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COVID-19 Lockdown and Implications for Household Food Security in Zambia: Quality of Diet or Economic Vulnerability?

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Abstract

The study examines changes in household food security and identifies their key determinants in Zambia by comparing the pre-pandemic period to the COVID-19 pandemic period. Using nationally representative surveys from 2015 and 2021 and the coarsened exact matching (CEM) approach, 8650 households were matched for comparison. Two complementary food security measures are analysed using multinomial logit regression models: household expenditure share, representing economic vulnerability, and household dietary diversity score (HDDS), representing diet quality. The results show that household food expenditure share significantly increased from 53.8% to 61.4%, indicating increased economic vulnerability. Notably, household dietary diversity improved from 7.1 to 8.2 out of 12, indicating better dietary quality. Consistent determinants of food security—such as household size, education level, marital status, region, and employment—remained significant, but their protective effects weakened during the pandemic. Specifically, the protective effect of education declined, urban households became relatively more vulnerable, and wealthier households experienced minimal changes. The study recommends targeted interventions, including expanding social protection programmes for economically vulnerable households, supporting informal food markets, enhancing rural–urban food supply linkages, and promoting nutrition education to ensure diverse, affordable food access during crises.

Keywords: COVID-19; food security; dietary diversity; household food expenditure share; multinomial logit model; Zambia

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1. Introduction

The COVID-19 pandemic has had devastating effects on global heath and economic systems, with the magnitude and nature of these effects varying across countries and sectors (Huynh et al., 2021; Obi et al., 2020; Pan & Yue, 2022). Initial projections showed that impacts would be particularly acute in developing countries with pre-existing structural vulnerabilities in health, food, and economic systems. Sectors dependent on temporary wage income—often in informal employment—have been especially vulnerable, as social distancing measures and mobility restrictions disrupted daily livelihoods (Diao et al., 2021).

Zambia was already experiencing declining food security before the pandemic, with the 2019 Global Hunger Index (GHI) ranking the country among those with alarming hunger levels, scoring 38.1—worse than Madagascar (38.0) and only marginally better

than countries in conflict or post-conflict situations, such as Yemen (39.7), Chad (45.4), and Central African Republic (53.7) (Von Grebmer et al., 2018). Nearly half (46.7 percent) of Zambia's population was undernourished. COVID-19 exacerbated this fragile situation, primarily through loss of household income across both formal and informal sectors and the disruption of food supply chains due to internal and cross-border movement restrictions (GRZ, 2020; Mofya et al., 2020).

In response to the pandemic, Zambia adopted containment measures aligned with WHO guidelines, including a partial lockdown from 20 March 2020. This included border closures (except for essential goods), school closures, limits on social gatherings, and teleworking directives for non-essential staff (Malambo et al., 2020). While necessary for public health, these measures triggered economic, social, and political consequences, disproportionately affecting those already vulnerable to poverty and malnutrition (Hamadani et al., 2020; Headey et al., 2020; Laborde Debucquet et al., 2020; Pérez-Escamilla et al., 2020).

There is growing evidence that the pandemic disrupted all the four pillars of food security—availability, access, utilisation, and stability—through both supply-side and demand-side channels (Devereux et al., 2020; Laborde Debucquet et al., 2020). These disruptions manifest through declining household incomes, reduced physical and economic access to food (Devereux et al., 2020; Kansiime et al., 2021; Savary et al., 2020; Siche, 2020; Torero, 2020), and damage to perishable food commodities (Kansiime et al., 2021; Nicola et al., 2020).

Recent studies have further examined the impacts of COVID-19 on household food security. For example, Abay et al. (2023) found that Ethiopia's social protection programmes mitigated food insecurity among rural households during the pandemic. Similarly, Akbar et al. (2023) emphasised the importance of household characteristics in shaping food security outcomes in Indonesia. Sohel et al. (2022) and Shahzad et al. (2024) highlighted the use of adaptive strategies by households—including the incorporation of locally available, affordable foods into their diets—which contributed to sustaining or improving dietary diversity during the pandemic. Hangoma et al. (2024) further suggest that economic support interventions, such as targeted cash transfers, can play a critical role in preventing the deterioration of household food security during crises. Existing studies on COVID-19's effects on food security tend to suffer from narrow geographical focus, small sample sizes, or lack of pre-pandemic comparisons, limiting their generalisability and policy relevance (Aaron et al., 2021; Béné et al., 2021; Ghosh-Jerath et al., 2024; Kansiime et al., 2021). For example, Matenga and Hichaambwa (2021) surveyed a small sample of smallholder farmers in one district, while the World Food Programme (WFP) focused only on Lusaka and Kafue districts. Other national-level studies, such as (Kabisa et al., 2021), did not disaggregate results by region or household characteristics. The World Bank's high-frequency phone surveys (HFPS) showed food insecurity increased during 2020, but did not analyse the underlying drivers (Finn & Zadel, 2020).

To address these limitations, this study leverages two large, nationally representative household surveys from Zambia—one conducted before and one during the COVID-19—and applies coarsened exact matching (CEM) to create comparable household samples. Our study makes three distinct contributions. First, it examines changes in both economic vulnerability and diet quality using food expenditure share and household dietary diversity score (HDDS) as complementary indicators. Second, it uses a matched pre/post-design to account for differences in sample composition and improve internal validity. Third, it explores the heterogeneity of these impacts across household characteristics, such as region source and gender of household head. As such, this study seeks to answer two primary questions: (1) To what extent did the COVID-19 pandemic affect the food security status of Zambian households, particularly those most economically

vulnerable? (2) How did the drivers of food security outcomes evolve during the pandemic? We hypothesise that: (1) COVID-19 lockdowns and income shocks significantly increased household economic vulnerability as reflected in food expenditure shares; and (2) dietary diversity improved through adaptive or compensatory household strategies, despite heightened economic constraints. Thus, we aim to inform more targeted and effective policy responses that address both immediate food access and the structural determinants of household vulnerability.

1.1. Conceptual Framework and Related Literature

The COVID-19 pandemic has undermined food security both directly—by disrupting food systems, processing, and marketing—and indirectly—by reducing household incomes and limiting access to food. According to the High-Level Panel of Experts on Food Security and Nutrition (HLPE, 2020), the most acute effects have occurred on the demand side. Figure 1, adapted from the HLPE conceptual framework, illustrates the pathways through which the pandemic affects food security and nutrition.

