be attributed to the seasonality of agricultural practices, whereby the most time-consuming activities are planting in November and weeding and fertilizer application in January. March is a relaxed time for farmers because it is the pre-harvest time when their time commitment to their farm is minimal. March also corresponds to an academic break for primary school children. This may indicate that children provided more help with domestic work during this period, which may explain why women spent less time on chores. This trend persisted in June 2023. By June, farming households have harvested and sold their produce to agricultural traders. Thus, the reduced time commitment to agricultural activities allows for more leisure time.

[Table 2]

Table 2 shows the regression results for the factors influencing household food insecurity and the HDDS. Women who experienced illness between the survey periods reported a higher HDDS. One possible explanation is that when the female representative becomes ill, the family increases her access to food as a way of helping her obtain better nutrition to recover quickly from the illness. A common practice is sourcing special foods for the patient, such as snacks, fruits, and other nutritious foods during their illness. Another prevalent coping strategy for sick days involves adjusting food consumption patterns (Ansah et al., 2021). During the sick period, households may modify their diets to prioritize less labor-intensive foods to prepare and consume. This dietary shift aims to conserve time and energy, allowing family members to meet their labor obligations without compromising the patient's nutritional intake. Nevertheless, given the relatively small magnitude of the estimated coefficient, the economic significance is low.

[10] The flexibility in household chores can be seen in the results based on the day of the week. Compared to Monday as the reference category, women work longer hours on Wednesday, Thursday, and Friday. This pattern can be linked to the standard practice of days dedicated to work. In contrast, these days negatively correlate with the time spent on household chores. This may be explained by how women consider work a higher priority (including farm work) than household chores, which can be delegated to other family members such as children. We also find that women spend less time on work and more time on leisure on Saturdays and Sundays. This empirical pattern is consistent with the standard practice in which locals attend festivals and community mobile markets on Saturdays. In contrast, Sunday is a day of rest for attending religious activities and visiting family members.

We now turn our discussion to seasonality in household-level food security. Compared to that in November 2022, food security deteriorated in January 2023, with a higher insecurity score and lower HDDS (Figures 8–9). Limited cash flow often correlates with reduced purchasing power, preventing individuals and families from consuming a diverse and nutritious diet (Benson & De Weerdt, 2023). The period between January and early March is the pre-harvest season, marked by low household food stock, reduced food availability in rural markets, higher food prices, and decreased purchasing power at the household level. A low HDDS in January is expected as food security worsens and household access to diverse diets is limited. Poor food access, low purchasing power, and low food availability in rural markets affect household diets during the hunger season.

The results for the March 2023 dummy show an interesting contrast between improved food security and lower HDDS before the main harvest. By March, households have access to green maize and some field vegetables. Although these early harvests ease food insecurity, they do not translate into dietary diversity because maize and vegetables are already part of the standard diet in January. The breakdown of the HDDS in March in Figure 10 shows the consumption of staples, vegetables, and spices (particularly salt). A few households consume oil, legumes, and sweets. On average, dietary diversity remained very poor in March, with an average HDDS of 3.21. Additionally, green maize in the early harvest differs from the kind that could fetch the money they would receive when selling dry maize. Thus, the income generated from the sale of green maize may not provide sufficient resources for the family to afford an adequate and nutritious diet, contributing little to purchasing other foods and changing dietary diversity (Benson & De Weerdt, 2023).

The situation changed in June 2023: the food security measures and HDDS improved. This result is consistent with our expectations: By June, households sell their farm produce, which improves their purchasing power, and adequate stocks of food supply lead to increased food availability and improved quality and quantity of meals, thus improving the household's nutritional status (Adekunle et al., 2020). The markets also respond to the demands of farmers who have money, and one would expect these markets to have food coming from places other than the village. The breakdown of the HDDS in Figure 10 supports this expectation. It shows an increase in the consumption of different food groups, in addition to cereals, vegetables, and salt, which were the only and main food consumed across all periods. Specifically, households improved their legume, fish, and oil consumption in June. Fish and oils are market goods in these communities. Thus, the increased consumption is related to income use, with cash income playing a significant role in the improvement of household diets.[11]

[11] The income of these households is closely linked to harvest season success and market agricultural prices. Poor harvests and low harvest prices would lead to no improvement in the household diets even during the post-harvest season.

[Table 3]

Finally, the regression analysis examines the effects of seasonality on measures of women's welfare. Table 3 presents the regression results for the determinants of the anthropometric measures of the main female household member (i.e., body weight and MUAC). The number of observations in this analysis differs from that in the previous analysis. These health outcomes are missing for 51 observations, partially because some respondents rejected the measurement. Additionally, we excluded 11 observations with implausible values when the first differences in body weight and MUAC were 10 kg or 5 cm, respectively. Thus, the analysis includes 1055 observations in total.

First, we discuss the determinants of body weight in kg shown in Columns 1–2 and log transformed body weight shown in Columns 3–4. While the food insecurity score and HDDS are significantly associated in the expected direction, statistical significance is lost after controlling for seasonal dummies (Columns 2 and 4). Additionally, we find no statistical significance for other channels, such as work hours and illness. In contrast, the results for season dummies suggest that women's body weights were lower in January and March 2023 than in November 2022. Thus, the results reveal only the direct effect of seasonality, while the indirect effect via food access plays a minor role in weight. The observed seasonal variations in women's body weight suggest influences beyond time use, illness, and household food security.

The negligible association between working time and body weight may reflect the interplay between two competing effects (Johnston et al., 2018). Longer work hours could contribute to weight loss due to increased energy expenditure (Higgins & Alderman, 1997). However, women engaged in paid work (e.g., *ganyu*) may have more financial resources to purchase food and potentially more nutritious options using their cash income even in the peak season. This could have positive nutritional implications and counterbalance the negative effects of energy consumption on body weight. Consequently, if these opposing effects cancel each other out, the relationship between women's working hours and body weight may become insignificant.

