World Development Perspectives 28 (2022) 100469

Contents lists available at ScienceDirect

World Development Perspectives

journal homepage: www.sciencedirect.com/journal/world-development-perspectives

COVID-19 outbreak and rural household food security in the Western Democratic Republic of the Congo

Victor Manyong [a], Mpoko Bokanga [b], Dieu-Merci Akonkwa Nyamuhirwa [c], Zoumana Bamba [d], Razack Adeoti [e], Gregoire Mwepu [f], Steven M. Cole [a], Paul Martin Dontsop Nguezet [g,*]

[a] International Institute of Tropical Agriculture, Dar Es Salaam, Tanzania
[b] International Institute of Tropical Agriculture (iita.org), IITA DRC, Congo
[c] Université catholique de Bukavu, Congo
[d] International Institute of Tropical Agriculture (IITA), Kinshasa, DR, Congo
[e] International Institute of Tropical Agriculture (IITA), Cotonou, Benin
[f] CAID, DRC, Congo
[g] International Institute of Tropical Agriculture, Bukavu, DR, Congo

ARTICLE INFO

Keywords:
COVID-19
Food security
Socioeconomic factors
The Democratic Republic of the Congo

ABSTRACT

Although global assessments of the initial impacts of the coronavirus disease (COVID-19) have focused on income, jobs, and health conditions, this study constitutes one of the first studies that assessed the impact of COVID-19 on food security in DRC and established the short-term implications of the COVID-19 outbreak on rural households' food security in DRC. In addition, the study recommendations contributed to shaping government interventions toward the pandemic in the Country. The study used data from four western provinces of the country on 1339 households. Our results show that 80 % of households experienced an increase in food prices, 61 % a noticeable decrease in the availability of food, and 54 % a decrease in their dietary diversity. Due to changes in food availability, dietary diversity, and food accessibility imposed by the COVID-19 outbreak, >70 % of households experienced either a decrease in the consumption of meat, milk, fish, and cereals or an increase in their consumption of traditional vegetables. In addition, COVID-19 significantly affected food security dimensions in larger households, households with a greater number of members aged 35 years and above, households headed by women, households where members participate in associations or cooperatives, households that depend on crop sales as the major source of income, and in poorer households. These findings highlight the significant implications of the COVID-19 outbreak on household food security in western DRC and underscore the need for emergency interventions to strengthen the resilience of rural people and accelerate their recovery and other long-term measures toward sustainable and inclusive development.

1. Introduction

The Democratic Republic of the Congo (DRC) has undergone several pandemics over the past decades such as repetitive outbreaks of the Ebola virus and cholera. The most recent is the coronavirus disease (COVID-19) (Khan et al., 2021), which is an infectious disease caused by the SARS-CoV-2 virus. First reported in Wuhan, China, the virus is transmitted from human to human and affects people in over 99 % of countries worldwide (Clark, Lusardi, & Mitchell, 2021; Vavra, 2021; Udmale et al., 2020). Lower-income countries, including DRC, with weak healthcare and food systems, are especially affected by COVID-19 (Chen, Qian, & Wen, 2021; Laborde, Martin, & Vos, 2021). Indeed, many such countries are currently facing a third or fourth wave of infection and are still imposing water, sanitation, and hygiene COVID-19 mitigation measures in response, while vaccine uptake remains marginal (WHO, 2020; Susilo, Floden, & Geurs, 2021; Ditekemena et al., 2021).

In DRC, the first case of COVID-19 was reported in March 2020 in Kinshasa (the capital) and spread to almost all provinces thereafter (Wimba et al., 2020; Zirhumanana, 2021). In response, the government

* Corresponding author.
E-mail addresses: V.Manyong@cgiar.org (V. Manyong), Mp.Bokanga@cgiar.org (M. Bokanga), d.nyamuhirwa@cgiar.org (D.-M. Akonkwa Nyamuhirwa), z.bamba@cgiar.org (Z. Bamba), R.Adeoti@cgiar.org (R. Adeoti), mwepug@gmail.com (G. Mwepu), s.cole@cgiar.org (S.M. Cole), P.Dontsop@cgiar.org (P.M. Dontsop Nguezet).

https://doi.org/10.1016/j.wdp.2022.100469
Received 7 March 2022; Received in revised form 20 October 2022; Accepted 7 November 2022
Available online 11 November 2022

imposed rigorous restriction measures such as lockdowns, closed borders, and social distancing. Due to these measures, which were consistent with World Health Organization (WHO) guidelines, the DRC's economic structures and the food security status of millions of people were negatively impacted (Khan et al., 2021; Écochard et al., 2021). For example, in 2020, 21.8 million people were classified as acutely food insecure compared to 15.6 million in 2019 (WFP, 2020). While it is evident that the COVID-19 pandemic has worsened the national progress toward achieving Sustainable Development Goal 2 (SDG2) of zero hunger, its implications at the individual and household levels have not sufficiently been investigated and are poorly understood (Kansiime et al., 2021).

This study constitutes one of the first studies that assessed the impact of COVID-19 on food security in DRC and established the short-term implications of the COVID-19 outbreak on rural households' food security in DRC. In addition, the study recommendations contributed to shaping government interventions toward the pandemic in the Country. The study pursues a twofold objective. First, it assesses various dimensions of rural households' food security during the initial stages of the pandemic, and second, it highlights the implications of the COVID-19 outbreak on three key dimensions of food security (food availability, dietary diversity, and food accessibility) in four provinces of western DRC (Pinstrup-Andersen, 2009; Tuholske et al., 2020; Ouoba & Sawadogo, 2021). After Section 1 which addresses the introduction, the rest of the paper proceeds as follows: Section 2 presents the study methodology. Section 3 presents the study findings and discusses the results. Section 4 concludes.

2. Methodology

2.1. COVID-19 outbreak and food security

Identifying the effect of the COVID-19 outbreak on rural households' food security is not an easy exercise as many other factors could come into play apart from the pandemic, known as the orthogonal effects (Wossen et al., 2019). Several approaches are used in the literature to assess the impact of a treatment or shock (such as COVID-19) on selected outcomes (food security in our case). These include the randomized controlled trial (RCT) (Banerjee et al., 2020), endogenous switching regression (ESR) (Ainembabazi et al., 2018; Wossen et al., 2019; Dontsop Nguezet et al., 2020), or the difference-in-difference approach (De Brauw et al., 2014; Rönkkö et al., 2021; Chen et al., 2021). The majority of these approaches rely on quantitative data for implementation. These approaches reduce estimation biases while controlling for observable and unobservable characteristics and change over time that could affect the selected outcome beyond the treatment or shock (Ravallion, 2001). However, given the short duration of the pandemic outbreak at the time data were collected for this study and the lack of baseline data for the pre-pandemic period, we applied a memory recall approach to constitute the baseline data necessary to assess the implications of COVID-19 at the household level. This approach has been used in recent literature by several studies to account for the impact of COVID-19 on agriculture and food systems in Iran and Myanmar (Pakravan-Charvadeh et al., 2021; Boughton et al., 2021; Kansiime et al., 2021); to compare households' income and food security levels before versus during the COVID-19 pandemic in Kenya and Uganda (Kansiime et al., 2021); to assess the impact of COVID-19 on households and small businesses in DRC (Stoop et al., 2021). Following this recent literature, we used a similar approach by asking study respondents to compare their food security levels during the COVID-19 outbreak (from March to October 2020) to their levels one year prior (March to October 2019).

Concretely, the attribution process was carried out using three steps (see Fig. 1). First, respondents were asked to report their perceptions of change (increased, no change, decreased) in three key dimensions of food security (food availability, dietary diversity, and food accessibility) compared to their pre-pandemic situation. Second, respondents identified the principal cause(s) and if there was a perceived change in any dimension of their food security. Finally, we isolated the proportion of respondents who attributed changes to aspects of their food security to COVID-19. Table 1 presents a sample of key questions asked during data collection.