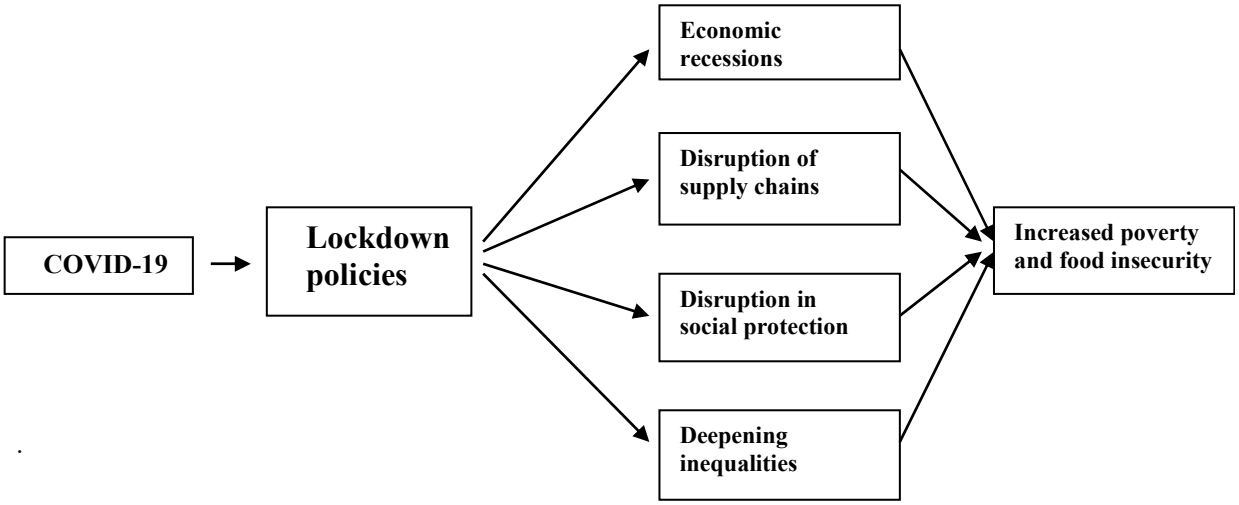


Figure 1. Pathways through which COVID-19 influences hunger and household food insecurity. Source: Adapted from the (HLPE, 2020).

Several Interrelated Factors Shape These Pathways

Supply chain disruptions: Lockdown measures disrupted food supply chains, causing shortages, higher prices, and lower quality food (Barrett, 2020). Restaurants and food service closures reduced demand for perishable foods, while border restrictions slowed international trade. Producers of perishable goods—fresh fruits, vegetables, and specialty crops such as cocoa—who depend on distant export markets were particularly vulnerable (Clapp & Moseley, 2020). Developing countries with high levels of food insecurity and a heavy reliance on imported food and commodity faced an even greater risk (FAO et al., 2019). Food availability also declined because transport bottlenecks prevented produce from reaching markets, resulting in higher prices and cutting farm incomes.

Global economic recession and associated income losses: The pandemic triggered a worldwide downturn that disproportionately impacted informal sector workers and vulnerable groups (World Bank, 2020). Remittances to developing countries were projected to fall by about 20 percent, further reducing household purchasing power (World Bank, 2020). Lower incomes worsened food insecurity and nutrition, undermining producers' livelihoods and the broader food system. The study by (Torero, 2020) estimates that food systems could lose 451 million jobs—about 35 percent of formal employment.

Widening societal inequities: The COVID-19 pandemic has deepened existing disparities in access to food, water, health care, and employment (Ashford et al., 2020). Poor and marginalised populations are more likely to experience food insecurity and face higher infection risks due to limited healthcare access (Klassen & Murphy, 2020). Gender inequities have also intensified: women bear additional care burdens and face greater risks of domestic violence (FAO, 2020; WHO, 2020). These inequities affect women's roles in food systems—as food producers, traders, wage workers, and primary managers of household nutrition.

Disruptions to social protection programmes: The pandemic disrupted social protection systems vital to food security. School closures halted meal programmes across income groups, while the recession strained government's capacities to support those most affected (FAO & WFP, 2020).

2. Methodology

2.1. Data

The study relied on two nationally representative cross-sectional household survey datasets available from the Zambia Statistics Agency (ZamStat): Living Conditions Monitoring Survey (LCMS), collected in 2015 (pre-COVID-19 pandemic), and the COVID-19 Socio-economic Impact of Assessment (SEIA), collected in 2021 (during or within the COVID-19 pandemic). The LCMS monitors policy impacts on living conditions and covered a representative sample of about 12,260 non-institutionalised private households in rural and urban areas. The SEIA aimed to assess COVID-19's socio-economic impact on household welfare, covering about 10,213 households from rural and urban areas.

Food security, as defined by the World Food Summit of 1996, is achieved when all people consistently have physical and economic access to sufficient, safe, and nutritious food to meet dietary needs and preferences for a healthy life (FAO, 1996). Given food security's multidimensional nature, accurately capturing it requires multiple indicators, beyond just food energy intake, including essential nutrients and micronutrients (FAO, 2013; Kennedy, 2002).

To address this complexity, this paper used two indicators to represent economic vulnerability and diet quality. Economic vulnerability refers to households unable to afford adequate food, as indicated by a high food expenditure share. These households are likely to compromise the quantity and/or quality of their diet, or reduce expenditures on basic, non-food needs, which may further undermine their food security status. The higher the share of households' consumption expenditures on food—out of total consumption expenditure—the more vulnerable the households are to food insecurity. The food expenditure share, a continuous variable, is calculated as:

$$HHFES = \left(\frac{Household\ expenditure\ on\ food}{Total\ household\ expenditure} \right) \times 100$$

We categorised the HHFES based on thresholds from the International Dietary Data Expansion (INDDEX) project (Data4Diets, 2023):

- $\geq$75% = very vulnerable and consequently food insecure.
- 65–74.9% = high food insecurity.
- 50–64.9% = medium food insecurity.
- $\leq$49.9% = low food insecurity.

Dietary quality is measured using the household dietary diversity score (HDDS), reflecting the number of food groups from which food was acquired over the survey period. Dietary diversity correlates with improved nutritional and health outcomes, including

birthweight (Rao et al., 2001), child anthropometric status (Allen et al., 1991; Hatløy et al., 2000), and improved haemoglobin concentrations. Dietary diversity is measured as the number of foods or nutritionally significant food groups from which food is acquired over the survey reference period. HDDS was categorised using the Swindale and Blinsky's thresholds (Swindale & Bilinsky, 2006):

- ≤3 food groups: low dietary diversity.
- 4–5 food groups: medium dietary diversity.
- 6–12 groups: high dietary diversity.

2.2. Models for Assessing Changes in and Determinants of Food Security

2.2.1. Coarsened Exact Matching Approach

To assess changes in household food security pre- and during the COVID-19 pandemic, coarsened exact matching (CEM) was employed to account for dataset heterogeneity and confounding factors. CEM is a matching technique used widely in observational studies to reduce selection bias (Blackwell et al., 2009; Iacus et al., 2012). By categorising covariates into broader, coarsened intervals, CEM facilitates greater matching efficiency and balance across treatment and control groups (Blackwell et al., 2009; Iacus et al., 2012). CEM has limitations, including sensitivity to large datasets (the 'curse of dimensionality'), potential data loss due to unmatched observations, result instability, and sensitivity to variable selection (Blackwell et al., 2009; Greifer & Stuart, 2021; Hughes et al., 2022). CEM was selected because it allows for the straightforward interpretation of match groups, robustly controls for observable confounders, and maintains methodological transparency. To address these limitations, we selected covariates strongly associated with food security, namely gender, age, marital status, education of the household head, household size, region, and household assets (bicycle and radio). Household assets were proxies for income, given income fluctuations due to the pandemic. We addressed potential data loss by employing k-to-k exact matching, ensuring equal representation from both pre- and within-pandemic groups. The multivariate imbalance measure (L1) assessed matching quality, decreasing from 0.166 pre-match to 0 post-match, confirming optimal balance (See Tables A1 and A2). Missing data were minimal (less than 5%) and handled using listwise deletion to ensure internal consistency across the matched sample. No significant systematic bias was detected. CEM analyses were conducted using Stata routines cem and imb (Blackwell et al., 2009).

2.2.2. Mean Difference Tests

Differences in household food security before and during COVID-19 were assessed using *t*-tests to compare mean values of key indicators (Wooldridge, 2002).

