# Assessing Food Security in the Post-COVID-19 Period: Evidence from Indian Households

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## Abstract

Most previous studies investigated food security situations before and during the Covid-19 pandemic. Therefore, how food insecurity status in the post-pandemic lockdown era has been changing is unknown. The present study examines the status of households' food insecurity severity during and after the pandemic lockdown in India, using multiple phone surveys made available by the World Bank. The results reveal a decline in food insecurity experienced in the post-lockdown era (July and September 2020) compared to the lockdown period (May 2020). This finding indicates a resiliency among Indian households, perhaps attributable to the government's fiscal policy responses.Our results provide additional evidence to the understanding of the dynamics of food security during and after the Covid 19 pandemic lockdown in India.



*Keywords:* Covid-19; food insecurity; India; resilience; survey.

*JEL classification*: D12; I30; O12; Q12; Q18.


## Introduction

The latest variants of Covid-19, such as Delta and now Omicron, continue to cloud the economic outlook uncertainty. Economists already have forecasted a lower global economic growth for the 1st quarter of 2022. In addition to the impacts of the COVID-19 pandemic, a number of factors including the recent food price inflation that started in the second half of 2021, high input costs such as high fertilizer prices, and the instability following the Russian invasion of Ukraine will complicate the recovery of economies around the world and negatively affect the food security situation of consumers. As a result, it is unlikely to foresee a complete economic rebound to the pre-pandemic level in a near future, and the pandemic could further threaten the worldwide food security situation. As Laborde et al. (2021) pointed out, the Covid-19 effects can aggravate the food security situation in various channels, such as income loss, food supply chain disruptions, consumer responses, and policy responses. Before the surge of Omicron, it was estimated that the number of poor worldwide could increase by 20 percent (around 150 million people) (Laborde et al., 2021). Furthermore, food-insecure people could increase as high as 211 million

(Beckman et al., 2021). However, the global estimates do not provide a country-specific picture of the Covid-19 effects on food insecurity.

Several country-level studies can be found in the COVID-19 outbreak and food insecurity literature (Table S1), and from which we can note several important lessons. First, although most studies found a positive association between the COVID-19 pandemic and food insecurity worldwide, the extent and severity diverge by country and urban status. Second, most of the studies investigated the food security situation before and after the pandemic, using the difference-in-difference estimation method. However, how food insecurity status in the post-pandemic is changing is unknown. Third, food insecurity measures differ among studies. Several studies used consumers' self-assessed recall-basis food insecurity scales (e.g., Ahmed et al., 2021; Hirvonen et al., 2021; Kansiime et al., 2021), constructed based on a set of questions related to whether households "reduced meals," "ran out of food," and "went without eating." Other studies used food gap, dietary score, and household consumption as food insecurity measures (e.g., Aggarwal et al., 2020; Mahmud & Riley, 2021; Maredia et al., 2021). Fourth, although a large growing body of literature on this topic can be found, most of the studies focused on sub-Saharan African countries (Abay et al., 2021; Adjognon et al., 2021; Aggarwal et al., 2020; Amare et al., 2021; Hirvonen et al., 2021; Ibukun & Adebayo, 2021; Kansiime et al., 2021; Mahmud & Riley, 2021; Maredia et al., 2021; Nchanji & Lutomia, 2021). Based on our knowledge, we have found only one study focused on Latin American countries (Argentina) (Cordero & Cesani, 2021) and five studies on Asian countries (Ahmed et al., 2021; Ceballos et al., 2020, 2021; Elsahoryi et al., 2020; Gupta et al., 2021) that investigated the effects of COVID-19 on food insecurity. The limited number of studies and geographical coverage may be due to the availability of microeconomic panel data (Bloem & Farris, 2021).

Concerning the country of our interest, India, the nexus of the Covid-19 risk has been extensively studied, such as the food supply chain disruption (Mahajan & Tomar, 2020), agricultural production dynamics (Jaacks et al., 2021), and price effects (Bairagi, Mishra, & Mottaleb, 2022; Ceballos et al., 2021; Harris et al., 2020; Narayanan & Saha, 2021; Varshney et al., 2020). However, relevant to our study, the three subsequent studies are noticeable with respect to the pandemic and food insecurity. First, at the onset of Covid-19, Ceballos et al. (2020) analyzed the impact of national lockdown on the income and food security of 1,515 producers from two states (Haryana and Odisha) in India. Using a phone survey during the pandemic lockdowns and after the harvest season (early April to mid-May 2020), the authors found farmers were affected heterogeneously in these two states. For example, farmers in Odisha benefited more from diversified crops, whereas Haryana farmers (as consumers) faced more disruptions than Odisha farmers. Later, the same authors (Ceballos et al., 2021) investigated the pandemic effects on farm prices, farm incomes, and food security of 1,767 tomato and wheat producers in Haryana state. The authors found a similar result as their previous study. For instance, tomato producers were more food insecure than wheat producers. Although authors used a reduced version of the Household Food Insecurity Access Scale (HFIAS, Coates et al., 2007), their main interests were to look into how perishable and non-perishable markets were affected. Finally, Gupta et al. (2021) estimated the impact of the Covid-19 lockdown on household income and food security indicators (consumption, variety of food items consumed, and reduced meal portions), using an in-person survey (from Nov 2018 to Oct 2019) and a phone survey (mid-April). The authors found that weekly household income fell by 88 percent, and households reduced meal portions significantly and consumed fewer food items. The main focus of this study (Gupta et al., 2021) centered on migrant workers' households in West Bengal.

