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*Exploring Disparate Effects of the Covid-19 Pandemic and its  
Containment Measures on Food Security within Ethiopia*

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## Abstract

Covid-19 affects food security of households through different pathways. Several studies from many developing countries, including Africa, show that the pandemic has had heterogeneous impacts on food security across various groups of households, livelihood options and sectors in the economy. This study aims to examine the trajectory of and potentially differential impacts of the early days of the pandemic on food security, outcome variable, in Ethiopia along households' location or sectors, ownership of assets and varying livelihoods and income sources. Also, the government's containment measures such as movement restrictions within the country, curfew or lockdown, and closure of non-essential businesses, are the key explanatory and indicator variables in the estimation. Using the World Bank's nationally representative harmonized panel data on households drawn from the high frequency phone survey (HFPS), the study undertakes fixed effects regression. The results indicated that the Covid-19 pandemic had a statistically significant impact on overall food insecurity in Ethiopia and households have experienced a declining trend in food insecurity along the survey rounds. Within country travel restriction has a statistically significant and heterogeneous impact on the outcome variable, i.e. probability of households' being moderately/severely food insecure. Households who had rental income sources were significantly exposed to food insecurity due to the pandemic. Moreover, the results identified the significant heterogeneity of the impacts between households with and without receiving remittance and assistance. The finding suggests the important role of social protection in guarding households from deteriorating trajectory of food insecurity during the pandemic in the short term. Overall, the paper determined that mobility restriction, ownership of land, rental income, remittance, and assistance are statistically significant indicators of heterogeneity of the pandemic's impacts on food security. Finally, it points that the findings of can be used to informing short term and medium-term policy responses and interventions by the government of Ethiopia and international donor organizations.

**Keywords:** Covid-19; pandemic; probability; impacts; food insecurity; heterogeneity; livelihood

## 1. Background

Covid-19 pandemic represents an unprecedented social and economic disruption in the modern history of the world. One of the most striking observations during these difficult times has been the extremely diverse performance across countries in containing the pandemic and the economic outcomes that have ensued (Penas et al., 2022). Amare et al. (2020) indicated that the World Bank had forecasted that Covid-19 pandemic was highly likely to push more than 49 million people into extreme poverty in 2020 and beyond. Among this figure, greater than 45 percent of these people are in Sub-Saharan Africa, implying that the region would be hit hardest in terms of increased extreme poverty. The United Nations World Food Programme had estimated that the number of people globally facing acute food insecurity would almost double by the end of 2020 (about 135 million people before the crisis), due to income and remittance losses, and disruption of food systems associated with the pandemic (WFP, 2020a; WFP, 2020b).

Covid-19 could affect food security of households through different pathways. For instance, lockdowns and social distancing measures can adversely affect incomes by reducing economic and livelihood activities, which directly affect food security. Several studies in different countries show that the pandemic has had heterogeneous impacts on various livelihood options and sectors (Amare et al., 2020). For instance, livelihoods and sectors that can operate on a remote basis with limited personal interactions or those functionally dependent on the internet are likely to be less affected, relative to those involving personal interactions (Abay et al., 2020). Similarly, some livelihood options and sectors are likely to experience a relatively higher disruption in economic activities. For instance, government-imposed mobility restrictions and shutdowns often disrupt supply chains, which may prove the most challenging for small businesses with smaller stock. Thus, those households relying on non-farm business activities are likely to experience disproportionately higher impacts associated with disruptions in value chains caused by the pandemic and related mobility restrictions (Amare et al., 2020).

Immediately after the first Covid-19 case was observed in mid-March 2020 in Ethiopia, the Government has put in place a range of measures to mitigate the economic impact of the pandemic, while aiming at containing transmission. Right after the first few cases of were detected, the government implemented a state of emergency, and adopted a comprehensive

Covid-19 NERP to ensure that efforts to fight the crisis are comprehensive and well-coordinated. Specifically, Ethiopia implemented surveillance at borders, conducted contact tracing, established designated quarantine facilities, ensured the supply of drugs and protective equipment, and embarked on several communication efforts to raise awareness on how to deal with the virus (Batana et al., 2021).

In order to contain transmission of the pandemic, the government put measures such as restrictions within country travel, restriction on international travel, limit on social gatherings, curfew or lockdown, closure of non-essential businesses, and closure of schools and universities, among others. To mitigate impacts on people and firms, authorities announced several economic measures, including additional expenditure on healthcare, provision of emergency food to the vulnerable, tax and social security payment deferrals, and liquidity injections and extension of forbearance measures in the financial sector. Covid-19 has brought devastating economic impacts to low - and middle - income countries. The containment measures implemented by the governments to prevent the spread of the virus, such as the orders of lockdowns, the closure of non-essential businesses, and social distancing, have resulted in employment and income loss among people with limited coping strategies. Moreover, Covid-19 exacerbated existing inequalities and those who were disadvantaged before the pandemic, such as women, youth, and low-skilled workers, have experienced even greater challenges (Bundervoet et al., 2021).

These lockdowns and restrictions are expected to disrupt food supply chains and community services, and social protection programs, which ultimately positively affect food prices. Decreased import of basic stuffs due to restriction of international travel could raise process and be an added financial burden that directly affects food security of households. Besides, national and state-level restrictions and lockdowns would affect food transportation within the country, with clear implications on food supply and consequently, on food prices (Amare et al., 2020). Obviously, this would bring significant repercussions on food insecurity in the country, particularly in poorer and vulnerable urban households.

One of the most salient features of the economic impacts of the pandemic and respective policy interventions is the asymmetry along several dimensions. The actions taken by agents and policymakers have resulted in very different economic effects across sectors and regions (Cerezo

et al., 2021). Studies have revealed that the impacts of the Covid-19 pandemic on household incomes, food security and welfare have been uneven across space, gender, and livelihood options. It has been widely observed that the pandemic more severely affected urban households, many of whom are informal, self-employed, or casual workers, in many low- and medium-income countries (Batana et al 2012; Bundervoet et al 2021). Economic effects of such a pandemic disproportionately impact members of the society, depending on their socio-economic status, livelihood strategies, access to markets, etc. Thus, it is important to understand the household level impacts and support mechanisms that can be enhanced to ensure income smoothing (Kansiime et al., 2021).

In Ethiopia, Covid-19 has affected economic activity with significant adverse effects on employment, particularly at the onset of the pandemic (Batana et al., 2021). The same study has also shown the existence of spatial heterogeneity on impacts of Covid-19, in which households in large towns faced a higher chance of reduced labor incomes. The pace of recovery among female-headed households has been slow in terms of labor incomes, particularly in large towns. Self-employed households experienced severer income loss in earlier rounds, but they recovered fast in terms of the probability of further reducing labor incomes both in small and large towns. Also, poor households experienced severer income shocks in the early rounds, and those in larger towns still had a higher probability of income loss even in the future.

