



## Review article

# Three years into the pandemic: Insights of the COVID-19 impacts on food security and nutrition in low and middle-income countries

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## ABSTRACT

The COVID-19 pandemic triggered a global crisis with unanticipated and diverse consequences. Moreover, the pandemic has considerably impacted food dynamics in low- and middle-income countries (LMICs), where food systems have already been challenged. These countries also have the highest share of the world's malnourished and food insecure. Therefore, this paper aims to analyze the pandemic's impact on food security dimensions (availability, accessibility, utilization, and stability), with a special emphasis on LMICs. According to the results, the pandemic immediately impacted food security by limiting food production and availability. It also had an indirect impact when lockdowns and other confinement measures (e.g., social distancing, movement restrictions) made it more difficult for individuals to access food and maintain a healthy, balanced diet (cf. food utilization). Indeed, with rising unemployment and poverty, access to food has been the most critically undermined aspect of food security. At the utilization level, COVID-19 adversely influences the nutritional state of both individuals and countries, leading to an increase in all forms of malnutrition. Finally, the impact of COVID-19 on the stability dimension is dependent on the length of the pandemic as well as the effectiveness with which recovery plans are followed to ensure universal vaccine availability, among other factors. As a result, including agricultural and food systems in recovery strategies is crucial to mitigating the pandemic's long-term effects on food security.

## 1. Introduction

Food security is one of the most fundamental pillars of human security, and it is essential for achieving the 2030 Agenda [1]. Over the past several decades, the concept of food security has evolved and expanded [2]. One of the most accepted definitions indicates that food security happens when "all people at all times have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life" [3]. Food security has four standard dimensions: availability (having a sufficient quantity of food available regularly); access (having enough resources to acquire suitable and healthy food); utilization (having a reasonable use based on knowledge of essential nutrition and care); and stability of availability, access, and utilization of food [4,5]. Consequently, consumers must be able to utilize food that improves their nutrition and is widely accessible, inexpensive, and available in various types. Over time, the three dimensions (availability, access, and utilization) are expected to remain stable throughout time [6]. Today, after availability improvements and physical access were made feasible by increasing global

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food production and rural infrastructure development in numerous countries, economic access to food remains the most significant structural hurdle to alleviating global undernourishment and malnutrition [7]. There is enough evidence to suggest that crises and conflicts are the most important contributors to global food insecurity [8].”

Indeed, the unprecedented public health crisis and economic recession brought on by the COVID-19 pandemic had disruptive social, economic, and psychological effects on diet, food-related activities, and food security [9]. Devereux et al. [10] argue that the pandemic might have a damaging impact on food security by disordering food systems on both the production (production and processing) and consumption (economic and physical access to food) sides of the food supply chain. Indeed, the COVID-19 pandemic has highlighted the agri-food supply chain’s vulnerabilities, yet the extent of disruption varies significantly worldwide. To stem the transmission of the virus, most countries have imposed strict non-pharmaceutical interventions (NPIs) that restricted everyday activities, including home confinement, social distancing, mobility restrictions, temporary closure of schools and universities, and remote work. While these procedures were critical to halting the spread of COVID-19, some voices have raised concerns about their potential influence on agri-food systems and food security [11,12].

Further, it appears that COVID-19 has significantly affected low- and middle-income countries (LMICs), where concerns about food insecurity were exacerbated due to the disturbances triggered by COVID-19 on food supply and demand [13,14]. The pandemic’s effects on food security and nutrition significantly impact these countries. LMICs also hold the most significant share of the world’s malnourished, food insecure, or suffering from one or more kinds of malnutrition [8]. Furthermore, they depend mainly on international trade for food supply. The percentage of food in LDCs’ imports is over three times higher than the global average, and the proportion of grains in their food imports is nearly three times higher [15].

The containment measures adopted in several countries had long-term impacts on the global economy [16]. Indeed, it seems that the pandemic affected all dimensions of food security (Fig. 1) with different impact pathways. Further, the pandemic impacted progress toward the UN Sustainable Development Goals (SDGs). Indeed, COVID-19 jeopardized the implementation of the SDGs, including SDG 1 (No Poverty), SDG 2 (Zero hunger), and SDG 3 (Good health and well-being). The COVID-19 pandemic reduced the priority level assigned to the SDGs, thereby slowing their implementation [17].

Furthermore, many LMICs were affected hard by the epidemic at a time when they were already dealing with severe socio-economic, political, and food security issues. Indeed, food systems had significant issues before the COVID-19 pandemic in guaranteeing equal access to healthy and nutritious food for everyone, environmental sustainability, and crisis resilience [18]. Indeed, conflict, socio-economic circumstances, natural disasters, climate change, and insect infestations all contributed to the increase in chronic and acute hunger [19]. Due to the COVID-19 pandemic, these pre-existing and continuing concerns have been intensified. Goals to eliminate hunger and malnutrition by 2030 will hardly be achieved. According to FAO [20], with less than a decade until the SDGs deadline, the pandemic has made it much more difficult to accomplish them. In fact, the prevalence of undernourishment (PoU) rose to 9.9% in 2020 due to the pandemic, making it harder to realize the Zero Hunger goal by 2030. Furthermore, in recent decades, food value chains in LMICs have grown and elongated considerably to feed rapidly increasing cities while fulfilling rural demand. As a result, they were more exposed to shocks [21].