Our interpretation of the insignificant statistical results regarding food security and dietary quality is that women's consumption and nutritional intake are relatively prioritized within the household, even when food security is low, because the food insecurity score and HDDS are at the household level, whereas the outcome is at the individual level. Thus, their returns to body weight are relatively high within the household, reflecting their vital role in household economies. During the lean season, intrahousehold food distribution may prioritize the leading woman's food share. However, such an arrangement may not be possible across seasons because of the limited ability to store food. Thus, our interpretation does not rule out the adverse effects of food unavailability.

Instead, January and March, marked by low food access and commonly known as the hunger season, have a remarkable impact on the nutritional status of main female household members.

The natural question to ask is what the significant seasonal dummies capture. Two omitted variables provide some possibilities. The first is that the seasonal dummies capture seasonal fluctuations in the quantity of food consumed. While the regression controlled for general household food security and dietary diversity, the quantity of food is unavailable in the dataset and not controlled in the regression. The sources of variation in food consumption amounts could include price fluctuations and the gradual reduction in stock. The severity of fluctuations in food prices and their impact on consumption are key considerations. Gilbert et al. (2017) observed the market performance of different foods across seasons and how fluctuating food crop prices affected consumer purchasing power and food security in selected African countries, including Malawi. The observation made in Malawi is of greater importance, where the acute effect of seasonality on the prices of the main staple crop, maize, is profound. They observed that Malawi's high seasonality in maize prices caused a double seasonality burden for most households. Incorporating the quantitative aspects of consumption into the survey design would help provide a clearer picture of seasonal variations in women's body weight. The second possibility is that the time dummies capture seasonal fluctuations in energy consumption, reflecting different agricultural practices across seasons. Given the potential non-linear relationship between work hours and energy consumption, caloric loss due to drudgery is missing in the right-hand side variables, which would be absorbed into the seasonal dummies.

Furthermore, family size was negatively associated with women's body weight. This result indicates that increasing the number of people living and eating from the same pot reduces women's weight in a particular season, because we incorporate individual fixed effects. However, we should interpret this result with caution because the migration decisions behind changes in household structure are endogenous.

Our analysis used MUAC to determine acute malnutrition in the short term. Several findings emerged. First, the number of household members, excluding the main female, who fell ill during the survey period was negatively associated with her MUAC. This interesting finding could be explained by the demands that the illness of a family member, which can be interpreted as a shock, places women as primary caregivers. As women juggle work demands and caring for the sick (even without reducing hours spent on chores), they may pay less attention to their own nutritional health, resulting in compromised nutritional outcomes. Similarly, food insecurity scores are negatively associated with women's MUAC even after controlling for seasonality (Column 6 in Table 3). Thus, poor food intake will rapidly affect MUAC measurements.

In contrast, the regression results only show a direct association between seasonality and MUAC in January, reflecting the high energy requirements due to drudgery work during this period (e.g., weeding). Thus, food (in)security is a primary channel through which seasons generate fluctuations in women's MUAC measurements. As the food insecurity score measures relatively severe situations, timely policy interventions to stabilize food security are warranted to avoid deteriorations in women's welfare.

5. **Conclusion**

This study highlights the critical role of seasonality in shaping labor allocation, food security, household dietary quality, and women's health outcomes in rural Malawi. The four key findings of our analysis are summarized below.

1. Seasonal Work and Leisure Imbalance: During peak agricultural months (November to January), women's work hours on farms increase significantly, leading to a marked reduction in their leisure time. Despite these seasonal shifts, time spent on household choirs remains stable throughout the year.
2. Health Shocks and Labor Productivity: During the peak farming season, women experience more illness and sick days. Despite this, they often continue working on farms with reduced productivity owing to the high labor demands and lack of alternative workers.
3. Food Security and Nutritional Declines: Food scarcity and poor dietary diversity are acute during the "lean season" (planting to harvest). Households mainly consume staples with limited nutrient-dense foods, leading to women's acute malnutrition proxied by MUAC. These outcomes then improve post-harvest in June.
4. Income for Nutrition: Dietary diversity shows improvement after harvest, especially in terms of fish and oil consumption, which are market goods. This indicates that cash income plays a significant role in improving household diets.

These findings have profound implications for policy and community interventions. Enhancing healthcare services, especially during peak agricultural periods, and ensuring year-round access to diverse nutritious foods are essential steps for mitigating the adverse effects of these seasonal challenges. A promising approach to addressing these seasonal challenges is timely lean-season food transfer (Gelli et al., 2017). Moreover, support for labor redistribution, such as childcare and community labor-sharing schemes, could significantly alleviate the disproportionate burden placed on women. Future research should focus on collecting longitudinal data to assess the long-term effects of these seasonal variations and explore how community networks can provide sustainable support against cyclical shocks. Our findings emphasize the need for a holistic approach to address the challenges faced by women in managing their nutrition, workload, and health during periods of intense agricultural activity. Addressing these issues is crucial for fostering the resilience and overall well-being of rural women and their families in rural Malawi and similar regions.