The pandemic is likely to disproportionately exacerbate food insecurity in those areas or household with preexisting vulnerabilities to food security likely to be magnified. Impacts are expected to be most severe for poorer households in both rural and urban areas (Ravallion et al., 2020). Additionally, the impact of Covid-19 is also expected to vary across livelihood options, with those activities that require face-to-face interactions likely to experience a significant loss in demand (Abay et al., 2020; Amare et al., 2020). Furthermore, value chain disruptions may extend deeply into rural areas, affecting both input supply and output demand for farming households and affecting the income of those employed in both forward and backward agricultural value chains (Amare et al., 2020; Reardon et al., 2020a). Closure or disruption of informal food markets, where the poor obtain the majority of their food, may be more severe in extent and food security impacts (Devereux et al., 2020; Barrett, 2020).

Beside the limited number of studies conducted in Ethiopia on the impacts of the pandemic, those available are skewed to analyzing its household level total income, labor income and partly on macroeconomic effects. Also, less is known about the asymmetric or disproportionate effects of the pandemic on Ethiopian households' food security situations. It is, therefore, against to these background that this study is motivated. It intends to shed light on the issue using a household level survey panel data. In particular, the paper aims to explore the potential heterogeneity in the impacts of Covid-19 on households' food security in Ethiopia along various socioeconomic characteristics of households and location dimensions. Alongside, it will examine the impacts of three Covid-19 containment measures (within-country travel restriction, curfew and closure of non-essential businesses) on household's food security.

## **2. Objectives of the Study**

The main objective of the study is examining the trajectory of the impacts of Covid-19 pandemic on households' food security situation in Ethiopian. Specifically, it aims to explore the trends of the impact of the pandemic on food security across the five survey rounds. Also, it aims to examine if the impact is heterogeneous across key explanatory and indicator variables. Finally, it intends to forward relevant policy implications.

## **3. Review of the Empirical Literature**

Since the onset of the Covid-19, many researches have been conducted and published on the multi-dimensional impact of the disease across the globe both in the developed and developing countries. For the purpose of substantiating the rational of making this study and also informing development of methodology for this study, a brief review of few empirical literatures on the impacts of the pandemic at international, regional and national level is conducted.

Bundervoet et al. (2021) combines data from high-frequency surveys with data on the stringency of containment measures to examine the short-term impacts of the Covid-19 pandemic on households in developing countries. Using data from 34 countries, accounting for a combined population of almost 1.4 billion, it runs logistic regressions of four main indicators on a set of explanatory variables and country or region dummies. The dependent variable includes stop

working, income loss, food insecurity, or continued learning. And, the vector of respondent and household characteristics mediating the impact of the COVID-19 shock, consists of age, gender, and education of the respondent, pre-pandemic sector of employment of the respondent, rural vs. urban location of the household and whether there are school-aged children in the household. It also includes country dummies and pick up all observed and unobserved country-level characteristics that may influence the outcome of interest.

The findings show that in the average country, 36% of respondents stopped working in the immediate aftermath of the pandemic, over 64% of households reported decreases in income, and over 30 % of children were unable to continue learning during school closures. Pandemic-induced loss of jobs and income translated into heightened food insecurity at the household level. The same study mentioned that the pandemic's effects were widespread and highly regressive, disproportionately affecting vulnerable segments of the population. It asserts the existence of heterogeneous impacts of the pandemic across women, youth, and lower-educated workers, who are significantly more likely to lose their jobs and experience decreased incomes. Self-employed and casual workers bore the brunt of the pandemic-induced income losses. Interruptions in learning were most salient for children in lower-income countries, and within countries for children in lower-income households with lower-educated parents and in rural areas. The unequal impacts of the pandemic across socioeconomic groups risk cementing inequality of opportunity and undermining social mobility and call for policies to foster an inclusive recovery and strengthen resilience to future shocks.

Using China's household finance survey data, Liu et al. (2020) explored the impact of Covid-19 on Chinese household consumption through ordinary least square (OLS) method. Several household and individual level control variables are included in the estimation. To capture the impact of inherent differences or heterogeneity (such as cultural environment, regional consumption habits, and savings preferences) at the regional level on household consumption, the study controlled for the city-level fixed effect. It finds that there was a significant decline in household consumption during the outbreak period. Heterogeneity analysis shows that the pandemic suppresses consumption in urban households, and rural households are, however, less affected. Moreover, mobile payment promotes urban household consumption during the pandemic, while rural households remain unaffected.



Through a computable general equilibrium model-based simulation, Kabir et al. (2021) assesses the gender dimensions of the impact of Covid-19 on economic outcomes, that is, labor force participation, employment, wages, and earnings. Using the 2020 high-frequency phone survey in Chad, the study applied a probit model to determine if differences in binary outcomes between female and male-headed households. For household income reduction, it constructed binary variables for the decline in household income from any source and for each income source: wage employment, non-farm enterprise income, farm income, remittance. The findings show that the Covid-19 pandemic brings disproportionately higher negative impact on women in urban areas. The situation is potentially dire, especially in service sectors, where most women are employed in urban areas. Moreover, the pandemic has notably impacted the households' income from enterprises and suggests that this negative impact is more prevalent for female-headed households. Although male- and female-headed households are using common coping strategies during the pandemic, female-headed households in rural and urban areas have been more reliant on aid from family and friends and less reliant on savings, credit, or the sale of assets.

Consolazio et al. (2021) assessed the role of five area level indicators in shaping the risk of contagion in the provinces of Milan and Lodi (Lombardy, Italy), namely: educational disadvantage, unemployment, housing crowding, mobility, and population density. Data on Covid-19 patients from the Integrated Data warehouse were used and matched with aggregate-level data from the National Institute of Statistics. Multilevel logistic regression models were used to estimate the association between the census block-level predictors and Covid-19 infection, independently of age, sex, country of birth, and preexisting health conditions. All the variables were significantly associated with the outcome, with different effects before and after the lockdown and according to the province of residence. This suggests a pattern of socioeconomic inequalities in the outbreak, which should be taken into account in the eventuality of future epidemics to contain their spread and its related disparities.

Bloem & Farris (2022) have conducted a review of findings from the emerging microeconomic literature on observed changes in food insecurity associated with the Covid-19 pandemic. To do so, the paper focuses on studies in low- and middle-income countries that include household survey data measuring food insecurity collected both before and after the onset of the Covid-19 pandemic. Initially, it focuses on several studies—seven from countries in Sub-Saharan Africa

and one from India—that estimate immediate changes in food insecurity associated with the Covid-19 pandemic. Next, it reviews subsequent analysis studying longer term changes in food insecurity associated with the Covid-19 pandemic. The review finds that most, but not all, studies find evidence of increasing food insecurity amid the Covid-19 pandemic, and increased food insecurity appears to be associated with pandemic-related disruptions in food markets and earned income. Despite evidence of pandemic-related disruptions across all studies, there is evidence of resilience, at least in terms of food security, among some subpopulations.