Even though the above three Indian studies provide a great deal of knowledge regarding the country's pandemic-led food security risks (before and immediately after Covid-19 situations), they fail to provide the dynamics of food insecurity in the post-pandemic time. Additionally, the geographical scope was limited—only three out of 28 states were covered in these studies. The knowledge of the differential effects of the pandemic is also unknown (how people from different religions and castes are affected). The present study aimed to investigate some of these unanswered questions with a high-frequency and large phone survey dataset made available by the World Bank. Specifically, the objectives of our study are two-fold: (i) how households are building resiliency or how their food insecurity situation is changing in the post-pandemic era (May 2020 versus July and September 2020), and (ii) how disadvantaged groups are affected.

**Data and methodology**

The study uses the high-frequency phone survey data from six states in rural India (Jharkhand, Rajasthan, Uttar Pradesh, Andhra Pradesh, Bihar, and Madhya Pradesh), made available by the World Bank (World Bank, 2020). The dataset consists of three rounds of phone surveys (Round 1, Round 2, and Round 3), administered during May 5-10, 2020, July 19-23, 2020, and 20-24 September 2020, respectively. However, the 2$^{nd}$ and 3$^{rd}$ rounds of survey data were used in this study because the food insecurity modules were added only to the latter of these two rounds. The 2$^{nd}$ round data was collected from 5,005 samples (46 percent response rate), whereas the 3$^{rd}$ round had 5,200 samples (55 percent response rate), consisting of 10,205 samples in total. We

used both an unbalanced panel (10,205 samples) and a balanced panel (2,018 samples in both rounds) to analyze the dynamics of the food insecurity situation in India.[1]

The central pandemic-related questions were posed to the respondent about the food security situation during May 2020 (during the height of the first lockdown) and then during the last 7 days of the 2nd week of July 2020 and the 2nd week of September 2020. Therefore, the Covid-19 lockdown corresponds to the food security situation in May 2020 and the post-lockdown corresponds to July and September 2020. The food security status of respondents was captured with a series of food access questions: During the lockdown, was there a time when, because of lack of money or other resources: (q1) your household limited portion size or reduced meals? (q2) your household ran out of food? (q3) you or someone in your household was hungry but did not eat? (q4) you or someone in your household went without eating for a whole day? (q5) none of the above has happened. Based on these questions, we developed the following food insecurity scale: mild (answered "yes" to at least one of q1-q4 questions), moderate (answered "yes" to any two questions from q1-q4), severe (answered "yes" to more than two above questions), and food secure (no effect, q5)[2]. This food insecurity classification (mild, moderate, and severe) is based on the literature on food insecurity scales (see details in Maxwell, Coates, & Vaitla, 2013).

As shown in Table 1, the sample of respondents is distributed across the six states in India. Based on the unbalanced panel, each Bihar and Rajasthan state represents almost 1 in 5

[1] The survey design involved a multiple-stage stratified cluster random sampling method to select eligible respondents and data were collected with Computer Assisted Telephone Interview (CATI) techniques (details can be found in World Bank (2020).

[2] Note that food security questions are different from the eight questions found in the standard Food Insecurity Experience Scale (FIES) regarding people's access to adequate food (Ballard, Kepple, & Cafiero, 2013). The questions in this study capture the last 4 of the 8 FIES food security questions. Based on the FIES 8 question respondent's scores, yes to Q1 to Q3 is considered as mild food insequrity; yes to Q4 to Q6 is considered as moderate food insecurity; yes Q7 to Q8 is considered as severe food insecurity.

respondents and 1 in 10 in Andhra Pradesh. This implies that samples may not be proportionally distributed, therefore, we used sampling weights to adjust for any possible bias in population estimates. The descriptive statistics of food insecurity responses in Table 2 indicate that nearly 1 in 3 respondents has experienced some form of food insecurity during the lockdown period based on the unbalanced sample. Food security conditions seemed to have improved in the post-lock down periods (such as either in the 2nd week of July or in the second week of September 2020), with about 15 percent of respondents experiencing some form of food insecurity. Based on the balanced panel, approximately one-third of respondents experienced some form of food insecurity during the lockdown, compared to 20 percent after the lockdown periods. These results highlight the respondents' relatively heightened food insecurity situation in general during the May 2020 COVID-related lockdown across India.

<Insert Tables 1-2 here>

**Ordered probit model**

The responses to the relevant food security questions required the use of an Ordered probit model (similar method used by several studied such as Kassie et al., 2014; Mallick & Rafi, 2010) to tease out the hierarchical food deprivation situation of respondents accurately. Explicitely, the dependent variable is an ordinal variable, which is categorical and ordered. In such case, the ordinary least square (OLS) is not appropriate because it implicitely assumes the same situation if two respondents give the same response (Mallick & Rafi, 2010). The following section is adopted from Wooldridge (2010).

Let *FIS* be an ordered response taking on the values of $\{0,1,2,\ldots,J\}$ for some integer *J*. In our case, food secure=0, mild=1, moderate=2, and severe=3, which indicate the severity of a household's food security situation. The higher the ranking, the more food deprivation is.