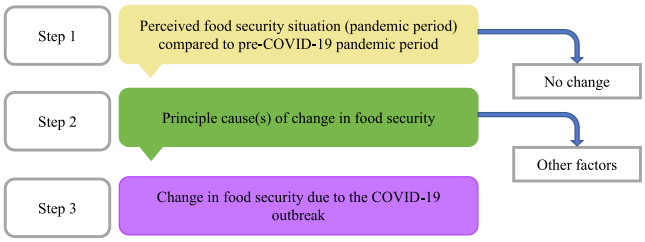

Fig. 1. Three-step attribution process. Notes. The pre-pandemic period covers the period from March to October 2019, while the pandemic period is from March to October 2020. Other factors include economic conjuncture, weather conditions, household internal shocks such as illness, and province-specific factors such as internal insecurity or lack of trade openness.

2.2. Econometrics estimations: an empirical model

Following Tuholske et al. (2020), Kansiime et al. (2021), and Boughton et al. (2021), we fitted an ordinary least squares (OLS) model to identify factors associated with rural households' food security during the initial stages of the COVID-19 outbreak and a logit model for factors associated with changes in the dimensions of food security attributed to COVID-19. The household dietary diversity score (HDDS) was the metric of food security used to reflect both economic capacity to access a variety of foods and diversity of consumer behavior based on a 24-hour recall and ranging from 0 to 12 (Kennedy, Ballard, & Dop, 2013). Also, following Pakravan-Charvadeh et al. (2021) we categorized households into three groups including low HDDS (HDDS $<$ 4.5), medium HDDS (HDDS between 4.5 and 6.0), and high HDDS (HDDS $>$ 6.0). Drivers of rural household i's food security during the initial stages of the COVID-19 outbreak can be accounted for using the following empirical model (Eq. (1)).

$$HDDS_i = \zeta_i + \omega Z_i + \theta X_r + \rho P + \mu_i \quad (1)$$

For which, we consider a vector of households i interest variables Z_i, and respondent r specific characteristics X_r, and province P is taken as a control variable. We specified various models of Eq. (1) for a sensitivity test. Model (1) is specified as in Eq. (1) and it includes all the variable vectors and the control variable. There were 3 other models. Model (2) has the same configuration as Model (1) but we did not control the province for a sensitivity test. Models (3) and (4) consider households and respondents' quantitative and qualitative socioeconomic characteristics, respectively.

The perceived change in food security attributed to COVID-19 is assumed to be a binomial variable that takes the value 1 if a particular

Table 1
Sample of survey questions used to assess any change in dimensions of household food security during the reference period.

Food security dimension	Question
Food availability	Have you experienced any unusual changes in the availability of basic food products you normally buy? Give the principal reason.
Dietary diversity	Have you noticed any change in the diversity of food consumption over the past few months? Give the principal reason.
Food accessibility	Have you noticed any unusual change in the price of foodstuffs (food baskets) that you normally buy? Give the principal reason.

dimension of household food security worsened during the initial stages of the COVID-19 pandemic, and 0 if otherwise. Also, we performed a logit model to estimate the factors associated with a change in a dimension of household food security attributed to the COVID-19 outbreak (Gujarati & Porter, 2009). From the logit results, we estimated the marginal effect which shows the magnitude of the effect of COVID-19 on household food security. The empirical model is specified as follows:

$$f_{id} = \zeta_i + \omega Z_i + \theta X_r + \rho P + \mu_i \quad (2)$$

where f_{id} is a binomial variable for household i's perception of a change in a dimension of food security and other parameters are specified as in Eq. (1). Eq. (2) was performed for each food security dimension considering one category of interest.

2.3. Household and respondent characteristics

Household composition. We measured the composition of the household in terms of age groups. We expect that the number of household members who are below 18 years old to be negatively associated with food security because their contributions to the household food basket and income are somewhat marginal, and off-farm opportunities decreased during the pandemic (Stoop et al., 2021; Amare et al., 2021). We considered other age group ranges as well, including the number of household members aged 35 years and above.

Household size. Considering the effects of household size on household food security is also important. First, larger households may be the most impacted by COVID-19 because food needs and expenditures are generally proportionate to the household size. Second, we may assume that the larger the size of the household the less vulnerable the household will be because of its members' contributions to the food basket (Kansiime et al., 2021; Boughton et al., 2021). The household size included all people who live together and eat out of the same pot as follows: someone who has temporarily moved for less than six months, students studying away from home, workers who have stayed for at least a month, and someone who lives away from home but is very involved in household economic decision-making.

Crop sales. Relying on crop sales as the main source of income during the COVID-19 outbreak could be risky because of food system disturbances (Ahmed et al., 2021; Amare et al., 2021; Béné et al., 2021). A binary variable was created and takes the value 1 if crop sale is the main source of income of the household, and 0 if otherwise.

Household members living with a disability. Having a household member who is living with a disability could reinforce the impact of COVID-19 on food security since healthcare expenditures may be prioritized compared to food expenditures on the one hand, and a member living with a disability may not contribute to the household needs on the other hand (Pakravan-Charvadeh et al., 2021). We included a variable to account for the effect of the pandemic on food security for those households with a member living with a disability. This variable takes the value 1 if the household had a member living with a disability, and 0 if otherwise.

Probability of being poor. The level of household poverty was measured using the poverty probability index (PPI) (Laborde, Martin, & Vos, 2021; Bargain & Aminjonov, 2021; Luo et al., 2020). The PPI is a country-specific poverty measurement tool developed by Innovations for Poverty Action (IPA). The construction of the PPI score was based on ten questions about a household's characteristics and asset ownership. Responses to the questions were allocated a value and then summed to derive a household's PPI score. Based on an international poverty line of US$1.9, the PPI score was converted to the likelihood of the respondent's household being below the poverty line (IPA, 2017). The final indicator is a numeric variable of the probability of being poor.

Cash savings. Cash saving is assumed to be a mitigating factor that lessens the impact of COVID-19 on household food security as it represents an important safety net for households in the absence or disturbance of financial services. As evidenced by Rönkkö et al. (2021), the functioning of routine financial services was disturbed by lockdowns and social distancing in Bangladesh, which reduced households' abilities to withdraw their savings in times of need. For this study, a variable was created that takes the value1 of the household holds cash savings, and 0 if otherwise.

Group membership. Similarly, social capital has routinely been shown to mitigate the impacts of a range of shocks and stressors on household food security and other outcomes and is oftentimes measured as an individual's or household's membership in a group (Niles et al., 2021). In rural areas, people's livelihood activities can be enhanced when they are part of cooperatives, groups, or associations. When mobility restrictions are imposed by authorities during certain circumstances, including during a pandemic, restrictions could disturb the normal functioning of such groups and limit people's interactions, connectivity, and support (Béné et al., 2021; Ahmed et al., 2021). The group membership variable used in this study takes the value 1 if the respondent is a member of a group, and 0 if otherwise.

Finally, other households and respondent characteristics were taken as exogenous factors, including household type (female-headed versus male-headed), age of the respondent, years of education of the respondent, whether the respondent was born in their current place of residence, and their number of years of farming experience (d'Errico, Romano, and Pietrelli 2018, Kansiime et al., 2021). The province the respondent resides in was used as a control variable.

2.4. Study area, sampling procedure, and data

The data were collected in October 2020 during a face-to-face interview by trained enumerators using tablets with a pre-loaded electronic questionnaire. The One CGIAR framework that considers five impact areas (https://www.cgiar.org/how-we-work/strategy/) served as the basis for the development of the questionnaire. These impact areas include (i) nutrition and food security; (ii) poverty reduction and job creation; (iii) gender equality, youth, and social inclusion; (iv) climate adaptation and reduction of greenhouse gases; and (v) healthy environment and biodiversity. The detailed questionnaire can be obtained upon request. The trained enumerators were from the Cellule d'Analyses des Indicateurs de Développement (CAID), which conducted several socioeconomic studies in the past in the target provinces (https://www.caid.cd). Enumerators were trained to strictly respect COVID-19 prevention measures such as social distancing, wearing a face mask, washing hands with soap, and/or using a hydroalcoholic gel to limit any exposure to the virus during the survey. During interviews, face masks and hydroalcoholic gels were provided to respondents.