The COVID-19 pandemic was expected to be contained and eradicated early, allowing the focus to move to recovery and resilience. Three years into the pandemic, over 644 million confirmed cases and 6.7 million deaths had been reported globally as of December 12, 2022 [22]. This figure will climb further as Omicron spreads. The pandemic is far from over and continues to transform food systems.

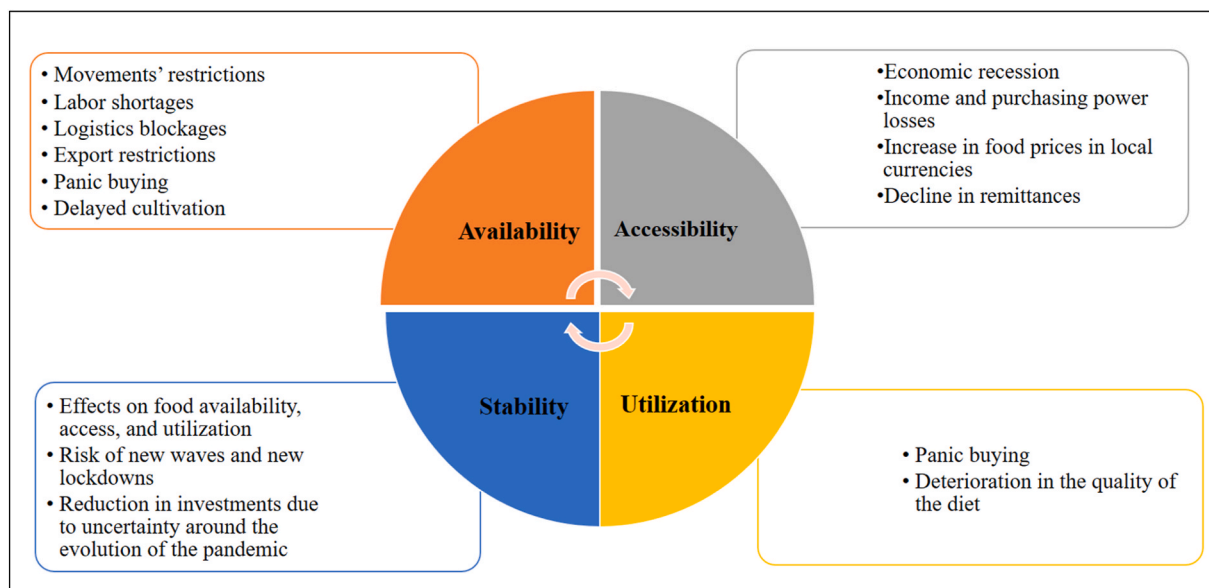


Fig. 1. The COVID-19 pandemic’s impacts on food security. Source: Authors’ elaboration based on the literature review

COVID-19 and its disturbances have continued and evolved, resulting in new outbreaks of infections and fatalities and continuing health, economic, and social impacts. It is believed that the effects of the pandemic will linger for many years, particularly in countries where health care is scarce, vaccination rates are low, and new strains are constantly emerging [23].

Even the countries that controlled the virus are anxious about approaching waves, notably the emergence of more infectious variants such as Delta, Omicron, etc. While vaccinations are a helpful weapon in combating the pandemic, it is uncertain how many more variants will emerge in the future and how effective present vaccines and therapies will be against them [24]. Due to the likelihood of new infections and waves, more lockdowns or the continuation of current restricted measures may be necessary for the coming months, causing severe economic and food supply disruptions. For example, since the new variant Omicron was first reported to the WHO in November 2021, it has created global fear and disrupted global markets, while further border controls implemented by several countries have hindered the economy’s recovery from the two-year pandemic [25]. Furthermore, with the reintroduction of restrictions and the effect of Omicron infections on workers and consumers, every component of the food supply chain is under pressure, and Omicron seems to rewind the global food system back to the pandemic’s start [26,27]. Although the worst of the Omicron wave has passed in most countries, several nations, such as China and Hong Kong, are experiencing their worst peak to date, dealing with significant breakdowns and tightening restrictions [28]. The global scientific community is being tested for future outbreaks and the severity of a further mutating disease [29].

However, evaluating the consequences of the COVID-19 pandemic on food security is challenging since the effects are not yet clear [30]. Furthermore, obtaining up-to-date figures on the pandemic’s impact, such as the total number of people suffering from hunger, was difficult, particularly during the first year, because the pandemic complicated data collection, either because regions are inaccessible, information is incomplete, or data collection in person is suspended and must be replaced by data collection online or on-site training [31]. Consequently, there is a need for a complete assessment of COVID-19’s first impact on global food security, documenting the type and intensity of the disruptions caused by the pandemic on food security dimensions. Accordingly, the purpose of this paper is to shed light on the effect of the pandemic on the four dimensions of food security (availability, access, use, and stability), with a particular emphasis on low and middle-income countries (LMICs), where the majority of the poor and food-insecure households currently reside. Such knowledge is vital for identifying variables that exacerbate or reduce the effect of the COVID-19 pandemic (e.g., location, food environment features, vulnerable people) and for targeting suitable early actions. Documenting and communicating

