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Impacts of COVID-19 on Food Security

Panel Data Evidence from Nigeria

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Abstract

This paper 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. We exploit spatial variation in exposure to COVID-19 related infections and lockdown measures along with temporal differences in our outcomes of interest using a difference-in-difference approach. We find 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, we find that COVID-19 significantly reduces labor market participation and increases food prices. We find that impacts differ by economic activities and households. For instance, lockdown measures increased households' experience of food insecurity by 13 percentage points and reduced the probability of participation in non-farm business activities by 11 percentage points. 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. These findings can help inform immediate and medium-term policy responses, including social protection policies aiming at ameliorating the impacts of the pandemic, as well as guide targeting strategies of governments and international donor agencies by identifying the most impacted sub-populations.

Keywords: COVID-19, Pandemic, Food security, labor market participation, food price.

JEL Codes: I12, O13, Q18, Q12, Q18

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1. Introduction

The COVID-19 pandemic is ravishing local, national, and global economies. In addition to the direct health impacts, the pandemic is having widespread effects on employment, poverty, food security, nutrition, education and health, and the overall functioning of food systems (Barrett, 2020; Devereux et al., 2020; Swinnen, 2020; GAIN, 2020). COVID-19 is destabilizing supply chains at all levels, and creating instability in food supply and food prices (Zurayk, 2020; Torero, 2020; Reardon et al. , 2020a; Reardon et al., 2020b; Ihle et al., 2020; Akter, 2020; FAO, 2020). The World Bank's recent forecasts show that, globally, the pandemic is likely to push 49 million people into extreme poverty in 2020 (World Bank, 2020a).¹ More than 45 percent (23 million people) of these people are in Sub-Saharan Africa, implying that the region will be hit hardest in terms of increased extreme poverty. The United Nations World Food Programme (WFP) 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).

This paper quantifies the impacts of COVID-19 and associated governmental lockdown measures on household food security and labor market participation in Nigeria. Nigeria is an interesting case study, as about 83 million people were already living below the national poverty line (World Bank 2020a). According to the recent World Bank projections, Nigeria is predicted to be one of the three countries with the highest increase in the number of poor people.² About 5 million Nigerians are projected to be pushed into poverty because of COVID-19 and associated mobility restrictions and lockdown measures (World Bank, 2020a; IMF, 2020). Food insecurity has been a major longstanding challenge in Nigeria, as reflected by Nigeria's high Global Hunger Index (GHI), low Food Consumption Score³ (FCS), and high-calorie deficiency (Global Hunger Index, 2019). The country also experiences significant seasonal and geographical food price fluctuations due to weather shocks to agricultural production, limited access to markets and

¹ The share of the world's population living on less than \$1.90 per day is projected to increase from 632 million to 665 million people (World Bank, 2020a).

² The three countries with the largest change in the number of poor are estimated to be India (12 million), Nigeria (5 million) and the Democratic Republic of Congo (2 million) (World Bank, 2020a).

³ FCS is a composite score constructed on the basis of dietary diversity, food frequency, and relative nutritional importance of different food groups.

infrastructure, and global food price volatility on imported staple foods.⁴ Disruptions in economic activities are likely to have direct repercussions on food security as household spending on food comprises 58% of household expenditures, with poorer households spending more than 75% of their resources on food (USDA, 2016; FAO, 2020). Disruptions in domestic economic activities and international food markets are therefore very likely to affect the food security of Nigerian households through various channels (Eriksson et al., 2008; Barrett et al., 2019; Arndt et al., 2020; Devereux et al., 2020; Baldwin and Weder di Mauro, 2020; Haddad et al., 2020; Béné, 2020). In addition, the availability of a large nationally representative panel of households observed before and after the start of the pandemic makes Nigeria an ideal setting for an early empirical examination of COVID-19's impacts.

Besides quantifying the impact of the spread of the pandemic and government lockdowns on food security outcomes, this research also aims to shed light on key impact pathways and differential impacts of the pandemic. COVID-19 could affect food security of households through different pathways (Baldwin and Weder di Mauro, 2020; Devereux et al., 2020). For instance, COVID-19 related lockdowns and social distancing measures can adversely affect incomes by reducing economic and livelihood activities (Devereux et al., 2020; Barrett, 2020; Reardon et al., 2020b), which directly affects food security. In Nigeria, recent projections show that the economy will contract by between 3.5 to 5 percent in 2020 during the period the government-imposed lockdown and mobility measures (World Bank, 2020c; IMF, 2020; Andam et al., 2020). These lockdowns and restrictions are also disrupting food supply chains and community services, including education-linked programs (e.g., school feeding) and social protection programs, which ultimately positively affect food prices (WFP, 2020a). For countries like Nigeria that heavily rely on imports of major staple foods such as rice and wheat, which registered marked rapid climbs in spot prices, this is creating an added financial burden that directly affects food security of households (World Bank, 2020a).⁵ National and state-level restrictions and lockdowns are affecting food transportation within the country, with clear implications on food supply and,

⁴ Nigeria imported 2.4 million metric ton of rice in 2019/2020. Nigeria spent more than USD 4.1 billion on food import (NBS, 2020).

⁵For example, the cost of rice in retail markets soared by more than 30% in March alone (Bloomberg: Key Food Prices Are Surging After Virus Upends Supply Chains: <https://news.bloomberglaw.com/international-trade/key-food-prices-are-surging-after-virus-upends-supply-chains>)

consequently, on food prices. This is expected to generate significant repercussions on food insecurity, particularly in poorer and vulnerable urban households (Erickson et al., 2010; Tendall et al., 2015; Gilligan, 2020). We thus evaluate direct effects on two key important channels through which food security outcomes are likely affected: the disruption of economic activities and increases in local food prices.

The effect of the pandemic are expected to differ both by geography and by type of household, with preexisting vulnerabilities to food security likely to be magnified (Amjath-Babu et al., 2020; Béné, 2020; Devereux et al., 2020; Ravallion et al., 2020; Mobarak and Barnett-Howell, 2020). Nigeria has significant longstanding geographical variation in poverty and food insecurity – more than 75 percent of poor Nigerians live in the north of the country – and the pandemic is likely to disproportionately exacerbate food insecurity in those already fragile and conflict-affected zones (World Bank, 2020b, 2020c). Impacts are expected to be most severe for poorer households in both rural and urban areas (Erickson et al., 2010; Ravallion et al., 2020; Mobarak and Barnett-Howell, 2020). As the spread of the pandemic initiates in urban areas, government responses, including mobility restrictions and lockdowns, will likely be most intense in urban areas and may affect urban residents more directly than rural households in the short term. However, 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 (e.g., Abay et al., 2020; Baldwin and Weder di Mauro, 2020). Value chain disruptions may extend deeply into rural areas, affecting both input supply and output demand for farmers and affecting the income of those employed in both upstream and downstream agricultural value chains (Barrett et al., 2019; Amjath-Babu 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 than impacts on formal markets (Devereux et al., 2020; Barrett, 2020). We thus explore potential differential impacts along these dimensions, including livelihood strategies and options.

Combining pre-COVID-19 face-to-face surveys with post-COVID-19 phone surveys and primary data on states' infections and lockdown measures, we exploit spatial variations in exposure to COVID-19 along with temporal changes in various food security indicators using a difference-in-difference approach. By comparing food security outcomes of households with varying exposure to the pandemic before and after the outbreak of the pandemic we can plausibly quantify

the overall and differential causal impact of the pandemic. We also quantify similar impacts associated with government state-level responses, mainly lockdown and associated mobility restrictions. With a similar methodology, we also test two main pathways that would, directly and indirectly, impact households' food security, i.e., the effects of COVID-19 on labor market participation and food prices.⁶

We find that those households exposed to higher COVID-19 cases or more strict government responses experience significant increase in food insecurity indicators. Also, as plausible drivers of this result, because of COVID-19, labor market activities deteriorate, and food prices increase in those areas most affected by the spread of the pandemic and lockdown measures. For instance, doubling of the number of confirmed cases increase households' experience of food insecurity by 2-3 percentage points, while it leads to a reduction in major economic activities by 1-3 percentage points. State-level lockdown measures have much larger impacts on these outcomes: lockdowns increased households' experience of food insecurity by 13 percentage points, and reduced non-farm business activities by 11 percentage points. These results remain consistent across alternative indicators of food insecurity and labor market participation, albeit some differences in the impacts across alternative activities. We show that food insecurity is also affected by COVID-19-related increases in food prices. We also document important differential impacts across various economic activities and households. For instance, state-level lockdown measures are more impactful in disrupting non-farm business activities, while farming activities appear to be less affected by state-level lockdowns. Similarly, poorer households, those with school-aged children, and those households living in remote and conflict-affected zones bear the highest brunt of the pandemic. In terms of livelihood options, those households engaged in non-farm business activities appear to be hardest hit, while those engaged in wage-related activities are relatively less affected.