However, if the food security situation is categorized as "moderate," it does not imply that the household is twice better off than a household classified as a "mild" food secure. The ordered probit model for *FIS* (conditional on exogenous variables **x**) can be derived from a latent variable model. Suppose a latent variable *FIS** is determined by

$$FIS^* = \boldsymbol{x\beta} + \eta, \quad \eta|x \sim N(0,1) \qquad (1)$$

where $\beta$ is $K+1$ and $\boldsymbol{x}$ does not contain a constant. Let $\alpha_1 < \alpha_2 < \cdots \alpha_J$ be unknown cut points (or threshold parameters) and defined as:

$$\begin{aligned} FIS_0 \quad & \text{if } FIS^* \leq \alpha_1 \\ = 1 & \\ FIS_0 = 2 \quad & \text{if } \alpha_1 < FIS^* \leq \alpha_2 \qquad (2) \\ & \vdots \\ FIS_0 = J \quad & \text{if } FIS^* > \alpha_J \end{aligned}$$

In our case, FIS takes on the values 0, 1, 2, and 3, thus there are three cut points, $\alpha_1, \alpha_2$ and $\alpha_3$. Given the standard normal distribution for $\eta$, the conditional distribution of $FIS$ given $\boldsymbol{x}$ can be derived computing each response probability:

$$P(FIS = 0|\boldsymbol{x}) = P(FIS^* \leq \alpha_1|\boldsymbol{x}) = P(\boldsymbol{x\beta} + \eta \leq \alpha_1|\boldsymbol{x}) = \Phi(\alpha_1 - \boldsymbol{x\beta})$$

$$P(FIS = 1|\boldsymbol{x}) = P(\alpha_1 < FIS^* \leq \alpha_2|\boldsymbol{x}) = \Phi(\alpha_2 - \boldsymbol{x\beta}) - \Phi(\alpha_1 - \boldsymbol{x\beta})$$

$$\vdots$$

$$P(FIS = J-1|\boldsymbol{x}) = P\left(\alpha_{J-1} < FIS^* \leq \alpha_J|\boldsymbol{x}\right) = \Phi\left(\alpha_J - \boldsymbol{x\beta}\right) - \Phi\left(\alpha_{J-1} - \boldsymbol{x\beta}\right)$$

$$P(FIS = J|\boldsymbol{x}) = P\left(FIS^* > \alpha_J|\boldsymbol{x}\right) = 1 - \Phi\left(\alpha_J - \boldsymbol{x\beta}\right)$$

To estimate the parameters $\alpha$ and $\beta$, the maximum likelihood can be used. The log-likelihood function is for each $i$ can be specified as:

$$l_i(\alpha,\beta) = 1[FIS_i = 0]\log[\Phi(\alpha_1 - \boldsymbol{x_i\beta})] + 1[FIS_i = 1]\log[\Phi(\alpha_2 - \boldsymbol{x_i\beta})] - [\Phi(\alpha_1 - \boldsymbol{x_i\beta})]$$
$$+ \cdots + 1[FIS_i = J]\log\left[1 - \Phi\left(\alpha_J - \boldsymbol{x_i\beta}\right)\right] \qquad (3)$$

The above log-likelihood function is estimated with STATA 15 and the results are presented in Table 4.

**Results and discussion**

**Descriptive statistics**

Descriptive statistics of the main variables of interest used in the study are presented in Table 3. The data show that a typical household in the sample has six members. Seventy-two percent of the respondents indicated that they had received essential foods (rice and wheat) from public distribution shop (PDS) or a fair price shop (FPS). These PDS and/or FPS are important public support sources, especially for low-income Indian households. Close to 40 percent of the respondents indicated that some household members belong to a self-help group. Most respondents (84 percent) belong to Hinduism, followed by Muslims (11 percent). The rest of the respondents subscribe to other religions. In terms of the Caste system, the majority belong to Other Backward Caste (56 percent), and the remaining 44 percent is made of General (17 percent), Scheduled Caste (18 percent), and Scheduled Tribe (8 percent). Respondents from the six Indian states are included in the regression analyses. Based on the unbalanced panel, 31 percent of respondents are in the Uttar Pradesh state, 20 percent are in the Andhra Pradesh state, and 17 percent are in the Bihar state. The rest are in Madhya Pradesh (14 percent), Rajasthan (12 percent), and Jharkhand (6 percent).

<Insert Table 3 here>

**Estimation results**

The results are based on two model estimations: an unbalanced panel model (UPM) and a balanced panel model (BPM). The rationale behind using these two sets of panels is to account for possible bias due to respondents' attrition. It also can help us to check the robustness of our estimated results. Table 4 presents the marginal effects from the empirical estimation of UPM (column 2-5) and BPM (column 6-9). In the case of UPM, the marginal effect in column 2 (food secure) shows that the COVID-19 lockdown is associated with decreased probability of a household being food secure by 14 percent. However, in the case of BPM, the marginal effect in column 6 (food secure) shows that the COVID-19 lockdown is associated with decreased probability of a household being food secure by 16 percent. Our findings indicate that the food security status in India deteriorated after the outbreak of the COVID-19 pandemic. Overall, 21-27 percent of the households experienced some form of food deprivation during the lockdown in May 2020 compared to the post-lockdown period (July and September 2020) (Figure 1). Also, note that the marginal effects from the unbalanced and balanced samples are not statistically different.