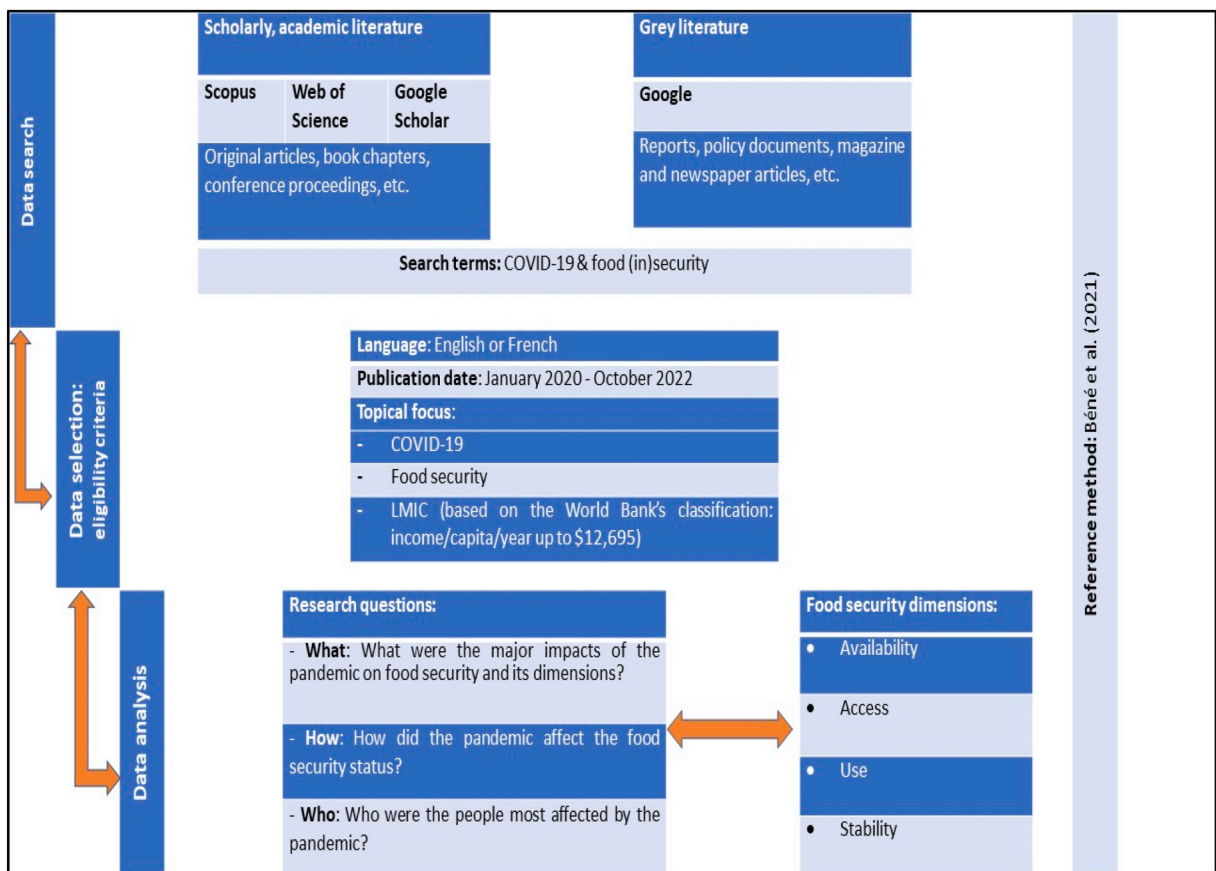


Fig. 2. Data search, selection and analysis.

Source: Authors’ elaboration

these lessons and growing data will be critical to adopt the most appropriate and sustainable pandemic strategies [32].

## 2. Methods

The methodology used in this review was informed by the methodological approach suggested by Béné et al. [33] in their assessment of the global impacts of COVID-19 on food security. Their research was based on 337 documents published between January and December 2020 in four different languages (English, French, Spanish, and Portuguese). It examined 62 nations from Africa, Asia, Europe, Oceania, and the Americas and analyzed the effect of COVID-19 on the different stakeholders in food systems. However, most of the 337 documents examined were published during the pandemic's early stages, when it was difficult for researchers to work in the field and gather direct source data. Consequently, most data presented in such sources are anecdotal or based on experiential knowledge.

As a result, this research employs a broader approach. It examines the research published between January 2020 and October 2022 from diverse sources to assess the pandemic's effect on LMICs. The research combines an academic literature review with a review of the grey literature (e.g., reports, and policy documents). It comprises the most recent studies on food insecurity and nutrition after the spread of the COVID-19 disease, which were found by searching academic journals and scholarly databases such as Scopus, Web of Science, and Google (Fig. 2).

The search was carried out by using different combinations of keywords that were specifically chosen to achieve the study objectives and refer to both COVID-19 (cf. "COVID-19", Coronavirus, "SARS-CoV-2") and food (in)security (cf. "food security", "food insecurity", hunger, malnutrition, undernourishment, wasting, stunting, "food availability", "food production", "food supply", "food access", "food environment", "food use", "food utilization", "food resilience", "food stability"). In order to be considered eligible and included in the review, a document must deal with both COVID-19 and food security and refer to at least one LMIC clearly. For the list of LMICs, reference was made to the classification of the World Bank. This group includes low-income economies (income per capita of \$1045 or less), lower-middle-income economies (income per capita from \$1046 to \$4095), and upper-middle-income economies (income per capita from \$4096 to \$12,695) [34].