Although considerable anecdotal evidence has been generated recently on the impacts of COVID-19 on the labor market and food security outcomes in Africa, rigorous empirical studies based on household-level survey data have largely not been available before now. Understanding the magnitude, distributional differences, and pathways of impacts of the COVID-19 pandemic on households' food security and economic activities is critical for designing effective policies and

⁶ <https://www.ifpri.org/blog/how-covid-19-may-disrupt-food-supply-chains-developing-countries>

interventions to mitigate the adverse effects of the pandemic. Using nationally-representative household survey, this paper contributes new evidence on the effects of COVID-19 on food security as well as on key impact pathways. These findings have important implications and hence can inform immediate and medium-term policy responses. For instance, our findings can inform social protection policies aiming at weathering the impacts of the pandemic, which rely heavily on effective targeting strategies. This is particularly imperative for governments like Nigeria, which has limited fiscal space and competing needs for post-COVID-19 recovery investment. Our findings can help governments and international donor agencies improve their targeting strategies to identify the most impacted sub-populations. The evidence that government responses, such as lockdowns and other mobility restrictions, have disproportionately large negative impacts on poorer households is consistent with arguments made by those who are critical of such policies for low- and middle-income countries (e.g., Ravallion et al., 2020, Mobarak and Barnett-Howell, 2020; Bargain and Aminjonov, 2020).

The remainder of this paper is organized as follows. Section 2 describes the context and data. Our empirical strategy is presented in Section 3. Section 4 presents estimation results and associated discussions, while Section 5 provides concluding remarks.

2. Context and Data

2.1 Context

Nigeria is Africa's most populous country, characterized by high poverty rate, large informal sector economy, high dependence on imported staples, and high exposures to shocks. Nigeria is one of the few African countries that first recorded COVID-19 cases and hence among those African countries who experienced significant economic disruptions because of the pandemic. The first COVID-19 case in Nigeria was recorded on February 27, and by late June, the number of confirmed cases passed the 30,000 mark (NCDC, 2020).⁷ As part of the measures to contain the spread of the pandemic, federal and state-level governments have introduced social distancing and mobility restrictions in March 2020 (FMBNP, 2020). The federal government closed all schools in mid-March, and several states and local authorities introduced bans on public and social gatherings. By late March, the Nigerian government closed its land and air borders to all travelers

⁷ The Nigerian Centre for Disease Control (NCDC) is responsible for overall management of testing, isolation, and treatment of COVID-19 patients.

and suspended passenger rail services within the country (Ogundele, 2020; NCDC, 2020). Furthermore, the federal government announced fiscal and stimulus measures, amounting up to 50 billion Naira to support households, and small and medium-scale enterprises affected by COVID-19 (FMBNP, 2020).

Nigeria's lockdown and mobility restrictions were mostly introduced by federal and state-level governments. Starting from March 29, 2020, federal and state governments announced lockdown measures and strict mobility restrictions for some states such as Abuja FCT, Lagos, Ogun, Kano, Delta, Ekiti, Kano, Kaduna, Kwara, and Taraba states.⁸ Lockdown measures in other states were introduced by state governments independently of the federal government, including in Akwa Ibom, Borno, Osun, and Rivers. In most cases, the lockdowns remained in force for about 5-8 weeks. These measures restricted movement of residents and led to the closure of business operations, and the 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. Nigeria is highly susceptible to income shocks and food insecurity associated with the spread of the pandemic. As we show in the next sections, 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.

2.2 Data and sampling strategy

In this study, we combine the pre-COVID-19 face-to-face survey with post-COVID-19 phone survey to quantify the overall and differential impact of COVID-19 on households' food security and labor market participation. These data and surveys are part of the World Bank's Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA) and are collected in collaboration with the Nigerian Bureau of Statistics (NBS). The LSMS-ISA data for Nigeria, also known as General Household Survey-Panel (GHS-P) include four rounds collected in 2010-

⁸ In addition to lockdown measures, federal and state government implemented different measures includes: (i) travel bans which includes restricted entry into the country for travelers from high risk countries; closure of two main international airports; suspension of all railway passenger services in the country; closure of all air and land borders. (ii) closure of schools and religious institutions. (iii) Bans on public and social gatherings across all states in Nigeria. (iv) Curfew hours which restrict movement of people.

11, 2012-13, 2015-16 and 2018-19. These data are nationally representative, and they provide detailed information on employment, income, food, and nutrition security indicators.

Following the COVID-19 pandemic, the LSMS-ISA program has initiated tracking of national samples of households that had been interviewed during the latest rounds of the LSMS-ISA surveys using phone surveys.⁹ Among the total sample of households (4,976) interviewed in the latest round (post-harvest January/February visit) of the GHS-P survey in 2019, 4,934 (99.2%) provided at least one phone number. Out of the full sample of households with phone numbers, a random sample of 3,000 households was selected for the phone survey, to collect a complete sample of 1800 households that enable statistical monitoring of (monthly) changes in key outcomes of interest. Out of these 3,000 households prepared for phone survey, 69 percent of sampled households were successfully contacted, and among these, 94 percent (1,950) households were fully interviewed (NBS and World Bank, 2020). The final complete sample for the phone survey constitutes these 1,950 households, and they are expected to be contacted in subsequent rounds of the survey. To create a balanced panel across rounds, we merged these households with the immediately previous round (2019) and kept those households with complete information in both rounds.

To adjust for potential (systematic) attrition in the phone survey and construct nationally representative statistics, one must construct and apply appropriate sampling weights. The LSMS-ISA team constructed the sampling weights using the weights for the GHS-Panel as the basis, with further adjustment for attrition in the phone survey. The weights for the final sample of households from the phone survey were calculated in several stages, and readers are referred to NBS and World Bank (2020).¹⁰ These weights are shown to sufficiently ensure comparable distribution of observable characteristics from the GHS-P and the phone survey (NBS and World Bank, 2020).

In this paper, we use the first round of the phone survey (the only available at the time of writing), which was administered in April-May 2020.¹¹ The LSMS-ISA phone surveys are planned to be monthly surveys and hence are high-frequency surveys. These high-frequency phone surveys covered topics including (1) knowledge regarding the spread of COVID-19; (2) prices and access

⁹ These phone surveys have been (are being) conducted in Ethiopia, Malawi, Nigeria, Tanzania and Uganda.

¹⁰ See <http://documents1.worldbank.org/curated/en/717901591889288314/pdf/Basic-Information-Document.pdf> for detail information on sampling weights.

¹¹ The outcomes and information from 2019 were collected during January and February 2019.

to food and non-food necessities; (3) employment and income losses; (4) food insecurity; and (5) subjective wellbeing. We are more interested in those outcomes, which can be observed in the face-to-face (pre-COVID-19) and phone (post-COVID-19) surveys. Since both the pre-and post-COVID-19 LSMS-ISA data contain important information on households' participation in economic activities and food insecurity experience, we can examine the patterns and dynamics of food insecurity and labor allocation along multiple periods. As we discuss below, we are particularly interested in tracking impacts on food insecurity and disruptions in economic activities, which are both followed and measured in similar ways in both rounds.

Table 1 presents weighted summary statistics of selected variables used in our analysis. For comparison purposes and for those variables observed in both rounds (and that are not expected to change significantly because of COVID-19), we report these summary statistics separately for each round. Those observable household characteristics that are observed for both rounds appear to be statistically comparable across both rounds. This is encouraging as most of these household characteristics are not expected to change in such a short period significantly. About 19 percent of our sample are female-headed in the 2019 round, while the corresponding figure for the 2020 round amounts 18 percent. We also show a few other pre-COVID variables which are used to capture eventual heterogeneity effects across the population.

Table 1: Descriptive results of key explanatory variables

	Pre-COVID-19 (2019)	Post-COVID-19 (2020)
Male headed households (yes=1)	0.81	0.82
Age of head (years)	49.64	49.42
Education of head (years)	8.21	8.87
Family size (numbers)	5.53	5.52
Value of assets (PPP US)	1677.66	-
Urban households	0.38	
Households with school going children	0.74	
Households living in North East Nigeria	0.17	
Distance to road (km)	5.31	-
Livelihood (income) sources during the last 12 months¹²		
Farming /agriculture	0.77	-
Non-farm business	0.64	-
Wage employment	0.34	-
Remittances and assistances	0.38	-
No. observations	1,906	1,906

Source: Authors' calculations based on Nigeria LSMS-ISA 2019 and 2020 rounds. Sample weights have been applied.

2.3 Definition of variables and descriptive results

Outcome variables

Food insecurity indicators: We measure food insecurity using three indicators, capturing households' experience of food insecurity. In both rounds, households' food insecurity experiences are elicited using the self-reported experience of hunger and food shortage in the last 30 days (Hoddinott, 1999; Carletto et al., 2013; Bellemare and Novak, 2017). The first indicator asks if a household head or any other adult in the household had to *skip a meal* because there was not enough money or other resources to get food. The second indicator elicits whether the household has *run out* of food and takes a value of 1 if the household ran out of food because there was not enough money or other resources to get food. The third indicator takes a value of 1 if the household or any other adult in the household *went without eating for a whole day* because of a lack of money or other resources.