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Figures

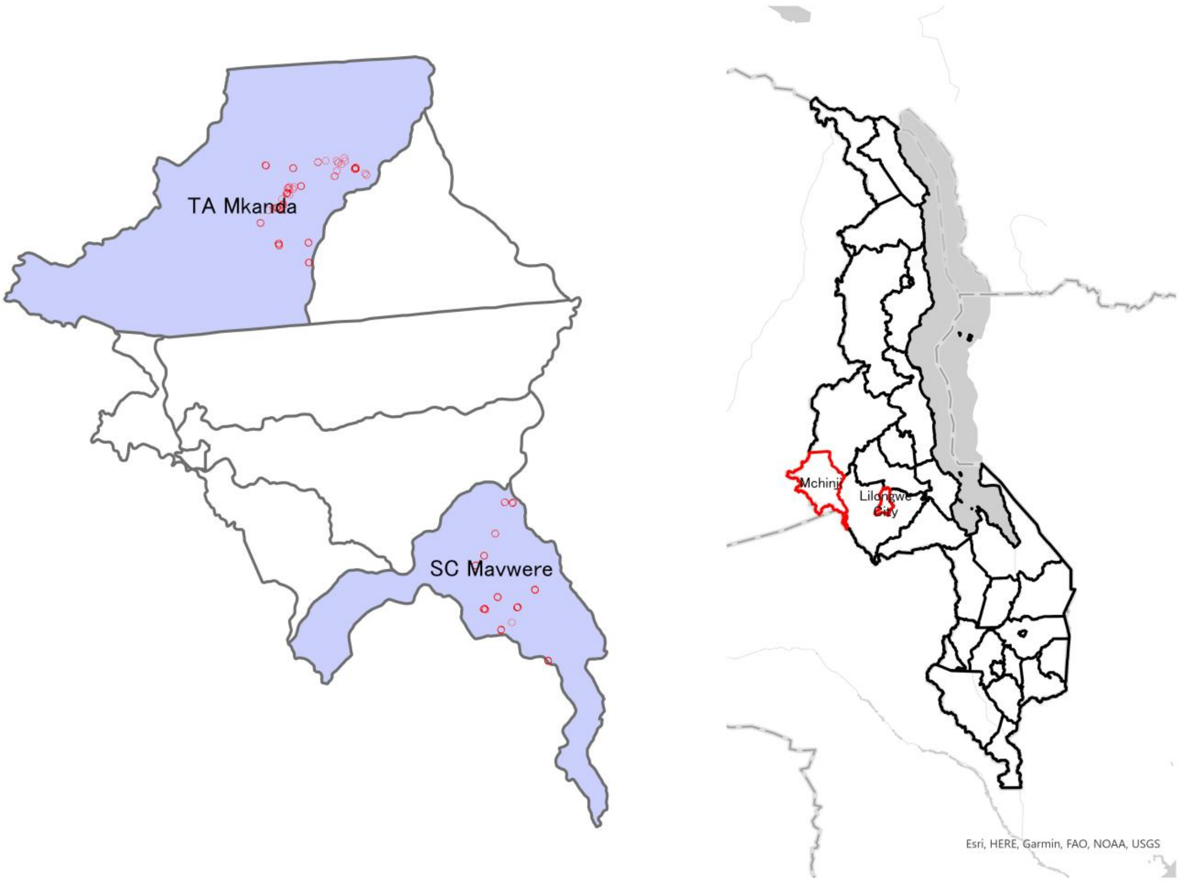

Figure 1. Location of survey villages in Mchinji district

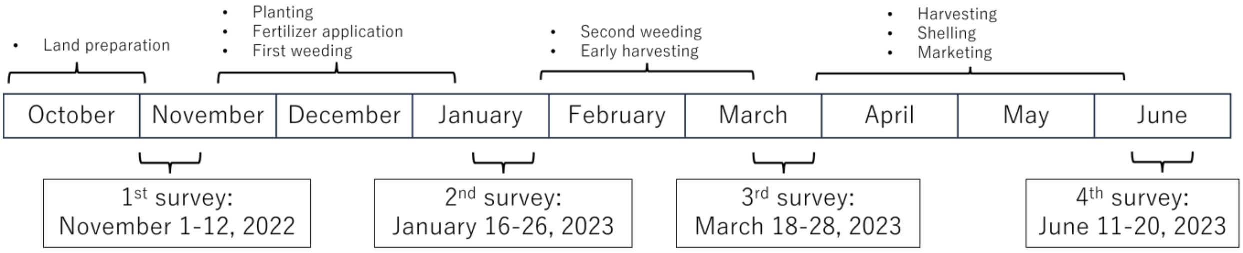

Figure 2. Timeline of the household surveys

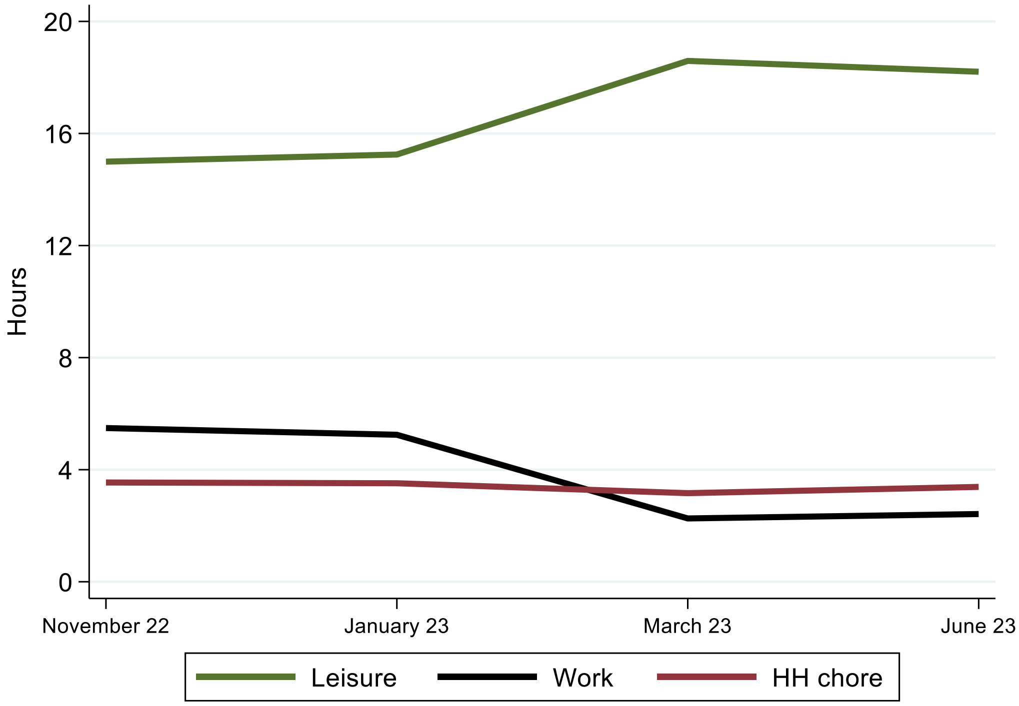

Figure 3. Time use by women across seasons

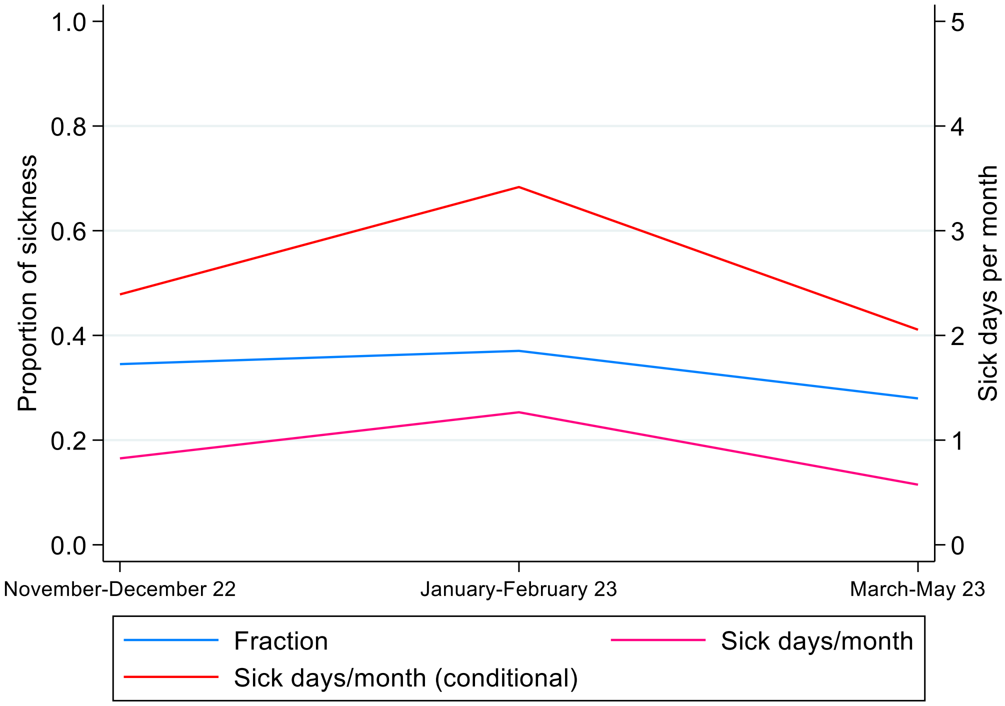

Figure 4. Illness incidence and the number of sick days among women by season

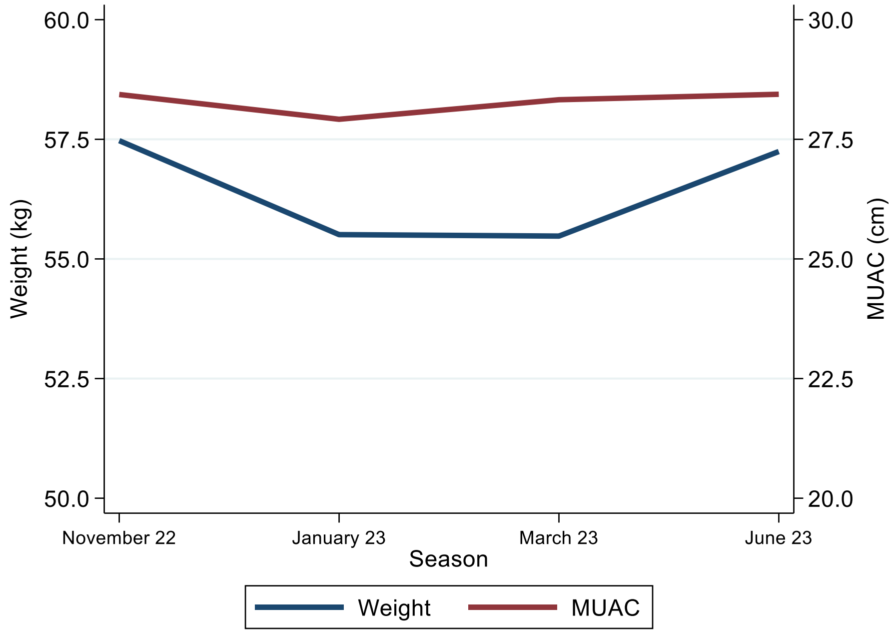

Figure 5. Women's weight and MUAC by season

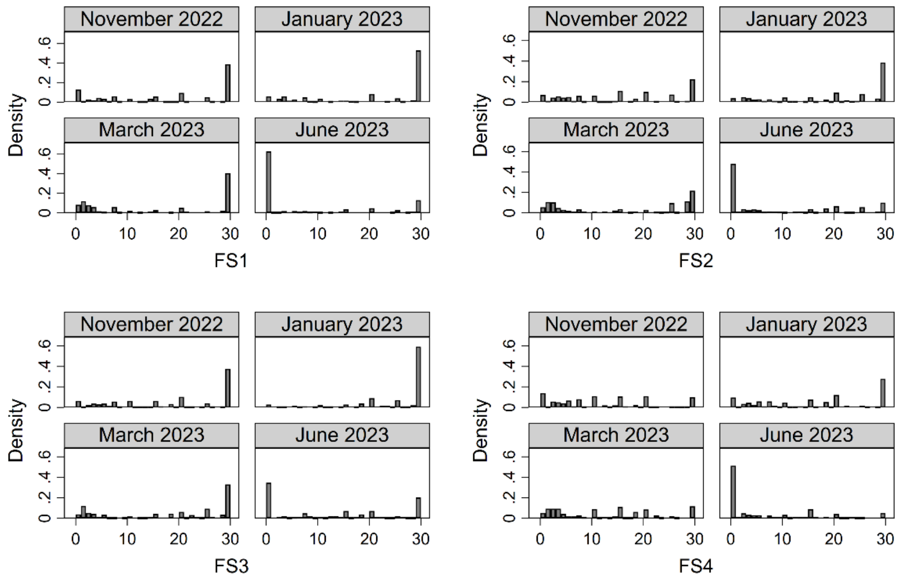