The grey literature consists of studies, policy documents/briefs, and working/discussion papers published by several organizations, including international organizations [e.g., FAO, World Bank, International Food Policy Research Institute (IFPRI), United Nations Development Program (UNDP), and Organization for Economic Cooperation and Development (OECD)], regional organizations [e.g., United Nations Economic and Social Commission for West Asia - ESCWA, The African Union (AU), etc.], NGOs [e.g., Oxfam, etc.], and consulting firms [e.g., Deloitte, KPMG, McKinsey, Oxford Business Group, etc.].

In line with the definition of food security, the analytical approach used in this study considers all its four dimensions: availability, access, use, and stability [4,5]. It addresses at the same time the what, how, and who relating to the impacts of the COVID-19 pandemic on food security in LMICs:

- What: What were the major impacts of the pandemic on food security and its dimensions? Which dimension of food security has been the most impacted by the pandemic?
- How: How did the pandemic affect the food security status of the populations in LMICs? And how did the impact pathways look like across regions and countries?
- Who: Who are the people and socio-economic groups most affected by the pandemic?"

Firstly, the paper investigates the impacts of the COVID-19 pandemic on food availability (sub-section 3.1), including mobility constraints, labor shortages, logistical blocks, export restrictions, and panic buying. Then it explores the pandemic's influence on food accessibility (sub-section 3.2), especially in the context of diminished buying power, income loss, and limited affordability. The following sub-section (3.3) examines how the COVID-19 pandemic altered food utilization, resulting in an increase in all types of malnutrition, including overeating and undernutrition. The last sub-section (3.4) briefly examines the consequences of the pandemic on food stability, demonstrating the inadequacy of current food systems in terms of sustainability and resilience to crises.

## 3. COVID-19 impacts on food availability

At the availability level, the major impacts of COVID-19 were movement restrictions, labor shortages, logistics blockages, export restrictions, and panic buying, especially at the start of the pandemic. However, with ample supplies of most commodities following a strong harvest in 2019, global food markets have remained robust during 2020 [35,36]. Further, the production of essential staples, such as cereals, is not likely to suffer interruptions from the COVID-19 crisis since much of it is mechanized, and there is a low prospect of disorders to international transport [37]. Nevertheless, despite these favorable initial conditions, COVID-19 affected the supply side via other channels [36,38].

Firstly, the food supply was affected by movement restrictions, labor shortages, and logistics blockages within countries and at borders, specifically during the first month of the pandemic [38]. These disruptions affected supplies of labor-intensive crops such as perishable foods (e.g., fresh milk, fruits, and vegetables) [39,40]. For example, in Liberia, the closure of borders reduced the workforce available during the harvest season of cocoa beans, as some planters were stuck in neighboring countries [41]. With border closure, the flow of international trade was affected, as well. In Afghanistan, In March 2020, consumers suffered from food shortages when Pakistan, a significant source of imports and exports, shut down its supply routes to stop the spread of COVID-19. Although the borders reopened in July 2020, the first closure caused significant disruption. By the end of 2021, acute malnutrition will affect almost half of

the children below five years old [42]. Further, food was wasted in the production phase because farmers could not go to marketplaces, buy inputs, and sell their products [43]. For instance, in Jordan, the severe measures prevented farmers from reaching their fields, causing delays in everyday activities and disrupting the harvest season. In Tunisia, local markets experienced a lack of locally grown fruits due to mobility restrictions and the difficulty of agricultural workers accessing fields [44]. In northwest India, the scarcity of migrant workers prevented wheat and pulse harvest [45]. In Bangladesh, farmers often hire seasonal workers from different parts of the nation and work just briefly to harvest their crops. However, because of the government's movement restrictions, there was a shortage of seasonal workers [46] (Box 1).

In fact, in several countries, the lack of adequate storage facilities, transport interruptions, and a drop in demand have led to a waste of perishable goods (milk and vegetables). Labor shortages have also affected crop harvesting [48]. Further, physical distancing measures and health checks at the borders have caused delays for containers, thus leading to the wastage of perishable products and increased food waste [43]. Due to the lockdown measures in Zimbabwe, a lack of customers and a shrinking market for commodities have resulted in millions of dollars worth of perishable crops rotting in the fields [41]. In Nigeria, Inegbedion [49] demonstrates that the COVID-19 lockdown has greatly hampered agricultural labor, transportation, and security. In Iraq, vegetable farmers cannot sell their products in local markets because of the curfew, resulting in spoiled produce and lost income [50].

Secondly, another issue that affects food supplies is export restrictions, especially for critical staples, such as cereals, raising concerns among importers, especially in developing countries with limited purchasing power [51]. In March 2020, the third global rice exporter, Viet Nam, temporarily put a temporary hold on new rice-export contracts. In April, it ended these restrictions and replaced them with export quota, and in May, all export restrictions were fully resumed [52]. Such restrictions can cause panic buying at the country level, leading to price increases and food supply chain disruptions. Thai broken rice prices, a worldwide market benchmark, jumped by more than 20% two weeks after implementing the Vietnamese rice export restrictions [52]. During the global food crisis of 2007–2008, export limitations substantially impacted commodity price increases, hurting food-importing countries [52,53].