These three indicators of food insecurity are strongly correlated among each other. Thus, we also employ principal component analysis (PCA) to construct an aggregate index and measure

¹² We note that households were asked to mention multiple sources of livelihood and hence choices are not mutually exclusive.

of food insecurity. This food insecurity index, which is standardized for facilitating interpretation, is a linear combination of the three indicators of food insecurity experience. We thus employ both these disaggregate binary indicators as well as the composite food insecurity index.

Labor market participation: The 2019 and 2020 surveys collect information on households' participation in income-generating activities over the last seven days. The major income-generating activities include farming, non-farm business, and wage-related activities. We thus can measure and quantify changes in labor allocation across both rounds. We define an indicator variable for *farming activities*, which takes a value of 1 if the household head or any member of the household worked on a household farm growing crops, raising livestock, or fishing, and 0 otherwise. Similarly, we define an indicator variable for *non-farm business*, which takes a value of 1 if the household head or any member of the household operated family business and zero otherwise. Both farm and non-farm activities are observed at the household level. We also generate an indicator variable for participation in *wage-related activities* (observed at the individual level), which assumes a value of 1 if the household head or any other member of the household did work wage job, either at their place of work or from home, and 0 otherwise. We also generate an indicator variable for participation in *any economic activity* which assumes a value of 1 if the household head or any member of the household participated in any of the above economic activities, and zero otherwise. Because of this, our estimations aim to quantify impacts of the pandemic at the extensive margin of labor market participation.

Food consumer price index (CPI): The Food Consumer Price Index (CPI) we employ in this study is collected and constructed by the Nigeria Bureau of Statistics (NBS), which measures the average change in prices over time consumers pay for a basket of food items. Food CPI measures changes in the retail prices of food items and is the principal indicator of changes in retail food prices. It is used to measure consumer inflation in Nigeria's economy. We use food CPI for May 2019 and May 2020, corresponding to both survey rounds we employ in this study.

Table 2 reports key outcome variables: households' food security and labor market participation rates in both rounds. The results in Table 2 show significant increases in all food insecurity indicators. For example, households' food insecurity experiences, as measured by incidence of skipping a meal, running out of food, and going without eating in the last 30 days

have increased by 47, 32, and 20 percentage points, respectively. Our empirical estimations explore whether these changes and increases in food insecurity can be attributed to COVID-19 and associated mobility restrictions. On the other hand, participation in income-generating activities significantly reduced in the post-COVID-19 round, while the food consumer price index increased substantially.

Table 2: Descriptive results of key outcome variables

Key outcome Variables	Pre-COVID-19 (2019)	Post-COVID-19 (2020)	Difference test
Food security indicators			
Skip a meal (0/1)	0.26	0.73	0.47***
Run out of food (0/1)	0.25	0.57	0.32***
Went without eating for a whole day(0/1)	0.05	0.24	0.20***
Food insecurity index (standardized PCA index)	-0.42	0.43	0.85***
Labor market participation			
Farm activities	0.65	0.45	-0.19***
Non-farm business activities	0.57	0.37	-0.20***
Wage employment	0.27	0.11	-0.15***
Work in any activity	0.95	0.69	-0.26***
Food consumer price index (CPI)	289.98	359.59	69.61***
No. observations	1,906	1,906	

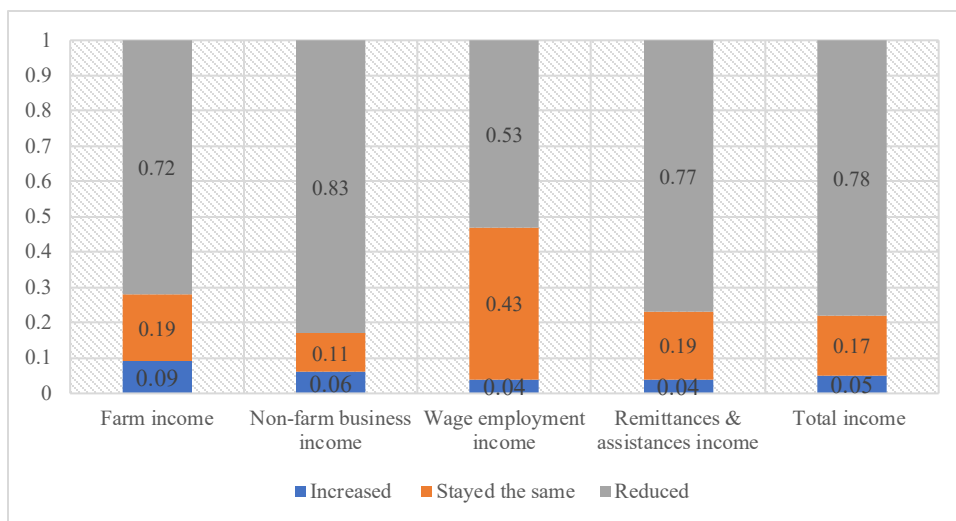
Source: Authors' calculations based on Nigeria LSMS-ISA 2018-19 and 2020 rounds. Values are weighted using the sampling weights discussed above.

Notes: Food security indicators are measured as household-level responses to a question that elicits food insecurity experienced in the last 30 days. The food insecurity index is constructed using principal component analysis. Labor market participation indicators take a value of 1 if any adult member of the household reported labor allocation for that category of activity within the last 7 days. The food consumer price index is computed at the state level.

Households were also asked about the impact of the pandemic on major livelihood sources. These are self-assessed subjective indicators, but they can provide suggestive evidence on the differential sectoral (livelihood) impacts of the pandemic, which can complement our forthcoming difference-in-difference estimations. Households were asked for major sources of livelihood in the last 12 months and changes in associated income since the outbreak of COVID-19. As shown in Figure 1, 72 percent of households reported that their income from farming and agricultural activities has reduced, 83 percent of households reported a reduction in income from non-farm businesses, and about half of them report reductions in wage-related incomes. These suggest that non-farm businesses are the most affected, and wage-related activities are relatively least affected.

This is not surprising as some wage-related activities are likely to be under formal contractual agreements, and some of these activities may be performed remotely and hence less affected by mobility restrictions.

Figure 1: Changes in income by sources since the outbreak of the pandemic. These statistics are adjusted for sampling weights.



Key explanatory variables: state-level COVID-19 cases and government lockdowns

We compiled the COVID-19 cases and lockdown measures from the Nigerian Centre for Disease Control (NCDC) (NCDC, 2020; IFPRI, 2020). As our post-COVID-19 survey was fielded in April and May 2020, we extract confirmed COVID-19 cases until the end of May 2020.

We compile government measures based on policy announcements by Federal and State Governments of Nigeria (FGN, 2020a; 2020b; NCDC, 2020). We focus on the strictest mobility restrictions, defining an indicator variable that takes a value of 1 for those states introducing lockdown measures to contain the spread of the virus, while those states which did not introduce lockdown measures take a value of 0.¹³ The timing and length of lockdowns vary across states. As our post-COVID-19 survey was fielded in April and May 2020 and our food security questions elicit food shortage experiences in the last 30 days we consider lockdown measures introduced

¹³ Nigeria has 36 states and one federal territory (the Federal Capital Territory). For simplicity, we refer to all these as 37 states. All states are included in the analysis.

between March 28 to May 15, which resulted in 17 states out of the total 37 states in Nigeria (see Figure 2).

Thus, our main explanatory variables of interest are the number of COVID-19 cases and an indicator variable for those states who introduced lockdown measures to contain the spread of the pandemic.¹⁴ The number of COVID-19 cases may underestimate the true rate of infections in most Nigerian states because of limited testing capacity, generating some form of non-classical measurement error which could correlate with our outcomes of interest.¹⁵ However, it is worth noting that what matters for household and state-level responses are actually confirmed cases and not the actual unknown infection rates.

The lockdown measures restrict movement of people and vehicles except for health personnel, fire service, security personnel, power and water supply agencies, pharmaceutical and medical services. We note that, although lockdown policies involve similar mobility restrictions, their implementation and stringency are likely to vary across states. To gauge the relevance and predictive power of our lockdown indicator, we conduct a quick validation exercise using data from Google mobility report. We particularly use daily state-level human mobility data from Google COVID-19 mobility reports. These data provides aggregate daily mobility changes after the pandemic, relative to some pre-COVID-19 baseline period, by tracing users' mobile device location history.¹⁶ If our state-level lockdown indicator is a valid measure of mobility restrictions we expect strong negative correlation between our indicator and the daily percentage change in mobility from Google mobility reports. Our simple regressions in Table 1A show that our lockdown indicator strongly predicts reduction in all types of mobility. For instance, lockdown measures are associated with about 11 percentage change (reduction) in daily transport-related mobilities. These results are encouraging.