2.2.3. Multinomial Logistic Regression

Multinomial logistic regression was used because the outcome variables (food security and dietary diversity categories) are nominal rather than ordinal (Wooldridge, 2002; Menard, 2010). This approach estimates the probability of each outcome category occurring, relative to a base category, given a set of household characteristics. The multinomial logistic model estimates the probability p_{ij} of household i falling in the jth category using:

$$p_{ij} = \frac{exp(x_i'\beta_j)}{\sum_{j=1}^{m} exp(x_i'\beta_j)} \ldots j \in \{1,2,3,4\}\ for\ the\ food\ expenditure\ share\ categories\ or\ j \in \{=1,2,3\}\ for\ the\ household\ dietary\ diversity\ groups \quad (1)$$

where x_i are case-specific regressors and $exp(x_i'\beta_j)$ is an unobserved variable (logit index) that follows a logistic distribution. The coefficients of the model are interpreted with respect to the base categories (low food insecurity or high HDDS). The marginal effect of a change

in a given regressor, X_i, on the probability of experiencing a food security outcome is expressed by:

$$\frac{\partial p_{ij}}{\partial x_i} = p_{ij}(\beta_j - \overline{\beta_i}) \ldots j \in \{=1,2,3\} \; or \; j \in \{=1,2,3,4\} \quad (2)$$

Expression (2) is a single-equation probability model that shows how the food security outcome of interest is affected by changes in the covariates included in the model. The multinomial logistic model can be represented as:

$$Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \ldots \beta_n X_n + u_i \quad (3)$$

where Z_i represents the household's latent food security index that determines the observed status for any of the mutually exclusive expenditure share categories (HHFES) or alternative household dietary diversity score (HDDS) groupings, and u_i is the error term. Average marginal effects were computed to compare predictors' relative influence. We interpreted the average marginal effects to indicate how a one-unit change in a covariate alters the likelihood of being in a particular food security category. The data were analysed using SPSS 20 and STATA 16.

3. Results and Discussion

3.1. Descriptive Statistics

Table 1 presents descriptive statistics of the respondents' demographic and socio-economic characteristics based on matched samples for 2015 and 2021. The results indicate a significant increase in the food expenditure share, rising from 53.9% in 2015 to 61.5% in 2021. Additionally, the proportion of households categorised with high food insecurity significantly increased from 15.7% in 2015 to 23.9% in 2021, and those with medium food insecurity rose substantially from 25.9% to 40.7%. On the other hand, the proportion of households classified as having low food insecurity significantly decreased from 41.8% to 18.7%. No significant change was observed for households categorised as very vulnerable and food insecure. The results also show a significant improvement in the HDDS, increasing from an average of 7.1 out of 12 in 2015 to 8.2 out of 12 in 2021. There was a notable increase in the proportion of households with high dietary diversity from 73.3% to 86.8%, accompanied by significant decreases in the proportions of households with low dietary diversity (from 8.0% to 2.8%) and medium dietary diversity (from 18.6% to 10.4%) over the same period.

Household demographic characteristics remained largely unchanged, with 75.0% of households headed by males and 71.7% of household heads married or cohabiting. Regarding household size, there was a slight but statistically significant reduction from 5.1 persons in 2015 to 4.9 persons in 2021. In terms of economic stratification, there was a substantial shift toward higher expenditure quintiles, with significant reductions in households in the lowest and second quintiles, and increases in the proportions of households in the third, fourth, and highest quintiles. Employment status categories remained statistically unchanged between the two periods.

Concerning the COVID-19 pandemic, approximately 36.9% of respondents perceived COVID-19 as a significant community issue, and 47.7% reported a negative impact on household income. Only 5.7% of households undertook actions to mitigate the pandemic's economic impact. Furthermore, the pandemic affected intra-household dynamics, with 16.1% reporting changes in decision-making power regarding household expenses. The primary food sources reported in 2021 were markets/stores (55.7%) and own production (42.3%). Additionally, 72.9% of households reported purchasing reduced quantities of food due to price increases, while only 13.9% had access to social protection programmes.

Table 1. Summary statistics of the demographic and socio-economic characteristics of the respondents, 2015 and 2021.

Variables	2015 (n = 8968) Pre-COVID-19 Period		2021 (n = 8650) Within COVID-19 Period			
	Mean/(%)	St. Dev	Mean/(%)	St. Dev	Difference	S.E
Food expenditure share	53.9	19.5	61.5	13.4	7.6 ***	0.250
Food expenditure share categories						
• Very vulnerable and food insecure (%)	16.4	37.1	16.8	37.5	0.3	0.006
• High food insecurity (%)	15.7	36.4	23.9	42.6	8.1 ***	0.006
• Medium food insecurity (%)	25.9	43.8	40.7	49.1	14.7 ***	0.007
• Low food insecurity (%)	41.8	49.3	18.7	39.0	−23.2 ***	0.007
Household dietary diversity score	7.1	2.5	8.2	2.3	1.1 ***	0.036
Household dietary diversity score (categories)						
• Low household dietary diversity (%)	8.0	27.0	2.8	16.5	−5.1 ***	0.003
• Medium household dietary diversity (%)	18.6	38.9	10.4	30.5	−8.2 ***	0.005
• High household dietary diversity (%)	73.3	44.2	86.8	33.8	13.3 ***	0.006
Sex of household head (male = 1)	75.0	43.3	75.0	43.30	0.0	0.007
Household head's age	43.0	14.5	43.0	14.8	0.0	0.219
Household size	5.1	2.6	4.9	2.4	0.3 ***	0.038
Household head's highest level of education						
• No education	9.4	28.7	9.1	28.7	0.0	0.004
• Primary	37.3	48.3	37.4	48.3	0.0	0.007
• Secondary	42.4	49.4	42.4	49.4	0.0	0.008
• Tertiary	11.1	31.4	11.1	31.4	0.0	0.005
Marital status						
• Never married	6.1	24.0	6.1	24.0	0.0	0.004
• Married or cohabiting	71.7	45.0	71.7	45.0	0.0	0.007
• Separated/divorced/widowed	22.2	41.5	22.2	41.5	0.0	0.006
Region (Rural = 1)	58.0	49.4	58.0	49.4	0.0	0.008
Expenditure quintiles						
• Lowest	31.8	46.8	8.7	28.2	−23.1 ***	0.006
• Second	24.0	42.5	17.6	38.1	−6.1 ***	0.006
• Third	17.9	38.3	23.6	42.4	5.7 ***	0.006
• Fourth	15.6	36.3	24.3	42.9	8.7 ***	0.006
• Highest	11.0	31.2	25.8	43.8	14.9 ***	0.006
Employment status						
• Wage employment	24.4	42.9	24.4	43.0	0.0	0.007
• Fishing, forestry, or farming	46.1	49.9	43.4	49.6	0.0	0.008
• Business (non-farm)	17.5	38.0	23.0	42.0	0.0	0.006
• Other (student, retired, or searching)	12.0	32.4	9.6	28.9	0.0	0.004
COVID-19 perceived as a considerable problem in community (Yes = 1)			36.9	48.3		
How COVID-19 pandemic affected household income						
Income: not affected			43.8	49.6		
Income: increased			4.4	20.6		
Income: reduced			47.7	50.0		
Income: complete loss of income			4.0	19.5		
Household has carried out anything to compensate for COVID-19 (Yes = 1)			5.7	23.1		
Decision-making power regarding expenses changed (Yes = 1)			16.1	36.8		
Main source of food for household						
• Own production			42.3	49.4		
• Buying from markets/stores			55.7	49.7		
• Other sources (i.e., donations, humanitarian assistance)			2.0	14.0		
How have changes in food prices affected the quantities purchased?						
• Quantities have remained the same			18.3	38.7		
• Quantities have increased			8.8	28.3		
• Quantities have reduced			72.9	44.4		
Any household member has access to social protection (Yes = 1)			13.9	34.5		

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Source: Authors' construction using the 2020 SEIA and 2015 LCMS datasets.