Thirdly, panic buying was a further factor affecting food availability, which was used to mitigate future shortage risk, particularly at the start of the outbreak [54]. Cases of panic buying were recorded in numerous African and Asian countries, especially for non-perishable foods (e.g., rice, flour, canned foods, pasta), just after confirming the first coronavirus cases [55]. For example, panic buying swept the country's supermarkets and grocery stores immediately after the Indonesian authorities declared the first two confirmed cases of COVID-19 on March 2 [56]. More recently, in April 2022, suspicions that Beijing would soon be locked down led to considerable panic buying, resulting in food shortages in certain stores [57]. According to Ben Hassen et al. [58] after the outbreak of COVID-19 in Lebanon, 73.13% of respondents said they had stockpiled food. When COVID-19 erupted in Morocco, 52.65% of participants had stockpiled food as a backup plan. Indeed, Moroccans flocked to stores just before the lockdown in March 2020, driving increased demand for grains like wheat. Concerned about the Coronavirus, Moroccans began stockpiling large amounts. Consequently, food prices have risen [59]. Indeed, panic buying increased the prices of food, causing food wastage and stock out [60], leading to overconsumption (obesity) and unequal food access [61,62]. It reduced food access for some vulnerable groups (e.g., women, the poor, elderly) [63]. In South Africa, the panic buying situation has been abused by merchants, who have raised food prices unfairly in response [55]. In Brazil, during the quarantine period in the first weeks of March, the prices of tomatoes and onions, widely used in local cuisine, increased. As a result of the restrictions, people started to cook more regularly at home, raising demand for food items while simultaneously lowering demand for perishable fruits like guava and avocado, resulting in waste and losses for producers [64]. Further, due to a lack of storage space, inadequate cooking skills, or overcooking, household food waste rose due to panic buying [65, 66].

#### 4. COVID-19 impacts on food accessibility

Because of the current economic crisis and the consequent increase in food costs in local currencies, inflation and income loss have major impacts on buying power. First, the foremost immediate danger to food security is the economic crisis brought on by the COVID-19 pandemic [67]. The pandemic caused a worldwide global recession in 2020, exacerbating unemployment and poverty [68]. With a

##### Box 1

Examples of the impact of COVID-19 on agriculture and food production in Bangladesh

- Various measures, such as movement limitations, social distancing, and the closure of restaurants and hotels, reduced agricultural and food production operations. Worker shortages further exacerbated production and supply issues.
- The pandemic hampered the harvest of staple crops such as rice, potatoes, onion, and maize, owing to a lack of employees to assist during harvesting. For example, Mymensingh city had a significant decrease in fruit supplies, particularly lemons, which could not be delivered from the south of the country.
- The drop in egg and chicken consumption impacted the poultry industry.
- Agricultural inputs, such as pesticides, seeds, fertilizers, and farming services, were scarce, except for a few suppliers who stayed open until the government decided to allow all agricultural supply businesses to remain open at particular hours to assist farmers.

Source [47]:

decline of 4.9%, the International Monetary Fund [68] estimates the most significant recession since World War II in 2020. More than 140 million people globally might be living in severe poverty by 2020, representing a 20% increase over the current year. The majority of these individuals live in Sub-Saharan Africa and South Asia. Sumner et al. [69] estimate that 420–580 million people will be impoverished due to the pandemic's economic impact. Evidence from several countries highlights widespread income losses in both urban and rural populations, such as Nigeria [70], Uganda, Ethiopia, Nigeria and Malawi [71], Kenya, and Uganda [72], Bangladesh [46,73] and Nepal [74]. Food accessibility was severely disturbed by the recession, and food insecurity was further exacerbated by the economic downturn [45,75]. Additionally, Laborde et al. [67] also point out that the economic downturn in China, Europe, and the United States affects low- and middle-income nations by reducing remittances, commerce, and demand for commodities, as well as restricting international travel and freight.

Secondly, the COVID-19 pandemic had significant unemployment impacts, especially in the informal sectors, generally characterized by a lack of social protection coverage and low and unstable revenues [76]. As COVID-19 spreads across regions with large informal economies, especially low- and middle-income countries, more informal workers lose their jobs, thus increasing extreme poverty and food insecurity [77]. Job losses and income cuts triggered by the COVID-19 crisis harmed household food security [74]. In Bangladesh, a survey has shown that 93% of participants had suffered a loss of income, and 54% reported no earnings in March. The study expected a 60% rise in extreme poverty, eventually increasing food insecurity [78]. Over the last few years, Bangladesh has made remarkable progress in food security, but the pandemic will offset progress [73]. Over two-thirds of the population works in the informal sector in major African cities like Lagos, Kinshasa, and Nairobi, leaving millions of employees unable to buy food for themselves and their families after losing their employment due to the pandemic [79]. In Nepal, inadequate food consumption and food insufficiency were more prevalent in households that reported job loss and income reduction than in households that did not [74]. In Indonesia, the pandemic harmed household food security in urban and semi-urban regions by decreasing job and income status, with 62.7% of the respondents having a reduced income [80]. In addition, 66.9% of Vietnamese respondents said that their household income has decreased due to COVID-19 [81]. In Afghanistan, the pandemic affected food accessibility significantly (Box 2).

Secondly, lower food prices on global markets during 2020 reduced global food security fears compared to the 2007–2008 crisis. However, they cannot stop local disturbances in food supply chains, nor will prices rise in local currencies, given the significant depreciation of some currencies against the US dollar [20]. Exchange rate fluctuations affected the quantity and price of domestic food [86]. Food price inflation due to the economic consequences of the COVID-19 pandemic and the measures put in place to mitigate it is visible and has serious ramifications. By the end of 2020, food prices for consumers worldwide were at an all-time high, surpassing those of any month in the preceding six years. This immediately impacted the global average cost of a healthy diet in 2020 across all regions and sub-regions [87].