In the case of UPM, the marginal effect in column 3 (mild food insecurity) reveals that the COVID lockdown is associated with an increased probability of a household experiencing mild food security by about 8 percent. Note that the association of the COVID lockdown with the status of food insecurity is smaller for moderate and severe food insecure categories (about 2.8 percent and 2.9 percent, respectively). In the case of BPM, columns 6-9, the impact of the COVID lockdown is slightly higher. For instance, the results in column 4 reveal that the COVID lockdown is associated with an increased probability of mild food security by about 9 percent.

Similarly, the effect the COVID lockdown is higher for moderate and severe food insecurity categories (about 3.7 percent)

The empirical results revealed that social networking is significantly associated with the status of food insecurity experiences. For example, regardless of the samples (UPM or BPM), households with membership in self-help groups (SHG) in the mild food insecurity category are about 2.5 more likely to report food insecurity. On the other hand, families in the moderate and severe food insecurity categories with membership in SHG are about 1 percent more likely to report food insecurity. During the COVID pandemic and especially during lockdowns, livelihood opportunities were severely impacted, and as a result, members of SHG realized reduced income and thus fewer savings.

The results in Table 4 also pointed out that households that received essential food items (rice and wheat) for free from PDS shops are likely to be food secure. For example, only for a UPM, households in the mild food insecurity category that received PDS commodities are about 1.5 percent more likely to report food insecurity. On the other hand, families in the moderate and severe food insecurity categories that received PDS commodities are about 0.5 percent more likely to report food insecurity. This might be in that the food items distributed through PDS are wheat and rice, and these food items are consumed with other commodities, like oil, fats, meats, and fresh vegetables to make complete meals. The latter food items were scarce during the COVID lockdowns. However, we do not find any statistical significance of the PDS program on food insecurity categories in the BPM. In a recent study, Varshney et al., (2021) examined the impact of India's government assistance package (known as *Pradhan Mantri Garib Kalyan Yojana* or PM-GKY), announced immediately after the COVID-19 lockdown, on the procurement of agricultural inputs for the upcoming farming season. The authors found that the

government transfer package was significant in alleviating credit constraints and increasing agricultural investments in agricultural inputs. Specifically, the farmers who received benefits from the PM-GKY scheme spent significantly higher on the procurement of seeds, fertilizers, and pesticides.

The results in Table 4 further show that other sociodemographic factors affected the food insecurity of Indian households. For example, households in the Scheduled Castes (SC) and Scheduled Tribes (ST) are likely to report food insecurity compared to families in the general caste category. In the case of UPM, SC/ST households, compared to general caste households, have higher food insecurity, 3.3 percent and 3.8 percent (column 2, Table 4), respectively. In most cases, SC/ST households were more likely to observe mild food insecurity (noted a lower marginal effect of 1.9 percent for mild, 0.67 percent for moderate, and 0.69 percent for severe categories). However, in the case of the BPM, we find that ST households, compared to general caste households, have higher food insecurity, 5.5 percent (column 6, Table 4).

Finally, the location of the Indian household had a significant effect on food security during the COVID pandemic. For example, regardless of the samples (UPM or BPM), households in Uttar Pradesh, Bihar, Jharkhand, Madhya Pradesh, and Andhra Pradesh are more likely to be food insecure (see columns 2 and 6, Table 4) compared to households located in Rajasthan. The marginal effects in columns 3-5 and columns 6-7 show that households in Uttar Pradesh, Bihar, Jharkhand, Madhya Pradesh, and Andhra Pradesh are more likely to report mild to severe food insecurity compared to families in Rajasthan, the base group. However, a higher percentage of families are likely to report mild food insecurity than moderate or severe food insecurity. Note that the marginal effects of the moderate and severe food insecurity categories are about the same. We also found a reversal in the food security status of families in Jharkhand

when it came to the BPM. The results in columns 7-9 (Table 4) show that compared to Rajasthan, families in Jharkhand reported less food insecurity—the likelihood of 4 %, 1.8%, and 1.8% lower in mild, moderate, and severe food insecurity categories, respectively.

<Insert Tables 4-5 here>

<Insert Figure 1 here>

**Conclusions**

The present study aimed to examine the food insecurity experience during and after the pandemic lockdown in India, using multiple phone surveys made available by the World Bank. The results indicate that the likelihood of food insecurity experience declined significantly in the post-lockdown era (July and September 2020) compared to the lockdown period (May 2020). This finding indicates a resiliency among Indian households, perhaps attributable to the government's fiscal policy responses. Our results may support other studies in India and elsewhere. Based on a systematic survey of key informants, in a review of the resilience of agricultural systems in 25 Asian countries, including India, Dixon et al. (2021) found that Asian farming and food systems were moderately resilient to the pandemic, reinforced by government policies in many countries that prioritized food availability and affordability. The authors noted that the strength of the resilience of Asian farming and food systems was a combination of inherent systems characteristics, effective public policies that prioritized staple food production and distribution, and complementary welfare programs. They also emphasized that improving the resilience of farming systems should be central to any recovery programs in view of future risks to plant- and animal-sourced food supplies from future zoonoses and the institutional vulnerabilities revealed by COVID-19.