In Africa, Kansiime et al. (2021) assessed implications of Covid-19 pandemic on household income and food security in two East African countries (Kenya and Uganda). The authors have collected data using an online questionnaire via Google forms, sent to respondents through social networks and email. Since the two countries have been affected by Covid-19 in varying degrees, and the containment measures put in place varied, with anticipated differences in effects on food and nutritional outcomes. The responses were obtained from 313 and 129 people in Kenya and Uganda respectively, making a total of 442 respondents. Analytically, food security was measured using the Food Insecurity Experience Scale (FIES), and fitted probit model so as to estimate the factors determining whether a respondent's source of income has been affected by the Covid-19 crisis and whether food and nutrition outcomes have worsened during the pandemic. Results show that more than two-third of the respondents experienced income shocks. Food security & dietary quality worsened, as measured by the food insecurity experience scale and the frequency of consumption of nutritionally-rich foods. The probit regressions show that the income-poor households and those dependent on labour income were more vulnerable to income shock, and had poorer food consumption during the Covid-19 pandemic compared to other respondent categories. Farmers were less likely to experience worsened food security compared to other respondent categories who depended to a great extent on market sources for food. Conversely, membership in savings and loan groups was correlated with less likelihood of suffering income shocks and reduction in food consumption (Kansiime et al., 2021).

Furthermore, Bukari et al. (2021) examined the effect of Covid-19 on poverty and living standards of households in Ghana. The study further analyzed which class of persons within the income distributions has been mostly hit by the pandemic. Data on 3,905 households were obtained via concurrent online survey and telephone interviews. Multiple analytical approaches

were employed: ordinary least squares, probit model and simultaneous quantile regressions. Results showed that Covid-19 had significantly increased the poverty levels of households while deteriorating living standards. The study also discovered that gender and locational heterogeneities exist regarding the impact of Covid-19 with females and rural dwellers mostly disadvantaged. However, simultaneous quantile regression result shows that in terms of overall household consumption, those in the middle and upper classes are profoundly affected compared to those in the lowest class.

On the other hand, a study by Amare et al. (2020) combines pre-pandemic face-to-face survey data with follow up phone surveys collected in April-May 2020 to quantify the overall and differential impacts of Covid-19 on household food security, labor market participation and local food prices in Nigeria. The study exploited spatial variation in exposure to Covid-19 related infections and lockdown measures along with temporal differences using a difference-in-difference approach. It found that those households exposed to higher Covid-19 cases or mobility lockdowns experience a significant increase in measures of food insecurity. Examining possible transmission channels for this effect, it indicated that Covid-19 significantly reduces labor market participation and increases food prices. Also, the study found that impacts differ by economic activities and households. These lockdown measures have smaller impacts on wage-related activities and farming activities. In terms of food security, households relying on non-farm businesses, poorer households, those with school-aged children, and those living in remote and conflicted-affected zones have experienced relatively larger deteriorations in food security.

Also, Josephson et al. (2020) provided some of the first evidence on the socioeconomic impacts of and responses to the pandemic among households and individuals in Sub-Saharan Africa. To do so, reduced-form econometric methods are applied to longitudinal household survey data from Ethiopia, Malawi, Nigeria, and Uganda—originating from the pre-Covid-19 face-to-face household surveys and from the novel phone surveys that have been conducted during the pandemic. It has indicated that around 256 million individuals, about 77 percent of the population in the four countries, were estimated to live in households that have lost income due to the pandemic. Secondly, attempts to cope with this loss were exacerbated by the inability to access medicine and staple foods among 20 to 25 percent of the households in each country.

Finally, it has mentioned that food insecurity is disproportionately borne by households that were already impoverished prior to the pandemic.

In Ethiopia, Beyene et al. (2020) examined the potential economy-wide impacts of the Covid-19. The authors have employed a dynamic computable general equilibrium model calibrated to a social accounting matrix for FY 2010/11 and covered the period from FY 2010/11 to FY 2029/30. The analysis accounts for the main channels through which the Covid-19 affects the economy. The domestic transmission channels include reduced labor market participation, lower productivity, and rising domestic trade costs. External channels include higher international trade costs, a drop in export demand, lower import supply, a reduction in foreign direct investment, reduction in remittances, and lower import price of oil. The impact of the Covid-19 crisis is analyzed using three scenarios, namely business as usual (or the baseline), and the Covid-19 scenario considered under mild and severe assumptions.

Economic impacts are expected to have differentiated impacts on a wide range of economic and social indicators. The pandemic is likely to have significant growth and welfare effects even under an optimistic scenario of mild shock and quick recovery. Employment is likely to be hardly hit. The Covid-19 crisis is likely to have medium-to-long-term negative effects. GDP growth rate is expected to converge to the no- Covid-19 baseline relatively swiftly if the scope of the shock is mild. However, the GDP and welfare losses are not likely to be fully recovered. In an amplified scenario, the economic and welfare losses would be higher and the gap with the no Covid-19 baseline would be much greater (Beyene et al., 2020).

Additionally, Batana et al. (2021) studied the existence of spatial heterogeneity in the impacts of the early days of the Covid-19 pandemic on urban household incomes in Ethiopia and Kinshasa, Democratic Republic of Congo. Combining new panel household surveys with spatial data, the fixed-effects regression analysis for Ethiopia finds that households in large and densely populated towns were more likely to lose their labor incomes in the early phase of the pandemic, and their recovery was slower than other households. Disadvantaged groups, such as female, low-skilled, self-employed, and poor, particularly suffered in those towns. In Kinshasa, labor income-mobility elasticities are higher among workers—particularly female and/or low-skilled workers—who live in areas that are located farther from the city core area or highly dense and

precarious neighborhoods. The between- and within-city evidence from two Sub-Saharan African countries points to the spatial heterogeneity of Covid-19 impacts, implying the critical role of mobility and accessibility in urban agglomerations.

On the other hand, Hirvonen (2020) at IFPRI suggests that the pandemic has not led to unusually large increases in food prices. However, a case study in the vegetable sector suggests that price dynamics are highly context and crop specific, calling for more comprehensive price monitoring to identify food value chains and areas where food price increases may have been unusually rapid. Second, employment losses have concentrated on informal sector workers while redundancies in the formal sector have been less significant. Third, there is considerable uncertainty about the income, poverty, and food security implications of this crisis. While most households report income losses, the qualitative and subjective nature of these questions mean that the magnitudes of these losses are unknown. In Addis Ababa, less subjective food security measures indicate only small negative changes in household food and nutrition security. Finally, the report mentioned that limited access to mobile phones in rural areas results in imperfect and incomplete information on how this crisis has been affecting rural households in Ethiopia.