A multi-stage sampling strategy was used to select a total of 1339 households. In the first stage, four provinces were purposively selected – Kwango, Kwilu, Kongo Central, and Kinshasa rural (see Fig. 2). These provinces were selected for two reasons. First, Kinshasa city was the main entry point of COVID-19, which accounted for 77 % of the total 10,514 cases in the country as of September 19, 2020 (WHO, 2020). From Kinshasa city, the virus penetrated the neighboring provinces of Kongo central, Kwango, and Kwilu. Therefore, the western part had been mainly exposed to the virus due to its proximity to Kinshasa, the heart of the pandemic in DRC. Second, the western DRC has strong trade ties with neighboring countries as well as overseas countries. The city of Matadi in Kongo Central is the transit center between the Atlantic Ocean and western DRC. The Ndjili airport and the port of Matadi receive goods and passengers from the eastern DRC through the ports of Dar es Salaam in Tanzania and Mombasa in Kenya, which serve as product portals. In terms of COVID-19 cases, Kinshasa had the most as of September 19, 2020, with 8107 cases (higher prevalence), followed by Kongo Central with 467, Kwilu with 6 cases, and Kwango with 1 case (low prevalence) (WHO, 2020).

In the second stage, three territories from Kwango and Kongo Central

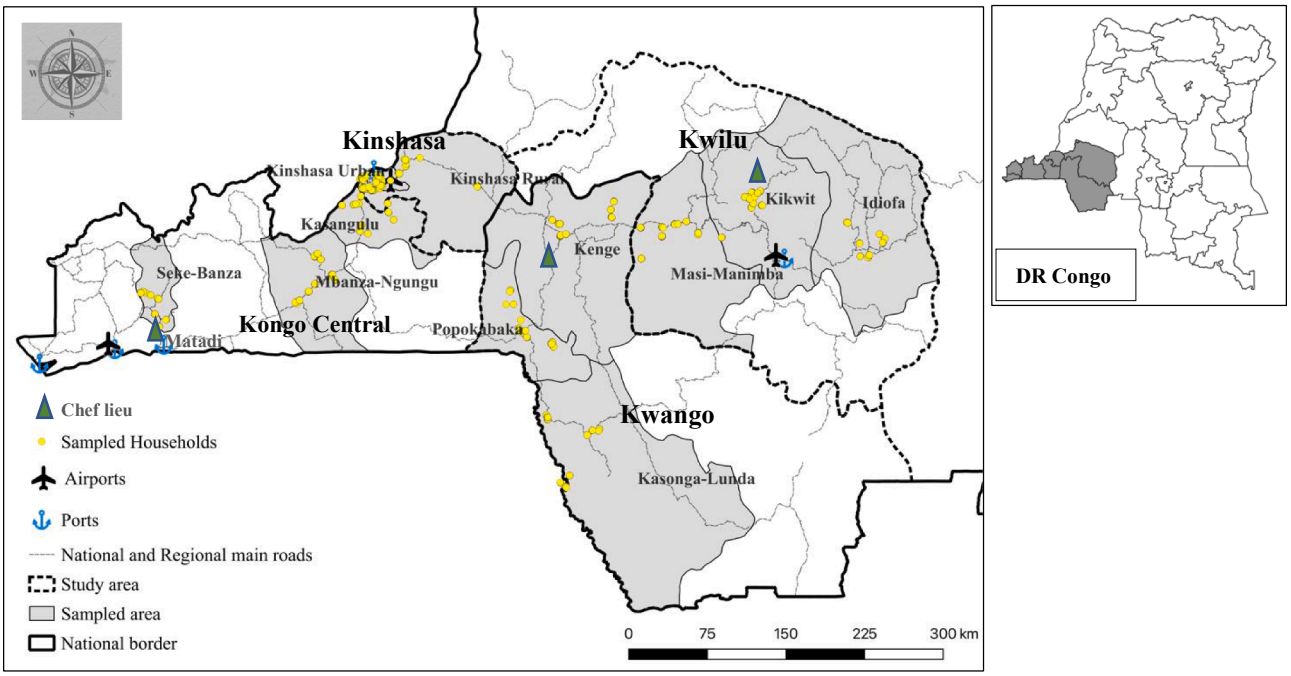

Fig. 2. Map showing the study area. Note: Only medium (Kikwit Airport, and Boma Lukandu International Airport) and large airports (Ndjili International Airport) were mapped. Ports include main river ports (Kikwit River port in Kwilu and Kinshasa River port in Kinshasa) and seaports (Banana, Boma, and Matadi Ports in Kongo Central). Local roads were overlooked. Authors conception using QGIS 3.10.Notes. the PPI score was estimated on 1330 observations.

provinces that are closest to Kinshasa city were purposively selected. For the Kwilu province, the three territories that are geographically the closest to Kikwit city were purposively selected. The same justification is that the virus responds from the capital city into its inner districts.

In the third stage, the three most populated sectors were selected in each territory, and within each sector, three villages close to its capital were purposively selected (same rationale and justification as above). At the village level, we followed the main road crossing the village starting from the main bus stop. Twelve households were systematically and regularly selected in each village. The reason is that villages are built around the same families, values, culture, and livelihood and as such, there is high homogeneity within the villages. However, heterogeneity exists between villages. The total sample of 1339 households was selected from the four provinces made of 349 households in Kongo Central, 336 in Kinshasa, 330 in Kwilu, and 324 in the Kwango.

The enumerator training was organized in two stages. The first stage included all the supervisors (with a minimum of BSc level) from the four provinces, along with personnel from the Ministry of Agriculture and the International Institute of Tropical Agriculture (IITA) who assembled in Kinshasa during three days of training in classrooms and the field during the pre-testing of the questionnaire. Upon return to their respective provinces, the supervisors organized the training of enumerators (holders of certificates of secondary school at a minimum and speaking the local language) at the headquarters of the province for two days before continuing with in-the-field training and supervision during data collection in the selected districts. Supervisors were trained to check the quality of completed questionnaires and make corrections if required daily. The use of tablets allowed timely assembling of data at the central server, where a second quality check was conducted instantly, and possible mistakes were brought back to the attention of the supervisor for correction in the field before the enumerators moved from one village to the next.

To get the adherence and compliance of respondents, given the unique circumstances during the initial phase of the pandemic, the head of the village was interviewed first to serve as an example to potential respondents based on local protocols. Data from the head of the village were not included in the analysis unless the sampling approach led to the selection of the household of the head of the village. In each household, both the male head of the household and his spouse were interviewed. In a female-headed household, the oldest male member of the household was also interviewed. In a polygynous household, the male head of household and the most senior spouse were interviewed. Before administering the questionnaire to the household members, enumerators explained the purpose of the survey, how it was to be conducted and how data would be managed and analyzed. Thereafter, enumerators sought and obtained the consent of the respondents to participate in the survey. This paper is based on the analysis of the data at the household level.

Table 2
Selected descriptive statistics of socioeconomic factors of households.