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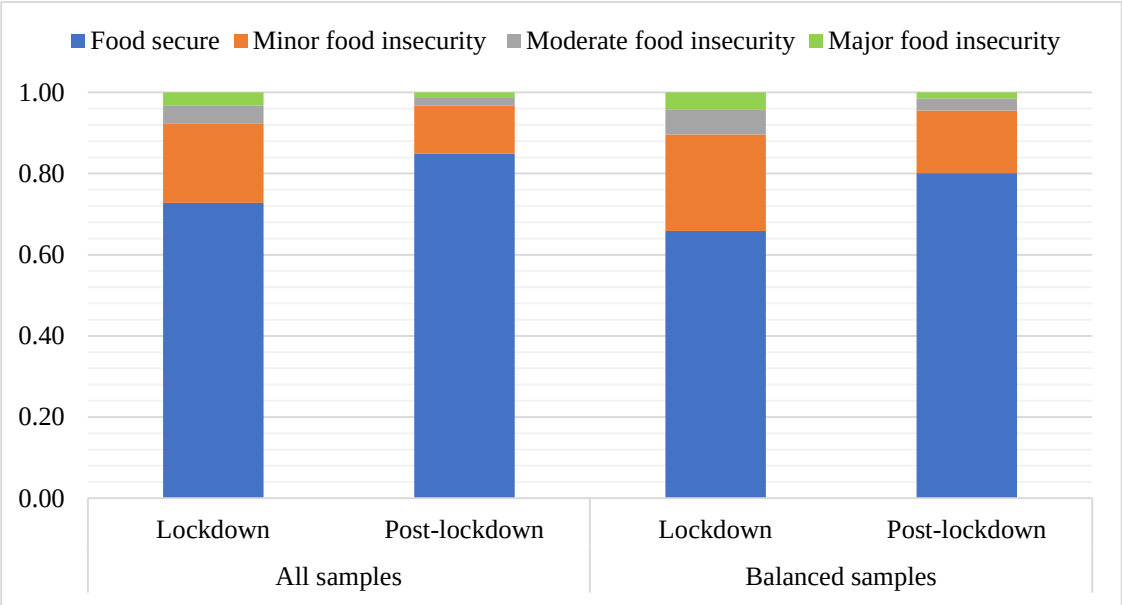
**Figure 1. Predicted probability of food insecurity status due to COVID-19 in India**




Source: Authors' estimated from data gathered from World Bank (2020).

**Table 1. Sample distribution across Indian states**

| States | Unbalanced samples | | | | Balanced samples | | | |
|---|---|---|---|---|---|---|---|---|
| | Round 1 | Round 2 | Total | Percent | Round 1 | Round 2 | Total | Percent |
| Andhra Pradesh | 511 | 396 | 907 | 8.9 | 97 | 97 | 194 | 4.8 |
| Bihar | 1,073 | 1,030 | 2,103 | 20.6 | 627 | 627 | 1,254 | 31.1 |
| Jharkhand | 890 | 995 | 1,885 | 18.5 | 147 | 147 | 294 | 7.3 |
| Madhya Pradesh | 823 | 944 | 1,767 | 17.3 | 544 | 544 | 1,088 | 27.0 |
| Rajasthan | 930 | 1,078 | 2,008 | 19.7 | 136 | 136 | 272 | 6.7 |
| Uttar Pradesh | 778 | 757 | 1,535 | 15.0 | 467 | 467 | 934 | 23.1 |
| Total | 5,005 | 5,200 | 10,205 | 100.0 | 2,018 | 2,018 | 4,036 | 100.0 |

Source: Authors' estimated from data gathered from World Bank (2020).

**Table 2. Food insecurity responses (%) at different points in time during the COVID-19 pandemic in 2020**

| Food security indicators | Round 2 survey | | Round 3 survey | | Unbalanced samples | | Balanced samples | |
|---|---|---|---|---|---|---|---|---|
| | Lockdown, (May) | Post-lockdown (2nd week of July) | Lockdown (May) | Post-lockdown (2nd week of Sep) | Lockdown | Post-lockdown | Lockdown | Post-lockdown |
| Food secure | 71.6 | 83.7 | 73.2 | 85.6 | 72.4 | 84.7 | 65.6 | 79.8 |
| Mild food insecurity | 20.4 | 12.3 | 19.4 | 11.4 | 19.9 | 11.8 | 23.9 | 15.5 |
| Moderate food insecurity | 4.6 | 2.0 | 4.5 | 1.8 | 4.5 | 1.9 | 6.3 | 2.9 |
| Severe food insecurity | 3.3 | 1.8 | 2.8 | 0.9 | 3.0 | 1.3 | 4.0 | 1.5 |
| Refuse to answer | 0.1 | 0.2 | 0.1 | 0.3 | 0.1 | 0.2 | 0.1 | 0.3 |
| Total responses | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Notes: Authors' estimated from data gathered from World Bank (2020). Figures within parentheses are the percent of the total responses.