Figure 6. Household Food Security by Season: FS1–FS4

Note: The FS1 panel shows the number of days the respondent worried that the household would not have sufficient food in the last 30 days on the X-axis. The FS2 panel indicates the number of days the respondent could not eat foods they preferred in the last 30 days on the X-axis. The FS3 panel shows the number of days the respondent had to eat a limited variety of foods in the last 30 days on the X-axis. The FS4 panel indicates the number of days the respondent had to eat some foods they did not want to eat in the last 30 days on the X-axis. The Y-axes show the fractions for all panels.

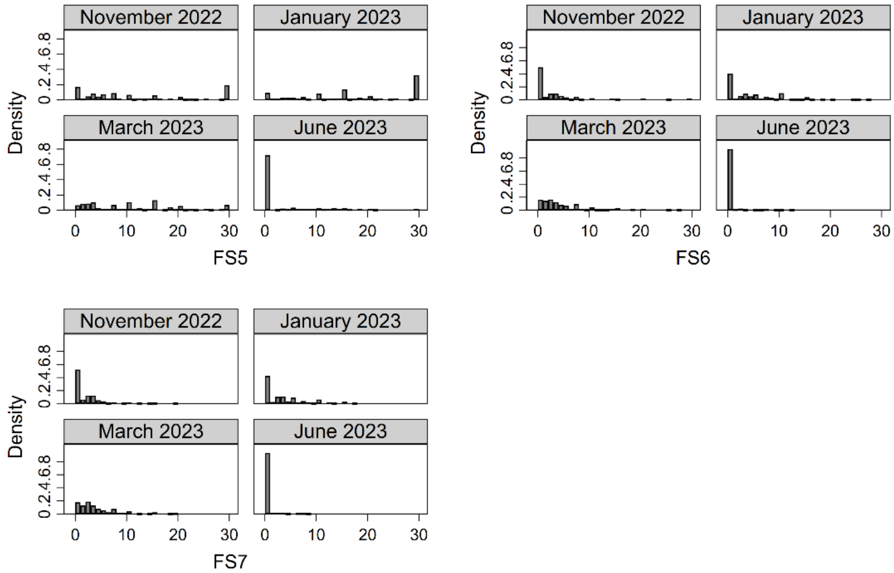

Figure 7. Household Food Security by Season: FS5–FS7

Note**:** The FS5 panel shows the number of days the respondent had to eat a smaller meal than needed in the last 30 days on the X-axis. The FS6 panel indicates the number of days the respondent had no food in the last 30 days on the X-axis. The FS7 panel shows the number of days the respondent went to sleep at night hungry in the last 30 days on the X-axis. The Y-axes show the fractions for all panels.

