Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Prevalence of household food insecurity in Ethiopia during the COVID-19 pandemic: Evidence from panel data

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ABSTRACT

The COVID-19 pandemic is a global problem that confronted the economy and household food security of many countries. This study aimed to analyze the determinants of a household's food insecurity status in the era of the COVID-19 pandemic in Ethiopia. A panel data of 2,410 households in a six-round High-Frequency Phone Survey were retrieved from the World Bank database. The product of the corresponding pairwise severity weight and household responses to each coping strategy was summed up to get the individual's Coping Strategy Index. The Random Effect Model (REM) for panel data analysis was used to identify factors associated with household-related food insecurity during the COVID-19 pandemic. The descriptive statistics result shows that 18.63% and 11.08% of rural households and 56.55% and 38.13% of urban residents were food secure in the first and sixth rounds, respectively. On the contrary, 3.65% and 3.2% of rural households and 6.8% and 7.18% of urban households experienced severe food insecurity from the first to the sixth round, respectively. Most households have maintained their food security in urban areas than rural residents. However, the number of food secure households was gradually reduced from Round-1 to Round-6. Besides, REM output indicates that access to financial services, farm income, wage employment, income from property, investment, and savings, and NGO assistance negatively affected household's food insecurity. Whereas government support showed a positive association with households' food insecurity. Based on the findings, we recommend that households should adopt the behavior of enhancing and diversifying their sources of income, and the government also emphasize the establishment of national social security services by taking experience from NGOs' emergency response mechanisms.

Introduction

The Coronavirus disease (COVID-19) was declared as a pandemic on 11 March 2020 after it broke out in 2019 in Wuhan city, China [1]. Following the WHO guidelines, several governments instituted various restrictions to tackle the spread of the disease [2]. Due to the COVID-19 lockdown, many people around the world have lost their jobs, creating concerns about food availability, distribution, access, utilization, and supply chains [3]. In addition, the pandemic has led to economic

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losses and threats to human health [4,5]. The crisis continues to threaten the food security and nutrition of millions of people worldwide [3]. Consequently, unemployment, underemployment, and job poverty are globally predicted for millions of people [6].

Coupled with climate change, the COVID-19 pandemic is a global risk [7]. Comparing 50 countries that reported in 2019 and 2020, the population in crisis or worse of food insecurity upsurges from 112 to 123 million [4]. According to the United Nations report, before the COVID-19 outbreak, more than 820 million people were chronically food insecure [3]. The study conducted in 134 countries shows that roughly half of the population in low-income economies experience food insecurity [8].

Evidence shows that the COVID-19 pandemic increased food insecurity in Mexico [9], South Asia [7], and the USA [10]. Similarly, 31% and 47% of the respondents faced food insecurity in South California and Brazil, respectively [11,12]. And in Bangladesh, moderate and severe food insecurity has risen by 30.9 and 2.6 percent points [13]. On the other hand, the study in Canada and Tehran shows that the prevalence of food insecurity was reduced, and specifically, in Tehran food secured households were increased from 35% (before the COVID-19) to 43% (during the COVID-19 outbreak) [14,15]. These results may be concluded only for relatively healthy populations [14].

In west Africa, *i.e.* Nigeria, the 1st wave of High-Frequency Phone Survey Household (HFPS-HH) data shows that households exposed to higher COVID-19 cases or lockdowns experience a significant increase in measures of food insecurity [5]. In East Africa, the first case of COVID-19 was reported in Kenya on March 13, 2020 [2]. The impact of COVID-19 on income and food security was studied in two East African countries, *i.e.* Kenya and Uganda [2]. Accordingly, household food insecurity shows 38% and 44% increments in Kenya and Uganda, respectively [2]. As a result of food shortage, increased food prices, and/or loss of income, global food insecurity alerts have been issued [6]. In 2019, over 27 million people in six IGAD member states (Ethiopia, Kenya, Somalia, South Sudan, Sudan, and Uganda) were classified in worsening food security [4].

Ethiopia faces several infectious and deadly diseases with higher mortality rates from Spanish flu (1918) [16] to COVID-19 (2019). Ethiopia has confirmed the first COVID-19 case on 13 March 2020. According to the Ethiopian Public Health Institute and Ministry of Health, a total of 133,767 cases and 2,066 deaths were reported on January 24, 2021 [17].

Food insecurity is a major issue of nations and the global development community. However, there is no clear understanding of the status and coping strategies of food-insecure households [18]. Measures of food security are pertinent where households are chronically vulnerable to deepening poverty, environmental and climatic shocks, rapid economic change, and conflict [3,4,19,20].

The impact of COVID-19 on food insecurity was studied using the web-based cross-sectional survey data [2,5,8,10,12,15,18] and repeated/longitudinal data [9,11,14]. This study also employed the six-round HFPS-HH dataset. However, determinants of food insecurity in more vulnerable populations during the COVID-19 have yet to be documented. This will help the nation's ability to respond to the major food security challenges and prepare for future chaos. Therefore, this study attempted to estimate the status and identify determinant factors associated with household food insecurity during the pandemic.

Methodology

Study area description

Ethiopia is situated between 33° - 48°E and 3° - 15°N and a landlocked nation in the Horn of Africa close to the Middle East and Red Sea market (Fig. 1). Ethiopia has a complex topography with massive highlands, rugged terrain, and low plains that ranges from 125 m below sea level at the Afar depression to 4,620 m above sea level at Ras Dejen mountain [21].

According to World Bank data, the country covers 1.1363 million Km^2 and have an estimated total population of 112 million (2019 estimate) (80% is rural resident dependent on rain-fed agriculture). This estimate increases by 2.6% annually and resides 96.7 people per Km^2 of land. This makes it the second-most populous country in Africa, next to Nigeria [22].