## Table 3. Descriptive statistics of the variables used in regression analysis

| Variables | Description of the variables | Unbalanced samples | | Balanced samples | |
|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD |
| Household size | Family size in numbers | 5.71 | 19.99 | 5.62 | 27.18 |
| Self-help group member | 1 = if any of the household members are members of self-help groups, otherwise 0 | 0.38 | 0.48 | 0.47 | 0.50 |
| Free foods from PDS | 1 = if any of the household members received essential foods (rice and wheat) from a public distribution shop or fair price shop (FPS), otherwise 0 | 0.72 | 0.45 | 0.73 | 0.44 |
| Hinduism | 1 = if the household head is Hindu, otherwise 0 | 0.84 | 0.37 | 0.84 | 0.36 |
| Islam | 1 = if the household head is Islam, otherwise 0 | 0.11 | 0.31 | 0.12 | 0.32 |
| Christianity | 1 = if the household head is Christian, otherwise 0 | 0.02 | 0.13 | 0.01 | 0.10 |
| Sikhism and Jainism | 1 = if the household head is Sikh or Jain, otherwise 0 | 0.01 | 0.08 | 0.01 | 0.09 |
| Buddhism | 1 = if the household head is Buddhist, otherwise 0 | 0.01 | 0.08 | 0.01 | 0.09 |
| Other | 1 = if the household head practice any other religions, otherwise 0 | 0.02 | 0.15 | 0.02 | 0.13 |
| General | 1 = if the household head belongs to a general caste, otherwise 0 | 0.17 | 0.38 | 0.15 | 0.36 |
| Scheduled Caste | 1 = if the household head belongs to a scheduled caste, otherwise 0 | 0.18 | 0.39 | 0.17 | 0.38 |
| Scheduled Tribe | 1 = if the household head belongs to a scheduled tribe, otherwise 0 | 0.08 | 0.27 | 0.07 | 0.25 |
| Other Backward Caste | 1 = if the household head belongs to any other Backward caste, otherwise 0 | 0.56 | 0.50 | 0.59 | 0.49 |
| Other | 1 = if the household head does not belong to any caste, otherwise 0 | 0.01 | 0.11 | 0.01 | 0.12 |
| Rajasthan | 1 = if the household head resides in Rajasthan state | 0.12 | 0.33 | 0.04 | 0.19 |
| Uttar Pradesh | 1 = if the household head resides in Uttar Pradesh state | 0.31 | 0.46 | 0.42 | 0.49 |
| Bihar | 1 = if the household head resides in Bihar state | 0.17 | 0.37 | 0.23 | 0.42 |
| Jharkhand | 1 = if the household head resides in Jharkhand state | 0.06 | 0.24 | 0.02 | 0.14 |
| Madhya Pradesh | 1 = if the household head resides in Madhya Pradesh state | 0.14 | 0.34 | 0.19 | 0.39 |
| Andhra Pradesh | 1 = if the household head resides in Andhra Pradesh state | 0.20 | 0.40 | 0.10 | 0.30 |
| Number of observations | | 10,205 | | 2,018 | |

Notes: Self Help Groups are groups of 10-20 people (usually women) in a locality formed for any economic purpose. For example, women coming together to pool savings, discuss social issues, take collective loans, etc. SD stands for standard deviation.