At zonal level, Asegie et al. (2021) has investigated the effect of Covid-19 on the livelihood activities of smallholder farm households located in South Wollo and Oromia Administrative Zones in Ethiopia. Data from 275 respondents were collected through interview schedules, key informants and case studies from September to November 2020. Descriptive statistics, binary logistic regression model and qualitative approaches were employed to analyze the data. The dependent variable is the household's livelihood status as a result of the Covid-19 pandemic, takes 1 if at least one livelihood activity was affected and 0, otherwise. As independent variables, it has included both continuous and categorical variables such as age of respondents, gender of respondent, family size of respondents, educational status of respondent, land holding size, use of irrigation, number of oxen, access to remittance, market distance, and membership to farmers' cooperatives. The lives and livelihoods impacts varied depending geo-local settings and pre-pandemic livelihood activities of the target districts. It concluded that the pandemic significantly affected all dimensions of livelihood diversification strategies. Particularly non-farm and off-farm livelihood activities of smallholder farmers are significantly affected.

## 4. Data and Methodology

### 4.1. Context and Data

**Context:** Ethiopia's first Covid-19 case was observed in mid-March 2020. The country is among those African countries that experienced significant economic disruptions because of the pandemic. The Government of Ethiopia has put in place a range of measures to mitigate the economic impact of the Covid-19 pandemic, while aiming at containing transmission. Right after the first few cases of Covid-19 were detected, the government implemented a state of emergency, which remained in effect until September 2020, and adopted a comprehensive Covid-19 National Emergency Response Plan to ensure that efforts to fight the crisis are comprehensive and well-coordinated. Specifically, Ethiopia implemented surveillance at borders, conducted contact tracing, established designated quarantine facilities, ensured the supply of drugs and protective equipment, and embarked on several communication efforts to raise awareness on how to deal with the virus. Ethiopia's lockdown and mobility restrictions were mostly introduced by federal and state-level governments. Also, in order to mitigate impacts on people and firms, authorities announced several economic measures, including additional expenditure on healthcare, provision of emergency food to the vulnerable, tax and social security payment deferrals, and liquidity injections and extension of forbearance measures in the financial sector.

The measures taken by the federal and regional governments have restricted movement of residents and led to the closure of business operations, and closure of regional borders linking lockdown areas with the rest of the country. These lockdown and mobility restrictions are likely to disrupt major economic activities, including local businesses. Ethiopia is highly susceptible to income shocks and food insecurity associated with the spread of the pandemic. As the reports of the World Bank (2020) reveals, food prices are already soaring in the country, food supply chains (domestic and international) are being disrupted, informal sector unemployment rates are likely to be increasing, and poor households are likely to be facing food shortages. All these effects are likely to increase food insecurity. The data collected by the World Bank (2020) indicated that the restrictions imposed by the government on people's movement and business operations in the early stage of the pandemic resulted in decrease in food and non-food consumption levels of households, which is considered as an impact on the consumption levels

of household, and thus impact their food security situations. This is an indication of the fact that the pandemic has impacted the food security levels of Ethiopian households.

**HFPS Data:** The empirical analysis in this study relies on a harmonized household phone surveys that have been collected since the outbreak of the Covid-19 pandemic in Ethiopia. The World Bank conducted a High Frequency Phone Survey (HFPS) of households to monitor the economic and social impacts of and responses to the Covid-19 pandemic on households, and thus inform interventions and policy responses (Wieser et al., 2020). The HFPS builds on the national longitudinal Ethiopia Socioeconomic Survey (ESS) that the Central Statistical Agency (CSA) carried out in 2019 in collaboration with the World Bank. The HFPS drew a subsample of the ESS sample that was representative of households with access to a working phone. It is conducted by calling a sample of households every three to four weeks for a total of 12 survey rounds, starting in April 2020. The survey questionnaire takes just 15 minutes, and covers topics such as knowledge of Covid-19 and mitigation measures, access to educational activities during school closures, employment dynamics, household income and livelihood, income loss and coping strategies, and assistance received.

From the HFPS of households, the World Bank has developed a harmonized dataset in order to create a comparable picture of how the pandemic affects the live of the poor around the world. Harmonized indicators help to track the impact of the pandemic and mitigating policies over time in a comparable manner. Since the outcome variable of this study, which is probability of being food insecure, is available only for five rounds (from round 2 – round 6) in the harmonized dataset for households in Ethiopia, the study uses a panel data extracted from these five rounds only. The main advantage of using panel data is that it enables us to deal with time-invariant and unobserved heterogeneity that would potentially cause bias in estimation results if it is not properly accounted for, or controlled or taken into consideration during the analysis.

Besides, the study exclusively focuses on household level characteristics as predictors and independent variables. Using the household's id and survey rounds as the main identifiers and following the required data management processes, a panel data of 14,506 observations has been organized and utilized for this study. The analysis includes data on total household food

insecurity situation, and various households' socioeconomic characteristics and location variables.

*Outcome variables: (food insecurity indicators):* Food insecurity is measured using two separate, but not exclusive, variables on probability of food insecurity. They are the “*probability of being moderately/severely food insecure  $\geq 50\%$* ” and the “*probability of being severely food insecure  $\geq 50\%$* ”. Each probability index takes binary values: 1 if “Yes” and 0 if “No”. That means, if the probability of being food insecure is greater than or equal to 0.50 ( $\geq 50\%$ ), it takes 1 and 0 otherwise.

*Key explanatory variables and predictors:* Covid19 containment measures (restriction on in-country travel, curfew/lockdown and closure of non-essential businesses) are the key explanatory variables that are used as indicators by themselves in the model. Also, the independent variables for the study comprised of household level socioeconomic characteristics only. Additional indicator variables are sector/location of the household, ownership of land, ownership of livestock, and ownership of non-farm family business enterprises, sources of incomes such as wage employment, rental income, remittance and assistance. Since they have time trend across the five (5) survey rounds as presented in the harmonized data by the world Bank, variables such as household size, change in household head, adult equivalence are included in the estimation as time-variant household characteristics in order to control their effects, if any.

Moreover, to better understand the differential impacts of the pandemic on households' food insecurity situation, the study used baseline characteristics of households so as to disentangle those vulnerable households and livelihood activities. As the impacts of the pandemic are likely to vary across households, it aims to uncover the heterogeneous impacts of the pandemic on various groups of households, measured based on different dimensions of indicators. The variables for identifying the differential impacts are location (rural/urban), ownership of assets (land; livestock; non-farm family enterprises), livelihood activities (such as wage employment); and income sources (such as rental income; remittance; assistance).