Soaring food prices are causing a global crisis, driving several million more people into extreme poverty and worsening hunger and malnutrition. A new World Bank report highlights the major setback of the COVID-19 pandemic on global poverty reduction. In addition, food and energy price increases caused by climatic shocks and conflicts have stalled the recovery [24]. Indeed, the COVID-19 pandemic was the most devastating blow to global poverty in decades, likely the most significant setback since World War II. The pandemic elevated the global severe poverty rate from 8.4% in 2019 to 9.3% in 2020. This means that more than 70 million people were forced into extreme poverty by the end of 2020, bringing the global total to more than 700 million [24]. In 2020, when the COVID-19 pandemic broke out, a 30-year effort to reduce poverty was stalled. Since 1990, the percentage of the world's population living in poverty has decreased from more than one in three persons (38% of the population) to less than one-tenth (8.4% of the population) [24].

As a result, the number of individuals who could not afford a nutritious diet climbed internationally and in every region worldwide in 2020. Over 3.1 billion people could not afford a nutritious diet in 2020. This is 112 million more than in 2019. Indeed, The economic implications of the COVID-19 pandemic and the efforts taken to manage it have caused inflation in consumer food prices, which has raised the cost and made a healthy diet unaffordable in many parts of the globe. Asia had the largest increase, with 78 million more

## Box 2

### Impact of the COVID-19 pandemic on food accessibility in Afghanistan

- In Afghanistan, the ability to control the virus has been impeded by a lack of government capability and insufficient public health resources, with just 0.9% of the population completely vaccinated.
- Food shortages are made worse by COVID-19 because of government restrictions and lockdown measures that have reduced economic activity and the number of available jobs.
- The United Nations [82] estimated that 12 million Afghans were severely food insecure and without reliable means of support in that year. Two of the worst pandemic results are a drop of 1.9% in GDP and an increase in poverty from 41.6% to 45.5%.
- These higher levels correlate to a significant increase in food insecurity due to price increases by suppliers in reaction to trade restrictions. During the pandemic, households have experienced a loss of income (36%), a loss of employment opportunities (18%), a severe illness or death of a breadwinner due to COVID-19 (12%), an increase in food prices (11%), and a severe illness or death of a breadwinner unrelated to COVID-19 (8%).
- Since August 2021, the country has been threatened by economic collapse and a rise in poverty. The price of necessities has more than doubled during the Taliban's military assault and is anticipated to climb further with inflation.

Source: [42,83–85].

people unable to afford this diet in 2020, followed by Africa with 25 million more people, then Latin America and the Caribbean with 8 million, and North America and Europe with 1 million [87]. As Dasgupta and Robinson [88] pointed out, increasing food prices have increased food insecurity across countries, mainly among poorer families and those who have lost income. Moreover, illness-related labor shortages, quarantine measures limiting market access, and logistics interruptions artificially increased food prices despite current availability because of the supply chain's pressure [40]. In India, during April 2020, average prices of rice, wheat flour, pulses, lentils, grams (i.e., chickpeas), and sugar have risen by 5%–10% [89]. In Kenya, Low- and middle-income householders rely heavily on local markets for fresh food and affordable pricing, which play an essential role in the informal sector. Therefore, due to market closures, food availability has been hampered [90].

Furthermore, global hunger grew in 2021 despite hopes that the world would recover from the COVID-19 epidemic and food security would improve. This rise reflects widened inequalities within and between nations as a result of the COVID-19 outbreak's disproportionate impact on some people, the uneven pace of economic recovery, the short-term nature of social protection measures, and the failure to fully compensate those who have lost income as a result of the outbreak [87]. From 2020 to 2021, the number of people suffering from hunger climbed by 46 million and 150 million since 2019, before the COVID-19 pandemic. Some areas are more affected than others, with Africa bearing the most burden. Indeed, in 2021, hunger affected 278 million Africans, 425 million Asians, and 56.5 million Latin Americans and Caribbeans, accounting for 20.2, 9.1, and 8.6% of the population, respectively. While Asia has most of the world's undernourished people, Africa has the highest prevalence [87]. For instance, with the pandemic, Brazil returned to the Hunger Map (Box 3).

Furthermore, in several nations, the closing of schools has decreased food availability for children. Additionally, schools provide food and other services that many families depend on. During the pandemic, such services were cut, causing a decrease in household food security. Almost 9 million students in Nigeria were left without regular school meals in March 2020 when all schools were abruptly shut down nationwide [70]. In India, many states have closed Anganwadi rural daycare centers, thus interrupting the provision of food for children under 6, pregnant women, and nursing mothers [93]. In addition, the pandemic has resulted in significant losses to India's school feeding program, which might erase years of progress in the battle against child malnutrition and hunger. Before the outbreak, India had the largest percentage of undernourished children globally and the most ambitious free school feeding program, the Mid-Day Meal (MDM) initiative [94]. Around 116 million children, and over 87% of children in rural government schools are covered. It offered healthy nutrition to millions of Indian children while simultaneously boosting school enrollment and attendance, especially for girls and children from disadvantaged backgrounds [95]. However, in the past two years, the pandemic and subsequent economic crisis have caused thousands of children, especially those from low-income households, to drop out of school [96]. After a long absence, many schools find restarting the program in April 2022 challenging. Economists and civil society activists claim that schools in urban areas have failed to sign contracts with centralized kitchens that cater to student meals. In contrast, schools in rural areas have experienced delays in delivering raw materials like grains and lentils, which are needed to make the meals [97].