## Table 4. Estimated marginal effects of ordered response models for food insecurity status due to COVID-19 in India

| Explanatory variables | Unbalanced samples (UPM) | | | | Balanced samples (BPM) | | | |
|---|---|---|---|---|---|---|---|---|
| | Food secure | Mild food insecurity | Moderate food insecurity | Severe food insecurity | Food secure | Mild food insecurity | Moderate food insecurity | Severe food insecurity |
| Post-lockdown (yes = 1) | 0.14*** | -0.079*** | -0.028*** | -0.029*** | 0.16*** | -0.087*** | -0.037*** | -0.036*** |
| | (0.01) | (0.00) | (0.00) | (0.00) | (0.01) | (0.01) | (0.00) | (0.00) |
| Household size, log | -0.0091 | 0.0053 | 0.0019 | 0.0019 | 0.0043 | -0.0023 | -0.001 | -0.0009 |
| | (0.01) | (0.01) | (0.00) | (0.00) | (0.02) | (0.01) | (0.00) | (0.00) |
| Self-help group membership (yes=1) | -0.042*** | 0.025*** | 0.0086*** | 0.0089*** | -0.047*** | 0.026*** | 0.011*** | 0.011*** |
| | (0.01) | (0.01) | (0.00) | (0.00) | (0.01) | (0.01) | (0.00) | (0.00) |
| Receive free rice and wheat from PDS shops (yes = 1) | -0.026** | 0.015** | 0.0053** | 0.0055** | -0.0093 | 0.0051 | 0.0022 | 0.0021 |
| | (0.01) | (0.01) | (0.00) | (0.00) | (0.02) | (0.01) | (0.00) | (0.00) |
| *Religion dummy variables (the base case is Hindus)* | | | | | | | | |
| Islam (yes = 1) | -0.072*** | 0.042*** | 0.015*** | 0.015*** | -0.059* | 0.032* | 0.014* | 0.013* |
| | (0.02) | (0.01) | (0.00) | (0.00) | (0.03) | (0.02) | (0.01) | (0.01) |
| Christianity (yes = 1) | -0.044* | 0.026* | 0.0090* | 0.0094* | -0.086 | 0.046 | 0.020 | 0.019 |
| | (0.03) | (0.02) | (0.01) | (0.01) | (0.07) | (0.04) | (0.02) | (0.02) |
| Sikhism and Jainism (yes = 1) | -0.17** | 0.10** | 0.035** | 0.036** | -0.30*** | 0.16*** | 0.069*** | 0.067*** |
| | (0.07) | (0.04) | (0.01) | (0.02) | (0.07) | (0.04) | (0.02) | (0.02) |
| Buddhism (yes = 1) | 0.011 | -0.0063 | -0.0022 | -0.0023 | -0.0016 | 0.00085 | 0.00036 | 0.0004 |
| | (0.03) | (0.02) | (0.01) | (0.01) | (0.05) | (0.03) | (0.01) | (0.01) |
| Other religions (yes = 1) | -0.029 | 0.017 | 0.0058 | 0.0061 | 0.045 | -0.024 | -0.010 | -0.010 |
| | (0.03) | (0.02) | (0.01) | (0.01) | (0.05) | (0.03) | (0.01) | (0.01) |
| *Caste dummy variables (the base is general caste)* | | | | | | | | |
| Scheduled Caste (yes = 1) | -0.033** | 0.019** | 0.0067** | 0.0069** | -0.038 | 0.021 | 0.0088 | 0.0086 |
| | (0.02) | (0.01) | (0.00) | (0.00) | (0.02) | (0.01) | (0.01) | (0.01) |
| Scheduled Tribe (yes = 1) | -0.038** | 0.022** | 0.0076** | 0.0080** | -0.055* | 0.030* | 0.013* | 0.012* |
| | (0.02) | (0.01) | (0.00) | (0.00) | (0.03) | (0.02) | (0.01) | (0.01) |
| Other Backward Caste (yes = 1) | -0.021 | 0.012 | 0.0042 | 0.0044 | -0.040 | 0.022 | 0.0093 | 0.0091 |
| | (0.02) | (0.01) | (0.00) | (0.00) | (0.03) | (0.01) | (0.01) | (0.01) |
| Other | -0.081** | 0.047** | 0.016** | 0.017** | -0.094 | 0.051 | 0.022 | 0.021 |
| | (0.04) | (0.02) | (0.01) | (0.01) | (0.06) | (0.03) | (0.01) | (0.01) |
| *Location dummy variables (Rajasthan is the base state)* | | | | | | | | |
| Uttar Pradesh (yes = 1) | -0.120*** | 0.068*** | 0.024*** | 0.025*** | -0.078*** | 0.042*** | 0.018*** | 0.018*** |
| | (0.02) | (0.01) | (0.00) | (0.00) | (0.03) | (0.02) | (0.01) | (0.01) |
| Bihar (yes = 1) | -0.22*** | 0.13*** | 0.046*** | 0.048*** | -0.20*** | 0.11*** | 0.047*** | 0.046*** |
| | (0.01) | (0.01) | (0.00) | (0.00) | (0.03) | (0.02) | (0.01) | (0.01) |
| Jharkhand (yes = 1) | -0.069*** | 0.040*** | 0.014*** | 0.015*** | 0.079* | -0.043* | -0.018* | -0.018* |
| | (0.02) | (0.01) | (0.00) | (0.00) | (0.04) | (0.02) | (0.01) | (0.01) |
| Madhya Pradesh (yes = 1) | -0.13*** | 0.076*** | 0.026*** | 0.027*** | -0.095*** | 0.051*** | 0.022*** | 0.021*** |
| | (0.01) | (0.01) | (0.00) | (0.00) | (0.03) | (0.01) | (0.01) | (0.01) |
| Andhra Pradesh (yes = 1) | -0.094*** | 0.055*** | 0.019*** | 0.020*** | -0.14*** | 0.074*** | 0.032*** | 0.031*** |
| | (0.02) | (0.01) | (0.00) | (0.00) | (0.03) | (0.02) | (0.01) | (0.01) |
| Observations | 20,287 | 20,287 | 20,287 | 20,287 | 8,032 | 8,032 | 8,032 | 8,032 |

Notes: ***, **, and * denote 1%, 5%, and 10% levels of significance, respectively. Numbers within () are robust standard errors. The "refuse" category is dropped in the regression analysis. PDS stands for public distribution shop.