Table 2 presents a comparison of the household consumption of nutrient-specific food groups before and during the COVID-19 pandemic. The observed increase in the HDDS between the two periods (Table 2) can be attributed to significant changes in the proportion of households consuming various nutrient-specific food groups. Specifically, there was a significant increase in the proportion of households consuming cereals, beans, dairy products, fats and oils, sugar and honey, as well as condiments. On the other hand, there were significant reductions in the proportions of households consuming tubers and fish. These findings suggest shifts in dietary patterns and food preferences over time.

Table 2. Changes in proportions of households consuming different nutrient-specific food groups during the reference period (2015 and 2021).

Food Types	2015 (n = 8650)		2021 (n = 8650)		Difference	
	Mean	St. Dev	Mean	St. Dev	Mean	SE
Cereals	0.863	0.344	0.965	0.185	0.102 ***	0.004
Tubers	0.538	0.499	0.489	0.500	−0.049 **	0.008
Vegetables	0.981	0.136	0.977	0.149	−0.004	0.002
Fruits	0.305	0.461	0.305	0.460	0.000	0.007
Meat	0.634	0.482	0.647	0.478	0.013 *	0.007
Eggs	0.453	0.498	0.463	0.499	0.010	0.008
Fish	0.825	0.380	0.728	0.445	−0.097 ***	0.006
Beans	0.579	0.494	0.805	0.396	0.226 ***	0.007
Dairy products	0.232	0.422	0.268	0.443	0.036 ***	0.007
Fats/Oils	0.168	0.374	0.901	0.299	0.733 ***	0.005
Sugar and honey	0.692	0.462	0.740	0.439	0.048 ***	0.007
Condiments	0.884	0.321	0.932	0.252	0.048 ***	0.004

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Source: Authors' construction using the 2020 SEIA and 2015 LCMS datasets.

3.2. COVID-19 Lockdowns and Household Food Insecurity

Table 3 presents the marginal effects of a multinomial logit regression model examining the drivers of food expenditure share before (2015) and during the COVID-19 pandemic (2021). Though minor variations in significant drivers occurred across food expenditure categories between the periods, most drivers remained consistent. For instance, the protective effects of gender and age of household head waned during the pandemic and became insignificant, while factors like household size, education, marital status, region, wealth, and employment status maintained consistency in their significance before and during the pandemic.

The results show that, in 2015, the probability of being very food insecure in female-headed households was 2.7 percentage points lower than in male-headed households. However, this protective effect slightly reduced to 2.3 percentage points during the COVID-19 period (2021). A one-year increase in the household head's age significantly lowered the probability of being very food insecure by 0.1 percentage points in 2015, but this effect became insignificant during the pandemic. An increase in household size by one member lowered the probability of a household being very food insecure by 0.7 and 0.8 percentage points before and during the pandemic, respectively, while increasing the probability of medium food insecurity by 0.3 percentage points in 2015 and 0.5 percentage points in 2021. These results suggest that the protective effects of gender and age of household head, and household size diminished during the pandemic, consistent with findings from other studies. For instance, in Nigeria, COVID-19 lockdown restrictions increased food expenditure and food insecurity among households (Samuel et al., 2021). Akbar et al. (2023) also reported negative relationships between household size, gender, age, and food security status in Indonesia.

Table 3. Average marginal effects estimates—food expenditure share categories, 2015 and 2021 *.

	1. Very Vulnerable and Food Insecure		2. High Food Insecurity		3. Medium Food Insecurity		4. Low Food Insecurity	
	2015	**2021**	**2015**	**2021**	**2015**	**2021**	**2015**	**2021**
Sex of household head								
• Female	−0.027 **	−0.023 *	0.004	0.007	0.014	0.001	0.009	0.015
• Male	(0.013)	(0.013)	(0.014)	(0.017)	(0.017)	(0.019)	(0.016)	(0.015)
Household head's age	−0.001 ***	−0.000	−0.000	−0.000	−0.001 **	0.000	0.002 ***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Household size	−0.007 ***	−0.008***	−0.000	0.003	0.003	0.005 *	0.004 **	0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
H/head's highest level of education								
• Primary education	−0.034 ***	−0.058 ***	0.009	−0.013	0.005	0.065 ***	0.020	0.005
	(0.011)	(0.011)	(0.013)	(0.016)	(0.017)	(0.023)	(0.017)	(0.020)
• Secondary education	−0.070 ***	−0.094 ***	−0.006	−0.023	0.015	0.087 ***	0.062 ***	0.029
	(0.012)	(0.013)	(0.014)	(0.017)	(0.018)	(0.023)	(0.018)	(0.020)
• Tertiary education	−0.290 ***	−0.200 ***	−0.059	−0.045	0.096 **	0.133 ***	0.253 ***	0.113 ***
	(0.087)	(0.038)	(0.044)	(0.032)	(0.045)	(0.033)	(0.035)	(0.022)
• No education	Ref							
Marital status								
• Married or cohabiting	0.049 **	−0.011	−0.004	0.038	−0.003	0.013	−0.043 **	−0.040 **
	(0.021)	(0.019)	(0.019)	(0.023)	(0.022)	(0.025)	(0.020)	(0.016)
• Separated/divorced/widowed	0.017	−0.042 **	0.003	0.033	0.005	0.040	−0.024	−0.032 *
	(0.022)	(0.020)	(0.021)	(0.024)	(0.024)	(0.027)	(0.021)	(0.018)
• Never married	Ref							
Region								
• Urban	0.111***	0.087 ***	0.043 ***	0.048 ***	−0.031 **	−0.087 ***	−0.123 ***	−0.048 ***
	(0.013)	(0.012)	(0.011)	(0.012)	(0.012)	(0.013)	(0.011)	(0.009)
• Rural	Ref							
Expenditure quintiles								
• Second quintile	−0.017 **	0.040 ***	−0.001	0.003	−0.017	−0.002	0.035 ***	−0.041 *
	(0.008)	(0.012)	(0.009)	(0.017)	(0.012)	(0.025)	(0.012)	(0.023)
• Third quintile	−0.078 ***	0.013	−0.044 ***	−0.004	−0.006	0.017	0.128 ***	−0.026
	(0.012)	(0.013)	(0.012)	(0.016)	(0.014)	(0.024)	(0.013)	(0.022)
• Fourth quintile	−0.139 ***	−0.053 ***	−0.075 ***	−0.048 ***	−0.036 *	0.060 **	0.249 ***	0.041 **
	(0.023)	(0.014)	(0.018)	(0.017)	(0.019)	(0.024)	(0.015)	(0.021)
• Highest quintile	−0.180 **	−0.104 ***	−0.155 ***	−0.156 ***	−0.178 ***	0.080 ***	0.512 ***	0.179 ***
	(0.071)	(0.020)	(0.050)	(0.022)	(0.045)	(0.026)	(0.031)	(0.021)
• Lowest quintile	Ref							
Employment status								
• Fishing, forestry, or farming	0.115 ***	0.093 ***	−0.010	0.001	−0.025	−0.062 ***	−0.079 ***	−0.031 **
	(0.016)	(0.015)	(0.013)	(0.015)	(0.015)	(0.017)	(0.014)	(0.013)
• Business (non-farm)	0.066 ***	0.042 ***	−0.009	−0.012	−0.024	−0.021	−0.033 **	−0.009
	(0.019)	(0.016)	(0.015)	(0.015)	(0.016)	(0.016)	(0.014)	(0.010)
• Other (student, retired, searching)	0.072 ***	0.050 ***	−0.023	−0.037 *	−0.001	−0.031	−0.048 ***	0.017
	(0.019)	(0.019)	(0.016)	(0.020)	(0.018)	(0.021)	(0.016)	(0.014)
• Wage employment	Ref							
Observations	8968	8764	8968	8764	8968	8764	8968	8764

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Standard errors in parentheses. Source: Authors' construction using the 2020 SEIA and 2015 LCMS datasets.