**Table 1: Descriptive results of key explanatory and indicator and outcome variables**

No.	Variable	Obs.	Mean	Std. Dev.	Min	Max
1	Restriction on in-country travel	14,436	.2195206	.4139362	0	1
2	Curfew/lockdown	14,436	.1364644	.3432929	0	1
3	Closure of non-essential business	14,436	.145816	.3529339	0	1
4	Urban	14,506	1.707638	0.454863	1	2
5	Land ownership	14,506	0.240245	0.427247	0	1
6	Non-farm family business	14,506	.2988419	.4577661	0	1
7	Livestock ownership	14,506	.359989	.4800133	0	1
8	Rental income	14,506	0.091755	0.288689	0	1
9	Received remittance	14,506	0.172342	0.377691	0	1
10	Received assistance	14,506	0.057562	0.232922	0	1
11	Wage employment	14,506	.3636426	.4810641	0	1
12	Household head changed	14,506	0.002550	0.050441	0	1
13	Household size	14,506	4.370812	2.203917	1	14
14	Adult equivalence in the household	14,506	3.438585	1.756451	0.73	11.98
15	Number of household members above 65 & below 15 years age	14,506	1.700813	1.556243	0	9
16	Probability of being moderately/severely food insecure $\geq 50\%$	14,506	0.303598	0.459827	0	1
17	Probability of being severely food insecure $\geq 50\%$	14,506	0.044395	0.205979	0	1

As mentioned earlier, the harmonized HFPS of households' data produced by the World Bank includes household characteristics of their baseline information applied from the national longitudinal Ethiopia Socioeconomic Survey (ESS) that the Central Statistical Agency (CSA) carried out in 2019 across the country. These data on household characteristics remain the same across all survey rounds. Only household size, adult equivalence and change in the household head vary across the rounds in the dataset. This makes the dataset more convenient and appropriate for analyzing heterogeneous or differential impacts of Covid-19 across the different groups of households.

Table 2 below presents a simple descriptive indicator (percentage) of the probability of food insecurity of households in all rounds in different groups of households. From the total, 30.36% of the households asked in all rounds (column 1) have reported that they have faced a moderately/severely food insecurity during the pandemic, while the remaining 69.64% (column 2) didn't face such food insecurity problem.

Table 2: Percentage of food insecurity probabilities by groups of households

	Probability of being moderately/severely food insecure (P >= 0.5)	
	Yes (1)	No (2)
<i>Rural/Urban</i>		
<i>Rural</i>	11.43%	17.81%
<i>Urban</i>	18.93%	51.83%
<i>Ownership of land</i>		
<i>Yes</i>	21.76%	54.21%
<i>No</i>	8.60%	15.43%
<i>Ownership of livestock</i>		
<i>Yes</i>	16.19%	47.81%
<i>No</i>	14.17%	21.83%
<i>Ownership of non-farm family business</i>		
<i>Yes</i>	8.87%	21.50%
<i>No</i>	21.02%	48.62%
<i>Rental income</i>		
<i>Yes</i>	28.60%	62.23%
<i>No</i>	1.76%	7.41%
<i>Received remittance</i>		
<i>Yes</i>	5.83%	58.24%
<i>No</i>	24.53%	11.40%
<i>Received assistance</i>		
<i>Yes</i>	27.55%	66.70%
<i>No</i>	2.81%	2.94%
<i>Wage employment</i>		
<i>Yes</i>	8.09%	22.27%
<i>No</i>	28.27%	41.37%
<i>Restriction on in-country travel</i>		
<i>Yes</i>	6.41%	23.91%
<i>No</i>	15.54%	54.12%
<i>Lockdown/curfew</i>		
<i>Yes</i>	4.69%	25.64%
<i>No</i>	8.96%	60.72%
<i>Closure of non-essential businesses</i>		
<i>Yes</i>	4.16%	26.17%
<i>No</i>	10.43%	59.25%

Source: Author's calculation from the harmonized HFPS data for Ethiopia

Also, 11.43% and 18.93% of the total households surveyed in all rounds who have faced moderately/severely food insecurity are located in rural and urban areas, respectively (column 1). From the total number of households surveyed in all rounds (14,506), different proportions who faced moderately/severely food insecurity are presented in column 1 of table 2.

From the total households in all rounds, around 21.95%, 13.65%, and 14.58% of the households have mentioned that they have faced restriction on in-country travel, curfew, and closure of non-essential business, respectively. In contrast to this, majority of the households asked in all rounds, i.e. 78.05%, 86.35% and 85.42% of the households reported that they did not face restriction on in-country travel, curfew, and closure of non-essential business, respectively.

## 4.2. Empirical Method

Given the household level fixed effects, how has the trajectory of Covid-19 food insecurity impacts varied by containment measures, sector of households, ownership of assets, livelihood options and income sources of households in Ethiopia? Panel regression models are used to determine the dimensions/indicator variables along which food insecurity situations of households have differentially or heterogeneously been affected by the Covid-19 pandemic.

For such situations, the standard econometric methodology suggests the use of efficient panel data estimators, such as fixed effect and random effect estimators (Wooldridge, 2002). Fixed effect estimators control for unobserved time-invariant characteristics of households and account for within-household variations across time. Random effects model takes care of both within- and between-household variations. Though our principal objective is heterogeneity analysis and the empirical literature on the topic suggest the use of fixed effect estimators, the paper estimated both fixed and random effects and applied the Hausman test to identify whether the fixed effect or random effect estimators is better for the estimation.

The analytical model is described as

$$y_{it} = \alpha + \beta_1 r_t + \beta_2 (r_t h_i) + \beta_3 x_{it} + \delta_i + \varepsilon_{it} \dots\dots\dots [1]$$

where,  $y_{it}$  is a dummy variable for household  $i$  indicating the change in the probability of being moderately/severely food insecure (greater than or equal to 0.5) at round  $t$  since the previous survey round  $t-1$ ;  $r_t$  is a dummy indicator for the survey round;  $h_i$  is indicator variable, which can be containment measures, sector, socioeconomic characteristic for household  $i$ ;  $\delta_i$  is a household fixed effect. Since  $h_i$  is a time-invariant variable (household characteristics), it is interacted with the round dummies.  $\beta_2$  is the parameter of interest, indicating how the probability of households' food insecurity varies by the time-invariant characteristics (heterogeneity parameter). In addition, those time-variant household characteristics are controlled in  $x_{it}$ .

In the next step, we estimate two-way fixed effects by interacting two indicators variables and thus create another new indicator variable so as to examine whether heterogeneity impact exists when the two variables are considered simultaneously. One form of such estimation is made by

interacting containment measures with urban indicator to explore if the impacts of the three containment measures have differential impact on food security among rural and urban households.

This is expressed by the following notation

$$y_{it} = \alpha + \beta_1 r_t + \beta_2 (r_t h_i) + \beta_3 (r_t c_i) + \beta_4 (r_t h_i c_i) + \beta_5 x_{it} + \delta_i + \varepsilon_{it} \dots\dots\dots [2]$$

The coefficient of interest is  $\beta_4$  which captures the impact of interaction between containment measures and urban households.

Finally, in order to check robustness of our estimates, we re-fit each model by some observations or variables from the sample. Firstly, we omit the data for Addis Ababa and estimate every model. Then, we drop the time-variant household characteristics ( $\beta_5 x_{it}$ ) and estimate each model. Next, we compare these estimates with the original estimates to check for robustness.

## 5. Results and Discussions

The nature of the data and main objective of the research imply that the fixed effects (FE) model is the appropriate model. The Hausman specification test also confirms that in all estimations the fixed effect model is better than the random effect model. So, the estimation results (coefficients and p-values) of the fixed effect model are used in the analysis and discussions below.