## 5. COVID-19 impacts on food utilization

At the utilization level, COVID-19 harms the nutritional state of both individuals and countries. Hence, there was a rise in all types of malnutrition, such as overeating and undereating [98]. With panic buying, consumers substituted across food categories,

### Box 3

#### Brazil's return to the Hunger Map

- The Hunger Map is a United Nations assessment of global food insecurity. If a country has 5% or more of its people undernourished, it is included in the list and so receives feedback on the activities taking place in its territory.
- In 2014, Brazil got off the Hunger Map after implementing several public policies within the MDGs framework.
- The country has managed to reduce the number of food insecure individuals, placing it among the top ten countries in terms of lowering the overall number of people suffering from hunger compared to the national population.
- Compared to the level observed in 2004, when hunger reached 9.5% of the Brazilian population, in 2020 alone, around 19 million Brazilians had nothing to eat. This number has worsened due to the COVID-19 pandemic, reaching 9% and, unfortunately, it is increasing.
- The pandemic caused many difficulties in the lives of Brazilians, who saw access to sufficient nutritious food decrease due to high inflation, rising unemployment, and the impossibility of accessing emergency aid because many requests were denied.
- Another factor in the aggravation of food insecurity during the pandemic is schools closing. School meals are no longer provided to students. In many cases, the meal provided was the only nutritious meal children and adolescents received daily. Brazil has the world's second-largest school meals program – the National School Feeding Program ('PANE'), covering approximately 40 million children and teenagers.
- It should be noted that the PNAE is linked to family farming. But with the budget cuts that caused the substantial reduction of the budget devoted to the Food Acquisition Program (PAN), these transfers have ceased to leave the family production, causing, on the one hand, another circumstance, which causes food insecurity for those who depend on school canteens and, on the other hand, the inability to sell these products.

Sources [91,92]:

discouraging them from eating the recommended portions of vegetables and fruits [99,100]. The physical, social, and economic consequences of COVID-19 worsened the nutritional situation of the most vulnerable segments of society [101]. FAO [86] highlighted an income reduction could not automatically result in a reduced calorie intake but a decline in diet quality. Reduced food budgets have forced some consumers to switch from more costly and nutritious items (such as meat, fruits, and vegetables) to less expensive ones (such as rice, roots, and tubers), harming the nutritional value of meals. It has been confirmed by recent findings from Ethiopia, where many families eat less often pricey but healthy items such as meats, fruits, and dairy products [102]. This change minimized the decline in caloric intake but increased micronutrient deficits, raising the likelihood of adverse health effects. According to Kansime et al. [72], the COVID-19 crisis caused income shocks for two-thirds of respondents in Kenya and Uganda. Meanwhile, food-insecure people grew by 38% and 44%, respectively, while regular fruit consumption declined by 30% during the COVID-19 epidemic.

Different studies suggest that the COVID-19 pandemic changed people's eating habits, although this evidence is conflicting. Consumers in North Macedonia purchased more vegetables and fruits during the COVID-19 pandemic and urged for a transition to better diets, according to Bogevska et al. [103]. However, Ben Hassen et al. [104] claim that Palestinians sought to eat healthily throughout the epidemic yet ate more between meals (e.g., snacks). Even though COVID-19 had a detrimental impact on food security, it also created a "window of opportunity" for people to switch to healthier diets.

Furthermore, the significant lifestyle shifts triggered by the crisis and the related measures contributed to negative emotions. In China, several psychological impacts, such as stress and depression, have been identified by Wang et al. [105]. These harmful emotions contribute to excessive food and emotional consumption [106]. However, COVID-19 had some positive effects. As observed in several countries such as Tunisia [66] and Palestine [104], throughout the pandemic, households adopted various good food management strategies during the pandemic, including greater pre-shop preparations (e.g., making a list), better in-home food storage and novel cooking/preparation methods (e.g., batch cooking and using up leftovers). As a result of the pandemic, food purchases became more efficient, and food waste decreased [66]. However, the pandemic's socio-economic deterioration (i.e., food supply, reduced mobility, and loss of income) prompted these adjustments rather than environmental concerns.

## 6. COVID-19 impacts on food stability

At the stability level, the outbreak affected food systems' functioning and highlighted their unsustainability and lack of resilience to crises. Moreover, the pandemic highlighted the importance of local and short food supply chains [107]. While global food markets are well provided [20], protective policies (e.g., export restrictions) could generate food shortages and raise uncertainty in global food markets [76]. Because the COVID-19 pandemic is new and continually evolving, and because the pathways of effect are numerous and interwoven internationally, the exact repercussions for food stability in the future are uncertain. Furthermore, even though it has been almost three years since the discovery of the Coronavirus, the pandemic is far from done, and several nations are still facing major outbreaks. Those who managed to control the virus are worried about future outbreaks, especially if new, more infectious strains like Delta, Omicron, etc. emerge. Economic activity and food security may be severely disrupted because of the potential for more outbreaks and subsequent quarantines [108]. Omicron's emergence in November 2021 has sparked panic and jolted financial markets worldwide, and recent border bans in numerous nations have delayed economic recovery from the two-year pandemic [25]. Indeed, workers worldwide are infected with the Omicron variant in the food production, processing, distribution, and retail industries [109]. In Australia, supermarkets run out of groceries like they did in 2020. However, this time it is different. Local supermarkets had difficulty supplying their shelves with fresh produce because many key workforce members were isolated. Also, shoppers bought more than they needed [26].