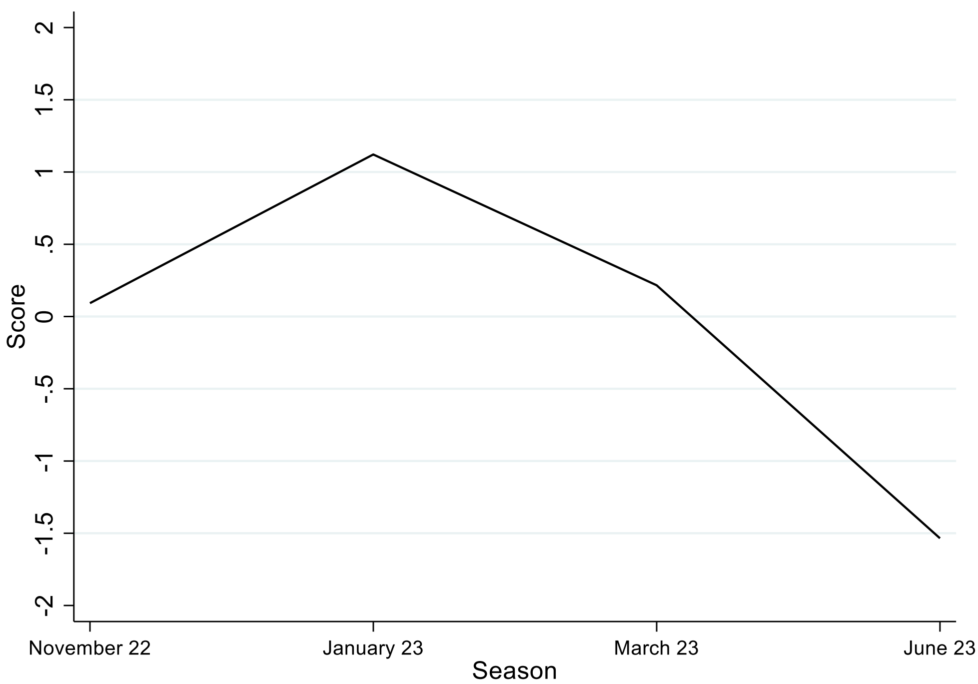

Figure 8. Household food insecurity scores

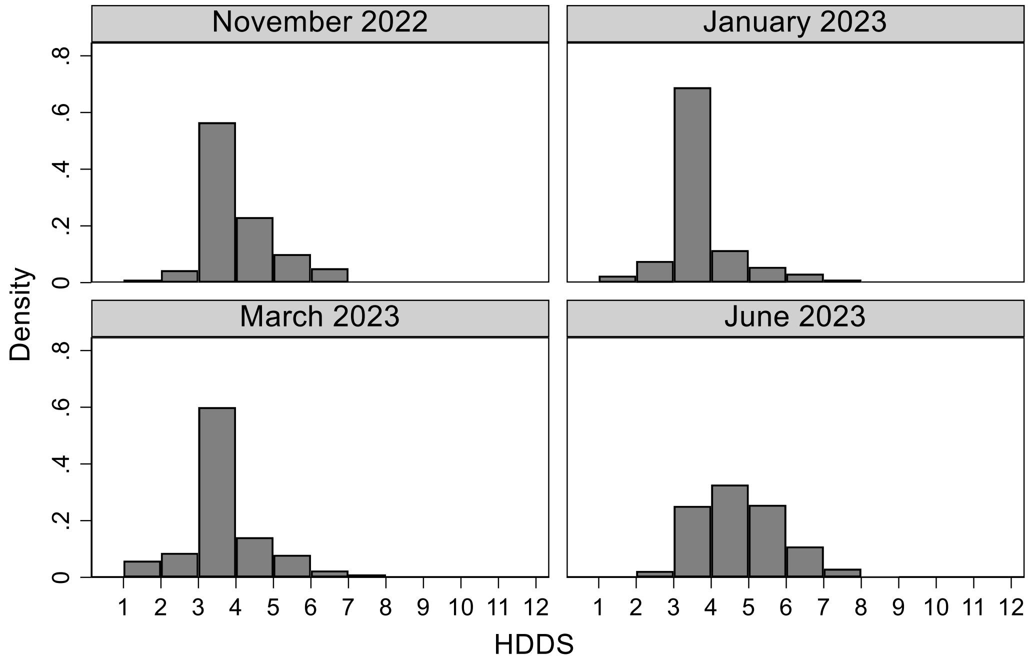

Figure 9. Household Dietary Diversity Scores (HDDS) by season

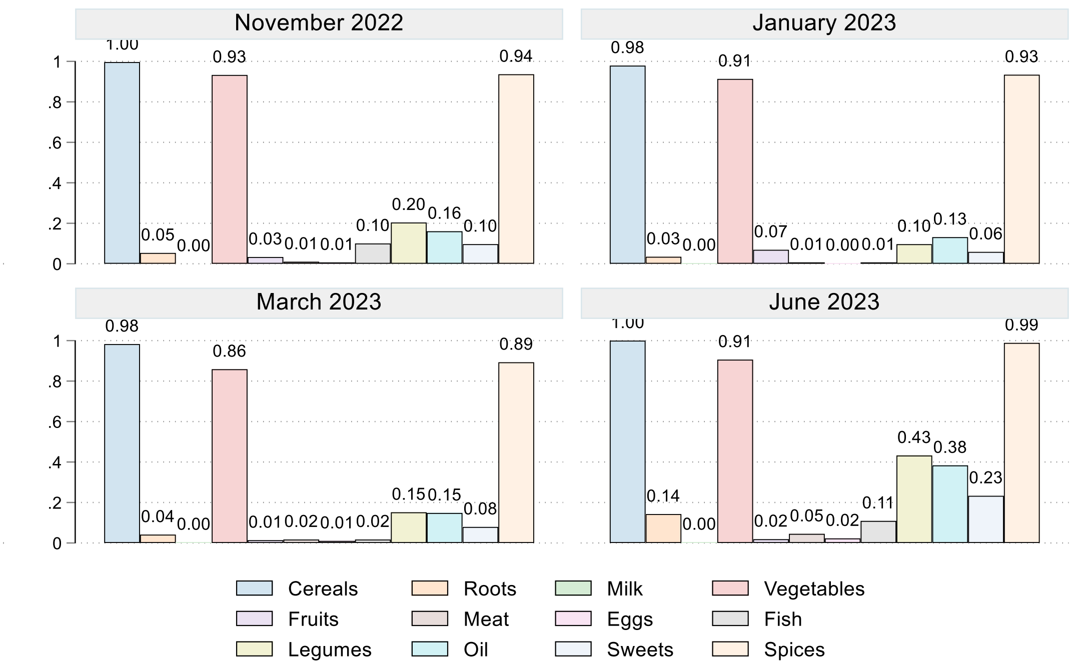

Figure 10. Breakdown of HDDS by season

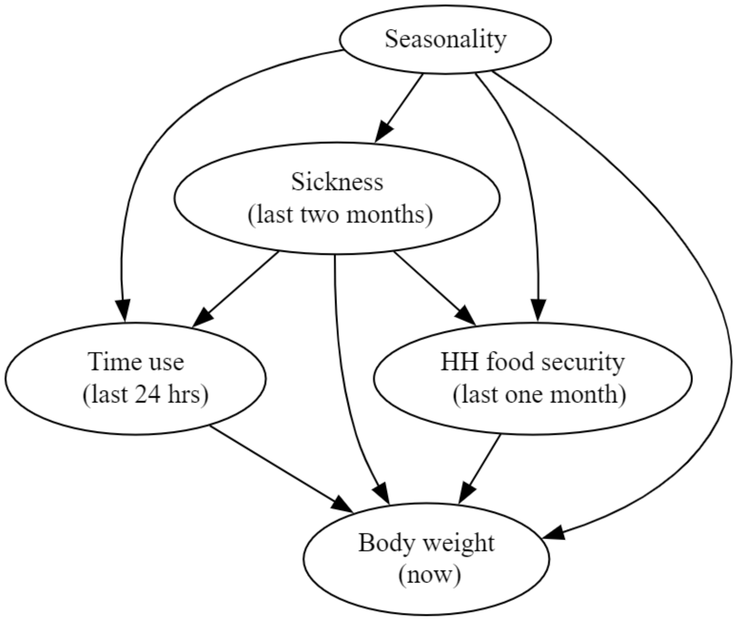

Figure 11. Graphical representation of the empirical framework

Tables

Table 1. Determinants of women's time use

	(1) Work	(2) Work	(3) HH chore	(4) HH chore	(5) Leisure	(6) Leisure
Own sick dummy	0.611*	0.481	-0.440*	-0.460**	-0.169	-0.021
	(0.342)	(0.313)	(0.230)	(0.228)	(0.307)	(0.275)
No. of sick family members	0.149	0.038	0.036	0.029	-0.186	-0.069
	(0.130)	(0.113)	(0.096)	(0.099)	(0.123)	(0.106)
Family size	0.405	0.262	-0.146	-0.189	-0.245	-0.062
	(0.269)	(0.268)	(0.170)	(0.172)	(0.245)	(0.238)
Tue	1.016**	0.262	-0.444	-0.558**	-0.568	0.297
	(0.439)	(0.399)	(0.279)	(0.281)	(0.455)	(0.393)
Wed	1.471***	0.938**	-0.647**	-0.742***	-0.829*	-0.205
	(0.449)	(0.391)	(0.283)	(0.282)	(0.456)	(0.370)
Thu	2.315***	1.505***	-0.780**	-0.950***	-1.529***	-0.557
	(0.563)	(0.441)	(0.308)	(0.315)	(0.576)	(0.425)
Fri	0.518	0.824*	-0.499	-0.437	0.012	-0.356
	(0.560)	(0.468)	(0.346)	(0.338)	(0.566)	(0.439)
Sat	-1.094**	-0.243	-0.553*	-0.459	1.652***	0.709*
	(0.490)	(0.394)	(0.291)	(0.297)	(0.476)	(0.378)
Sun	-2.425***	-1.950***	-0.074	0.043	2.519***	1.931***
	(0.406)	(0.366)	(0.278)	(0.283)	(0.420)	(0.359)
January 2023		0.302		-0.191		-0.124
		(0.306)		(0.193)		(0.280)
March 2023		-2.561***		-0.570**		3.113***
		(0.302)		(0.225)		(0.259)
June 2023		-2.311***		-0.405*		2.696***
		(0.324)		(0.215)		(0.304)
Individual FE	YES	YES	YES	YES	YES	YES
Mean Y	5.49	5.49	3.54	3.54	14.99	14.99
R squared	0.42	0.53	0.35	0.36	0.39	0.55
N	1117	1117	1117	1117	1117	1117

Notes: Robust standard errors clustered by female respondent are reported in parentheses. Monday is the reference category for the day of the week. Mean Y represents the averages of the outcome variables in November 2022. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2. Determinants of household food insecurity and HDDS

	(1)	(2)	(3)	(4)