In this section, results on the impact of the pandemic on food security and associated heterogeneity factors are presented, corresponding to the model equations above. Estimation is made by interacting the round dummies with the time-invariant variables such as containment measures (travel restriction, curfew, closure), location of the households, ownership of land, livestock and non-farm family business, sources of income (rent, remittance or assistance), and livelihood activities (wage employment). It is worth to mention at this point that the parameter associated with the round dummy captures aggregate trends in food insecurity situation of Ethiopian households across the five survey rounds. It also captures aggregate potential differences in food insecurity situations across the survey rounds.

## 5.1. Impacts of Government's Responses

Initially, we estimate the empirical specification in equation (1) to quantify the implication of variations in responses to the pandemic. In this estimation, the containment measures are considered as indicator variables. We mainly focus on the mobility restrictions, lockdown measures and closure of non-essential businesses and hence generate an indicator variable for the measures. We then compare temporal evolutions in food security outcomes across households with and without the containment measures. The results are presented in table 3 below.

Table 3: Government responses and probability of being severely food insecure

<i>Probability of being severely food insecure (P &gt;= 50%)</i>						
	<i>Full Sample</i>			<i>Without household controls</i>		
	(1)	(2)	(3)	(4)	(5)	(6)
<i>round 3</i>	-.1.244972 (0.000)	-1.209733 (0.000)	-1.264487 (0.000)	.0718991 (0.000)	-1.20274 (0.000)	-1.260099 (0.000)
<i>round 4</i>	-1.541994 (0.000)	-1.448419 (0.000)	-1.615612 (0.000)	-1.525313 (0.000)	-1.425835 (0.000)	-1.609042 (0.000)
<i>round 5</i>	-1.224418 (0.000)	-1.065079 (0.000)	-1.061888 (0.000)	-1.211038 (0.000)	-1.051957 (0.000)	-1.051267 (0.000)
<i>round 6</i>	-1.328784 (0.000)	-1.241458 (0.000)	-1.218614 (0.000)	-1.327939 (0.000)	-1.237228 (0.000)	-1.218042 (0.000)
<i>round 3*travel</i>	.0262483 (0.941)			.0310876 (0.929)		
<i>round 4*travel</i>	.1620033 (0.664)			.1784768 (0.632)		
<i>round 5*travel</i>	.9398987* (0.006)			.9385458 (0.006)		
<i>round 6*travel</i>	.4606033 (0.205)			.4745023 (0.191)		
<i>round 3*curfew</i>	-.0713252 (0.867)			-.0781803 (0.854)		
<i>round 4*curfew</i>	-.2362286 (0.612)			-.2551341 (0.583)		
<i>round 5*curfew</i>	.662784*** (0.103)			.6567044 (0.104)		
<i>round 6*curfew</i>	.260838 (0.548)			.2630354 (0.544)		
<i>round 3*closure</i>	.2081027 (0.617)			.2192122 (0.596)		
<i>round 4*closure</i>	.68812*** (0.098)			.7606778 (0.065)		
<i>round 5*closure</i>	.66547*** (0.102)			.6658979 (0.100)		
<i>round 6*closure</i>	.0718991 (0.875)			.0945024 (0.836)		
<i>Household FE</i>	Yes	Yes	Yes	No	No	No
<i>Obs.</i>	5,623	5,623	5,623	5,623	5,623	5,623

Note: \*, \*\* and \*\*\* represent 1%, 5% and 10% levels of significance

The results show that state-level restrictions in travel with in country and curfew/lockdown increase the probability of being food insecure between round 5 and round 6. Likewise, coefficient of interaction between closure of non-essential business and round dummies are significant in round 4 and round 5. This implies that closure of non-essential businesses increases the probability of being food insecure among Ethiopian households.

Finally, we re-estimated the models by excluding time-variant household characteristics (column 4, 5 and 6 in Table 3), and by dropping the observations for Addis Ababa, the biggest city in Ethiopia, which is used to check if its exclusion sways away the results (see results in the log file in the Appendix). In both cases, the results remain almost the same and thus are robust.

Both table 4 and table 5 below present estimates of the parameter of the round dummy in each case. In almost all estimations, the coefficients of all round dummies are negative and statistically different from zero, except in round 4 of the probability of being moderately/severely food insecure. That means households' overall likelihood of becoming moderately/severely food insecure increases between round 3 and round 4 in Ethiopia, while it decreases in the other survey rounds. Thus, we can safely argue that households in Ethiopia have experienced a declining trend in food insecurity between round 2 (June 2020) and round 6 (late Sept 2020).

The impact of Covid-19 is likely to vary across households due to differences in underlying conditions of the households. Table 4 reports the results for the probability of households being moderately/severely food insecure (column 1-4) across various indicator variables. The interaction terms between dummy rounds and the indicator variables capture the temporal variation in the evolution of food insecurity associated with households' location/sectors, ownership of land, ownership of livestock, and ownership of non-farm family enterprises (table 4). The same estimation is also conducted along income sources (rental income, remittance, assistance) and livelihood source, wage employment (Table 5).

## 5.2. Covid-19 Impacts across Location and Ownership of Assets

The interaction terms between the survey rounds and rural (column 1), between round dummies and ownership of livestock and non-farm family enterprises are all statistically insignificant, indicating that there is no heterogeneity in the impacts of the pandemic on food insecurity. As the spread of the pandemic initiates and also spreads in urban areas, government responses, including mobility restrictions and lockdowns, were mostly intensified in urban areas and expected to affect urban residents more directly than rural households at least in the short term. This, however, is not the case in the context of Ethiopian households.

Ownership of land has positive and significant coefficients in round 5 and 6 (column 2, table 4) on the probability of being moderately/severely food insecure. The significant coefficient of ownership of land, in column 2 of table 4, presents unexpected results on the differential impact of the pandemic on food insecurity. It tells that those households who own land face increased probability of being moderately/severely food insecure between round 4 and round 5, and round 5 and round 6. In fact, it is whether the land is cultivated or not; whether the land is being used for the intended purpose that should determine the variation in food security, not just a simple ownership of the land. This result could also be understood as ownership of land serves as a proxy for the rural community, who are already in deteriorating food security situation exacerbated by the pandemic's containment measures as well. Whatsoever the reality is, the implication of ownership of land by households in Ethiopia could be a subject of further discussions and researches.

Moreover, ownership of livestock and its interaction with round dummies are each statistically insignificant. This suggests the absence of heterogeneity by ownership of livestock in the impacts of the Covid-19 pandemic in households' food security situation in Ethiopia.

Finally, in the last column table 4, the paper presents the interaction terms between round dummies and ownership of non-farm family businesses. Though the literature identifies ownership of non-farm family businesses as a potential factor that could bring differential impact of the pandemic on food security, this study finds a contrasting result that the variable is not a significant one to put in such heterogeneous impacts.