Variables (n = 1339)	Min	Max	Mean	SD.
Household head (1 if the household head, and 0 otherwise)	0	1	0.86	0.45
Age of head of household (years)	17	95	46.76	13.26
Farming experience of the respondent (years)	0	70	22.56	14.56
Household size (#)	1	22	6.16	2.82
Members of the household < 18 years old (#)	0	17	2.31	2.02
Members of the household ≥ 35 years old (#)	0	6	1.20	0.93
PPI score (probability household is < US$1.9 poverty line)	0.5	98.8	61.92	31.19
Household type (1 if female-headed, and 0 otherwise)	0	1	0.19	0.39
Education of respondent (years)	0	30	9.01	3.93
Natal village (1 if the respondent was born in the current place of residence, and 0 otherwise)	0	1	0.75	0.43
Group membership (1 if member, and 0 otherwise)	0	1	0.18	0.38
Crop sales (1 if yes, and 0 otherwise)	0	1	0.84	0.37
Cash savings (1 if yes, and 0 otherwise)	0	1	0.19	0.40
Household member living with a disability (1 if yes, and 0 otherwise)	0	1	0.03	0.17

3. Results and discussion

3.1. Selected characteristics of households

Table 2 shows that, on average, 86 % of the respondents identified themselves as household heads, and were 47 years old. Female-headed households comprised 19 % of the sample. The average household size was 6 persons. Households consisted of 2 persons below the age of 18 years and 1 person 35 years and above, on average. According to the PPI score, 62 % of households were considered poor. On average, respondents completed 9 years of education, which corresponds to the secondary education level following the DRC educational system. Seventy-five percent of respondents indicated the village they currently reside in was their natal village. Only 18 % of respondents indicated they were members of a group. Respondents had 23 years of farming experience. Crop sale was the main source of income for 84 % of households. Only 19 % of the respondents indicated their households held cash savings. A marginal proportion of households had a member living with a disability at 3 %.

3.2. COVID-19 outbreak, marketing of agriculture products, and food accessibility

The outbreak of COVID-19 has disrupted the normal functioning of agricultural markets and food accessibility as presented in Table 3. Around 59 % of market-oriented farmers experienced a decrease in the demand for agricultural products they usually sold on the market, and about 38 % of them reduced the number of agricultural products sold. Furthermore, prices of agricultural products increased generally, as reported by 46 % of farmers. This corroborates with CAID data that shows that before the announcement of COVID-19 in DRC, a 25-kg bag of rice and maize flour cost US $19 and US $13, respectively, while the price of the same 25-kg bag in June 2020 was estimated at the US $25–27 for rice and the US $20 for maize flour. In addition, in Kinshasa, where shortly after the provincial government announced full containment, food prices increased by two to three times what they were before COVID-19. In Lubumbashi, prices had already risen excessively before the arrival of the pandemic in the city, due to panic in neighboring provinces and countries, especially for maize flour (the most consumed food in the region), so much so that the governor ordered traders and wholesalers to sell only a maximum of two 25-kg bags of maize flour per person (https://www.caid.cd).

Table 3
COVID-19 outbreak, marketing of agriculture products, and food accessibility.

Variables	Changes in marketing and food accessibility			Main reasons for changes		
	Increase	No change	Decrease	COVID-19	Other factors	Both
The demand for agricultural products	14.9	26.0	59.0	75.3	15.5	9.2
Supply of agricultural products (# products sold)	17.5	44.8	37.7	76.8	16.5	6.7
Price of agricultural products	46.2	21.8	32.1	75.4	13.5	11.0
Number of meals per day	0.8	51.9	47.3	68.9	17.5	13.6
Informal mechanisms for obtaining food-stuffs	5.0	68.5	26.5	82.8	11.8	5.4
Reliance upon on-farm production versus market products	37.6	45.4	17.0	74.2	18.1	7.7

Note. The answer "both" includes both COVID −19 and other factors as causes of change.

As markets were also subject to sanitary and hygiene measures such as the reduction in the number of market opening days, social distance, and mobility restrictions, these measures led to the disturbance of distribution channels of agricultural products and an increase in the prices of such products. This corroborates the empirical studies by Ahmed et al. (2021), Adewopo et al. (2021), Narayanan and Saha (2021), and Susilo et al. (2021).

Consequently, about 47 % of households experienced a decrease in the number of meals consumed per day, 38 % increased their dependence on on-farm production, and 27 % of households recorded a change in the informal mechanisms for obtaining food-stuffs. Informal mechanisms of access to food include barter, donations or mutual aid within the community, between family members, neighbors, etc., or any other channel not taken into account by market mechanisms (Morton et al., 2021.

3.3. Links between household dietary diversity and the prevalence of COVID-19

Fig. 3 shows the prevalence of COVID-19 measured in terms of COVID-19 recorded cases in the study provinces, Kinshasa having the highest prevalence and the Kwango ranking the last. The figure also establishes a linkage between rural households' dietary diversity and COVID-19 prevalence. It shows that the proportion of households with a high HDDS decreases with the prevalence of COVID-19 across provinces. Concretely, in Kwilu 49 % of households had a high HDDS and only 6 COVID-19 cases were reported in the province. In Kongo Central, 35 % of households had a high HDDS and 467 COVID-19 cases were reported in the province. While in Kinshasa, 21 % of households had a high HDDS and 8107 COVID-19 cases were reported in the province. This result can be explained by the fact that the higher the COVID-19 prevalence the more severe the restriction measures at both national and local levels. This result was also found by Rönkkö et al. (2021), that during the lockdown, people's abilities to use conventional coping strategies such as borrowing, withdrawing savings, and receiving monetary gifts from friends and family declined. The lockdown led to an increase in food prices, which in turn reduced people's purchasing powers and their abilities to access sufficient and diversified food baskets (Adewopo et al., 2021; Béné et al., 2021). Finally, Chen et al. (2021) demonstrated that the huge uncertainty regarding the virus negatively affected people's food behaviors.

In the Kwango we found an uncommon linkage between food security and COVID-19 prevalence probably because of the smallest percentage of households classified high HDDS (24 %) and very low COVID-19 prevalence (1 case). This contrasting result can also demonstrate that low versus high dietary diversity scores can be explained by several factors beyond the COVID-19 outbreak such as economic, environmental, political, and/or social changes.

3.4. COVID-19 outbreak's implications on key dimensions of household food security

This section presents findings on the implications of COVID-19 on the key household food security dimensions (Table 4). The results show that 61 % of respondents indicated that basic food products such as rice, maize flour, cassava flour, and beans were not available for their households to purchase. The attribution process was made possible by asking respondents to give the major cause(s) of the change. The analysis shows that the COVID-19 outbreak was the main cause of the low availability of basic food products for 73 % of households. One potential explanation could be the low DRC agricultural production at around 4 % of 2020 Gross Domestic Production (GDP) (Pauw et al., 2021). However,