# Appendix

**Table S1. Covid-19 and food security: a review from developing countries' perspectives**

| Country | Data | Method | Food security indicators | The effect of covid-19 on food security | Source |
|---|---|---|---|---|---|
| *Asia* | | | | | |
| Bangladesh | Phone surveys (10,000 households) | Linear probability model | Food Insecurity Experience Scale (FIES) | Increased food insecurity<br>• Daily laborers were affected the most | Ahmed et al. (2021) |
| India (Haryana and Odisha) | Phone surveys (April and May 2020, 1515 producers) | Descriptive analysis | Food availability, affordability, and access | Mixed results<br>• Increased food insecurity in Haryana<br>• No changes in Odisha | Ceballos et al. (2020) |
| India (Haryana) | 1767 producers | Difference-in-difference | Household Food Insecurity Access Scale (HFIAS) | Mixed results<br>• Tomato producers were more food insecure than wheat producers | Ceballos et al. (2021) |
| India (rural) | Pre-pandemic in-person (March April 2019) and post-pandemic (mid-April 2020) phone surveys | Difference-in-difference | Income, expenditure, and consumption | Increased food insecurity<br>• Household income fell by 88%<br>• Reduced meal portions and consumed fewer food items<br>• Impacts were heterogenous | Gupta et al. (2021) |
| India | Pre- and post-pandemic Covid-19 phone surveys by the World Bank | Inverse demand function | Price of essential food | Increased food insecurity (in terms of prices)<br>• Price of atta(wheatflour) and rice increased<br>• Price of onions declined | Bairagi, Mishra, and Mottaleb (2022) |
| Jordan | Cross-sectional online surveys | Multinomial logistic regressions | Food Insecurity Experience Scale | Increased food insecurity<br>• One-quarter of the surveyed household experienced severe food insecurity<br>• Poor, younger adults, and households that do not own homes were affected the most | Elsahoryi et al. (2020) |
| *Africa* | | | | | |
| Ethiopia (urban) | Panel survey (in-person (two rounds): Aug-Sep, 2019 and Jan-Feb, 2020; phone (four rounds): May-Aug 2020) | Difference-in-difference | Household Dietary Diversity Score (HDDS) | No changes in food insecurity | Hirvonen et al. (2021) |

| | | | | | |
|---|---|---|---|---|---|
| Ethiopia (rural) | Pre-pandemic in-person (2535, Mar-Aug 2019) and post-pandemic phone (1497, June 2020) surveys | Fixed effects difference-in-difference | Food gap (binary response): the number of months a household is unable to satisfy its food needs | Increased food insecurity<br>• PSNP participants: 2.4%<br>• Non-PSNP participants: 11.7% | Abay et al. (2021) |
| Kenya and Uganda | Online surveys (April 2020) | Probit regression | Food Insecurity Experience Scale (FIES) | Increased food insecurity<br>• Food-insecure households increased by 38% and 44% in Kenya and Uganda, respectively<br>• Poor households and laborers consumed less | Kansiime et al. (2021) |
| Liberia and Malawi (rural) | Phone survey (panel, Jan and Aug 2020) | Fixed effect model | Dietary diversity score, hunger scale, and food consumption score | No changes in food insecurity | Aggarwal et al. (2020) |
| Mali (rural and urban) | Pre-pandemic in-person (October 2018 and July 2019) and phone (May-June, 2020) surveys | Difference-in-difference | Food Insecurity Experience Scale (FIES) | Increased food insecurity<br>• Urban households experienced eight percentage points higher than rural households (equivalent to a 33% increase in moderate food insecurity) | Adjognon et al. (2021) |
| Nigeria | Panel data: pre-pandemic in-person (2019) and post-pandemic (April-May 2020) surveys (1882 samples) | Difference-in-difference | Food Insecurity Experience Scale (FIES) | Increased food insecurity by 6-15% | Amare et al. (2021) |
| Nigeria (northern and southern) | Phone survey | Ordered probit model | Food Insecurity Experience Scale (FIES) | Increased food insecurity<br>• Over two-thirds of the surveyed households were threatened (mild: 5%; moderate: 24.5%; severe: 58.5%)<br>• Education, income and wealth status are the main drivers | Ibukun & Adebayo (2021) |
| Uganda (rural) | Pre-lockdown in-person (early March 2020) and post-lockdown phone (May 2020) surveys (1,277 samples) | Difference-in-difference | Consumption expenditure (per adult equivalent) | Declined food expenditure by 26% | Mahmud & Riley (2021) |
| Sub-Sahara Africa (five countries) | Phone survey (Sep-Nov, 2020; 4,000 rural and urban households) | Difference-in-difference | Self-assessed food consumption (quality and quantity) indicators | Declined food consumption<br>• Increased skipping meals by all countries<br>• Kenya and Nigeria were most affected | Maredia et al., (2021) |

| | | | | | |
|---|---|---|---|---|---|
| | | | | • Rural and urban households were affected differently | |
| Sub-Sahara Africa (11 countries) | March-April, 2020 | Descriptive analysis | Food consumption, diet and quality, and food shortage | Food access and availability were negatively impacted<br>• Heterogenous impacts | Nchanji & Lutomia (2021) |
| *Latin America* | | | | | |
| Argentina (Tucumán) | Cross-sectional households survey: 3915, April-May 2020 | Bivariate and multivariate logistic regression | Perceptions of daily life affected due to lack of resources for food access | Increased food insecurity<br>• More than half of the total households were affected (mild: 39.3%; moderate: 10.8%; severe: 5.8%)<br>• Household size, presence of children, socioeconomic status are the main drivers | Cordero & Cesani (2021) |
| *Global studies* | | | | | |
| Bangladesh, Kenya, and Nigeria | Phone surveys (October 2020 to April 2021) | Difference-in-difference | Food insecurity incidence and composition index | Mixed results<br>• Increased food insecurity in Bangladesh and Nigeria (5 and 7 percentage points higher, respectively)<br>• No changes in Kenya | Mueller et al. (2021) |
| Worldwide | IFPRI's global CGE model, MIRAGRODEP, and the POVANA household dataset | Simulation models | Rural household consumption | Declined household consumption by 1.0% globally<br>• Asia: -3.7% to -4.2%<br>• Africa: -3.2% to -4.0%<br>• LAC: -4.4% to -6.2% | Laborde et al. (2021) |

Notes: PSNP: Productive Safety Net Program (PSNP).