Table 4: Estimation results of FE models in Ethiopia for location and ownership heterogeneity

Probability of being moderately/severely food insecure (P >= 50%)				
	(1)	(2)	(3)	(4)
round 3	-0.1959 (0.159)	-0.1125 (0.251)	-0.1031 (0.340)	-.1711233 (0.087)
round 4	0.307** (0.032)	0.3659* (0.000)	0.409* (0.000)	.4689469 (0.000)
round 5	-0.606* (0.000)	-0.664* (0.000)	-0.518* (0.000)	-.5148625 (0.000)
round 6	-0.8244 (0.000)	-0.840* (0.000)	-0.650* (0.000)	-.7056107 (0.000)
rural*round 3	0.1292 (0.451)			
rural*round 4	0.1624 (0.353)			
rural*round 5	0.1075 (0.556)			
rural*round 6	0.1171 (0.532)			
round 3*land		0.0122 (0.947)		
round 4*land		0.1795 (0.334)		
round 5*land		0.469** (0.015)		
round 6*land		0.339*** (0.088)		
livestock*round 3			-0.0220 (0.895)	
livestock*round 4			0.0144 (0.932)	
livestock*round 5			-0.0379 (0.829)	
livestock*round 6			-0.2367 (0.192)	
nfe*round 3				.199622(0.263)
nfe*round 4				-.1725839 (0.339)
nfe*round 5				-.0619466 (0.742)
nfe*round 6				-.1372542 (0.482)
Household FE	Yes	Yes	Yes	Yes
Obs.	5,658	5,658	5,658	5,658

Note: \*, \*\* and \*\*\* represent 1%, 5% and 10% levels of significance.

### 5.3. Covid-19 Impacts across Income Sources and Livelihood Activity

In the next section, the study explores potentially heterogeneous impacts of the pandemic across households with varying livelihoods and income sources. Our analysis in this regard is also in line with several studies across the world suggesting that the pandemic has had heterogeneous impacts on different livelihood options and sectors (Amare et al., 2020). The availability of baseline data regarding household's socioeconomic characteristics allows estimating the impact of the pandemic across various socioeconomic groups and regions. In order to better understand



possible differential impacts, the study utilizes the baseline characteristics of households. It would us to discern vulnerable households and income sources from their counterparts. So, the heterogonous impacts of the pandemic across households' income and livelihood sources such as rental income, remittance, assistance, and wage employment are estimated and the results are presented in table 5 below. Each of these variables is interacted with the round dummies to determine evolution of the food insecurity across the rounds vis-à-vis the differential impact of the pandemic across each group of households.

Column 1 presents the interaction results between round dummies and rental income of households. Thus, coefficients in round 3 (0.5817), round 4 (0.9418), and round 5 (0.8929) are positive and statistically significant at 10%, 1% and 5%, levels, respectively. This means that households who had rental income source previous to the onset of the pandemic have increased likelihood of being moderately/severely food insecure between round 2, round 3, round 4 and round 5 (between May and August 2020). This also suggests that the impact of the pandemic is significantly heterogeneous among households with and without rental income.

Rental income includes income from shop or store or house or car or truck or other vehicle. It also includes rental income from land or agricultural tools or transport animals. Therefore, businesses closure measure by the government and decrease in economic activity due to the direct impacts of the pandemic and also other government's containments measures could be attributed to this differential impact of the pandemic across rental income sources.

Secondly, the interaction term between round and remittance is negative and significant only in round 5 (-0.428 at 10%) which indicates that remittance had a role of decreasing probability of becoming food insecure in Ethiopia during the pandemic (column 2). Likewise, households who have been receiving assistance from the government before the onset of the pandemic have decreased chance of becoming moderately or severely food insecure in Ethiopia. The interaction between round dummies and assistance are negative and statistically significant and different from zero in round 3 (-0.585), round 5 (-1.206) and round 6 (-0.736) at 10%, 1% and 5%, respectively, levels of significance. So, households relying on remittance and assistance income are significantly not harmed by the pandemic.

Table 5: Estimation results of FE models for heterogeneity by households' income sources

<b>Probability of being moderately/severely food insecure (P &gt;= 50%)</b>				
	<b>(1)</b>	<b>(2)</b>	<b>(3)</b>	<b>(4)</b>
round 3	-0.146*** (0.091)	-0.062 (0.505)	-0.070 (0.418)	-.1014559 (0.309)
round 4	0.359* (0.000)	0.385* (0.000)	0.429* (0.000)	.4306635 (0.000)
round 5	-0.586* (0.000)	-0.454* (0.000)	-0.451* (0.000)	-.5523385 (0.000)
round 6	-0.752* (0.000)	-0.707* (0.000)	-0.696* (0.000)	-.8315111 (0.000)
round 3*rent	0.5817*** (0.091)			
round 4*rent	0.94185* (0.009)			
round 5*rent	0.89286** (0.017)			
round 6*rent	0.0501 (0.900)			
round 3*remit		-0.253 (0.224)		
round 4*remit		0.171 (0.427)		
round 5*remit		-0.428*** (0.055)		
round 6*remit		-0.215 (0.349)		
round 3*assist			-0.585*** (0.056)	
round 4*assist			-0.253 (0.415)	
round 5*assist			-1.206* (0.001)	
round 6*assist			-0.736** (0.034)	
round 3*wage_emp				-.0326948 (0.855)
round 4*wage_emp				-.0510748 (0.777)
round 5*wage_emp				.0587911 (0.753)
round 6*wage_emp				.272986 (0.155)
Household FE	Yes	Yes	Yes	Yes
Obs.	5,658	5,658	5,658	5,658

Note: \*, \*\* and \*\*\* represent 1%, 5% and 10% levels of significance.

Finally, column 4 (table 5) presents the differential impact of the pandemic across wage employment as an income source. And, the interaction coefficients between wage employment indicator and round dummies are mixed in sign and are insignificant in all rounds, which indicates that involvement in wage earning activities does not significantly differentiate the impacts of the pandemic on households' food insecurity situation. Wage employment's impact is mixed and insignificant.

Joint significance of the interactions between each indicator variable and the round dummy are tested and presented in table 6 above. The impact of Covid-19 on the probability of households being moderate/severe food insecure is heterogeneous between those households who own land, earn rental income, and receive remittance and assistance and those households who do not. So, we can deduce that the variables (land, rent, remit and assist) are heterogeneity indicator variables.

Table 6: Test of joint significance of interaction terms (heterogeneity indicator variables)

No.	Interactions terms (heterogeneity indicators)	Probability of being moderately/ severely food insecure $\geq 0.5$	
		Chi2(4)	Prob>chi2
1	travel*round	9.12***	0.0582
2	curfew*round	4.65	0.3250
3	closure*round	4.63	0.3276
4	rural*round	1.00	0.9099
5	land*round	8.72***	0.0685
6	livestock*round	2.36	0.6701
7	nfe*round	5.16	0.2716
8	rent*round	10.70**	0.0302
9	remit*round	8.30***	0.0812
10	assist*round	13.47*	0.0092
11	wage_emp*round	3.50	0.4782

(Source: own organization from STATA results)

Among the containment measures, in-country mobility restriction is the only jointly significant indicator variable. Hence, the government's restriction on in-country travel has had a significant and heterogeneous impact on households' food insecurity during the pandemic period.