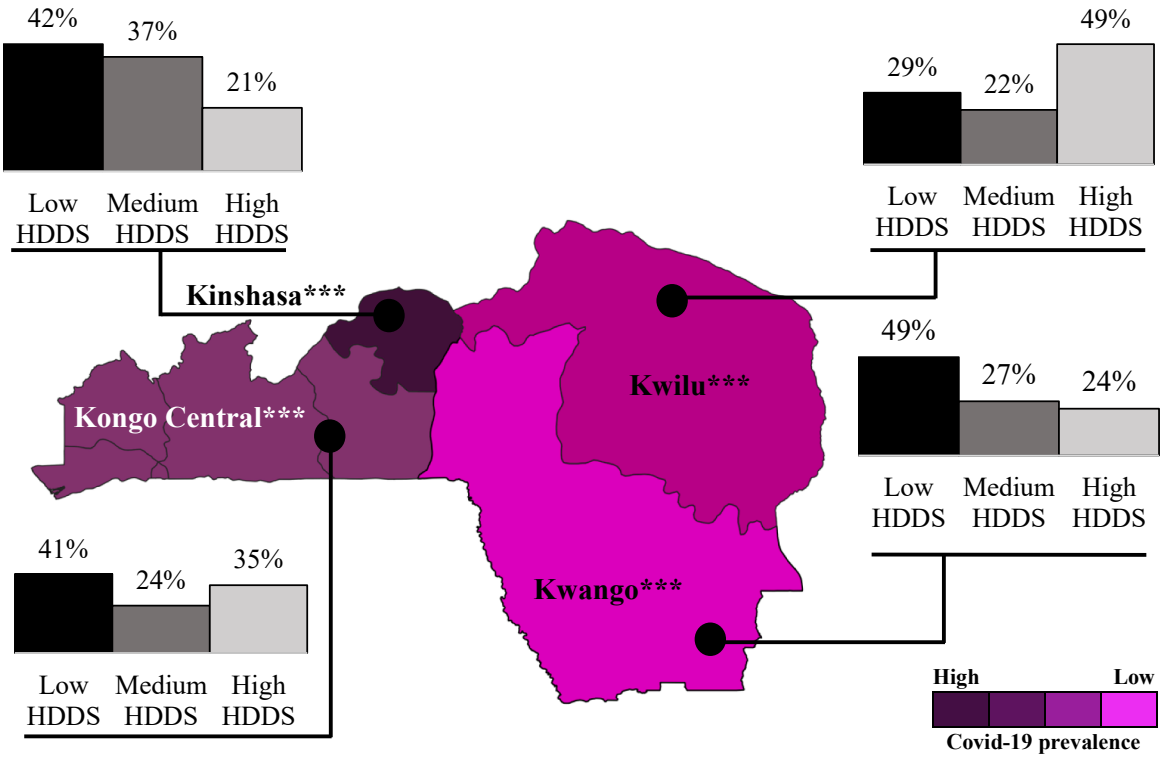

Fig. 3. Rural households' dietary diversity scores and Covid-19 prevalence in the target provinces. Notes: Low HDDS = HDDS < 4.5, Medium HDDS = HDDS between 4.5 and 6.0, High HDDS = HDDS > 6. ***p < 0.01 %, **p < 0.05, and *p < 0.1. The proportions of HDDS categories are significantly different across provinces at the 1 % level, using the Chi-square test.

Table 4
Self-reported changes in food security status during the initial COVID-19 outbreak.

	Food security dimensions								
	Food availability			Dietary diversity			Food accessibility (price)		
	Freq.	Percent	Mode	Freq.	Percent	Mode	Freq.	Percent	Mode
I. Change in food security									
Increase	154	11.5		69	5.15		1074	80.2	√
No change	368	27.5		543	40.6		205	15.3	
Decrease	817	61.0	√	727	54.3	√	60	4.50	
II. Cause:	Decrease			Decrease			Increase		
COVID-19	597	73.1	√	537	73.9	√	798	74.3	√
Other factors	120	14.7		97	13.3		140	13.0	
Both	100	12.2		93	12.8		136	12.7	

Notes. The response "both" includes both COVID-19 and other factors as a cause of the change while "Modes" are associated with categories that have the highest frequencies.

COVID-19 could affect food availability through many other channels such as disruption in the supply chain due to restricted movements, ill health by some transporters/traders, and blockages at border crossings due to positive cases.

Concerning food prices, the results show that 80 % of respondents reported that the price of basic food products increased during the initial stages of the COVID-19 outbreak compared to the same period in 2019. The outbreak presumably reduced people's purchasing powers while simultaneously decreasing their revenues. These results are consistent with those reported by Adewopo et al. (2021) who found that the price of maize and rice increased by 26 % and 44 %, respectively, during the pandemic in Nigeria. Over 74 % of respondents attributed the perceived change in food prices to COVID-19, as was also evidenced by Béné et al. (2021) in their global assessment of COVID-19′s impacts on food systems. One plausible explanation for the findings is that food markets were not exempted from restriction measures caused by the COVID-19 outbreak. The closure of markets created constraints in the supply chain and the fear of contamination reduced the inflow of products into markets, thus increasing both the demand for such products and their prices (Narayanan & Saha, 2021; Susilo et al., 2021).

Table 4 shows that 54 % of respondents indicated that their households experienced a general decline in dietary diversity and 74 % of them attributed the perceived change to COVID-19. These results demonstrate that rural people were negatively impacted by the pandemic in their ability to access sufficient and diversified foodstuffs (Ahmed et al., 2021; Pakravan-Charvadeh et al., 2021; Stoop et al., 2021; Rönkkö et al., 2021).

Fig. 4 shows the change (or no change) in the consumption of different food groups by households in each study province. Overall, the consumption of protein-rich food items (meat, fish, and milk products)

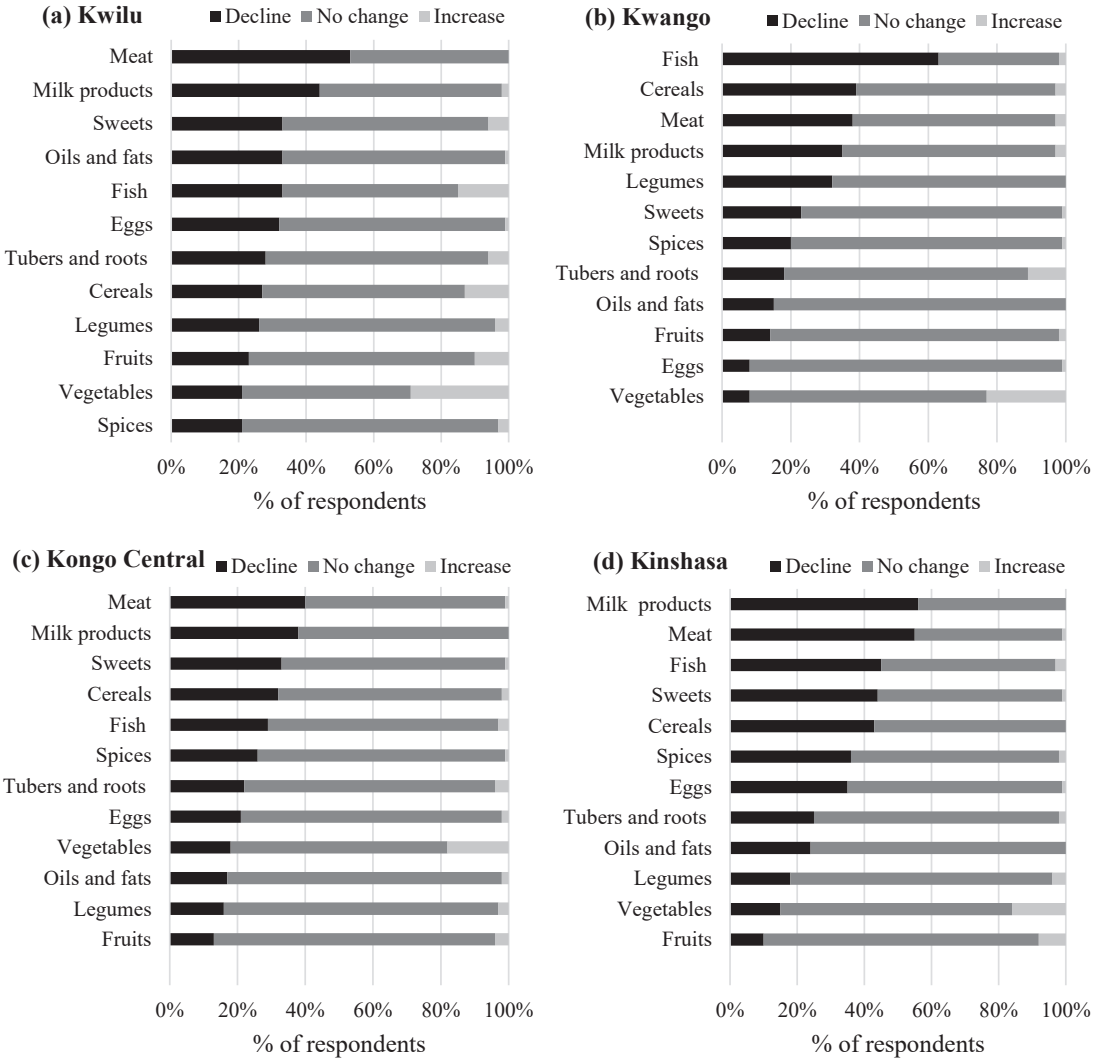

Fig. 4. Change in the consumption of food groups during the initial COVID-19 outbreak.

declined. In Kwilu and Kongo Central, the consumption of meat products declined for 53 % and 40 % of households, respectively. The consumption of fish declined for 63 % of households in the Kwango, while the consumption of milk products declined for 56 % of households in Kinshasa. The consumption of vegetables, such as vitamin A-rich dark green amaranth, cassava, or sweet potato leaves, increased across all provinces compared to other food groups. Interestingly, the consumption of sweets declined across most provinces and relatively significantly compared to other more nutritious food groups. This suggests that some rural households were unwilling to prioritize their consumption of sweets during uncertain times, and instead, use their likely limited resources for the purchase of other foods.