Temporally, the rainfall is concentrated in mid.-June to mid.-September. However, the spatial distribution ranges from 2276 mm at highland to 141 mm at the lowland areas, in case the mean annual value is 1200 mm. Subsequently, the country has an ample amount of water resources sheds into 8 river basins, one lake basin, and 3 dry basins. Moreover, the annual surface and groundwater potential of Ethiopia is estimated at 124.4 and 2.6 billion cubic meters (BCM), respectively, where only 3% of the surface flow is endorheic and the remaining leaves the country [21]. Rainfall variability, limited studies, financial capacity, and the transboundary nature of the water resources hinder its utilization for energy in specific and economic development in general.

The livelihood sources are mainly allied to agriculture (mixed crops and livestock) and forest-based activities. Agricultural expansion attributed to lower production and/or productivity, posing soil/land degradation is the leading cause of deforestation dwindling the country's forest resource which was 40% a century before to 15.7% in 2018 [23]. The net annual forest loss is estimated to be 73,000 ha/year, however, the annual report on rehabilitation is about 19,000 ha/year [23].

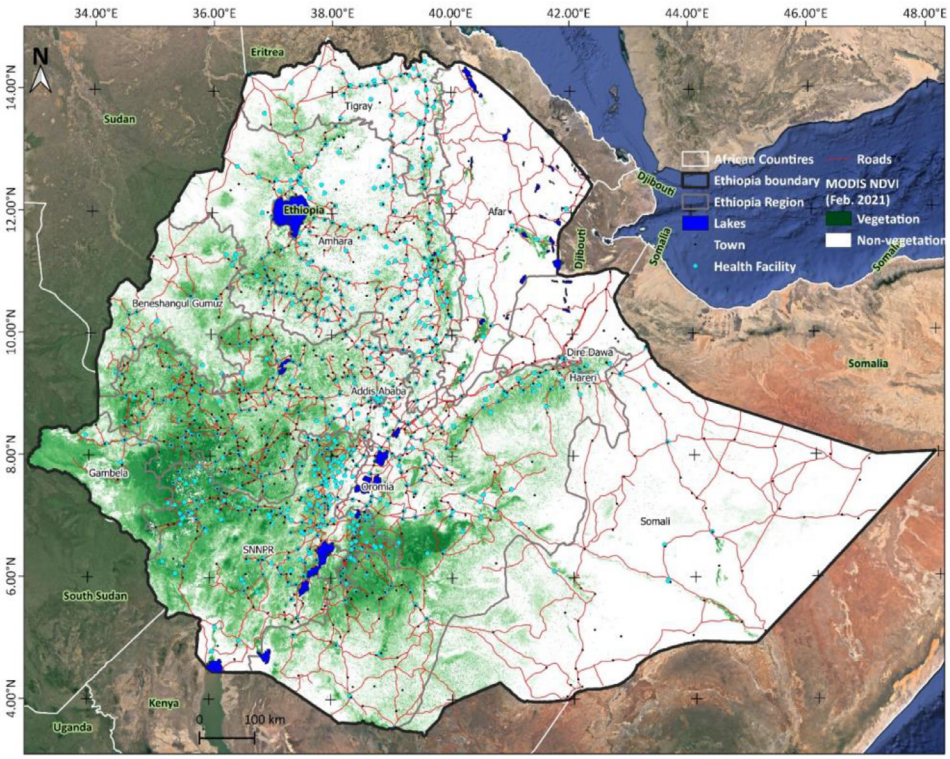

Figure 1. Location map of the study area. The background map is retrieved from Google Earth 2021; the MODIS NDVI map is accessed from https://earthexplorer.usgs.gov/; administrative, town, road, and health facility data were taken from Central Statistical Agency of Ethiopia (2016).

Table 1
Surveyed HH in all rounds

Round	Survey period	Surveyed HH
Round-1	end of April/beginning of May	3,249
Round-2	end of May/beginning of June	3,107
Round-3	June	3,058
Round-4	end of July/beginning of August	2,878
Round-5	end of August/beginning of September	2,770
Round-6	end of September/beginning of October	2,704

Source: www.microdata.worldbank.org

Data source and sampling procedure

Data source

The World Bank is implementing the Living Standards Measurement Study–Integrated Survey on Agriculture (LSMS-ISA) program to implement the High-Frequency Phone Survey of households (HFPS-HH) on the social and economic impacts of COVID-19 in five African countries. This study used the six-round panel data of HFPS-HH dataset that is nationally representative in both urban and rural areas of Ethiopia retrieved from the World Bank database (www.microdata.worldbank.org). The survey was conducted from April 2020 (round 1) to September 2020 (round 6) by the World Bank and Central Statistical Agency of Ethiopia [24]. The HFPS-HH was collected by calling a sample of households every three to four weeks over six months.

Sampling procedure

The High-Frequency Phone Survey (HFPS) is the sub-sample of the 2018/19 Ethiopian Socioeconomic Survey (ESS) collected from 7,527 households. Out of these households, only 5,374 households have their own personal and referred phone numbers (Appendix Table A1). To obtain the representative strata at the national, urban, and rural levels, the World Bank's LSMS-ISA project jointly with ESS has interviewed a total of 3,300 households (1300 rural and 2000 urban) (Table 1). Thus, 5,374 households were the sample frame for HFPS-HH.