	Food Insecurity	Food Insecurity	HDDS	HDDS
Own sick dummy	0.040	-0.095	0.083	0.152*
	(0.169)	(0.151)	(0.100)	(0.090)
No. of sick family members	0.108	-0.010	-0.009	0.038
	(0.072)	(0.060)	(0.048)	(0.043)
Family size	-0.131	-0.164	-0.031	0.005
	(0.157)	(0.116)	(0.071)	(0.071)
January 2023		0.975***		-0.254***
		(0.145)		(0.091)
March 2023		0.205		-0.295***
		(0.187)		(0.096)
June 2023		-1.592***		0.765***
		(0.155)		(0.109)
HH FE	YES	YES	YES	YES
Mean Y	0.09	0.09	3.52	3.52
R squared	0.36	0.56	0.39	0.52
N	1117	1117	1117	1117

Notes: Robust standard errors clustered by household are reported in parentheses. Household fixed-effects are included. Six dummy variables indicating the day of the week for the last 24 hours reference period are included with Monday as the reference but not reported. Mean Y represents the averages of the outcome variables in November 2022. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 3. Determinants of women's body weight

	(1) Weight	(2) Weight	(3) lnWeight	(4) lnWeight	(5) MUAC	(6) MUAC
Own sick dummy	-0.014	0.003	-0.000	0.000	0.020	0.010
	(0.223)	(0.197)	(0.004)	(0.003)	(0.096)	(0.094)
No. of sick family members	-0.102	-0.031	-0.002	-0.001	-0.088**	-0.084**
	(0.083)	(0.076)	(0.001)	(0.001)	(0.040)	(0.040)
Food insecurity score	-0.155***	0.029	-0.003***	0.001	-0.144***	-0.138***
	(0.047)	(0.056)	(0.001)	(0.001)	(0.031)	(0.032)
HDDS	0.308***	0.066	0.006***	0.001	-0.028	-0.027
	(0.098)	(0.091)	(0.002)	(0.002)	(0.045)	(0.049)
Family size	-0.285*	-0.409**	-0.004	-0.007**	-0.029	-0.057
	(0.168)	(0.163)	(0.003)	(0.003)	(0.070)	(0.073)
Work	0.005	0.015	0.000	0.000	-0.008	-0.007
	(0.046)	(0.040)	(0.001)	(0.001)	(0.024)	(0.024)
Leisure	-0.066	-0.005	-0.001	0.000	0.008	0.010
	(0.048)	(0.048)	(0.001)	(0.001)	(0.024)	(0.025)
January 2023		-1.661***		-0.029***		-0.199**
		(0.186)		(0.003)		(0.096)
March 2023		-1.962***		-0.035***		-0.100
		(0.252)		(0.004)		(0.126)
June 2023		-0.128		-0.002		-0.133
		(0.275)		(0.005)		(0.131)
Individual FE	YES	YES	YES	YES	YES	YES
Mean Y	57.44	57.44	4.04	4.04	28.42	28.42
R squared	0.97	0.98	0.97	0.97	0.94	0.94
N	1055	1055	1055	1055	1055	1055