The education level of the household head remained significantly associated with food expenditure share before and during the pandemic, with effects increasing during the pandemic. For example, the probability of being very food insecure for households headed by someone with primary education was 3.4 percentage points lower in 2015 and further reduced to 5.8 percentage points during the pandemic. Similarly, for secondary education, the probability of very high food insecurity reduced from 7.0 percentage points in 2015 to 9.4 percentage points in 2021. This increasing protective effect of higher education during COVID-19 aligns with findings from other studies (Giacoman et al., 2021), attributed to more stable income sources for educated individuals.

However, among those in the food secure category, the protective effect of education declined during the pandemic. The probability of low food insecurity for households headed by individuals with secondary education decreased from 6.2 percentage points in 2015 to 2.9 percentage points during the pandemic. A similar trend was observed for tertiary education, decreasing from 25.3 to 11.3 percentage points. This reduced protective effect aligns with findings from other studies; Reimold et al. (2021) found that higher education predicted a higher risk of food insecurity due to the COVID-19 pandemic in the USA. One explanation for this unexpected finding could be that those with higher education may have experienced new financial hardship and stressors regarding availability and access to food for the first time, amplifying the negative effects.

Marital status significantly impacted food security, with the protective effects of marital unions increasing during the pandemic. Before the pandemic, being married increased the probability of very high food insecurity by 4.9 percentage points, but this effect became insignificant in 2021. Additionally, the negative impact of being married on the probability of low food insecurity slightly reduced from 4.3 to 4.0 percentage points during the pandemic. Contrary to expectations, the urban–rural divide showed a diminishing protective effect for rural areas during the pandemic. While urban residence increased the probability of very high food insecurity by 11.1 percentage points before the pandemic, this effect reduced slightly to 8.7 percentage points during the pandemic. Similarly, urban residence reduced the probability of low food insecurity by 12.3 percentage points in 2015, but only by 4.8 percentage points in 2021.

Household wealth was significantly associated with food security outcomes, with diminishing protective effects of higher wealth during the pandemic. For instance, the probability of being very food insecure for households in the highest expenditure quintile was 18.0 percentage points lower in 2015, reducing to 10.4 percentage points in 2021. The probability of low food insecurity also decreased significantly during the pandemic for higher quintiles. Employment status continued to influence food expenditure share significantly, though the protective effects of wage employment relative to other forms of employment reduced during the pandemic. The probability of being very food insecure for households conducting in fishing, forestry, or farming was 11.5 percentage points higher in 2015, reducing slightly to 9.3 percentage points during the pandemic. Similar trends were observed for non-farm businesses and other employment categories.

We also examined the relationship between food expenditure share variables associated with COVID-19, including economic recession, disruptions in supply chains, and social protection and inequalities using the 2021 SEIA data. The results in Table 4 indicate that household income, food prices, and market access significantly influenced food security outcomes as measured by food expenditure share during the COVID-19 period. Contrary to expectations, the study found that reduced income due to COVID-19-related lockdowns decreased the probability of being very vulnerable and food insecure by 2.1 percentage points compared to those whose income remained unchanged. Similarly, a complete loss of income reduced the probability of experiencing severe food insecurity by 4.4 percentage points compared to those whose income remained unchanged. Conversely, a complete loss of income increased the probability of being food secure by 4.3 percentage points compared to those with unchanged income. These results contradict findings from similar studies. In Kenya, Onyango et al. (2021) showed that economic shocks arising from COVID-19, such as food price increases, loss of employment, and reduced income, were associated with increased food insecurity. Similarly, loss of income due to COVID-19 was found to be significantly related to household food security during the pandemic in Australia (Kent et al., 2020) and Indonesia (Syafiq et al., 2022), even after controlling for confounding factors. In Australia, respondents who lost the majority of their income due to COVID-19-related factors showed up to a seven-fold increase in the odds of food insecurity.

Table 4. Average marginal effects for COVID-19 variables—food expenditure share categories, 2021.

	1. Very Vulnerable and Food Insecure		2. High Food Insecurity		3. Medium Food Insecurity		4. Low Food Insecurity	
Is COVID-19 perceived as a big problem in the community?	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
• Yes	−0.015 *	−0.014 *	0.005	0.005	−0.002	−0.002	0.011	0.011
	(0.009)	(0.009)	(0.010)	(0.010)	(0.011)	(0.011)	(0.008)	(0.008)
• No	Ref							
How has the COVID-19 pandemic affected HH income?								
• Income increased	−0.016	−0.015	0.018	0.018	0.009	0.010	−0.012	−0.012
	(0.020)	(0.020)	(0.022)	(0.022)	(0.026)	(0.026)	(0.020)	(0.020)
• Income reduced	−0.021 **	−0.021 **	−0.004	−0.004	0.027 **	0.026 **	−0.002	−0.002
	(0.008)	(0.008)	(0.010)	(0.010)	(0.012)	(0.012)	(0.009)	(0.009)
• Complete loss of income	−0.045 **	−0.044 **	−0.025	−0.025	0.027	0.027	0.043 **	0.043 **
	(0.021)	(0.021)	(0.026)	(0.026)	(0.028)	(0.028)	(0.019)	(0.019)
• Income not affected	Ref							
How did COVID-19 affect decision-making power in HH?								
• Changed	0.018 *	0.017 *	0.012	0.012	−0.026 *	−0.026 *	−0.003	−0.003
	(0.011)	(0.011)	(0.013)	(0.013)	(0.015)	(0.015)	(0.011)	(0.011)
• Did not change	Ref							
Main source of food for the household								
• Buying from markets/stores	−0.027 ***	−0.027 ***	−0.022 *	−0.022 *	0.051 ***	0.050 ***	−0.002	−0.001
	(0.010)	(0.010)	(0.013)	(0.013)	(0.016)	(0.016)	(0.013)	(0.013)
• Other sources (i.e., donations, humanitarian)	−0.009	−0.011	−0.036	−0.034	0.087 **	0.085 **	−0.042	−0.040
	(0.026)	(0.026)	(0.033)	(0.033)	(0.041)	(0.041)	(0.034)	(0.034)
• Own production	Ref							
How have changes in food prices affected the quantities purchased?								
• Quantities have increased	0.031 **	0.031 **	−0.011	−0.011	0.016	0.016	−0.036 **	−0.035 **
	(0.015)	(0.015)	(0.018)	(0.018)	(0.023)	(0.023)	(0.018)	(0.018)
• Quantities have reduced	−0.014	−0.014	−0.012	−0.012	0.013	0.013	0.012	0.012
	(0.010)	(0.010)	(0.012)	(0.012)	(0.014)	(0.014)	(0.011)	(0.011)
• Quantities have remained the same	Ref							
Has household has carried out anything to compensate for COVID-19?								
• Yes	−0.008	−0.008	0.001	0.001	-0.004	−0.003	0.011	0.011
	(0.023)	(0.023)	(0.023)	(0.023)	(0.024)	(0.024)	(0.016)	(0.016)
• No	Ref							
Has any household member has access to social protection?								
• Yes	0.018 *	0.078 ***	−0.005	−0.036	−0.016	−0.010	0.003	−0.033
	(0.010)	(0.027)	(0.013)	(0.035)	(0.016)	(0.037)	(0.013)	(0.028)
• No	Ref							
Interaction: gender * social protection		−0.020		0.019		−0.030		0.031
		(0.020)		(0.026)		(0.034)		(0.028)
Interaction: region * social protection		−0.054 ***		0.019		0.015		0.020
		(0.027)		(0.033)		(0.035)		(0.026)
Controls **	YES	YES	YES	YES	YES	YES	YES	YES
Interaction terms	NO	YES	NO	YES	NO	YES	NO	YES
Observations	8718		8718		8591		8591	