In all rounds, the whole sample households were not addressed (Table 1). In this study, the households found in all rounds are filtered from the dataset and taken as panel data. It was aimed to obtain information about the dynamics of

Table 2
Pairwise comparison matrix of coping strategies for food insecurity

Coping strategies	A	B	C	D	E	F	G	Weight (%)
Unable to eat Healthy and nutritious/ preferred foods (A)	1	0.2	0.1	1	0.1	0.1	0.1	3.3
Ate only a few kinds of foods (B)	5	1	0.2	3	0.1	0.1	0.1	7.9
Skip a meal (C)	5	3	1	0.2	0.1	0.1	0.1	8.2
Ate less than you thought you should (D)	1	0.3	3	1	0.2	0.2	0.1	5.9
Went without eating for a whole day (E)	3	3	5	3	1	0.1	0.1	13.2
Ran out of food (F)	5	3	5	5	5	1	1	29.8
Hungry but did not eat (G)	5	5	5	5	5	1	1	31.6
Consistency Ratio								0.09

a household's behavior, increase the degree of freedom, and better detect and measure effects that cannot be observed in pure cross-sectional or pure time-series data [25]. Therefore, from the total of 3,300 surveyed households, 2,410 households that persisted in all rounds were considered for this study.

Copping strategy index (CSI)

Measuring food insecurity is a costly and complicated task [26]. Several methods are used to measure food insecurity [27,28]. Findings on the prevalence and severity of food insecurity are inconsistent and often depend on the measures used [18]. However, the Coping Strategies Index (CSI) measures behavior like the things that people do when they cannot access enough food which is quick and easy to administer, straightforward to analyze, and rapid enough to provide real-time information to program managers [26,29]. The CSI was developed as a context-specific indicator of food insecurity that counts up and weighs coping behaviors at the household level [19]. Generally, the CSI is a tool for an emergency and is used to monitor impacts on food insecurity [19].

The CSI needs to follow four distinct steps [26,29]. The first step is identifying the behavior of different coping strategies. The households have adopted seven different strategies to cope-up with their food insecurity issues during the outbreak (Table 2). In the second step, data on the frequency of coping strategies practiced by the households for the last 30 days were counted. Then, setting the severity and weighting the strategies comes at the third step. The severity level of the household's coping strategies was identified using focus group discussions (FGD) consisting of 6 to 8 community members [26,29]. Unfortunately, it was difficult to discuss with the respondents to determine the severity of the coping strategies they have adopted. Therefore, the researcher organized a team of experts on Rural Development and Agricultural Extension (two), Food Security and Development (two), Environment and Development Studies (two), Agricultural Economics (two), Food Security and Nutrition (two), Public Health and Rural Livelihoods (two) from Samara University. Referred their perception with existing literature, the discussant assigned an ordinal rank to each strategy. Then, a pairwise comparison technique was adapted to obtain the weight of an individual's behavior [19,27,29].

According to Maxwell [29], the seven food insecurity indicators were considered as coping strategies (Table 2). Then, the coping strategies were managed using Analytical Hierarchy Process (AHP). It consists of hierarchy construction, priority analysis, and consistency verification [30]. In the first stage, the pairwise matrix was built using a one-to-seven scale of relative importance and the pairwise comparison values were adjusted by the discussants and entered for each coping strategy (Table 2). Second, the pairwise adjustment was continued until the pairwise assessment is consistent (consistency ratio $\leq$ 10%) [30]. Afterward, the pairwise weight referring to the severity of coping strategies was obtained.

For this study, the phoned household was asked, "During the last 30 days, was there a time when you or any other adult in your household were worried about not having enough food to eat because of a lack of money or other resources? ". For the households who replay "yes" for the above question, we employed the following coping strategies during the survey periods (Table 2).

The last step of CSI is scoring/combining frequencies and severity. The weight/severity of each copping strategy was multiplied by the frequency of corresponding copping strategies for all strategies and then summed to obtain an overall score for the individual household food insecurity index. The coping mechanism varies due to the cultural and socio-economic factors of the community. The CSI score indicates whether household food security status is worsening or improving [19,29]. Therefore, the higher the CSI score refers to a greater level of food insecurity. Here, the CSI score increases with the severity of food insecurity.

Categorization of the prevalence of food insecurity

The categorization is strongly dependent on the choice of cutoff points [27]. The CSI and reduced CSI do not have universal thresholds for different categories of food insecurity [27]. Assigning cutoff points to a continuous quantitative measure is a matter of analytical judgment and can often be controversial [27]. Therefore, recent studies were sourced to develop a categorical rank of the prevalence of food insecurity [8,9,15,27]. Accordingly, the households were categorized as food secure (CSI score of 0); mild food insecurity (1-12); moderately food insecure (13-50), and severely food insecure ($\geq$51).

Statistical analysis and model specification

Descriptive statistics and model specification

Descriptive statistics were used to show the socioeconomic characteristics of the households. There are three most applied models for panel data; these are pooled OLS regression model, random-effect model, and fixed-effect model. Here, both model accounts for inter-temporal (i.e. dynamics of change) and individual differences and provides better control for an unobserved variable [25]. However, each model has its characteristics and the latter two models (random effect and fixed effect model) are mostly used by scholars. Pooled OLS regression model incorporates all observations together by neglecting the cross-sectional and time-series nature of the data while fixed effect and Random effect models allow the heterogeneity nature of each observation. The random and fixed-effect model differs from each other on the assumptions about the association of X_{it} and α_i. If it is assumed that α_i (individual intercept) and the X_{it} (regressors) are uncorrelated, the random-effect model may be appropriate, whereas if α_i (individual-specific intercept) and X_{it} (regressors) are correlated, the fixed-effect model may be appropriate. The random-effects model can provide separate estimates of the parameters on the time-invariant variables, while the fixed effect estimator cannot. Then, the Hausman test was undertaken to select the model that fits the data set [25].

Afterward, the random effect model was suitable and accepted for further analysis, and also all diagnostic tests were effected to check serial correlation in the residual. The general empirical random effect panel data model is specified in Eq. (1) as follows and analyzed using Stata software version 14.

$$Y_{it} = \alpha_1 + \beta X_{it} + \mu_{it} + e_{it} \tag{1}$$

Where, Y_{it} is the dependent variable (food insecurity index derived from the coping strategies index); α_1 is a common mean value of the intercept; X_{it} is the explanatory variable which determines food insecurity index of the household i at the time of t; β is a coefficient and μ_{it} is the between the error term and e_{it} is the within entity error term.