#### 5.4. Impacts of Containment Measures across Urban/Rural

At last, a model (eq. 2) is fitted to examine the differential impacts of government containment measures on food security among rural and urban households. The results are presented in table 7. Restriction on in-country travel in urban households is statistically significant between round 5 and round 6. Thus, restriction on in-country travel has brought a statistically significant differential impact on food security between urban and rural households in these rounds.

The other statistically significant containment indicator is the closure of non-essential businesses between round 3 and round 4, and round 4 and round 5. Its interaction coefficients with urban are statistically significant in round 4 and round 5, at 5% level of significance each. Thus, closure of non-essential business has affected more strongly rural households than urban households. It brought a differential impact on food security among urban and rural households.

Therefore, from the table we can deduce that urban households have lesser probability of being affected than their rural counterparts because of the in-country travel restrictions and closure of non-essential businesses in Ethiopia.

Table 7: Differential impacts of measures on food security across location of households

Probability of being moderately/severely food insecure (P >= 50%)		
	<i>Coefficient</i>	<i>P&gt; z </i>
<i>travel* urban *round 3</i>	-0.5489889	(0.167)
<i>travel* urban *round 4</i>	-0.4349969	(0.282)
<i>travel* urban *round 5</i>	-1.047096**	(0.014)
<i>travel* urban *round 6</i>	-0.6029585	(0.162)
<i>curfew* urban *round 3</i>	-0.3817449	(0.394)
<i>curfew* urban *round 4</i>	-0.6499698	(0.154)
<i>curfew* urban *round 5</i>	-0.2971929	(0.532)
<i>curfew* urban *round 6</i>	0.6558487	(0.174)
<i>closure* urban *round 3</i>	-0.6870287	(0.132)
<i>closure* urban *round 4</i>	-0.9730496**	(0.037)
<i>closure* urban *round 5</i>	-1.115285**	(0.024)
<i>closure* urban *round 6</i>	-0.286051	(0.566)
<i>Household FE</i>		Yes
<i>Obs.</i>		5,623

Note: \*, \*\* and \*\*\* represent 1%, 5% and 10% levels of significance

## 5.5. Checking Robustness of the Estimates

As a robustness check, we estimate each model above using subsamples and different specifications (*estimation results are available in the log-file attached as appendix*). First, we estimate the fixed effect model specifications using only the subsample of households that do not live in Addis Ababa. That means the observations for Addis Ababa are dropped from the sample and the model is re-fitted. This is to test the possibility that our findings are driven by households in Addis Ababa, by far the largest city in Ethiopia and unique in many aspects. Secondly, the fixed effect models are re-estimated by excluding the additional time-variant controls for household characteristics, such as change in household head, household size, and adult equivalence. As it can be checked from the log results of the analysis given in the appendix, our findings are robust against the change in the subsample and model specifications used in the estimation. Excluding Addis Ababa from the sample and omitting the time variant household characteristics from the specification and estimation of the fixed effect model does not substantially change the results. In all cases, the findings remain almost the same. So, the fixed effect models that are specified and estimated in this study are appropriate.

## 6. Conclusions and Implications

Covid-19 affects food security of households through different pathways. The mobility restrictions, lockdowns, and closure of businesses can adversely affect incomes by reducing economic and livelihood activities, which directly affect food security of households. Several studies from developing countries, including Africa, show that the pandemic has had heterogeneous impacts on food security, various livelihood options and sectors in their economy. This study aims to explore heterogeneity in impacts of early days of the Covid-19 pandemic on food insecurity across households across containment measures and location or sectors, ownership of assets and varying livelihoods and sources of incomes in Ethiopia. It has employed a nationally representative harmonized panel data on households drawn from the HFPS-H and national longitudinal Ethiopia Socioeconomic Survey (ESS).

The fixed-effects regression results show that Covid-19 had a statistically significant impact on overall food insecurity in Ethiopia and the households have experienced a declining trend in food insecurity between round 2 (June 2020) and round 6 (late September 2020). The joint significance test shows that within-country travel restriction, ownership of land, rental income, remittance, and assistance are statistically significant heterogeneous indicator variables on the impacts of the early days of Covid-19 on households' overall food insecurity in Ethiopia. Among the containment measures taken by the government of Ethiopia against the spread of Covid-19, the in-country restriction on mobility of individuals has had a statistically significant impact on food insecurity. It increases the probability of households being moderately/severely food insecure during the early days of the pandemic.

Though its effect and implication has to be a subject for future researches, ownership of land has statistically jointly significant coefficients in determining the impacts of Covid-19 on households' food security. Also, households who had rental income source previous to the onset of the pandemic have increased likelihood of being moderately/severely food insecure between round 2, round 3, round 4 and round 5 (between May and August 2020). Rental income is also jointly significant indicator variable which mediates the impacts of Covid-19 on households' food security. Thus, the impact of the pandemic was significantly and statistically heterogeneous among households with and without rental income.

The interaction term between round dummies and remittance is negative and statistically significant only in round 5, and between round dummies and assistance are negative and statistically significant different from zero in round 3, round 5 and round 6. These variables are also jointly statistically significant factors which mediate the differential impact of Covid-19. These findings, therefore, suggest the significant role that has been played by remittance and assistance income in protecting households from deteriorating trajectory of food insecurity during the pandemic in the short term.

The findings can be used to informing short term and medium-term policy responses and interventions by the government at different levels and international donor organizations. Firstly, the paper can inform tailored strategies by identifying the most impacted households or members of the populations. Secondly, it could serve as a base to safety net and social protection policy measures aiming at ameliorating the impacts of the pandemic. In the short term, it was important to provide direct support to those households in the form of, for example, cash transfers and food rationing. In the medium term, it might have been useful to build disadvantaged groups and households' resilience against shocks by improving their accessibility to jobs, and markets for food and transactions. This lesson informs that the country should have been strengthened its programs and works on social protection and rehabilitation through safety net programs so that it could have supported the severely exposed households. This is an important lesson that the same preparedness is required for future unforeseen shocks that hit the economy.

Finally, the scope of the analysis does not allow distinguishing specific pathways in the Covid-19 impacts on urban households' only or rural households only. For instance, in large and densely populated towns, people are less likely to travel during the pandemic in view of the high contagion risk and relatively strict mobility restrictions and lockdowns. This could be a source of heterogeneity in covid-19 impacts among urban households only. Also, it does not look at other potential paths of differential impacts of the pandemic. For example, the disadvantaged groups of workers who live far from their workplace are supposed to be hit hard by mobility restrictions. Those household members with no option to work remotely and need to travel around for their jobs in self-employment may have been particularly vulnerable to mobility shocks and exposed to food insecurity problem.

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