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Standard errors in parenthesis. All models control for variables including gender, age marital status, education, household size, region, assets, and employment status. Interaction terms tested include region * social protection and gender * social protection. Column (1) includes controls—household head gender, age, household size, education level, marital status, region, expenditure quintile and economic activities; column (2) includes controls and interaction terms: gender * social protection; and region * social protection. Source: Authors' construction using the 2020 SEIA and 2015 LCMS datasets.

The observed decrease in the probability of food insecurity among households that reported income loss may reflect coping behaviours not fully captured by standard economic indicators. These strategies may include reliance on own food production, informal support networks, and various forms of aid distributions. This interpretation is consistent with findings from Bangladesh, where households, despite experiencing income losses,

maintained food security through mechanisms such as accessing support from friends and neighbours, receiving government assistance, and liquidating household assets, including livestock and property, to purchase food (Sohel et al., 2022). Additionally, some households may have underreported financial stress due to social desirability or temporarily buffered the impact of income loss through savings or informal credit.

The study revealed changes in decision-making power regarding expenses. Relative to households indicating no change in decision-making power, the probability of being very vulnerable and food insecure increased by 1.7 percentage points for households where decision-making power had changed. Additionally, the findings indicate that households relying on markets or donations were more vulnerable and food insecure compared to those producing their own food. Households that reported increased quantities of food purchased during the pandemic were more likely to be highly vulnerable and food insecure, compared to households whose food purchases remained unaffected by food prices. Conversely, the probability of being very vulnerable and food insecure for those indicating reduced quantities purchased was 1.4 percentage points lower than for those with unchanged quantities.

We also explored the heterogeneous effects based on the region of residence and household head gender. Notably, the probability of being highly vulnerable and food insecure reduced by 5.4 percentage points for rural residents with at least one member benefiting from social protection. This suggests that social protection measures had a protective effect. Similar findings were found elsewhere; Picchioni et al. (2022) found that existing and well-functioning social protection programmes and public food distribution could buffer adverse food insecurity effects, though broader food systems interventions and investments were necessary for sustainable and inclusive food systems. Onyango et al. (2021) noted that the lack of functioning social safety nets in Nairobi led to severe food insecurity and related health effects. Similarly, Abay et al. (2023) showed that participation in Ethiopia's flagship social protection programme significantly reduced the likelihood of food insecurity during COVID-19, especially in rural areas.

Table 5 presents the marginal effects from a multinomial logit regression model investigating household dietary diversity in 2015 and during the COVID-19 pandemic. The results show that older-headed households had a 0.1 percentage point higher chance of moderate dietary diversity, a trend that persisted during the pandemic. Conversely, these households were less likely to have high diversity, a trend unchanged in 2021. Larger households saw reduced probabilities of achieving high dietary diversity, with the likelihood decreasing from 1.2 percentage points in 2015 to 0.4 percentage points during the pandemic.

Education significantly influenced household dietary diversity. Households headed by individuals with primary or secondary education were significantly less likely to experience low dietary diversity compared to those headed by individuals without any education in both periods. Specifically, the protective effect for low dietary diversity decreased from 2.4 to 1.0 percentage points for those with primary education and from 3.5 to 1.9 percentage points for those with secondary education. In terms of high dietary diversity, households headed by individuals with secondary education saw their advantage decline from 6.9 percentage points in 2015 to 2.4 percentage points in 2021 relative to those with no education. Interestingly, tertiary education showed no statistically significant effects across any dietary diversity categories in both periods.

Marital status had minimal influence on dietary diversity. During the pandemic, households headed by individuals who were married or separated/divorced/widowed were less likely to have low dietary diversity compared to those who had never married. Urban residence was associated with a higher probability of low and moderate dietary diversity compared to rural areas. Specifically, urban households had a 3.0 percentage point

higher likelihood of low dietary diversity in 2015, but this advantage largely diminished to 0.2 percentage points in 2021. Urban households were also significantly less likely to achieve high dietary diversity, though this protective effect decreased from 4.9 to 1.4 percentage points during the pandemic.

Table 5. Average marginal effects estimates—household dietary diversity categories, 2015 and 2021.

	Low HDDS		Medium HDDS		High HDDS	
	2015	**2021**	**2015**	**2021**	**2015**	**2021**
Sex of household head						
• Female	−0.002 (0.009)	−0.001 (0.006)	0.012 (0.014)	0.004 (0.010)	−0.009 (0.014)	−0.003 (0.010)
• Male	Ref					
Household head's age	0.000 (0.000)	0.000 * (0.000)	0.001 *** (0.000)	0.001 *** (0.000)	−0.001 *** (0.000)	−0.001 *** (0.000)
Household size	0.002 (0.001)	0.002 ** (0.001)	0.010 *** (0.002)	0.002 * (0.001)	−0.012 *** (0.002)	−0.004 *** (0.001)
H/head's highest level of education						
• Primary education	−0.024 *** (0.007)	−0.010 ** (0.004)	−0.018 (0.011)	0.018 ** (0.009)	0.042 *** (0.012)	−0.008 (0.009)
• Secondary education	−0.035 *** (0.009)	−0.019 *** (0.006)	−0.034 *** (0.013)	−0.005 (0.010)	0.069 *** (0.013)	0.024 *** (0.011)
• Tertiary education	0.037 (0.028)	−0.001 (0.014)	0.011 (0.030)	0.027 (0.024)	−0.048 (0.029)	−0.026 (0.024)
• No education	Ref					
Marital status						
• Married or cohabiting	−0.002 (0.014)	−0.012 (0.007)	−0.014 (0.021)	−0.007 (0.016)	0.016 (0.021)	0.020 (0.016)
• Separated/divorced/widowed	−0.001 (0.014)	−0.017*** (0.007)	−0.001 (0.022)	−0.015 (0.017)	0.002 (0.021)	0.033 ** (0.017)
• Never married	Ref					
Region						
• Urban	0.030 *** (0.009)	0.002 (0.005)	0.019 * (0.011)	0.012 (0.009)	−0.049 *** (0.011)	−0.014 (0.009)
• Rural	Ref					
Expenditure quintiles						
• Second quintile	−0.128 *** (0.009)	−0.040 *** (0.004)	−0.107 *** (0.009)	−0.084 *** (0.007)	0.236 *** (0.008)	0.124 *** (0.007)
• Third quintile	−0.160 *** (0.019)	−0.057 *** (0.005)	−0.220 *** (0.016)	−0.167 *** (0.008)	0.380 *** (0.013)	0.224 *** (0.008)
• Fourth quintile	−0.249 *** (0.031)	−0.079 *** (0.009)	−0.276 *** (0.027)	−0.214 *** (0.011)	0.523 *** (0.024)	0.294 *** (0.011)
• Highest quintile	−0.219 *** (0.039)	−0.084 *** (0.015)	−0.403 *** (0.043)	−0.268 *** (0.020)	0.623 *** (0.037)	0.352 *** (0.019)
• Lowest quintile	Ref					
Employment status						
• Fishing, forestry, or farming	0.009 (0.012)	0.009 (0.008)	0.012 (0.015)	0.036 * (0.013)	−0.021 (0.014)	−0.045 *** (0.013)
• Business (non-farm)	−0.035 ** (0.014)	0.002 (0.010)	0.020 (0.016)	0.018 (0.014)	0.015 (0.016)	−0.020 (0.015)
• Other (student/retired/searching)	−0.003 (0.014)	0.020 *** (0.009)	0.006 (0.018)	0.039 ** (0.015)	−0.003 (0.018)	−0.059 *** (0.015)
Observations	8968	8772	8968	8772	8968	8772