By incorporating all determinant variables, the empirical model of REM is stated below (Eq. 2)

$$FII_{it} = \alpha_i + \beta_1 AHH_{it} + \beta_2 FSA_{it} + \beta_3 ES_{it} + \beta_4 FIS_{it} + \beta_5 NFIS_{it} + \beta_6 WE_{it} + \beta_7 RC_{it} + \beta_8 RA_{it} + \beta_9 IPIS_{it} + \beta_{10} PSH_{it} + \beta_{11} GA_{it} + \beta_{12} ANGO_{it} + \mu_{it} + e_{it} \tag{2}$$

Description of the variables

The food insecurity index (FII): is a continuous variable that is computed based on the weighted value of each coping strategy multiplied by individual coping strategies response. Then the horizontal sum is performed for each household.

Age of household head (AHH) (Years): indicates the age of the household in years. The age of households has a negative association with food insecurity through access and dietary diversity [31]. Though we hypothesized that the age of a household would have been expected to negatively affect food insecurity.

Financial services access (FSA): is the variable that indicates whether the households get access to different financial services from financial intermediaries or not. Individuals who have access to financial service institutions are less likely to be food insecure [32]. Therefore, we would have been expected a negative association of access to financial service and food insecurity status of households.

Employment status (ES): is a dummy variable that takes a value of one, if the household is working in any government and non-government organization, and zero otherwise. Unemployment status in the USA shows a significant and positive effect on food insecurity [33]. Another report confirmed that being fully employed increases the chances of being food secure and higher household income eliminated food insecurity [18]. Similarly, the employment status of a household has been expected to pose a negative effect on food insecurity.

Farm income sources (FIS): is the variable that indicates the households participated in different farm income sources, like livestock, crop production, and other agriculture-allied activities. Farm income has more favorable nutrition effects than off-farm income [8,34]. Therefore, FIS is hypothesized to have a negative impact on food insecurity.

Non-Farm income sources (NFIS): is defined as the household's activities associated with wage work or self-employment in income-generating activities that are not agricultural, like construction, tourism, education, mining, etc. The study in Nigeria revealed that off-farm income has a positive effect on food security and nutrition [34]. Likewise, we have been expected a negative effect of NFIS on food insecurity.

Wage Employment (WE): is defined as the households participated in any paid job under contract to another person or organization in both the formal and informal economy. Studies confirmed that wage earner household is less likely affected by COVID-19 [2,15,35]. Hereafter, we hypothesized a negative association between WE and food insecurity.

Remittances from within Country (RC): it is defined as the household received money from their relatives or friends within the countries. Remittances help the household to lower anxiety about not being able to procure sufficient food and improve the ability to secure the adequate quality of food and lower experience of insufficient quantity of food intake [36]. Similarly, our hypothesis was allied to the negative effects of RC on food insecurity.

Remittances Abroad (RA): is defined as the household received money or goods from abroad, like diaspora communities or emigrants. Household's received remittance abroad are less affected by the COVID-19 [5]. In line with this, we have been expected a negative association between RA and food insecurity.

Table 3
Description of the variables in the regression models

Variable	Description & measurement	Expected Sign	Reference
Food insecurity index (FII)*	Continuous variable (Number)		
Age of household head (AHH)	Continuous variable (Year)	-tive	[31]
Financial services access (FSA)	Categorical variable (0=No; 1= Yes, and successfully received the service; 2= Yes, but did not receive the service)	-tive	[32]
Employment status (ES)	Dummy variable (0=No;1=Yes)	-tive	[2,33]
Farm income sources (FIS)	Dummy variable (0=No;1=Yes)	-tive	[8,34]
Non-Farm income sources (NFIS)	Dummy variable (0=No;1=Yes)	-tive	[34]
Wage Employment (WE)	Dummy variable (0=No;1=Yes)	-tive	[2,15,35]
Remittances from Within Country (RC)	Dummy variable (0=No;1=Yes)	-tive	[5]
Remittances Abroad (RA)	Dummy variable (0=No;1=Yes)	-tive	[5]
Income from Properties, Investments, and Savings (IPIS)	Dummy variable (0=No;1=Yes)	-tive	[37]
Pension Supported Household (PSH)	Dummy variable (0=No;1=Yes)	-tive	[38]
Government Assistance (GA)	Dummy variable (0=No;1=Yes)	-tive	[31]
Assistance from an NGO (ANGO)	Dummy variable (0=No;1=Yes)	-tive	[31]

Note
* indicates the dependent variable

Income from Properties, Investments, and Savings (IPIS): is the income of a household from their properties, investment, and saving in any financial institution. Income from current/savings was associated with reduced food insecurity of Ghanaian adults [37]. Therefore, we hypothesized that IPIS would have a negative association with food insecurity.

Pension Supported Household (PSH): refers to payments for households who retire from work in the form of periodic payments. The study in South Africa confirmed that an increase in pension income of 100 Rand is associated with a reduction in adults skipping meals of 3.5 percentage points [38]. Likely, we have expected that an individual who received a pension would be less affected by COVID-19.

Government Assistance (GA): refers to the support of the household (material and non-material support) by any government organization. In line with [31], we hypothesized that individuals assisted by the government would be better off than their counterparts.

Assistance from an NGO (ANGO): reference to the material and non-material support for the household by the non-governmental organization both domestic (i.e. local associations) and international organization. Study shows that financial and material support helped marginalized households to improve their food security during the COVID-19 pandemic [31]. Similarly, we have been expected a negative association between NGO assistance and food insecurity.

In summary, Table 3 describes the nature of the variable and the expected sign concerning food insecurity.

Results and Discussion

Descriptive statistics

Table 4 shows that 72.9% of the respondents are urban dwellers and the majority of the surveyed households are male-headed (69.4%).