The average state-level COVID-19 cases (at the end of May) is 222, and 46 percent of the states have imposed lockdown restrictions in the period March 28 through May 15. Figure 2 presents the geographic distribution of confirmed COVID-19 cases and lockdown interventions (measured at the state levels) across states in Nigeria. As expected, federal and state-level

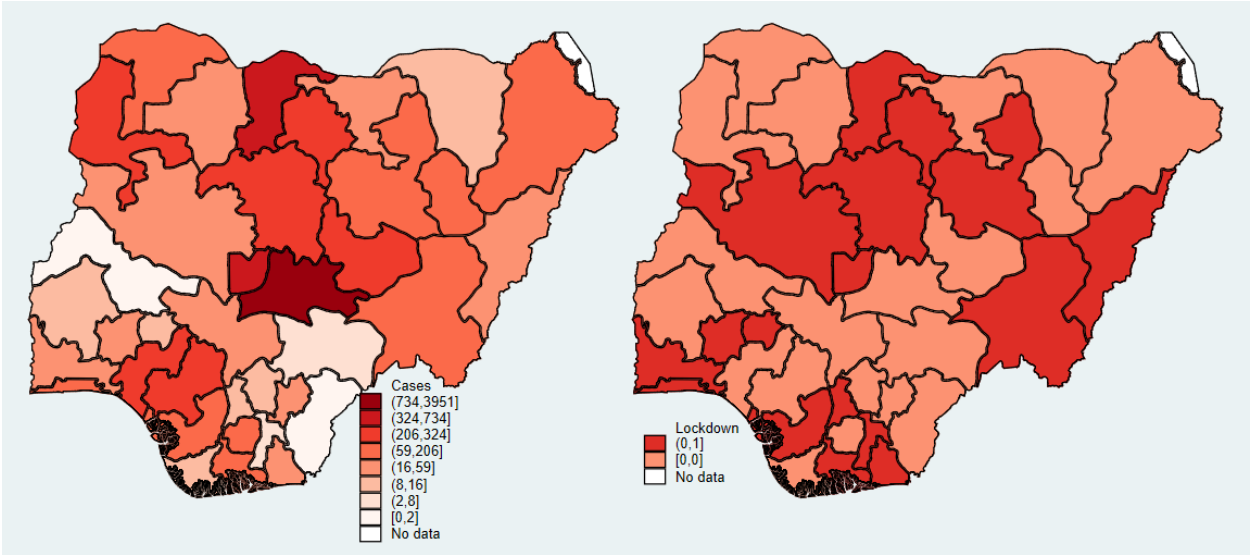
¹⁴ We also construct an indicator variable assuming a value of 1 for states above the median confirmed COVID-19 case and 0 for those states below the median COVID-19 case in our sample.

¹⁵ The implication of such correlated non-classical measurement error is ambiguous (e.g., Abay et al., 2019).

¹⁶ For details about these data, see: <https://www.google.com/covid19/mobility/>

governments are likely to introduce lockdown measures with increasing confirmed COVID-19 cases. However, some states with a high level of COVID-19 cases have abstained from introducing lockdown measures while some other states with low COVID-19 cases have announced lockdown measures. We exploit these variations in some of our estimations.

Figure 2: Confirmed COVID-19 cases and Lockdown restrictions by states



Source: Federal Government of Nigeria (2020) and Nigeria Center for Disease Control (NCDC, 2020).

"Heterogeneity" variables:

To better understand the differential impacts of COVID-19 cases and associated lockdown measures on households' food security and labor market participation rates, we employ baseline characteristics of households to differentiate "vulnerable" households and livelihoods. As the impacts of the pandemic are likely to vary across households, we aim to uncover heterogeneous impacts across various groups, especially those deemed to be vulnerable households and regions. The availability of baseline surveys allows us to estimate the impact of the pandemic across various socioeconomic groups and regions (see the mean value of these variables in Table 1). For instance, we explore potential differential impacts across rural and urban households as well as across poor and non-poor households. We also classify households in remote and more accessible areas as well as across households living in conflicted affected and other states. Households with school-going children may experience further deterioration in food security due to the nationwide school closures and associated school-feeding programs. To test this hypothesis, we estimate differential

impacts for those households with and without school-going children. We also construct indicators of household sources of livelihood in the past twelve months, including farming/agriculture, non-farm business, wage employment, remittances, and assistances.¹⁷ We then estimate heterogeneous responses and impacts across livelihood options.

3. Empirical Strategy

To quantify the impact of COVID-19 on households' food insecurity (our main outcome of interest) as well as labor market participation and food prices (our intermediate outcomes of interest), we exploit spatial variations in the spread of the pandemic across states in Nigeria, along with the temporal variations in our outcomes of interest. We specifically estimate the following fixed effects specification to quantify the impact of COVID-19:

$$Y_{ht} = \alpha_h + \beta_0 Post_t + \beta_1 Cases_s * Post_t + \varepsilon_{ht} \quad (1)$$

where Y_{ht} stands for food insecurity and labor market outcomes for each household h and round t .¹⁸ α_h captures household fixed effects, $Cases$ represent the number of confirmed COVID-19 cases for each state, which is expressed in absolute numbers as well as, in alternative specifications, per million population in each state. $Post_t$ is a dummy variable, assuming a value of 1 for the post-COVID-19 round and 0 for the pre-COVID-19 round. The parameter associated with this round dummy captures aggregate trends in food security and labor market outcomes. This variable also captures aggregate potential differences in our outcomes of interest driven by differences in survey methods (face-to-face or phone survey). ε_{ht} is an error term that is assumed to be uncorrelated with COVID-19 cases, at least conditional on household fixed effects and state-level policy responses. The household fixed effects in equation (1) capture time-invariant heterogeneities across households. The specification in equation (1) is a standard difference-in-difference approach, except that our treatment intensity variable is continuous.

Our identifying variation in equation (1) comes from a combination of spatial variations in COVID-19 and temporal variations in our outcome of interest. The interaction term, between COVID-19 cases and post-COVID-19 round dummy, captures differential temporal evolution in

¹⁷ Remittances and assistances are defined as remittances and assistances received from inside the country or foreign sources.

¹⁸ For the food price estimation, the unit of analysis is the state, and we control for state fixed effects.

our outcome of interest across states with varying exposure to the pandemic. We hypothesize that those states experiencing a higher intensity of the pandemic are more likely to witness a higher reduction in labor market participation and a higher increase in food insecurity. Thus, the estimation in equation (1) entails comparing the temporal evolution of food security and labor market outcomes for those states with high and low exposure to the pandemic.

Potential temporal variations in food security and labor market participation rates are likely to be driven by both government responses to the pandemic as well as household-level responses associated with precautionary measures to reduce the contraction of the virus. The economic repercussions of the pandemic are expected to vary depending on individuals' precautionary measures and state-level government responses (Abay et al., 2020; Koren and Peto, 2020). In line with this, various states in Nigeria have imposed alternative forms of restrictions and lockdowns, which are likely to affect individuals' mobility and hence the labor market and food security outcomes. To quantify the differential and compounding impact of these lockdown measures, we estimate the following fixed effects specification:

$$Y_{ht} = \alpha_h + \beta_0 Post_t + \beta_1 lockdown_s * Post_t + \varepsilon_{ht} \quad (2)$$

where $lockdown_s$ now stands for a dummy variable indicating for the introduction of lockdown measures.¹⁹ To gauge and identify the relative impact of government measures and individually-driven precautionary measures driven by the spread of the pandemic, we further interact the spread of the pandemic with lockdown measures. More specifically, we create an indicator variable for states recording above-median cases and interact this with lockdown measures. However, the breadth and implementation of these lockdown measures are likely to vary across states. Thus, although such an exercise can give us some latitude to identify the relative impacts of the spread of the pandemic and government-induced restrictions, such results can only provide suggestive evidence.

The impacts of the pandemic are likely to vary across households with varying socioeconomic status, livelihood options, and underlying conditions. We, thus, aim to uncover the potential differential impact of COVID-19 across various groups of households. In particular, the impacts are expected to be higher among those households and regions deemed to be vulnerable, including poor households, those households with school-going children and those living in

¹⁹ We note that as the number of COVID-19 cases are strongly correlated with government responses to the pandemic, we cannot control for both COVID-19 cases and government measures in the same specification.

conflict-affected and remote zones. Using baseline information on households' residence, socioeconomic status, and livelihood options, we quantify the differential impact of the pandemic on households' food security and labor market participation using the following empirical specification:

$$Y_{ht} = \alpha_h + \beta_0 Post_t + \beta_1 Cases * Vulnerable_h * Post_t + \varepsilon_{ht} \quad (3)$$

where all the terms, except the term "*Vulnerable*", are as defined above. Our vulnerable group of households includes poorer, households with school children, urban households and those living in remote and conflict-affected zones and neighborhoods. β_1 in equation (3) capture differential trends in food security and labor market outcomes of those deemed "vulnerable" households, which can be attributed to the spread of the pandemic and associated lockdown restrictions.