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Standard errors in parentheses. Source: Authors' construction using the 2020 SEIA and 2015 LCMS datasets.

Wealth, measured through expenditure quintiles, played a substantial role in determining dietary diversity. Households in higher expenditure quintiles had significantly lower probabilities of experiencing low dietary diversity and higher probabilities of achieving high dietary diversity compared to the lowest quintile. For example, being in the second quintile reduced the probability of low dietary diversity by 12.8 percentage points in 2015 and by 4.0 percentage points in 2021. Similarly, the likelihood of high dietary diversity decreased from 23.6 percentage points in 2015 to 12.4 percentage points for the second quintile.

Employment status was consistently influential. Households with members engaged in fishing, forestry, farming, non-farm business, or those with unemployed or retired members were more likely to experience low or moderate dietary diversity compared to households with wage-employed members. These effects were statistically significant during the COVID-19 period, although the probabilities were slightly reduced. Conversely, such households were less likely to achieve high dietary diversity compared to those in wage employment, a finding consistent across both periods, particularly for those engaged in fishing, forestry, farming, and other employment categories.

Table 6 highlights the impact of COVID-19 on household dietary diversity using the 2021 SEIA data. The perception of COVID-19 as a significant community issue reduced the probability of a household having moderately diversified diets by approximately 1.5 percentage points compared to households that did not perceive COVID-19 as a major community problem. Similarly, income reductions associated with COVID-19 lockdowns significantly influenced dietary diversity: households experiencing reduced income had a

1.5 percentage point higher probability of moderately diverse diets than those with unaffected income. Additionally, households relying on donations or humanitarian assistance as their food source had approximately a 1.8 percentage point higher probability of low dietary diversity compared to those relying on their own food production. Furthermore, reductions in quantities of food purchased due to price increases led to a 0.7 percentage point lower likelihood of low dietary diversity. The analysis also suggests interaction effects: specifically, female-headed households with access to social protection had a 1.5 percentage point higher probability of low dietary diversity.

Table 6. Average marginal effects for the multinomial logit model, including COVID-19 variables—household dietary diversity categories, 2021 SEIA data.

	Low HDDS		**Medium HDDS**		**High HDDS**	
	(1)	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
Is COVID-19 perceived as a big problem in the community?						
• Yes	0.006 (0.004)	0.006 (0.004)	−0.015 ** (0.007)	−0.015 ** (0.007)	0.009 (0.007)	0.009 (0.007)
• No	Ref					
How has the COVID-19 pandemic affected household income?						
• Income increased	−0.014 (0.011)	−0.014 (0.011)	0.008 (0.018)	0.009 (0.018)	0.006 (0.019)	0.006 (0.019)
• Income reduced	−0.004 (0.004)	−0.004 (0.004)	0.015 *** (0.007)	0.015 *** (0.007)	−0.011 (0.007)	−0.011 (0.007)
• Complete loss of income	0.011 (0.008)	0.010 (0.008)	0.009 (0.017)	0.009 (0.017)	−0.020 (0.018)	−0.020 (0.018)
• Income not affected	Ref					
Has decision-making power regarding expenses changed?						
• Yes	0.001 (0.005)	0.001 (0.005)	0.007 (0.009)	0.007 (0.009)	−0.008(0.009)	−0.008 (0.009)
• No	Ref					
Main source of food for the household						
• Buying from markets/stores	−0.002 (0.004)	−0.001 (0.004)	−0.009 (0.008)	−0.010 (0.008)	0.011 (0.009)	0.011 (0.009)
• Other sources (i.e., donations, humanitarian assistance)	0.017 * (0.008)	0.018 ** (0.008)	−0.024 (0.020)	−0.025 (0.020)	0.007 (0.021)	0.008 (0.021)
• Own production	Ref					
How have changes in food prices affected the quantities purchased?						
• Quantities have increased	0.000 (0.006)	0.001 (0.006)	0.006 (0.013)	0.006 (0.013)	−0.006 (0.013)	−0.006 (0.013)
• Quantities have reduced	−0.007 * (0.004)	−0.007 * (0.004)	0.004 (0.008)	0.004 (0.008)	0.003 (0.008)	0.003 (0.008)
• Quantities have remained the same	Ref					
Household has carried out anything to compensate for COVID-19						
• Yes	−0.017(0.010)	−0.018 (0.010)	0.015 (0.017)	0.016 (0.017)	0.002 (0.018)	0.002 (0.018)
• No	Ref					
Has any household member has access to social protection?						
• Yes	−0.002 (0.005)	−0.003 (0.013)	0.001 (0.008)	0.018 (0.023)	0.000 (0.009)	−0.015 (0.024)
• No	Ref					
Has any household member has access to social protection?						
• Yes		−0.015 (0.013)		0.025 (0.023)		−0.010 (0.024)
• No		Ref				
Gender						
• Female		−0.004 (0.006)		0.006 (0.010)		−0.001 (0.011)
• Male		Ref				
Region						
• Urban		0.002 (0.005)		0.012 (0.010)		−0.014 (0.010)
• Rural		Ref				
Interaction: gender * social protection		0.015 * (0.009)		−0.016 (0.016)		0.001 (0.017)
Interaction: region * social protection		−0.009 (0.012)		−0.008 (0.023)		0.017 (0.023)
Controls	YES	YES	YES	YES	YES	YES
Interaction terms	NO	YES	NO	YES	NO	YES
Observations	8718		8718		8718	

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Standard errors in parenthesis. All models control for variables, including gender, age marital status, education, household size, region, assets, and employment status. Interaction terms tested include region * social protection and gender * social protection. Column (1) includes controls—household head gender, age, household size, education level, marital status, region, expenditure quintile, and economic activities; column (2) includes controls and interaction terms: gender * social protection; region * social protection. Source: Authors' construction using the 2020 SEIA and 2015 LCMS datasets.