3.5. *Factors affecting the level of dietary diversity*

In our study, we assessed the determinants of household dietary diversity during the COVID-19 outbreak. The results in Table 5 show that the age of the household head was significantly associated with an increase in HDDS (Models (2) and (3)). This result follows that of d'Errico, Romano, and Pietrelli (2018), who showed that older people were more resilient to food insecurity in Tanzania and Uganda. A potential explanation could be that in rural areas the ability of the households to mobilize means that could reinforce households' resilience toward shocks is usually the responsibility of the household head and less of the younger household members. Similarly, holding cash savings was positively associated with household dietary diversity. These findings are in line with Pakravan-Charvadeh et al. (2021) who found that personal savings and investment in livestock (as a form of savings) improved food security during the COVID-19 outbreak. Similar to Kansiime et al. (2021), household size was associated with an increase in HDDS, which suggests that in times of crisis, and especially in rural areas, multiple household members help contribute to diversifying the household diet.

Furthermore, the lockdown and other restrictions that limited both people's mobility and resources worsened the situation of some, including those people who depend on crop sales as a source of income as found by Ahmed et al. (2021) and their social capital based on group membership (Niles et al., 2021). Social distancing and mobility restrictions had disturbed the normal functioning of groups that oftentimes reinforce people's livelihood, community support, and people's connectivity as evidenced by Béné et al., (2021) and Ahmed et al., (2021). As expected, the HDDS decreased as the probability of being poorly increased, demonstrating the close linkage between poverty and low dietary diversity. This result is consistent with that of Luo et al. (2020) and Bargain and Aminjonov (2021) who found that the lockdown reduced the probability of people's participation in off-farm activities, and thus exacerbated poverty. A larger number of household members below 18 years old worsened household dietary diversity. This may be explained by younger people's limited capacities to participate in productive work and contribute less to the household income.

Table 5
Socioeconomic factors associated with a household dietary diversity score.

Variables	Four ordinary least squares models			
	Coef. (1)	Coef. (2)	Coef. (3)	Coef. (4)
Age of the respondent (years)	0.012	0.020**	0.017**	
	(0.009)	(0.009)	(0.008)	
Size of household (#)	0.174***	0.205***	0.181***	
	(0.037)	(0.037)	(0.038)	
Farming experience of the respondent (years)	−0.004	−0.015**	−0.006	
	(0.007)	(0.007)	(0.007)	
Members of the household aged < 18 years old (#)	−0.072	−0.104**	−0.058	
	(0.050)	(0.049)	(0.051)	
Members of the household aged ≥ 35 years old (#)	0.087	0.010	0.075	
	(0.096)	(0.094)	(0.096)	
PPI score (probability household is < US$1.9 poverty line)	−0.025***	−0.026***	−0.028***	
	(0.003)	(0.003)	(0.003)	
Household head respondent (1 if the household head, and 0 otherwise)	0.408	0.516		0.614*
	(0.325)	(0.333)		(0.323)
Household type (1 if female-headed, and 0 otherwise)	0.400	0.485*		0.572*
	(0.282)	(0.285)		(0.314)
Education of respondent (years)	−0.014	−0.014		−0.007
	(0.020)	(0.020)		(0.020)
Natal village (1 if the respondent was born in their current place of residence, and 0 otherwise)	0.101	0.261		−0.024
	(0.186)	(0.174)		(0.193)
Group membership (1 if member, and 0 otherwise)	−0.488**	−0.352*		−0.773***
	(0.213)	(0.207)		(0.216)
Crop production sales (1 if yes, and 0 otherwise)	−0.608***	−0.649***		−0.723***
	(0.217)	(0.228)		(0.217)
Cash saving (1 if yes, and 0 otherwise)	0.809***	0.732***		0.983***
	(0.203)	(0.200)		(0.202)
Household member with a disability (1 if yes, and 0 otherwise)	−0.073	0.007		−0.015
	(0.456)	(0.470)		(0.444)
Kinshasa	−0.915***	–	−0.935***	−0.109
	(0.229)		(0.219)	(0.226)
Kongo Central	0.031	–	−0.153	0.585**
	(0.252)		(0.250)	(0.243)
Kwango	−0.666**	–	−0.718***	–
	(0.274)		(0.253)	
Kwilu	–	–	–	1.393***
				(0.265)
Constant	6.248***	5.412***	5.768***	5.404***
	(0.771)	(0.748)	(0.375)	(0.635)
Number of observations	1330	1330	1,330	1330
Adjusted R-squared	0.159	0.142	0.135	0.095

Note. Robust standard errors are in parentheses. ***p < 0.01 %, **p < 0.05, and *p < 0.1. PPI = poverty probability index. Model (1) is specified as in Equation (1) and includes all the variable vectors and the control variable. Model (2) has the same configuration as Model (1) but we do not control for the variable province for a sensitivity test. Models (3) and (4) consider quantitative and qualitative variables, respectively. Kwilu was selected as the base for the four provinces.

3.6. Socioeconomic factors associated with the change in food security dimensions

We estimated the marginal effects of the logit model of factors associated with the change in each dimension of food security attributed to the COVID-19 outbreak. The main results in Table 6 show that the likelihood of respondents reporting a shortage in available food and a reduction in dietary diversity decreased significantly with the number of household members below 18 years old. These results can be explained by the fact that households with larger numbers of members below 18 years old are less resilient to food security shocks due to their lower level of productivity as evidenced by Bargain and Aminjonov (2021), Luo et al. (2020), and Béné et al. (2021).

Table 6
Determinants of self-reported change in food security outcomes.

Variables	Food availability	Dietary diversity	Food price
	Reduce (1 = yes)	Reduce (1 = yes)	Increase (1 = yes)
	dy/dx	dy/dx	dy/dx
	(1)	(2)	(3)
Age of the respondent (years)	−0.002	−0.000	−0.000
	(0.002)	(0.000)	(0.001)
Size of household (#)	0.011	0.004*	0.002
	(0.008)	(0.002)	(0.005)
Farming experience of the respondent (years)	−0.001	0.000	0.001*
	(0.001)	(0.000)	(0.001)
Members of the household aged < 18 years old (#)	−0.025***	−0.008*	0.005
	(0.009)	(0.004)	(0.006)
Members of the household aged ≥ 35 years old (#)	0.050**	0.009	0.023
	(0.021)	(0.007)	(0.014)
PPI score (probability household is < US$1.9 poverty line)	−0.000	−0.000	−0.001
	(0.001)	(0.000)	(0.000)
Household head respondent (1 if the household head, and 0 otherwise)	−0.083*	−0.000	0.041
	(0.043)	(0.015)	(0.042)
Household type (1 if female-headed, and 0 otherwise)	0.021	0.022*	0.040**
	(0.049)	(0.012)	(0.019)
Education of respondent (years)	−0.004	−0.000	0.002
	(0.004)	(0.001)	(0.005)
Natal village (1 if the respondent was born in their current place of residence, and 0 otherwise)	0.005	−0.015*	0.026
	(0.035)	(0.008)	(0.022)
Group membership (1 if member, and 0 otherwise)	0.016	−0.019*	−0.001
	(0.043)	(0.010)	(0.024)
Crop production sales (1 if yes, and 0 otherwise)	0.079*	−0.023**	−0.018
	(0.043)	(0.010)	(0.020)
Cash saving (1 if yes, and 0 otherwise)	0.104***	0.034***	0.033*
	(0.027)	(0.011)	(0.019)
Household member with a disability (1 if yes, and 0 otherwise)	0.112	−0.010	−0.011
	(0.095)	(0.016)	(0.042)
Kinshasa	0.202***	0.028	−0.066
	(0.030)	(0.021)	(0.043)
Kongo Central	0.012	−0.119**	−0.004
	(0.041)	(0.058)	(0.032)
Kwango	0.093***	−0.153**	−0.001
	(0.031)	(0.069)	(0.035)
Number of observations	747	599	866

Note: dy/dx denote marginal effect. Robust standard errors are in parentheses. ***p < 0.01 %, **p < 0.05, and *p < 0.1. For food prices, we were interested in the increase in food prices while the reduction category was considered for food availability and dietary diversity.