We also examine potential differential impacts across households with varying exposure to the pandemic because of their livelihood strategies and sectoral engagement in labor markets. For example, some sectors are likely to experience a disproportionately higher impact associated with social distancing and lockdown measures. For example, several recent economywide analyses of the impact of the pandemic show that services are the most affected sectors (e.g., Breisinger et al., 2020). Abay et al. (2020) show that those sectors and services involving face-to-face interactions experience much higher loss in demand for services, while those services meant to substitute personal interactions (e.g., ICT services) enjoy a significant boost in demand. Traditional small non-farm businesses in Africa are likely to involve personal interactions and hence may be more affected than those activities that can be performed remotely. Similarly, rural activities might be less prone to the spread of the pandemic and associated lockdown measures for several reasons. First, the spread of the pandemic is likely to be higher among urban areas. Second, government responses and restrictions are expected to be more strict and intense among urban areas. Third, urban food systems and value chains are likely to be more affected by short-term shocks than rural livelihoods. We thus estimate the following empirical specification to quantify the differential impact of the pandemic across livelihood options.

$$Y_{ht} = \alpha_h + \beta_0 Post_t + \beta_1 Cases * Livelihood_h * Post_t + \varepsilon_{ht} \quad (4)$$

Where all notations except "*Livelihood*" are as defined above. As shown in Table 1, households' livelihood options and sources of income in our sample include farming (agriculture), non-farm business, wage-employment, and remittances and assistances.

To account for systematic non-response in the post-COVID-19 phone survey, we weighted all our estimates by the sampling weight associated with the LSMS-ISA phone survey data.²⁰ This weighting procedure enables recovering unbiased and representative statistics under the assumption that data are “missing at random” conditional on some observable factors that are accounted in the construction of weights (e.g., Wooldridge, 2007; Korinek et al., 2007). As we are following households across rounds, error terms are expected to be correlated across time. We, thus, cluster standard errors at the household level.

4. Results

4.1. Food security impacts

In this section, we present estimation results on the impact of the pandemic and associated lockdowns on food security, corresponding to equations (1) and (2). Table 3 shows the impact of COVID-19 on food security outcomes, measured as binary indicators of food insecurity experience.²¹ The number of reported COVID-19 cases for each state are transformed using an inverse hyperbolic sine transformation, to accommodate those few states with zero reported cases.²²

The interaction between COVID-19 cases and the post-COVID-19 dummy captures the temporal variation in the evolution of our outcomes of interest associated with varying exposure to the spread of the pandemic. A positive and significant impact shows that states registering higher numbers of COVID-19 cases are likely to experience greater increases in the probability of food insecurity, relative to the pre-COVID-19 period. The coefficients in Table 3 show that doubling the number of COVID-19 cases is associated with a 2.4-2.7 percentage point increase in the probability that a household ran out of food or skipped a meal in the last 30 days.²³ Similarly, one percent increase in the number of COVID-19 cases is associated with 0.08 standard deviations increase in food insecurity index. The size of the impact is plausible, although we expect

²⁰ A discussion on the construction of these sampling weights are given in NBS and World Bank (2020).

²¹ Because of the low number of zero-valued cases in the infection rates, the inverse hyperbolic sine transformed values differ very little from log transformed values and can be effectively interpreted in the same manner. The only state which didn't report COVID-19 cases in May 2020 was Cross Rivers.

²² As we have large positive values of COVID-19 cases for most states, such a transformation is expected to be innocuous (e.g., Bellemare and Wichman, 2019).

²³ We note that, as the spread of the pandemic remains fast globally, doubling of COVID-19 cases takes only a few weeks (in some cases less than a week) in many countries, including in Nigeria.

significant heterogeneities across different types of households and contexts, an empirical question we address in the next section.²⁴

Table 3: Impact of COVID-19 cases on household food security outcomes

	(1) Skip a meal	(2) Ran out of food	(3) Went without eating for a whole day	(4) Food insecurity index
Post dummy (2020 round)	0.369*** (0.052)	0.217*** (0.054)	0.072 (0.050)	0.639*** (0.083)
COVID-19 cases*Post	0.025** (0.011)	0.024** (0.011)	0.027*** (0.010)	0.079*** (0.025)
Constant	0.262*** (0.010)	0.251*** (0.010)	0.056*** (0.009)	-0.409*** (0.019)
Household fixed effects	Yes	Yes	Yes	Yes
R-squared	0.39	0.22	0.15	0.37
No. observations	3812	3812	3812	3812

Source: Authors' calculations based on Nigeria's LSMS-ISA 2018-19 and 2020 rounds.

Notes: All estimation results are adjusted by sampling weights accounting for systematic non-response in the phone survey. The number of confirmed COVID-19 cases are transformed using an inverse hyperbolic sine transformation to accommodate one state with zero case. Standard errors, clustered at the household level, are given in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The impacts shown in Table 3 are likely to be compounded by national and state-level government responses to the pandemic, which included social distancing and mobility restrictions as well as partial and complete lockdown measures. We thus estimate the empirical specification in equation (2) to quantify the implication of variations in state-level responses to the pandemic. We mainly focus on the strictest mobility restrictions and hence generate an indicator variable for states introducing lockdown measures. We then compare temporal evolutions in food security outcomes across states with and without lockdown measures. Table 4 generally shows that lockdowns increase food insecurity. For example, we find that state-level lockdowns increase the probability that a household skips a meal in the last 30 days by 13 percentage points.

²⁴ When we use the number of infections per 1 million inhabitants, the results are qualitatively the same. Results are reported in the Appendix (Table 2A-6A).

Table 4: Government responses and food security indicators

	(1) Skip a meal	(2) Ran out of food	(3) Went without eating for a whole day	(4) Food insecurity index
Post dummy (2020 round)	0.426*** (0.027)	0.299*** (0.029)	0.172*** (0.024)	0.782*** (0.057)
Lockdown*Post	0.130*** (0.038)	0.071* (0.038)	0.059* (0.034)	0.215*** (0.076)
Constant	0.262*** (0.010)	0.251*** (0.010)	0.056*** (0.009)	-0.409*** (0.019)
Household fixed effects	Yes	Yes	Yes	Yes
R-squared	0.41	0.27	0.19	0.37
No. observations	3812	3812	3812	3812

Source: Authors' calculations based on Nigeria LSMS-ISA 2018-19 and 2020 rounds.

Note: Dependent variables are as defined in Table 2. All estimations are adjusted by sampling weights accounting for non-response in the phone survey. Standard errors, clustered at the household level, are given in parentheses. *Lockdown* is an indicator variable taking a value of 1 for those states which introduced lockdown measures to contain the spread of the virus. Standard errors, clustered at the household level, are given in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

To jointly examine the effects of infection rates and lockdowns, we also interact the indicator variables for the spread of the pandemic with lockdown measures. To facilitate this, we construct an indicator variable assuming a value of 1 for states above the median confirmed COVID-19 case and 0 for those states below the median COVID-19 case in our sample. Interacting these indicators gives us four groups: high COVID-19 cases with lockdown, high COVID-19 cases without a lockdown, low COVID-19 cases with lockdown, and low COVID-19 cases without lockdown. The estimation results are shown in Table 5. As expected, households in states recording high COVID-19 cases and with lockdown measures are hit hardest and hence experience the greatest increase in food insecurity. Coefficient estimates suggest that both the spread of the pandemic as well as government-induced lockdown measures are increasing food insecurity. However, the former seems to dominate.

Table 5: Disentangling the impact of COVID-19 cases and government measures

	(1)	(2)	(3)	(4)
	Skip a meal	Ran out of food	Went without eating for a whole day	Food insecurity index
Post dummy (2020 round)	0.409*** (0.035)	0.238*** (0.036)	0.125*** (0.031)	0.672*** (0.070)
High COVID-19 cases*Lockdown*Post	0.203*** (0.047)	0.176*** (0.048)	0.119*** (0.044)	0.430*** (0.093)
High COVID-19 cases*No-lockdown*Post	0.038 (0.055)	0.131** (0.057)	0.103** (0.049)	0.239** (0.113)
Low COVID-19 cases*Lockdown*Post	0.018 (0.061)	0.025 (0.055)	0.077* (0.042)	0.076 (0.110)
Constant	0.262*** (0.010)	0.251*** (0.010)	0.056*** (0.009)	-0.409*** (0.019)
Household fixed effects	Yes	Yes	Yes	Yes
R-squared	0.42	0.26	0.16	0.38
No. observations	3812	3812	3812	3812

Source: Authors' calculations based on Nigeria LSMS-ISA 2018-19 and 2020 rounds.

Note: "High" and "Low" COVID-19 cases are defined as above and below the median confirmed values in our sample, respectively. All estimations are adjusted by sampling weights for accounting non-response in the phone survey. The number of confirmed COVID-19 cases is transformed using inverse hyperbolic sine transformation to keep zero cases for one state. Lockdown stands for indicator variables for those states who introduced lockdown measures to contain the spread of the virus. Standard errors, clustered at the household level, are given in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.2. Mechanisms and Intermediate outcomes

The impact of COVID-19 on labor market participation

Reduction in income is one of the most important mechanisms through which the COVID-19 pandemic can affect food insecurity. Results in Table 6 show the implication of the spread of the pandemic on labor market participation rates. As expected, the spread of the pandemic is associated with a significant reduction in economic activity. The interaction term in column 1 of Table 6 shows that doubling the number of COVID-19 cases is associated with a 2 percentage points reduction in the probability of participation in any economic activity (in the last seven days). The second column presents impacts on-farm activities, while the third and fourth columns report impacts on non-farm business and wage-related activities. Overall, these results imply that households in areas with a higher degree of exposure to the pandemic have experienced significant reductions in economic engagement. Wage-related activities are the least affected, probably because some of these activities can be performed remotely (e.g., Dingel and Neiman, 2020) and/or are under formal contracts. As shown in our data (not reported here for lack of space), the majority of wage workers are employed in the public sector and non-governmental organizations, which are less likely to fire employees and allow employees operate some of their functions in some

form. These findings are consistent with global evidence on the differential sectoral impact of the pandemic (e.g., Dingel and Neiman, 2020; Abay et al., 2020).