Notably, the observed increase in dietary diversity despite greater economic vulnerability may be explained by increased reliance on diverse, inexpensive local foods groups. Households may have substituted more expensive or unavailable foods with more affordable, locally sourced alternatives. Evidence from Bangladesh shows that households adapted their diet by incorporating locally available food items, which were more affordable and accessible during the pandemic (Sohel et al., 2022). Such dietary adjustments reflect pragmatic coping strategies under financial constraint. Additionally, some households may have prioritised food-related expenditures by reducing spending on non-essential goods, thus temporarily sustaining dietary quality through internal resource reallocation.

4. Conclusions

This study aimed to assess changes in household food security between the pre-pandemic and COVID-19 pandemic periods, and to identify shifts in determinants influencing food security outcomes. The analysis employed two complementary food security indicators of economic vulnerability and diet quality: household food expenditure share and the HDDS, respectively. The findings reveal a significant increase in the food expenditure share during the pandemic compared to the pre-pandemic period, indicating heightened economic vulnerability and reduced overall food security. Given that households producing own food may not be affected by the food expenditure share, further analysis into household-level production strategies is necessary to better understand how internal household food sources influence resilience to food insecurity during economic shocks. In contrast, dietary diversity scores improved over the same period, suggesting that households employed adaptive coping behaviours. Households might have sustained their food consumption by reducing non-food expenditures or financing food consumption through savings or debt acquisition.

However, over time, the HDDS indicator might have deteriorated if the lockdown measures had persisted as coping strategies would be exhausted. Furthermore, households possibly prioritised dietary diversification by reallocating expenditure from non-essential items to affordable local foods, which can temporarily mask underlying food security challenges. Households may have also adapted to shortages or price hikes by diversifying their diet with cheaper, locally available food groups. However, sustained lockdown measures could have led to the deterioration of dietary diversity, highlighting the limitations of HDDS as a crisis-sensitive food security indicator. Future studies should investigate the role of targeted social support mechanisms to confirm their influence on outcomes related to income loss and food security.

Regarding the drivers of food insecurity and how they changed between the two periods, the findings indicate that the determinants of household food security remained largely consistent before and during the pandemic, albeit with varying magnitudes of effects. Education played a significant role in food security outcomes, but its protective effects waned during the pandemic. Additionally, the educational attainment of the household head, a relevant factor before the pandemic, saw diminished protective effects during the COVID-19 crisis. The diminished protective effects of education and urban residency maybe linked to pandemic-induced shifts in employment patterns. For example, urban dwellers with higher education worked in sectors affected by the lockdown, leading to income instability, which may have exposed educated households to food insecurity.

Wealthier households were more likely to maintain food security during the pandemic, highlighting the importance of inclusive economic growth and reducing wealth disparities. The findings also highlight the protective role of wage employment in preventing food insecurity, although this effect weakened during the pandemic due to reduced incomes resulting from lockdowns. It is worth noting that non-wage workers may have faced more

severe income losses. This highlights the vulnerability of non-wage workers and those with lower educational levels during crises such as the pandemic, necessitating government interventions, especially targeted cash transfers to protect these groups.

To ensure long-term food security in Zambia—particularly in the face of future shocks such as pandemics or climate-related crises—there is a need to move beyond reactive approaches and focus on building systems that are adaptive, inclusive, and sustainable. There is need to expand and institutionalise adaptive social protection systems. Social cash transfer programmes should be scaled up with built-in flexibility to respond to emergencies. This includes introducing shock-responsive features such as emergency top-ups or mobile-delivered e-vouchers that can be rapidly deployed to cushion vulnerable households during periods of income loss or rising food prices. Promoting climate-resilient and localised food systems is equally important. Strategic investment in decentralised food production, along with improvements in post-harvest storage and rural feeder roads, can increase household access to diverse and affordable foods while reducing dependence on fragile supply chains.

Given the importance of informal food markets in everyday food access—especially for low-income households—there is a need to support these markets more deliberately. Policies should aim to improve hygiene, food safety standards, and access to working capital, while ensuring these markets remain open and functional during public health or environmental emergencies. Additionally, nutrition education and food budgeting should be integrated into public health messaging and social assistance programmes. Empowering households with information on how to prepare diverse and nutritious meals using affordable, locally available ingredients can help sustain dietary quality even in times of economic constraint. Furthermore, strengthening the real-time monitoring of food availability, prices, and household vulnerability will ensure timely and better-targeted interventions that prevent deterioration in food security conditions. Finally, future research should explore the long-term impacts of the COVID-19 pandemic on household food security, particularly in relation to chronic poverty, intergenerational nutrition outcomes, and changes in food systems' resilience.

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Abbreviations

The following abbreviations are used in this manuscript:

AERC	African Economic Research Consortium
AGRA	Alliance for a Green Revolution in Africa
BMJ	*British Medical Journal*
CEM	Coarsened Exact Matching
COVID-19	Coronavirus Disease-19
CUTS	Consumer Unity & Trust Society
DC	District Commissioner
FAO	Food and Agriculture Organization
GHI	Global Hunger Index
GRZ	Government of the Republic of Zambia
HDDS	Household Dietary Diversity Score
HFPS	High-Frequency Phone Surveys
HHFES	Household Food Expenditure Share
HLPE	High-Level Panel of Experts on Food Security and Nutrition
IAPRI	Indaba Agricultural Policy Research Institute
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IJSEI	*International Journal of Social Economics and Inequality*
JEL	*Journal of Economic Literature*
LCMS	Living Conditions Monitoring Survey
MA	Ministry of Agriculture
MIT	Massachusetts Institute of Technology
SEIA	Socio-economic Impact Assessment
SPSS	Statistical Package for the Social Sciences
SSRN	Social Science Research Network
STATA	Data Analysis and Statistical Software
UNDP	United Nations Development Programme
USA	United States of America
WFP	World Food Programme
WHO	World Health Organization
ZNPHI	Zambia National Public Health Institute

Appendix A

Table A1. Results of the coarsened exact matching.

Imbalance Test (Pre-Match)	L1	Mean Difference	Min	25%	50%	75%	Max
Univariate imbalance:							
Household head age	0.02694	−0.04248	0	0	0	0	0
Sex of household head	0.05391	−0.05391	0	−1	0	0	0
Marital status	0.03726	−0.01645	0	0	0	0	0
Household head education	0.07068	−0.15877	0	0	0	0	0
Region	0.03837	0.03837	0	0	0	0	0
Radio	0.02201	0.02201	0	1	0	0	0
Bicycle	0.00374	0.00374	0	0	0	0	0
Multivariate L1 distance:	0.16607897						
CEM *							
Univariate imbalance:							
Household head age	0	0	0	0	0	0	0
Sex of household head	0	0	0	0	0	0	0
Marital status	0	0	0	0	0	0	0
Household head education	0	0	0	0	0	0	0
Region	0	0	0	0	0	0	0
Radio	0	0	0	0	0	0	0
Bicycle	0	0	0	0	0	0	0
Multivariate L1 distance:	0						

* Using the k2k algorithm to create strata with equal numbers of observation in the pre-COVID-19 and within the COVID-19 period by randomly dropping observations. Number of strata = 670; number of matched strata = 441. L1 = 0 indicates perfect balance, and the maximum L = 1 means heterogeneity between the groups (Iacus et al., 2012).

Table A2. Number of matched and unmatched observations.

	0	**1**
All	11,810	10,200
Matched	8968	8968
Unmatched	2842	1232

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