Concerning the employment status of the households, 74.1% of the participants were employed. The minimum age of the surveyed household was similar from wave one to six. However, the maximum age was changed (98 and 99 in Round-1 and Round-6, respectively) (Table 4).

Prevalence of food insecurity

Table 5 shows the food-insecurity status of rural and urban households in the six rounds. Out of the 1,757 urban households, 1,363 (77.57%) are food secure at the end of April/beginning of May 2020 (Table 5). In addition, out of 653 surveyed households, 449 (68.7%) of them were food secure at the end of April/beginning of May 2020. At Round-2, 36.76% and 16.2% of urban households were food secure and moderately food insecure, respectively. From the total interviewed households, 35.52% of urban residents were food secure in June 2020 which shows decrement as compared with Round-1 and Round-2 (Table 5).

From the total surveyed households, 20.83% of urban households were mild food insecure in June 2020. At Round-4, 35.81%, 14.94%, and 13.57% of the rural households were food secure, moderate food insecure, and mild food insecure, respectively (Table 5). The urban households, who were in severe food insecurity status got worse at the end of May/beginning

Table 4
Households characteristics participated in HFPS

Item		Frequency	Percent	
Sectors	Rural	653	27.1	
	Urban	1757	72.9	
	Total	2410	100	
Household head	Male	1673	69.4	
	Female	737	30.6	
	Total	2410	100	
Employment status	Yes	1787	74.1	
	No	623	25.9	
	Total	2410	100	
Household Head Age (Round-1)	N	Minimum	Maximum	Mean
	2410	17	98	40.85
Household Head Age (Round-6)	N	Minimum	Maximum	Mean
	2410	17	99	41.49

Table 5
Household's food insecurity status (rural and urban)

Status	Sectors	Round-1 (N & %)	Round-2 (N & %)	Round-3 (N & %)	Round-4 (N & %)	Round-5 (N & %)	Round-6 (N & %)
Food secure	Rural	449 (18.63)	236 (9.79)	237(9.83)	252 (10.46)	266 (11.04)	267 (11.08)
	Urban	1363 (56.55)	886 (36.76)	856(35.52)	863 (35.81)	860 (35.68)	919 (38.13)
Mild food	Rural	-	119 (4.94)	214(8.88)	135 (5.60)	145 (6.02)	147 (6.10)
insecure	Urban	-	262 (10.87)	502(20.83)	327 (13.57)	359 (14.90)	330 (13.69)
Moderately food	Rural	116 (4.8)	207 (8.59)	202(8.38)	199 (8.26)	170 (7.05)	162 (6.72)
insecure	Urban	230 (9.57)	386 (16.02)	399(16.56)	360 (14.94)	355 (14.73)	335 (13.90)
Severe food	Rural	88 (3.65)	91 (3.78)	-	67 (2.78)	72 (2.99)	77 (3.20)
insecure	Urban	164 (6.80)	223 (9.25)	-	207 (8.59)	183 (7.59)	173 (7.18)
Total		2410 (100)	2410 (100)	2410 (100)	2410 (100)	2410 (100)	2410(100)

Note: N refers to the number (count) of households

of June 2020 and the end of July/beginning of August 2020. Indeed, 35.68%, 14.90%, and 14.73% of urban households were classified as food secure, mild food insecure, and moderately food insecure, respectively, during the end of August/beginning of September 2020 (Table 5). At the end of September/beginning of October (2020), 38.13% and 13.90% of urban households were food secure and moderately food insecure, respectively. Similarly, a report in Pakistan showed that food insecurity among households has increased 44.2% due to the COVID-19 pandemic [31].

In the Appendix (Table B1-B5), the diagonal figures indicate the portion of households that shows persistent in their food security status in all rounds. Households' food security status was not steady over time. On average, 38.4% of 449 households in rural and 48.3% of 1363 households in urban are food secure in all rounds. Therefore, the pandemic exacerbated existing disparities in food insecurity, which will persist after the pandemic.

Determinants of food insecurity over time

Access to financial service possesses a negative association with the status of food insecurity at the 1% level of significance (Table 6). It implies that the food insecurity status of households who have access to financial services decreased by 10.090 indexes than their counterparts. Financial institutions help to provide a way to maintain or improve the quality of life for households in the face of uncertainty like COVID-19. Gaining access to financial services (like credit, withdrawing, saving/deposit) from financial institutions helps in building the confidence to face the challenge. Through financial services, farmers can easily purchase their daily consumption bundles and agricultural inputs. Similarly, urban inhabitants also make transactions and ease their life. Studies also confirmed that financial services reduced households' food insecurity related to hunger and skipping meals and help to put themselves in a better food security status [32,33,37,39].

The food insecurity index for households having farm income sources was reduced by 3.798 as compared to households with no farm income source. The rationale is that the agriculture sector is not much affected by the lockdown and social distancing measures during the pandemic. Therefore, households with different farm incomes help themselves to diversify food variety and reduce the level of food insecurity. Studies also attested that farm income plays a strategic role in reducing the risk of food insecurity by improving food availability and favorable nutrients [3,8,34].