## 7. Conclusion

The pandemic hit when food security and nutrition were already threatened, especially in low- and middle-income nations, due to various causes, including war, natural catastrophes, drought, climate change, and desert locusts. COVID-19 has uncovered weaknesses that have been increasing in some countries before the pandemic. The COVID-19 pandemic has revealed the susceptibility of the present food system to external factors, reinforcing the importance of global food security [110].

With the pandemic, food security has been affected by a mix of factors, including a reduced food supply (due to labor shortages, a lack of supplies, and food loss), barriers to accessing food (due to physical limitations, supply disruption, and rising prices), and a loss of dietary quality and diversity. These repercussions have also impacted the most vulnerable social groups, such as informal laborers and minorities, and the health crisis has swiftly become a socio-economic issue. The pandemic is already continuing, so food security is still unstable, and the seriousness of the consequences would depend on the efficiency of policymakers in alleviating the disease and the trajectory of the pandemic. Furthermore, COVID-19's impacts on food systems and diets materialized with varying degrees of severity, duration, and shape. The following factors caused these discrepancies between and within nations: 1) the timing, duration, and stringency of national COVID-19 restriction policies in order to minimize their adverse effects; 2) context-specific food value chain reactions to domestic and international containment measures; and 3) distinct impacts of restriction measures on different groups based on gender, age, socio-economic status, and work conditions [32].

The final COVID-19 findings differ from country to country due to these and other factors, not just because of the epidemiological conditions but also because of the pre-pandemic situation and resilience to shocks. COVID-19's long-term implications will be dictated by the pandemic's duration and the effectiveness of recovery measures. Certain LMICs are more susceptible than others regarding economic and food security. The pandemic's effect on long-term food security must be reduced by including agricultural and food systems in recovery measures. Furthermore, while economies are gradually recovering, uncertainties and disruptions persist, and



deteriorating fiscal capacity, the food and nutrition security prognosis in several LMICs remain severe [19].

Furthermore, the impacts of the current war in Ukraine on food systems and supply chains worldwide (cf. increase in food prices) suggest that the transition towards more sustainable and resilient food systems that ensure food and nutrition security in the face of crises is timely, urgent, and highly needed. Indeed, the conflict is causing broad concern about global food security in the context of globalized agricultural markets and as a confrontation between two important players in the global food and fertilizer sectors [111, 112]. Due to the war, Russia and Ukraine's food export delays expose global food markets to increased risks of tighter supply, unmet import demand, and higher international food prices [113,114]. The conflict in Ukraine puts global food security at risk since food prices are predicted to remain high for the foreseeable future, pushing millions of new people into severe food insecurity [19]. In that context, this conflict challenged many countries, particularly low-income food import-reliant countries and vulnerable populations [115,116]. The COVID-19 pandemic is both a warning about the operation of agri-food systems and a booster for innovation [117]. Food systems are confronting several issues, and successfully resolving them requires the development of research that straddles disciplines and innovates at their intersections to provide various solutions that address the social, economic, technological, and regulatory components of these challenges [118]. Nonetheless, current and future studies will provide the groundwork for organizational and governmental preparedness for future shocks, crises, and pandemics. Indeed, the global reaction to the pandemic may be employed to prepare for future shocks and contribute to food system reform [18]. Food systems may be made more accessible, efficient, sustainable, and healthful by using the lessons learned from the pandemic and the innovations it spawned (such as e-commerce, worker benefits, and automation) [21,117].

To rebuild better, many developing countries must concentrate on resource sustainability, inclusive communities, and sustainable economies [44]. To reach their SDG commitments by 2030, countries and communities need resilience to natural (flood, drought, climate change), man-made (war, social unrest, trade restrictions), market-based (volatility, increasing prices), or health-related (e.g., COVID-19) food security shocks [44,119].

By bolstering food system resilience, enhancing agricultural resource efficiency, and guaranteeing social equality, innovations and modern technology may contribute to long-term food security [120]. Finally, the success of food system transformation requires a broader outlook that involves producers of various sizes who face a varied set of constraints that may vary by economic and social factors such as gender and ethnicity, as well as the importance of the food system as a source of livelihood for the majority of the world's poor [121].

This study main limitation is that research on the effects of the COVID-19 pandemic is still in its early stages. This has two implications. First, the present study focuses on the pandemic's immediate and medium-term consequences. Second, although covering grey literature, the review does not include all relevant material. As a result, systematic reviews of the COVID-19 pandemic's medium- to long-term effects on food security and food-related activities in LMICs are highly required.

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## Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article.

## CRedit authorship contribution statement

**Tarek Ben Hassen:** Conceptualization, Formal analysis, Funding acquisition, Supervision, Writing – original draft, Writing – review & editing. **Hamid El Bilali:** Conceptualization, Formal analysis, Methodology, Software, Validation, 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.

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