The likelihood of reporting a shortage in available food and reduction in dietary diversity increased with the number of household members above 35 years old and for those households holding cash savings. Adult members contribute to the household income and food basket in normal periods through two paths: own on-farm activities and off-farm job opportunities. The latter were negatively impacted by the initial COVID-19 outbreak (see Béné et al., 2021), hence less income was generated from off-farm work to purchase foodstuffs, as found by Amare et al. (2021) and Stoop et al. (2021). Furthermore, the disturbance in financial services associated with lockdowns could explain the positive linkage between holding cash savings and the likelihood to report a shortage in available food and reduction of dietary diversity as found by Chen et al. (2021) and Rönkkö et al. (2021) in China and Bangladesh, respectively. Lockdowns reduced the mobility of people and food assistance from friends and family, such that respondents were more likely to report a reduction in dietary diversity.

Respondents, and especially those whose households depend entirely on their crop sales for income, were more likely to report a shortage in available food due to a negative impact of the pandemic on food systems but less likely to report a reduction in dietary diversity similar to Ahmed et al. (2021). Respondents from households of larger sizes were more likely to report a reduction in dietary diversity. Finally, households headed by women were more likely to report a reduction in dietary diversity and an increase in food prices as was also found by Boughton et al. (2021) in their study in Iran.

4. Conclusion

As millions of Congolese are experiencing food insecurity, the country's progress towards SDG2 may be threatened by the COVID-19 outbreak. Therefore, assessing the implications of the COVID-19 outbreak on food systems is recognized as necessary among scholars, development practitioners, and policymakers alike. Such analyses serve as a basis on which various stakeholders, including government, development actors, and local communities can plan and expect a faster recovery. COVID-19 may continue for an indefinite period while destabilizing the livelihoods of millions of Congolese. While restricting people's mobilities and instituting lockdowns may be effective strategies to slow down the spread of the pandemic, their impact on economic structures will likely be most apparent (Bargain & Aminjonov, 2021; Chen, Qian, & Wen, 2021; Laborde, Martin, & Vos, 2021).

Many measures against COVID-19 also disturb the food and agricultural system, restrict access to financial services, reduce the adaptive capacity of those who depend on a daily off-farm income, as well as people's purchasing power (Pauw et al., 2021; Béné et al., 2021; Clark, Lusardi, & Mitchell, 2021; Stoop et al., 2021). Some actions can be taken to mitigate the negative effects of corrective measures against COVID-19 and improve rural people's resilience to COVID-19 and other like shocks. These actions include among others input subsidies, implementation of emergency activities that include the distribution of basic food commodities, or promotion of financial transfers to the most vulnerable populations.

Since food accessibility is the dimension of food security that has been disrupted most by the pandemic, interventions that maintain or lower food prices are likely to bring about a rapid and positive change in the dietary behavior of rural people. This could be achieved in the short run by providing and ensuring increased access to affordable agricultural inputs. Over the long run, other measures must be taken, including increasing funding for agricultural research, promoting strong partnerships between research and development actors for rapid delivery of technologies and knowledge, and ensuring sustainable and inclusive food systems.

CRediT authorship contribution statement

Victor Manyong: Conceptualization, Methodology, Supervision, Funding acquisition, Writing – original draft, Writing – review & editing. **Akonkwa Nyamuhirwa Dieu-Merci:** Software, Validation, Data curation, Formal analysis, Investigation, Supervision, Writing – original draft, Writing – review & editing. **Zoumana Bamba:** Funding acquisition, Validation, Writing – original draft, Writing – review & editing. **Razack Adeoti:** Visualization, Investigation, Supervision, Writing – original draft, Writing – review & editing. **Gregoire Mwepu:** Visualization, Investigation, Supervision. **Steven M. Cole:** Conceptualization, Methodology, Supervision, Writing – original draft. **Paul Martin Dontsop Nguezet:** Conceptualization, Methodology, Supervision, Data curation, Formal analysis, Investigation, Software, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgments

We thank all the respondents who, despite the circumstances, wished to contribute to the study by providing their time and attention. We express our gratitude to the Cellule d'Analyses des Indicateurs de Développement (CAID) for their valuable contribution. Moreover, we acknowledge all the anonymous reviewers who devoted their time to this study.

References

Adewopo, J. B., Solano-Hermosilla, G., Colen, L., & Micale, F. (2021). Using crowdsourced data for real-time monitoring of food prices during the COVID-19 pandemic: Insights from a pilot project in northern Nigeria. *Global Food Security, 29*, Article 100523. https://doi.org/10.1016/j.gfs.2021.100523

Ahmed, F., Islam, A., Pakrashi, D., Rahman, T., & Siddique, A. (2021). Determinants and dynamics of food insecurity during COVID-19 in rural Bangladesh. *Food Policy, 101*, Article 102066. https://doi.org/10.1016/j.foodpol.2021.102066

Ainembabazi, John Herbert, Abdoulaye, Tahirou, Feleke, Shiferaw, Alene, Arega, Dontsop-Nguezet, Paul M., Ndayisaba, Pierre Celestin, Hicintuka, Cyrille, Mapatano, Sylvain, & Manyong, Victor (2018). Who benefits from which agricultural research-for-development technologies? Evidence from farm household poverty analysis in Central Africa. *World Development, 108*. https://doi.org/10.1016/j.worlddev.2018.03.013

Amare, M., Abay, K. A., Tiberti, L., & Chamberlin, J. (2021). COVID-19 and food security: Panel data evidence from Nigeria. *Food Policy, 101*, Article 102099. https://doi.org/10.1016/j.foodpol.2021.102099

Banerjee, A., Faye, M., Krueger, A., Niehaus, P., & Suri, T. (2020). *Effects of a Universal Basic Income during the pandemic*. Working Paper.

Bargain, O., & Aminjonov, U. (2021). Poverty and COVID-19 in Africa and Latin America. *World Development, 142*, Article 105422. https://doi.org/10.1016/j.worlddev.2021.105422

Béné, C., Bakker, D., Chavarro, M. J., Even, B., Melo, J., & Sonneveld, A. (2021). Global assessment of the impacts of COVID-19 on food security. *Global Food Security, 31*, Article 100575. https://doi.org/10.1016/j.gfs.2021.100575

Boughton, D., Goeb, J., Lambrecht, I., Headey, D., Takeshima, H., Mahrt, K., & Diao, X. (2021). Impacts of COVID-19 on agricultural production and food systems in late transforming Southeast Asia: The case of Myanmar. *Agricultural Systems, 188*, Article 103026. https://doi.org/10.1016/j.agsy.2020.103026

Chen, H., Qian, W., & Wen, Q. (2021). The Impact of the COVID-19 pandemic on consumption: Learning from high-frequency transaction data. *AEA Papers and Proceedings, 111*, 307–311. https://doi.org/10.1257/pandp.20211003

Clark, R., Lusardi, A., & Mitchell, O. (2021). Household consequences of the Coronavirus and its aftermath: Microeconomic Outcomes. *AEA Papers and Proceedings, 111*, 292–296. https://doi.org/10.1257/pandp.20211000

De Brauw, A., Gilligan, D. O., Hoddinott, J., & Roy, S. (2014). The impact of Bolsa Família on women's decision-making power. *World Development, 59*, 487–504. https://doi.org/10.1016/j.worlddev.2013.02.003

d'Errico, M., Romano, D., & Pietrelli, R. (2018). Household resilience to food insecurity: Evidence from Tanzania and Uganda. *Food Security, 10*, 1033–1054. https://doi.org/10.1007/s12571-018-0820-5

Ditekemena, J., Nkamba, D., Mutwadi, A., Mavoko, H., Fodjo, J., Luhata, C., … Colebunders, R. (2021). COVID-19 Vaccine Acceptance in the Democratic Republic

of Congo: A Cross-Sectional Survey. *Vaccines, 9*(153). https://doi.org/10.3390/vaccines9020153

Dontsop Nguezet, P. M., Ainembabazi, J. H., Alene, A., Abdulaye, T., Feleke, S., Nziguheba, G., … Manyong, V. (2020). Are farmers using cropping system intensification technologies experiencing poverty reduction in the Great Lakes Region of Africa? *Food and Energy Security, 9*(3), e205.