The REM model output shows that there is a significant and negative association between wage employment and household food insecurity. During the pandemic, employed households are more advantageous to purchase food-related commodities in need and, therefore, it reduces the status of being food insecure. This is consistent with the findings in the USA,

Table 6
Determinants of food insecurity over time (random effect panel data model)

Food Insecurity Index	Coefficient	SE
Age Of Household Head	-0.024	0.059
Needed Financial Services Access	-10.090***	1.591
Employment Status	-2.038	1.851
Farm Income Sources	-3.798**	1.981
Non-Farm Income Sources	-2.845	1.952
Wage Employment	-6.067***	1.742
Remittances From Within Country	0.591	3.250
Remittances From Abroad	1.293	4.234
Income From Properties, Investments & Savings	-9.855***	2.419
Pension Supported Household	-4.366	3.467
Government Assistance	7.192**	3.749
Assistance From Ngo	-14.987**	7.133
Constant Term	25.853***	3.121
Random-Effects GLS Regression	Number of observations =14448	
Group Variable: Household Id.	Number of groups =2185	
R-Square: within = 0.0013	Observation per group: min =1	
Between = 0.044	Average =6.6	
Overall = 0.008	Maximum =36	
	Wald chi2(12) =110.32	
Correlation (U_I, X) = 0 (Assumed)	Probability > chi2 =0.0000	
Sigma_U	9.766	
Sigma_E	87.628	
RHO	0.123 (fraction Of variance due to u_i)	
Hausman Test	Test: Ho: Difference in Coefficients Not Systematic Chi-square (12) = (b-B)'[(V_b-V_B) ^ (-1)] (b-B) = 40.63 Probability >chi-square = 0.0001	

SE standard error
*** Statistically significant at $p < 0.01$
** statistically significant at $p < 0.05$; *statistically significant at $p < 0.1$.

Kenya, and Uganda, depicting that the prevalence of food insecurity was higher among the unemployed households and there is a negative relationship between wage employment and food insecurity [2,10,15,33,35].

Households earning income from properties, investment, and saving have a significant and negative relationship with the level of food insecurity. To reduce the risk of food insecurity and improve economic performance, households sold out assets or withdraw saved income as a coping strategy in the era of COVID-19. Similarly, household assets and savings are an important source of food security not only in a peaceful environment but also used to withstand any economic shocks [15,37,39].

Contrary to the hypothesis, government support is associated with the worsening food insecurity status of the households. The plausible agreement is that the government support is intended to respond to urgent incidents where the root causes of food insecurity and sustainability of the support are not in concern. Similarly, during the pandemic, the report in Pakistan confirmed that the financial aid obtained from the government was negatively and significantly associated with the food insecurity status of the households [31]. On the other hand, different kinds of assistance from NGOs depicted a significant and negative association with the food insecurity status of households by 14.987 indexes than their counterparts. Before socio-economic shocks, NGOs are primarily working on economic empowerment and asset-building activities of households in need other than emergency response. Therefore, during the pandemic, the households can reinforce food and income sources. The study conducted in Pakistan also revealed that households who received income support from charity organizations can improve their livelihood gaps and reduce the risk of food insecurity [31].

Conclusion

This study analyzed the status and determinants of households' food insecurity in the era of the COVID-19 pandemic using HFPS-HH panel data. The descriptive statistics show that rural households were more food insecure than urban households in comparison between Round-1 and Round-6. The average number of households that persisted food secure in all-round accounted for 38.4% from 449 households in rural and 48.3% from 1363 in urban dwellers. However, 3.2% of rural households and 7.18% of urban households were moved to a severe level of food insecurity at the 6th Round. Here, food-secure households are gradually reduced from Round-1 to Round-6. Explicitly, an extended lockdown and related measures taken to reduce the spread of the pandemic worsened the food insecurity status of both urban and rural dwellers.

The random effect model result shows that farm income and NGO assistance have revealed a negative and significant association with food insecurity ($p<0.005$). In further, access to financial services, wage employment, and

income from properties, investment, and saving affected the food insecurity of households negatively and significantly ($p<0.01$). On the other hand, government assistance has a positive association with household food insecurity ($p<0.05$).

Based on the findings, we recommend that the government and stakeholders of the financial intermediaries should fasten the accessibility of their financial services to enhance income and meal diversification of households. In additions, households are ought to adopt the behavior of enhancing and diversifying their source of income to face the challenges of different socioeconomic catastrophes. The government also have to establish national social security services like emergency response through taking experience related to livelihood development planning and execution from the NGOs.

Contributors

All authors contributed equally

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Declaration of Competing Interest

None.

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Appendix: Household food insecurity transition matrix over all rounds

Table A1
Households participated in 2018/19 socioeconomic survey

Region	Urban Sample EAs	Sample HH	Rural Sample EAs	Sample HH	Total Sample EAs	Sample HH
Tigray	19	285	35	420	54	705
Afar	15	225	31	372	46	597
Amhara	19	285	43	516	62	801
Oromia	20	300	45	540	65	840
Somali	17	255	36	432	53	687
Benishangul Gumuz	16	240	30	360	46	600
SNNP	18	270	42	504	60	774
Gambela	20	300	22	264	42	564
Hareri	24	360	18	216	42	576
Addis Ababa	53	795	-	-	53	795
Dire Dawa	28	420	14	168	42	588
Ethiopia	249	3,735	316	3,792	565	7,527

Table B.1
Round-1 to Round-2 transition

	Round 1						
			0	1	2	3	Total
Round 2	0	Rural	**204**	0	20	9	233
		Urban	**789**	0	75	25	889
	1	Rural	104	**0**	7	9	120
		Urban	223	**0**	19	19	261
	2	Rural	96	0	**65**	50	211
		Urban	257	0	**85**	40	382
	3	Rural	39	0	24	**26**	89
		Urban	100	0	51	**74**	225
		Total	1812	0	346	252	

Table B.2
Round-2 to Round-3 transition

			Round 2				
			0	1	2	3	Total
Round 3	0	Rural	**147**	51	27	8	233
		Urban	**622**	106	100	32	860
	1	Rural	50	**45**	71	44	210
		Urban	156	**96**	125	129	506
	2	Rural	36	24	**113**	37	210
		Urban	111	59	**157**	64	391
	3	Rural	0	0	0	**0**	0
		Urban	0	0	0	**0**	0
		Total	1122	381	593	314	