Table 6: Impact of COVID-19 cases on participation in economic activities

	(1)	(2)	(3)	(4)
	Working any activity	Farm activities	Non-farm business	Wage employment
Post dummy (2020 round)	-0.459*** (0.052)	-0.056 (0.056)	-0.214*** (0.063)	-0.073* (0.043)
COVID-19 cases*Post	-0.021** (0.010)	-0.033*** (0.012)	-0.016* (0.009)	-0.013 (0.009)
Constant	0.958*** (0.009)	0.676*** (0.010)	0.662*** (0.008)	0.235*** (0.007)
Household fixed effects	Yes	Yes	Yes	Yes
R-squared	0.54	0.18	0.22	0.26
No. observations	3812	3812	3812	3812

Source: Authors' calculations based on Nigeria LSMS-ISA 2018-19 and 2020 rounds.

Note: All estimations are adjusted by sampling weights for accounting non-response in the phone survey. The number of confirmed COVID-19 cases is transformed using inverse hyperbolic sine transformation to keep zero cases for few states. Standard errors, clustered at the household level, are given in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Similar to the food security results, the results shown above are likely to be compounded by government lockdown measures. Table 7 shows that lockdowns limit economic activities and hence households' participation in labor market activities. Interestingly, state-level lockdown measures are more impactful in reducing non-farm business activities. As expected, wage-related activities appear to be less affected by state-level lockdown measures, perhaps due to the following important reasons. First, wage-related activities may still be operated remotely and hence individuals can continue working. Second, individuals engaged in wage-related activities are likely to have formal contracts and hence are less likely to lose their job at short notice. For instance, more than half of the wage employees in our data are employed in government and non-governmental organizations, which are less likely to fire employees.

Table 7: Government responses and participation in economic activities

	(1) Working any activity	(2) Farm activities	(3) Non-farm business	(4) Wage employment
Post dummy (2020 round)	-0.239*** (0.025)	-0.176*** (0.027)	-0.311*** (0.029)	-0.116*** (0.023)
Lockdown*Post	-0.024* (0.013)	-0.079** (0.039)	-0.112*** (0.041)	-0.036 (0.031)
Constant	0.958*** (0.008)	0.676*** (0.010)	0.602*** (0.010)	0.238*** (0.008)
Household fixed effects	Yes	Yes	Yes	Yes
R-squared	0.54	0.14	0.19	0.25
No. observations	3812	3812	3812	3812

Source: Authors' calculations based on Nigeria LSMS-ISA 2018-19 and 2020 rounds.

Note: All estimations are adjusted by sampling weights for accounting non-response in the phone survey. Lockdown stands for indicator variables for those states who introduced lockdown measures to contain the spread of the virus. Standard errors, clustered at the household level, are given in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The impact of COVID-19 on food prices

As discussed in Béné (2020), COVID has various adverse effects on local food systems' agents and is likely to have negative impacts on food security. These effects include but are not limited to, the disruption in inputs' supply chain, the drop in the demand of certain food commodities, the reduction in workers' availability, and the disruption in transportation (of inputs and final products), as well as the effect on food retailers and vendors' activities. All these inevitably have an upward effect on food consumer prices. The food price increase is another likely supply-side channel through which COVID-19 can affect food insecurity (e.g., Mogue, 2020). We used the pre-COVID-19 food consumer price index (May-2019) and post-COVID-19 food consumer index (May-2020) to quantify the effects of the pandemic on the change in the consumer price index, as well as the COVID-19 related change in food prices on household food security. As reported in Table 8, the country experiences an increase in food price due to the pandemic, both when related to infection rates and to lockdown measures. In Table 9, we also show that pandemic-related food price increase harms food security, irrespective of the food security indicator that is used.

Table 8: Impact of COVID-19 cases and lockdown on the food consumer price index

	(1) CPI	(2) CPI	(3) CPI
Post dummy (2020 round)	0.217*** (0.002)	0.203*** (0.005)	0.205*** (0.005)
Lockdown*Post	0.005* (0.003)		0.008*** (0.003)
COVID-19 Cases* Post		0.004*** (0.001)	0.005*** (0.001)
Constant	6.362*** (0.001)	6.362*** (0.001)	6.362*** (0.001)
R-squared	0.76	0.81	0.88
No. observations	3812	3812	3812

Source: Authors' calculations based on Nigeria LSMS-ISA 2018-19 and 2020 rounds

Note: All estimations are adjusted by sampling weights for accounting non-response in the phone survey. The number of confirmed COVID-19 cases is transformed using inverse hyperbolic sine transformation to keep zero cases for one state. CPI values are log-transformed. Standard errors, clustered at the household level, are given in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 9: COVID-19, Food Consumer Price Index and food security

	(1) Skip a meal	(2) Ran out of food	(3) Went without eating for a whole day	(4) Food insecurity index
Post dummy (2020 round)	4.983 (5.950)	2.707 (5.949)	-1.630 (4.463)	-1.215 (13.172)
CPI	-0.673** (0.331)	-0.294 (0.343)	-0.498* (0.275)	-0.004* (0.002)
CPI*Post	-0.701 (0.904)	-0.378 (0.904)	0.258 (0.677)	0.317 (2.010)
COVID-19 Cases*CPI*Post	0.004** (0.002)	0.004** (0.002)	0.004*** (0.002)	0.013*** (0.004)
Constant	0.262*** (0.010)	0.251*** (0.010)	0.056*** (0.008)	0.636 (0.629)
Household fixed effects	Yes	Yes	Yes	Yes
No. observations	3812	3812	3812	3812

Source: Authors' calculations based on Nigeria LSMS-ISA 2018-19 and 2020 rounds.

Note: All estimations are adjusted by sampling weights for accounting non-response in the phone survey. The number of confirmed COVID-19 cases is transformed using inverse hyperbolic sine transformation to keep zero cases for few states. CPI values are log-transformed. Standard errors, clustered at the household level, are given in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.3. Heterogeneous impacts

Differential household impacts of COVID-19 on food security and labor market participation

The impact of COVID-19 is likely to vary across households due to differences in underlying conditions and exposure to the pandemic as well as in associated government measures and responses. For instance, urban households are likely to experience higher exposure to the pandemic, and hence they are likely to experience reductions in economic activities. Similarly,

poorer households' and those in remote areas and conflict zones could see further deterioration in food security because of disruptions in local and national transportation systems and markets. Such heterogeneous impacts may also vary by type of outcome. For instance, while urban households are likely to experience reductions in economic activities, poorer and remotely located households may be more likely to face food security challenges. For this purpose, we define indicator variables for urban and poor households, those in remote (measured by the distance to the main road) and conflict-affected areas, and those with school-going children. These variables are interacted with state-level COVID-19 cases and lockdown indicators to quantify the differential impact of the spread of the pandemic and associated lockdown measures.

Results, presented in Table 10, show that those households living in remote areas and conflict-affected North-East Nigeria (Yobe, Borno, Bauchi, Gombe, Taraba, and Adamawa States) are more likely to experience deterioration in food security. On the other hand, although urban households reduce economic activities (as we show in Table 11), they do not suffer from significant reductions in food security. This finding is probably because of better underlying food security and improved access to markets. On the other hand, poorer households experience significant increases in all indicators of food insecurity, although some of their activities are not meaningfully affected by state-level lockdowns (Table 11). This is likely driven by differences in responses to lockdown measures between poor and non-poor households. Consistent with this argument, Bargain and Aminjonov (2020) use Google mobility data and document that mobility reductions are relatively smaller in poor neighborhoods in developing countries, possibly because poorer households in such settings are less able to afford the costs of reduced mobility in compliance with government restrictions.

Our results also show that households with school attending children, who are likely to miss government school meals because of school closure, are likely to face food security challenges. This is anticipated in the context of Nigeria, where about 7.5 million pupils in 46,000 schools are enrolled in the national school feeding program (World Bank, 2020c). The closure of schools is likely to reduce the food intake of these children, potentially exacerbating any negative effects on their human capital development.