Écochard, R., Wimba, P., Bengehya, J., Katchunga, P. B., Lugwarha, S., Oyimangirwe, M., … Vanhems, P. (2021). The COVID-19 pandemic is deepening the health crisis in SouthKivu, the Democratic Republic of Congo. *International Journal of Infectious Diseases, 105*, 716–720. https://doi.org/10.1016/j.ijid.2021.03.043

Gujarati, D., & Porter, D. (2009). *Basic econometrics* (5th ed). New York: Mc-Graw-Hill Education.

IPA. (2017). Zambia 2015 Poverty Probability Index (PPI). Innovations for Poverty Actions (IPA). https://www.povertyindex.org/country/zambia. Accessed on May 02, 2021.

Kansiime, M., Tambo, J., Mugambi, I., Bundi, M., Kara, A., & Owuor, C. (2021). COVID-19 implications on household income and food security in Kenya and Uganda: Findings from a rapid assessment. *World Development, 139*, Article 105199. https://doi.org/10.1016/j.worlddev.2020.105199

Kennedy, G., Ballard, T., & Dop, M. (2013). *Guidelines for Measuring Household and Individual Dietary Diversity*. Rome: Food and Agriculture Organization.

Khan, F., Hasan, M., Kazmi, Z., dos Santos Costa, A., Aborode, A., Ahmad, S., & Essar, M. (2021). Ebola and COVID-19 in the Democratic Republic of Congo: Grappling with two plagues at once. *Tropical Medicine and Health, 49*(1), 1–4.

Laborde, D., Martin, W., & Vos, R. (2021). Impacts of COVID-19 on global poverty, food security, and diets: Insights from global model scenario analysis. *Agricultural Economics*. https://doi.org/10.1111/agec.12624

Luo, R. F., Liu, C. F., Gao, J. J., Wang, T. Y., Zhi, H. Y., Shi, P. F., & Huang, J. K. (2020). Impacts of the COVID-19 pandemic on rural poverty and policy responses in China. *Journal of Integrative Agriculture, 19*(12), 2946–2964. https://doi.org/10.1016/S2095-3119(20)63426-8

Morton, L. W., Bitto, E. A., Oakland, M. J., & Sand, M. (2008). Accessing food resources: Rural and urban patterns of giving and getting food. *Agriculture and Human Values, 25*(1), 107–119.

Narayanan, S., & Saha, S. (2021). Urban food markets and the COVID-19 lockdown in India. *Global Food Security, 29*. https://doi.org/10.1016/j.gfs.2021.100515

Niles, M. T., Rudnick, J., Lubell, M., & Cramer, L. (2021). Household and community social capital links to smallholder food security. *Frontiers in Sustainable Food Systems, 5*. https://doi.org/10.3389/fsufs.2021.583353

Ouoba, Y., & Sawadogo, N. (2021). Food security, poverty, and household resilience to COVID-19 in Burkina Faso: Evidence from urban small traders' households. *World Development Perspectives, 100387*. https://doi.org/10.1016/j.wdp.2021.100387

Pakravan-Charvadeh, M., Mohammadi-Nasrabadi, F., Gholamrez, S., Vatanparast, H., Flora, C., & Nabavi-Pelesaraei, A. (2021). The short-term effects of COVID-19 outbreak on dietary diversity and food security status of Iranian households (A case study in Tehran province). *Journal of Cleaner Production, 281*, Article 124537. https://doi.org/10.1016/j.jclepro.2020.124537

Pauw, P., Randriamamonjy, J., Thurlow, J., & Ulimwengu, J. (2021). République Démocratique du Congo: Impacts du COVID-19 sur la production, la pauvreté et le système alimentaire. *International Food Policy Research Institute*. Washington: International Food Policy Research Institute.

Pinstrup-Andersen, P. (2009). Food security: Definition and measurement. *Food Security, 1*, 5–7. https://doi.org/10.1007/s12571-008-0002-y

Ravallion, M. (2001). The mystery of the vanishing Bénéfits: An introduction to impact evaluation. *The World Bank Economic Review, 15*(1), 115–140. https://doi.org/10.1093/wber/15.1.115

Rönkkö, R., Rutherford, S., & Sen, K. (2021). The impact of the COVID-19 pandemic on the poor: Insights from the Hrishipara diaries. *World Development, 105689*. https://doi.org/10.1016/j.worlddev.2021.105689

Stoop, N., Desbureaux, S., Kaota, A., Lunanga, E., & Verpoorten, M. (2021). COVID-19 vs. Ebola: Impact on households and small businesses in NorthKivu, Democratic Republic of Congo. *World Development, 140*, Article 105352. https://doi.org/10.1016/j.worlddev.2020.105352

Susilo, Y., Floden, J., & Geurs, K. (2021). Six lessons from first-year COVID-19 restrictions: What can we do better in the future? *European Transport Research Review, 13*(48). https://doi.org/10.1186/s12544-021-00513-2

Tuholske, C., Andam, K., Blekking, J., Evans, T., & Caylor, K. (2020). Comparing measures of urban food security in Accra, Ghana. *Food Security*, 417–431. https://doi.org/10.1007/s12571-020-01011-4

Udmale, P., Pal, I., Szabo, S., Pramanik, M., & Large, A. (2020). Global food security in the context of COVID-19: A scenario-based exploratory analysis. *Progress in Disaster Science, 7*, Article 100120. https://doi.org/10.1016/j.pdisas.2020.100120

Vavra, J. (2021). Tracking the pandemic in real time: Administrative micro data in business cycles enters the spotlight. *Journal of Economic Perspectives, 35*(3), 47–66. https://doi.org/10.1257/jep.35.3.47

WFP. (2020, December 24). Reliefweb. Retrieved from WFP D. R. Congo External Situation Report #20: https://reliefweb.int/report/democratic-republic-congo/wfp-d-r-congo-external-situation-report-20.

WHO. (2020, September 31). Bulletin épidemiologique COVID-19 N° 233/2020. Kinshasa, Kinshasa, DR Congo. Retrieved 01, 2022 from fscluster : https://fscluster.org/sites/default/files/documents/bulletin_epid_covid-19_n_233_20200919.pdf.

Wimba, P., Bazeboso, J.-A., Katchunga, P., Tshilolo, L., Longo-Mbenza, B., Rabilloud, M., … Écochard, R. (2020). A dashboard for monitoring preventive measures in response to COVID-19 outbreak in the Democratic Republic of Congo. *Tropical Medicine and Health, 48*(74). https://doi.org/10.1186/s41182-020-00262-3

Wossen, T., Alene, A., Abdoulaye, T., Feleke, S., Rabbi, I. Y., & Manyong, V. (2019). Poverty reduction effects of agricultural technology adoption: The case of improved cassava varieties in Nigeria. *Journal of Agricultural Economics, 70*(2), 392–407. https://doi.org/10.1111/1477-9552.12296

Zirhumanana, B. D. (2021). Mathematical model for the mitigation of the economic effects of the COVID-19 in the Democratic Republic of the Congo. *PloS One, 16*(5), e0250775.