Table B.3
Round-3 to Round-4 transition

			Round 3				
			0	1	2	3	Total
Round 4	0	Rural	**160**	61	27	0	248
		Urban	**560**	171	136	0	867
	1	Rural	33	**64**	33	0	130
		Urban	141	**115**	76	0	332
	2	Rural	33	55	**114**	0	202
		Urban	110	123	**124**	0	357
	3	Rural	7	30	36	**0**	73
		Urban	49	97	55	**0**	201
		Total	1093	716	601	0	

Table B.4
Round-4 to Round-5 transition

			Round 4				
			0	1	2	3	Total
Round 5	0	Rural	**170**	47	36	9	262
		Urban	**632**	102	85	45	864
	1	Rural	40	**56**	40	11	147
		Urban	108	**153**	75	21	357
	2	Rural	26	22	**101**	23	172
		Urban	97	54	**152**	50	353
	3	Rural	12	5	25	**30**	72
		Urban	30	23	45	**85**	183
		Total	1115	462	559	274	

Table B.5
Round-5 to Round-6 transition

			Round 5				
			0	1	2	3	Total
Round 6	0	Rural	**180**	40	42	5	267
		Urban	**686**	126	85	22	919
	1	Rural	39	**72**	29	7	147
		Urban	90	**160**	66	14	330
	2	Rural	34	28	**82**	18	162
		Urban	72	61	**164**	38	335
	3	Rural	9	7	19	**42**	77
		Urban	16	10	38	**109**	173
		Total	1126	504	525	255	

Note: 0: Food secure; 1: Mild food insecure; 2: Moderate food insecure; 3: Severe food insecure

Reference

[1] WHO, Archived : WHO Timeline COVID-19, (2020). https://www.who.int/news/item/27-04-2020-who-timeline-covid-19o6gIVyyMrCh2JRgUIEAAYASAAEgLo3_D_BwE.
[2] M.K. Kansiime, J.A. Tambo, I. Mugambi, M. Bundi, A. Kara, C. Owuor, COVID-19 implications on household income and food security in Kenya and Uganda: Findings from a rapid assessment, World Dev 137 (2021), doi:10.1016/j.worlddev.2020.105199.
[3] UN, Impact of COVID-19 on food security and nutrition (FSN):Policy Brief, 2020. http://www.ceigram.upm.es/wp-content/uploads/2020/03/HLPE.-Impact-of-COVID-19-on-FSN-2020-03-24.pdf.

