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Effect of COVID-19 on food security, hunger, and food crisis

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1. Introduction

COVID-19 outbreak has brought hunger to millions of people around the world.¹ Various strategies such as physical distance, school closures, trade restrictions, and countries' lockdown to control the pandemic have increased the nutritional challenges around the world, especially in low- and middle-income countries (LMICs) with the highest populations.^{2,3} These restrictions have likely disrupted agricultural production and concerned millions of people about access to adequate food. Various experts in this field believe that this hunger crisis is global. The sudden loss of productivity and income, falling oil prices, low tourism revenue, problems such as climate change, and other factors are all related to the outbreak of COVID-19.¹ A recent FAO report (2019) found that 820 million people have been suffering from starvation worldwide. The Global Report on Food Crisis (FSIN, 2020) also showed that approximately 135 million people in 55 countries are affected by acute food insecurity, of which 73 million are in 36 countries in Africa.⁴ The United Nations reported that COVID-19 is likely to increase poverty and food insecurity on a global scale. Therefore achieving the goals of sustainable development is considered a top priority. Other international organizations such as the Food and Agriculture Organization of the United Nations (FAO) and the International Food Policy Research Institute (IFPRI) have also supported this concept.⁵ People's health and nutrition in food crises are at greater risk due to their inability to access healthcare and their inability to reimburse their expenses.⁴



2. Food insecurity

Food insecurity is one of the factors contributing to the increase in food poverty and malnutrition in middle and low standard of living communities, which during epidemics such as COVID-19 can affect the nutritional conditions of a large population of the world.

Food insecurity is defined as the persistent concern about access to sufficient and affordable food at all times.¹ Food insecurity causes stress in people. One of the most important reasons for people's stress is where and how to get enough food due to unemployment and low income during the COVID-19 epidemic.⁶ Poverty, low-income family health, poor livelihoods and household management strategies can lead to food insecurity. The severity and classification of food insecurity depend on family members' perceptions of food and food budgets. Consequences and threats of food insecurity hurt mental, social, and psychological-emotional status. Food insecurity can be mild, moderate, or severe. The classification depends on the severity of the uncertainty, anxiety about access to food, unbalanced diet, and changes in diet quality (Fig. 1).⁵

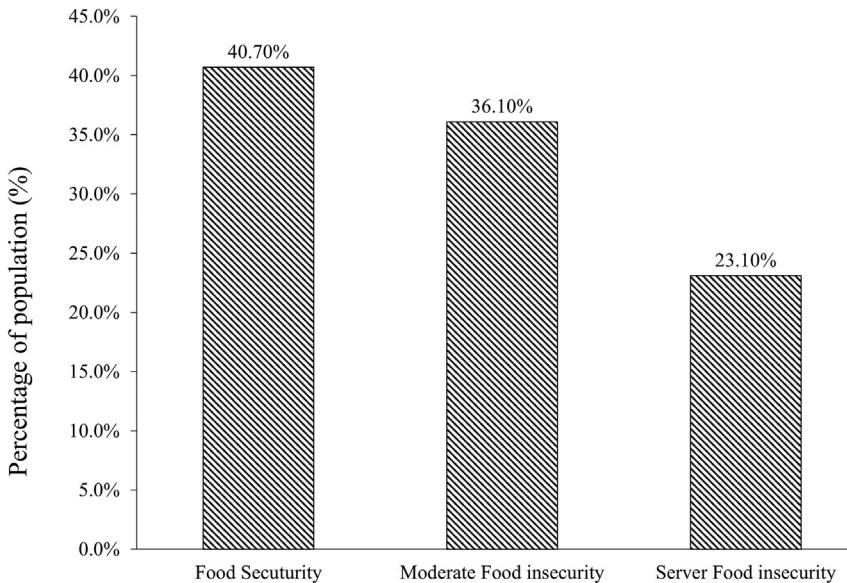


Fig. 1 Food insecurity among the population in Jordan during the quarantine.⁵

The FAO defines food security as “the right of all persons to have adequate physical, economical and safe access to meet their nutritional needs at all times, as well as to choose their food preferences for an active and healthy life.” Food is specifically mentioned, as a part of the right to a standard of living (adequacy of food to protect the health of the individual and family), in Article 25 of the Universal Declaration of Human Rights.^{7–9} The right to food has been discussed in several international conferences since 1948. In the Rome Declaration on Global Food Security (1996), all countries except Australia and the United States agreed that food is a fundamental human right.^{9,10}