Table 10: Differential impact of COVID-19 on household food security

Panel A: Differential impact of COVID-19 cases on household food security				
	(1)	(2)	(3)	(4)
	Skip a meal	Ran out of food	Went without eating for a whole day	Food insecurity index
Post dummy (2020 round)	0.481*** (0.021)	0.320*** (0.022)	0.186*** (0.019)	0.860*** (0.045)
COVID-19 cases*Urban*Post	0.006 (0.014)	0.017 (0.015)	0.021 (0.014)	0.021 (0.025)
COVID-19 cases*log(Distance to road)*Post	0.007 (0.004)	0.010** (0.004)	0.009** (0.004)	0.021** (0.008)
COVID-19 cases*Asset poor tercile*Post	0.048*** (0.015)	0.029* (0.017)	0.031* (0.017)	0.069** (0.027)
COVID-19 cases*North East Zone*Post	0.011 (0.017)	-0.000 (0.016)	0.042** (0.017)	0.027* (0.014)
COVID-19 cases*School children*Post	0.021** (0.010)	0.018* (0.011)	0.023*** (0.009)	0.027** (0.012)
Constant	0.262*** (0.010)	0.251*** (0.010)	0.056*** (0.009)	-0.409*** (0.019)
Household fixed effects	Yes	Yes	Yes	Yes
No. observations	3812	3812	3812	3812

Source: Authors' calculations based on Nigeria LSMS-ISA 2018-19 and 2020 rounds.

Note: All estimations are adjusted by sampling weights for accounting non-response in the phone survey. The number of confirmed COVID-19 cases is transformed using inverse hyperbolic sine transformation to keep zero cases for few states. Lockdown stands for indicator variables for those states who introduced lockdown measures to contain the spread of the virus. Standard errors, clustered at the household level, are given in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The results in Table 11 provide differential impacts of COVID-19 cases and associated lockdown measures on households' labor market participation in economic activities. These results indicate that urban households and those households located in remote areas and conflict-affected areas of North East Nigeria are likely to experience significant reductions in economic activities. For example, urban households are more likely to experience a reduction in economic activities, despite significant variations across various types of economic activities. Households in urban areas reduce non-farm business and wage-related activities while increasing farm activities. This implies that the pandemic can also lead to the reallocation of labor resources across alternative economic activities and sectors of economies. Similarly, households in remote areas and those in conflicted-affected areas are disproportionately affected by the COVID-19 crisis and hence reduce all forms of economic activities. These patterns are consistently observed when using both COVID-19 cases and lockdown measures.

Table 11: Differential impacts of COVID-19 cases on economic activities

Panel A: Differential impacts of COVID-19 cases on economic activities				
	(1)	(2)	(3)	(4)
	Working any activity	Farm activities	Non-farm business	Wage employment
Post dummy (2020 round)	-0.530*** (0.021)	-0.285*** (0.023)	-0.230*** (0.025)	-0.203*** (0.017)
COVID-19 cases*Urban*Post	-0.018** (0.008)	0.054*** (0.009)	-0.023** (0.009)	-0.025*** (0.007)
COVID-19 cases*log(Distance to road)*Post	-0.007** (0.003)	-0.016*** (0.004)	-0.008** (0.004)	-0.001 (0.003)
COVID-19 cases*Asset Poor*Post	-0.024*** (0.008)	-0.025*** (0.009)	0.010 (0.009)	-0.020*** (0.006)
COVID-19 cases*North East Zone*Post	-0.022*** (0.009)	-0.048*** (0.010)	-0.032*** (0.011)	-0.005 (0.009)
Constant	0.958*** (0.009)	0.676*** (0.010)	0.602*** (0.010)	0.238*** (0.007)
Panel B: Differential impacts of government measures on economic activities				
Post dummy (2020 round)	-0.228*** (0.019)	-0.237*** (0.021)	-0.260*** (0.023)	-0.112*** (0.017)
Lockdown*Urban* Post	-0.041* (0.022)	0.183*** (0.054)	-0.003 (0.054)	-0.146*** (0.041)
Lockdown*log(Distance to road)* Post	0.002 (0.013)	-0.040*** (0.015)	-0.041*** (0.016)	-0.017 (0.012)
Lockdown*Asset poor tercile*Post	-0.032 (0.060)	-0.165*** (0.057)	-0.098* (0.056)	-0.080* (0.042)
Constant	0.958*** (0.008)	0.676*** (0.010)	0.602*** (0.010)	0.238*** (0.008)
Household fixed effects	Yes	Yes	Yes	Yes
No. observations	3812	3812	3812	3812

Source: Authors' calculations based on Nigeria LSMS-ISA 2018-19 and 2020 rounds.

Note: All estimations are adjusted by sampling weights for accounting non-response in the phone survey. The number of confirmed COVID-19 cases is transformed using inverse hyperbolic sine transformation to keep zero cases for few states. Lockdown stands for indicator variables for those states who introduced lockdown measures to contain the spread of the virus. Standard errors, clustered at the household level, are given in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Differential impacts of COVID-19 on various livelihoods

In this section, we explore potentially heterogeneous impacts of the pandemic across households with varying livelihoods and sources of incomes. Several studies from developed countries, where administrative and transaction-level data are available, show that the pandemic has had heterogeneous impacts on different livelihood options and sectors. 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 (Dingel and Neiman, 2020; Abay et al., 2020; Gilligan, 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. Although not many rural activities in Nigeria are functionally dependent on the internet, some activities can be operated without many personal interactions with others and hence may be relatively less prone to these restrictions and lockdown measures.

We hypothesize that households relying on alternative livelihood options and economic sectors may be relatively more resilient to the shocks associated with pandemic. For instance, as shown in Figure 1 and Table 6, those households relying on non-farm businesses, witness the highest reduction in income and economic activities. On the other hand, wage-related activities and income sources are least affected by lockdown measures (Figure 1 and Table 6). The estimations in Table 12 probe these relationships further to explore heterogeneous impacts across households' livelihood and income sources.

The results in Table 12 consistently show that those households relying on on-farm activities and non-farm businesses experience a significant increase in food insecurity associated with COVID-19 cases and associated lockdowns. Those households relying on wage, remittance, and assistance income are not significantly affected by the pandemic and associated lockdowns. This is consistent with the self-assessed evidence from Figure 1. This is not surprising as some wage-related activities may still be operated remotely, or individuals engaged in wage-related activities have longer-term contracts or savings that they can draw on during crises of this type.

Table 12: Differential impact of COVID-19 and government measures on household food security

Panel A: Differential impacts of COVID-19 cases on household food security				
	(1)	(2)	(3)	(4)
	Skip a meal	Ran out of food	Went without eating for a whole day	Food insecurity index
Post dummy (2020 round)	0.409*** (0.034)	0.253*** (0.037)	0.183*** (0.032)	0.724*** (0.066)
COVID-19 cases*Farming* Post	0.020*** (0.008)	0.021** (0.008)	0.004 (0.007)	0.063*** (0.021)
COVID-19 cases*Non-farm business* Post	0.016** (0.007)	0.015** (0.008)	0.015** (0.007)	0.056*** (0.021)
COVID-19 cases*Wage employment* Post	-0.018** (0.008)	-0.003 (0.008)	-0.017** (0.008)	-0.029 (0.021)
COVID-19 cases*Remittances and assistances*Post	-0.001 (0.008)	0.004 (0.008)	-0.002 (0.007)	0.017 (0.024)
Constant	0.262*** (0.010)	0.251*** (0.010)	0.056*** (0.009)	-0.409*** (0.019)
Panel B: Differential impacts of government measures on household food security				
Post dummy (2020 round)	0.425*** (0.025)	0.295*** (0.026)	0.180*** (0.022)	0.779*** (0.052)
Lockdown*Farming* Post	0.161*** (0.039)	0.095** (0.038)	0.050 (0.035)	0.267*** (0.076)
Lockdown*Non-farm business* Post	0.126*** (0.039)	0.075* (0.040)	0.078** (0.035)	0.223*** (0.078)
Lockdown*Wage employment* Post	-0.054 (0.050)	0.005 (0.052)	-0.074 (0.052)	-0.062 (0.099)
Lockdown*Remittances & assistances*Post	0.057 (0.047)	0.066 (0.050)	-0.049 (0.046)	0.113 (0.097)
Constant	0.262*** (0.010)	0.251*** (0.010)	0.056*** (0.009)	-0.409*** (0.019)
Household fixed effects	Yes	Yes	Yes	Yes
No. observations	3812	3812	3812	3812

Source: Authors' calculations based on Nigeria LSMS-ISA 2018-19 and 2020 rounds.

Note: All estimations are adjusted by sampling weights for accounting non-response in the phone survey. Lockdown stands for indicator variables for those states who introduced lockdown measures to contain the spread of the virus. Standard errors, clustered at the household level, are given in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

5. Concluding remarks

This study employed recent nationally representative data from Nigeria to document the ways in which the COVID-19 pandemic has been affecting both urban and rural households' food security outcomes. Our analysis suggests that the spread of the pandemic, as well as governmental mobility restrictions (i.e. "lockdowns"), have both had significant impacts on food security outcomes reported by households in our sample. Furthermore, our analysis shows clear effects of infection rates and lockdowns on key intermediate channels, including restricted household economic activity and increased local food prices. We do not have enough information to relate lockdown restrictions to the avoided (or delayed) number of new cases, and so cannot directly speak to the tradeoffs that government lockdown policies imply. However, our analysis indicates that there are measurable food insecurity costs associated with infection rates, as well as the restrictions designed to contain the spread of the pandemic. State-level lockdown measures reduced the probability of participation in non-farm business activities by 11 percentage points and increased households' experience of food insecurity by 13 percentage points. Our finding that government-imposed lockdowns are increasing food insecurity is consistent with a recent review of grey literature indicating that the main food security impacts of the pandemic have been through lockdown and mobility restrictions, with direct effects operating through income losses and reduced purchasing power, particularly for the poorest households (Béné, 2020). This finding is directly relevant to the debate on the aggregate social welfare and economic impacts of lockdown restrictions in low-and-middle-income countries, which has come under some criticism (e.g., Ravallion et al., 2020, Mobarak and Barnett-Howell, 2020, Bargain and Aminjonov 2020).