[4] FSIN, Global Report on Food Crises((GRFC 2020), 2020. https://www.fsinplatform.org/sites/default/files/resources/files/GRFC_2020_ONLINE_200420.pdf.
[5] M. Amare, K.A. Abay, L. Tiberti, J. Chamberlin, Impacts of COVID-19 on Food Security Panel Data Evidence from Nigeria, 2020.
[6] G. Paslakis, G. Dimitropoulos, D.K. Katzman, A call to action to address COVID-19-induced global food insecurity to prevent hunger, malnutrition, and eating pathology, Nutr. Rev. 79 (2021) 114–116, doi:10.1093/nutrit/nuaa069.
[7] G. Rasul, Twin challenges of COVID-19 pandemic and climate change for agriculture and food security in South Asia, Environ. Challenges 2 (2021) 100027, doi:10.1016/j.envc.2021.100027.
[8] M.D. Smith, M.P. Rabbitt, A. Coleman-Jensen, Who are the World's Food Insecure? New Evidence from the Food and Agriculture Organization's Food Insecurity Experience Scale, World Dev 93 (2017) 402–412, doi:10.1016/j.worlddev.2017.01.006.
[9] P. Gaitán-Rossi, M. Vilar-Compte, G. Teruel, R. Pérez-Escamilla, Food insecurity measurement and prevalence estimates during the COVID-19 pandemic in a repeated cross-sectional survey in Mexico, Public Health Nutr 24 (2021) 412–421, doi:10.1017/S1368980020004000.
[10] J. Soldavini, H. Andrew, M. Berner, Characteristics associated with changes in food security status among college students during the COVID-19 pandemic, Soc. Behav. Med. (2020) 1–10, doi:10.1093/tbm/ibaa110.
[11] J. Raifman, J. Bor, A. Venkataramani, Unemployment insurance and food insecurity among people who lost employment in the wake of COVID-19, MedRxiv (2020) 1–22, doi:10.1101/2020.07.28.20163618.
[12] C.V. Manfrinato, A. Marino, V.F. Condé, E.S. Maria do Carmo Pinho Franco, L.Y. Tomita, High prevalence of food insecurity, the adverse impact of COVID-19 in Brazilian favela, MedRxiv Prepr (2020), doi:10.1101/2020.07.31.20166157.
[13] J.D. Hamadani, M.I. Hasan, A.J. Baldi, S.J. Hossain, S. Shiraji, M.S.A. Bhuiyan, S.F. Mehrin, J. Fisher, F. Tofail, S.M.M.U. Tipu, S. Grantham-McGregor, B.A. Biggs, S. Braat, S.R. Pasricha, Immediate impact of stay-at-home orders to control COVID-19 transmission on socioeconomic conditions, food insecurity, mental health, and intimate partner violence in Bangladeshi women and their families: an interrupted time series, Lancet Glob. Heal 8 (2020) e1380–e1389, doi:10.1016/S2214-109X(20)30366-1.
[14] B. Lamarche, D. Brassard, A. Lapointe, C. Laramée, M. Kearney, M. Côté, A. Bélanger-Gravel, S. Desroches, S. Lemieux, C. Plante, Changes in diet quality and food security among adults during the COVID-19–related early lockdown: results from NutriQuébec, Am. J. Clin. Nutr. (2021) 1–9, doi:10.1093/ajcn/nqaa363.
[15] M.R. Pakravan-Charvadeh, F. Mohammadi-Nasrabadi, S. Gholamrezai, H. Vatanparast, C. Flora, A. Nabavi-Pelesaraei, The short-term effects of COVID-19 outbreak on dietary diversity and food security status of Iranian households (A case study in Tehran province), J. Clean. Prod. 281 (2021) 124537, doi:10.1016/j.jclepro.2020.124537.
[16] Y. Kitaw, M. Kaba, A Century after Yehedar Besheta (The Spanish Flu in Ethiopia): Are We Prepared for the Next Pandemic? Ethiop. J. Heal. Dev. 32 (2018) 59–62.
[17] EPHI and MoH, Ethiopia COVID-19 Pandemic Preparedness and Response in Ethiopia, EPHI Wkly. Bull. (2021) 39 https://www.ephi.gov.et/images/novel_coronavirus/EPHI_-PHEOC_COVID-19_Weekly-bulletin_1_English_05042020.pdf.
[18] M.D. Smith, W. Kassa, P. Winters, Assessing food insecurity in Latin America and the Caribbean using FAO's Food Insecurity Experience Scale, Food Policy 71 (2017) 48–61, doi:10.1016/j.foodpol.2017.07.005.
[19] D. Maxwell, R. Caldwell, M. Langworthy, Measuring food insecurity: Can an indicator based on localized coping behaviors be used to compare across contexts? Food Policy 33 (2008) 533–540, doi:10.1016/j.foodpol.2008.02.004.
[20] S. Abebaw, T. Betru, A Review on Status and Determinants of Household Food Security in Ethiopia, Ethiop. J. Environ. Stud. Manag. 12 (2019) 497–508.
[21] B. Berhanu, Y. Seleshi, A.M. Melesse, SurfaceWater and Groundwater Resources of Ethiopia: Potentials and Challenges ofWater Resources Development, in: A.M. Melesse, W. Abtew, S.G. Setegn (Eds.), Nile River Basin Ecohydrol. Challenges, Clim. Chang. Hydropolitics, Springer International Publishing Switzerland, 2015, pp. 97–117, doi:10.1007/978-3-319-02720-3.
[22] World BankWorld Development Indicators - Country profile: Ethiopia, World Bank, 2021 https://databank.worldbank.org/ (accessed June 6, 2021).
[23] FAO, Global Forest Resources Assessments (FRA) Report, Ethiopia, Rome, Italy, 2020.
[24] CSA and World Bank, Ethiopia Socioeconomic Survey (ESS) Baseline Basic Information Document, Addis Ababa, Ethiopia, 2021.
[25] D.N. Gujarati, Basic Econometrics, The McGraw−Hill Companies, 2004.
[26] CARE/WFP, The Coping Strategies Index: Field Methods Manual, Nairobi, Kenya, 2003.
[27] D. Maxwell, B. Vaitla, J. Coates, How do indicators of household food insecurity measure up ? An empirical comparison from Ethiopia, J. Food Policy 47 (2014) 107–116, doi:10.1016/j.foodpol.2014.04.003.
[28] C. Carletto, A. Zezza, R. Banerjee, Towards better measurement of household food security : Harmonizing indicators and the role of household surveys, Glob. Food Sec. 2 (2013) 30–40, doi:10.1016/j.gfs.2012.11.006.
[29] D.G. Maxwell, Measuring food insecurity: The frequency and severity of "coping strategies,", Food Policy 21 (1996) 291–303, doi:10.1016/0306-9192(96)00005-X.
[30] T.L. Saaty, Decision making with the analytic hierarchy process, Int. J. Serv. Sci. 1 (2008), doi:10.1504/IJSSci.2008.01759.
[31] M.A. Shahzad, P. Qing, M. Rizwan, A. Razzaq, M. Faisal, COVID-19 Pandemic, Determinants of Food Insecurity, and Household Mitigation Measures : A Case Study of Punjab, Pakistan, Healthcare 9 (2021) 1–17, doi:10.3390/healthcare9060621.
[32] R. Baborska, E. Hernandez-Hernandez, E. Magrini, C. Morales-Opazo, The impact of financial inclusion on rural food security experience: a perspective from low-and middle-income countries, Econ. Policy (2017) 0–33.
[33] J. Birkenmaier, J. Huang, Y. Kim, Food Insecurity and Financial Access during an Economic Recession: Evidence from the 2008 SIPP, J. Poverty 20 (2015) 194–213, doi:10.1080/10875549.2015.1094767.
[34] R.O. Babatunde, M. Qaim, Impact of off-farm income on food security and nutrition in Nigeria, Food Policy 35 (2010) 303–311, doi:10.1016/j.foodpol.2010.01.006.
[35] A. Mokari-Yamchi, A. Faramarzi, A. Salehi-Sahlabadi, M. Barati, D. Ghodsi, M. Jabbari, A. Hekmatdoost, Food security and its association with social support in the rural households a cross sectional study, Prev. Nutr. Food Sci. 25 (2020) 146–152, doi:10.3746/pnf.2020.25.2.146.
[36] A. Rahman, S. Mishra, Does Non-farm Income Affect Food Security? Evidence from India, J. Dev. Stud. 56 (2020) 1190–1209, doi:10.1080/00220388.2019.1640871.
[37] R.M. Gyasi, D.R. Phillips, A.M. Adam, How Far Is Inclusivity of Financial Services Associated With Food Insecurity in Later Life? Implications for Health Policy and Sustainable Development Goals, J. Appl. Gerontol. 40 (2021) 189–200, doi:10.1177/0733464820907441.
[38] A. Case, A. Menendez, Does money empower the elderly? Evidence from the Agincourt demographic surveillance site, South Africa, Scand. J. Public Health 35 (2007) 157–164, doi:10.1080/14034950701355445.
[39] T.A. Sisha, Household level food insecurity assessment: Evidence from panel data, Ethiopia, Sci. African 7 (2020), doi:10.1016/j.sciaf.2019.e00262.