Notes: The outcome variables for Columns 1–2 are women's body weight in kg. The outcome variables for Columns 3–4 are women's body weight after log transformation. Robust standard errors clustered by female respondent are reported in parentheses. Fixed effects for each female respondent are included. Six dummy variables indicating the day of the week for the last 24 hours reference period are included with Monday as the reference but not reported. Mean Y represents the averages of the outcome variables in November 2022. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Appendix Tables

Appendix Table 1. Determinants of each food insecurity component

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	FQ1	FQ2	FQ3	FQ4	FQ5	FQ6	FQ7
Own sick dummy	-0.664	-1.280	-0.653	-0.568	-0.650	0.326	0.309
	(1.067)	(1.048)	(1.002)	(0.910)	(0.917)	(0.419)	(0.273)
No. of sick family members	0.069	-1.095**	0.624	-0.477	-0.229	0.321*	0.205**
	(0.439)	(0.429)	(0.436)	(0.360)	(0.353)	(0.184)	(0.101)
Family size	-1.257	-0.945	-1.843***	-0.793	-0.724	0.214	0.248
	(0.838)	(0.840)	(0.652)	(0.692)	(0.790)	(0.260)	(0.201)
January 2023	2.498**	4.047***	5.869***	4.467***	5.214***	1.072**	1.419***
	(1.023)	(1.018)	(0.962)	(0.979)	(1.027)	(0.532)	(0.304)
March 2023	-1.174	0.755	0.020	0.819	-1.066	1.120*	2.000***
	(1.221)	(1.171)	(1.138)	(0.998)	(0.967)	(0.578)	(0.339)
June 2023	-10.516***	-6.948***	-5.325***	-5.548***	-8.460***	-2.704***	-1.411***
	(1.155)	(1.107)	(1.083)	(0.949)	(0.884)	(0.434)	(0.234)
HH FE	YES	YES	YES	YES	YES	YES	YES
Mean Y	17.80	15.64	18.41	11.48	11.47	3.27	1.85
R squared	0.49	0.43	0.45	0.41	0.49	0.43	0.52
N	1117	1117	1117	1117	1117	1117	1117

Notes: Robust standard errors clustered by household are reported in parentheses. Household fixed effects are included. Six dummy variables indicating the day of the week for the last 24 hours reference period are included with Monday as the reference but not reported. Mean Y represents the averages of the outcome variables in November 2022. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Appendix Table 2. Determinants of each food group intake

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Cereals	Roots	Vegetables	Fruits	Milk	Meat	Eggs	Fish	Nuts	Oil	Sweets	Spices
Own sick dummy	0.007	-0.012	0.054*	0.005	0.005	0.013	0.004	-0.001	0.010	0.025	0.031	0.010
	(0.012)	(0.023)	(0.030)	(0.019)	(0.005)	(0.016)	(0.010)	(0.019)	(0.037)	(0.036)	(0.029)	(0.024)
No. of sick family members	-0.004	0.015	-0.026*	0.007	0.001	0.000	0.003	0.011	0.018	0.013	0.003	-0.002
	(0.006)	(0.014)	(0.015)	(0.008)	(0.001)	(0.006)	(0.004)	(0.010)	(0.017)	(0.016)	(0.011)	(0.011)
Family size	-0.010	0.013	-0.013	-0.005	0.003	0.013	0.001	-0.007	-0.028	0.029	0.018	-0.010
	(0.008)	(0.014)	(0.020)	(0.009)	(0.003)	(0.009)	(0.011)	(0.016)	(0.028)	(0.022)	(0.022)	(0.016)
January 2023	-0.019	-0.024	-0.003	0.034	0.006	0.002	-0.002	-0.094***	-0.112***	-0.015	-0.033	0.007
	(0.012)	(0.021)	(0.028)	(0.022)	(0.005)	(0.011)	(0.008)	(0.022)	(0.035)	(0.034)	(0.027)	(0.024)
March 2023	-0.012	-0.030	-0.068**	-0.021	0.007	0.003	0.005	-0.081***	-0.052	-0.016	-0.010	-0.020
	(0.013)	(0.022)	(0.034)	(0.016)	(0.007)	(0.012)	(0.009)	(0.025)	(0.037)	(0.035)	(0.030)	(0.028)
June 2023	-0.001	0.085***	-0.008	-0.012	0.007	0.033*	0.017	0.002	0.216***	0.220***	0.146***	0.059***
	(0.009)	(0.031)	(0.031)	(0.017)	(0.007)	(0.017)	(0.011)	(0.032)	(0.047)	(0.040)	(0.037)	(0.022)
HH FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Mean Y	0.99	0.05	0.93	0.03	0.00	0.01	0.01	0.10	0.20	0.16	0.10	0.93
R squared	0.28	0.29	0.32	0.30	0.45	0.29	0.28	0.34	0.38	0.44	0.37	0.35
N	1117	1117	1117	1117	1117	1117	1117	1117	1117	1117	1117	1117

Notes: Robust standard errors clustered by household are reported in parentheses. Household fixed effects are included. Six dummy variables indicating the day of the week for the last 24 hours reference period are included with Monday as the reference but not reported. Mean Y represents the averages of the outcome variables in November 2022.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.