Furthermore, we find that impacts vary considerably by household and geographic context. Most of these results tally with expectations: for example, the food security outcomes of poorer households, those households with school attending children, and those living in conflict-affected areas are most sensitive to COVID-19 effects. For instance, lockdown measures are more impactful in disrupting non-farm business activities, and those households relying on these activities experience the highest reduction income and increase in food insecurity. These lockdown measures have smaller impacts on wage-related activities. It is important to note that the current analysis is measuring the short-term impacts of the pandemic, i.e., those occurring during the first 3 months of significant disruption. It is not yet clear how these impacts may change over time, as the epidemic continues to play out over time and space. It is possible that the estimated elasticities

of food insecurity, economic engagement, and food prices to the spread of the pandemic and lockdowns may evolve over time. Nevertheless, income deterioration experienced by households soon after the outbreak of the pandemic may have longer-term effects because of potential impacts on agricultural inputs, health care, schooling and other investments in the coming months. Our results align with other evaluations of the urgency of effective social safety net expansion to address such exacerbated vulnerabilities and mitigate against their longer term economic and welfare implications (Amjath-Babu et al., 2020; Béné, 2020).

This article contributes new empirical analysis of the impacts of the pandemic at a point where there is an abundance of conceptual papers and opinion pieces but still scant evidence on the actual economic and welfare impacts of the pandemic, particularly in developing countries. One of the policy implications of our study is the need to address social safety nets in rural areas as well as urban areas, which have been the focus of much of the discussion in the region to date (Gentilini et al., 2020; Gilligan, 2020; Devereux, et al., 2020). These findings can inform immediate and medium-term social protection policies as well as help governments and international donor agencies improve their targeting strategies to identify the most impacted sub-populations.

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Appendix

Table 1A: Relationship between lockdown indicators and reduction in mobilities (using Google mobility report).

	(1) Change in mobility related to retail and recreation	(2) Change in mobility related to grocery and pharmacy	(3) Change in mobility related to parks	(4) Change in mobility related to transit stations	(5) Change in mobility related to workplaces
Lockdown	-4.008*** (0.503)	-2.843*** (0.417)	-8.459*** (0.431)	-11.123*** (0.456)	-1.351*** (0.239)
Constant	-16.541*** (0.362)	-10.515*** (0.300)	-16.214*** (0.310)	-16.956*** (0.328)	-12.759*** (0.172)
<i>No. obs</i>	2840	2840	2840	2840	2840

Notes: Authors' calculations based on Google mobility report data for Nigeria. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2A: Impact of COVID-19 cases (per 1 million inhabitants) on household food security outcomes

	(1) Skip a meal	(2) Ran out of food	(3) Went without eating for a whole day	(4) Food insecurity index
Post dummy (2020 round)	0.391*** (0.042)	0.229*** (0.042)	0.106*** (0.037)	0.593*** (0.107)
COVID-19 cases*Post	0.031** (0.013)	0.033*** (0.013)	0.030*** (0.012)	0.061*** (0.022)
Constant	0.262*** (0.010)	0.251*** (0.010)	0.056*** (0.008)	-0.409*** (0.019)
Household fixed effects	Yes	Yes	Yes	Yes
R-squared	0.39	0.22	0.15	0.36
No. observations	3812	3812	3812	3812

Source: Authors' calculations based on Nigeria's LSMS-ISA 2018-19 and 2020 rounds.

Notes: All estimation results are adjusted by sampling weights accounting for systematic non-response in the phone survey. The number of confirmed COVID-19 cases per million inhabitants is transformed using an inverse hyperbolic sine transformation to accommodate one state with zero cases. Standard errors, clustered at the household level, are given in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3A: Disentangling the impact of COVID-19 cases (per 1 million inhabitants) and government measures

	(1) Skip a meal	(2) Ran out of food	(3) Went without eating for a whole day	(4) Food insecurity index
Post dummy (2020 round)	0.423*** (0.030)	0.267*** (0.029)	0.137*** (0.026)	0.758*** (0.054)
High COVID-19 cases*Lockdown*Post	0.164*** (0.052)	0.166*** (0.053)	0.061 (0.049)	0.232** (0.096)
High COVID-19 cases*No-lockdown*Post	0.097** (0.044)	0.117*** (0.043)	0.126*** (0.040)	0.216** (0.088)
Low COVID-19 cases*Lockdown*Post	-0.046 (0.086)	-0.111 (0.086)	0.064 (0.053)	-0.093 (0.210)
Constant	0.262*** (0.009)	0.251*** (0.010)	0.056*** (0.008)	-0.409*** (0.019)
Household fixed effects	Yes	Yes	Yes	Yes
R-squared	0.41	0.26	0.16	0.37
No. observations	3812	3812	3812	3812

Source: Authors' calculations based on Nigeria LSMS-ISA 2018-19 and 2020 rounds

Note: "High" and "Low" COVID-19 cases are defined as above and below the median confirmed values in our sample, respectively. All estimations are adjusted by sampling weights for accounting non-response in the phone survey. Lockdown stands for indicator variables for those states who introduced lockdown measures to contain the spread of the virus. Standard errors, clustered at the household level, are given in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4A: Impact of COVID-19 cases on participation in economic activities

	(1) Working any activity	(2) Farm activities	(3) Non-farm business	(4) Wage employment
Post dummy (2020 round)	-0.512*** (0.040)	-0.084* (0.043)	-0.208*** (0.046)	-0.084** (0.036)
COVID-19 cases*Post	-0.014** (0.007)	-0.042*** (0.013)	-0.017* (0.009)	-0.016 (0.011)
Constant	0.958*** (0.009)	0.676*** (0.010)	0.602*** (0.010)	0.238*** (0.008)
Household fixed effects	Yes	Yes	Yes	Yes
R-squared	0.54	0.18	0.22	0.26
No. observations	3812	3812	3812	3812

Source: Authors' calculations based on Nigeria LSMS-ISA 2018-19 and 2020 rounds

Note: All estimations are adjusted by sampling weights for accounting non-response in the phone survey. The number of confirmed COVID-19 cases per million inhabitants is transformed using inverse hyperbolic sine transformation to keep zero cases for few states. Standard errors, clustered at the household level, are given in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5A: Impact of COVID-19 cases and lockdown on the food consumer price index

	(1) CPI	(2) CPI	(3) CPI
Post dummy (2020 round)	0.212*** (0.002)	0.203*** (0.005)	0.203*** (0.005)
Lockdown*Post	0.011*** (0.003)		0.009*** (0.003)
COVID-19 Cases* Post		0.004*** (0.001)	0.003** (0.001)
Constant	6.362*** (0.001)	6.362*** (0.001)	6.362*** (0.001)
R-squared	0.76	0.81	0.88
No. observations	3812	3812	3812

Source: Authors' calculations based on Nigeria LSMS-ISA 2018-19 and 2020 rounds

Note: All estimations are adjusted by sampling weights for accounting non-response in the phone survey. The number of confirmed COVID-19 cases is transformed using inverse hyperbolic sine transformation to keep zero cases for a few states. CPI values are log-transformed. Standard errors, clustered at the household level, are given in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 6A: COVID-19, Food Consumer Price Index and food security

	(1) Skip a meal	(2) Ran out of food	(3) Went without eating for a whole day	(4) Food insecurity index
Post dummy (2020 round)	1.058 (6.374)	0.659 (6.548)	-4.356 (5.078)	0.045 (13.187)
CPI	-0.665** (0.332)	-0.290 (0.343)	-0.491* (0.275)	-0.003 (0.002)
CPI*Post	-0.081 (0.972)	-0.056 (1.000)	0.693 (0.775)	0.116 (2.011)
COVID-19 Cases*CPI*Post	0.005** (0.002)	0.005*** (0.002)	0.005*** (0.002)	0.010*** (0.004)
Constant	4.491** (2.114)	2.096 (2.182)	3.183* (1.751)	0.562 (0.630)
Household fixed effects	Yes	Yes	Yes	Yes
No. observations	3812	3812	3812	3812

Source: Authors' calculations based on Nigeria LSMS-ISA 2018-19 and 2020 rounds.

Note: All estimations are adjusted by sampling weights for accounting non-response in the phone survey. The number of confirmed COVID-19 cases per million inhabitants is transformed using inverse hyperbolic sine transformation to keep zero cases for one states. CPI values are log-transformed. Standard errors, clustered at the household level, are given in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

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