Some important factors of food insecurity can include conflict, poverty, climate change, economic downturn, and ecosystem disruption. Therefore the ability of a country to create food security depends on the available resources, policies, cultural and natural capacity of the country, and the extent of practical use of these resources.¹¹ According to the United Nations, food insecurity has now increased from 23.3% in 2014 to 26.4% in 2018. Before COVID-19 in September 2019, about 821 million people (more than 10% of the world’s population) suffered from hunger.¹² The report on the use of the Food Bank in the UK shows that about three million people received food packages between 2018 and 2019, compared to approximately 41,000 in 2009 and 2010.¹³ However, at the height of the COVID-19 crisis, there was a further gap in food demand and rising food prices.¹⁴

In the United States, household food insecurity increased from 11% in 2018 to 38% in March 2020. In April 2020, 35% of households with children aged 18 years old and under were food insecure. Households with food insecurity may be less likely to follow social distancing recommendations during the COVID-19 epidemic for access to food resources. Because these people have less flexibility in their jobs, they are inevitably at greater risk due to reduced incomes and, consequently, reduced access to food.¹⁵ The Food and Agriculture Organization of the United Nations (FAO) believes that food insecurity can be investigated in four dimensions: availability, access, quality, and stability. Despite the few instances of food access disruption and instability due to transportation disruption or temporary hoarding, the main effects of COVID-19 on people’s food security are related to physical access.^{16–19} The FAO reports that the COVID-19 outbreak has affected agriculture and food security in two important ways: food supply and demand. For this reason, food security is exposed to serious risks during the COVID-19 crisis.²⁰



3. COVID-19 and food access

The food chain is a network that connects the agricultural system to the consumer fork. This food chain includes the processes of production, packaging, distribution, and storage of food. At the beginning of the COVID-19 pandemic, social quarantine by governments caused people to flock to food products sales centers, leading to shortages of some food products in many countries.²⁰ Behavioral patterns of people with food insecurity can change through the food supply.^{21,22} Weak monitoring systems, job losses, and limited transportation systems are key factors that hinder the national food supply and demand.²³ Demand is related to the ability of consumers to buy certain goods or services in any given period. Purchasing power and income also have a large impact on demand (Fig. 2).²⁰

As a result, food prices (for example, wheat and rice) have risen and continue to rise. Hence, global food security warnings have been issued due to food shortages, rising food prices, or loss of income due to the high rate of unemployment.¹ The COVID-19 pandemic has boosted demand for online food delivery. For example, during COVID-19, a 20 to 30% increase in restaurant food delivery was observed online in Taiwan.³ In China, online food demand was increased during COVID-19 due to quarantine conditions but did not lead to food shortages.²⁰ COVID-19 directly and strongly affects food access. These effects are felt through a disruption of food access, shifts in consumer demand for cheaper foods with low nutritional value, and instability in food prices.²⁴ Access to food during COVID-19 is very poor in many countries. In the United States, of the approximately 520 food retailers, about 88% of them present no fresh and unprocessed food. Only 12% provide enough fresh food to support a healthy diet.²⁵

COVID-19 primarily threatens access to food through the loss of income to buy food. The poorest households spend about 70% of their income on food and have limited access to financial markets; therefore, their food security is particularly vulnerable to income shocks. The International Monetary Fund (IMF) has forecasted a 5% decline in the world economy during 2020.²⁶ This report shows that the global recession is much deeper than the global financial crisis of 2008–09. These economic consequences will reduce trade, sales of oil and other commodities, international travel, and transportation restrictions in the early countries of the epidemic (China, Europe, and the United States) and low- and middle-income countries. In developing countries, the economic costs include COVID-19

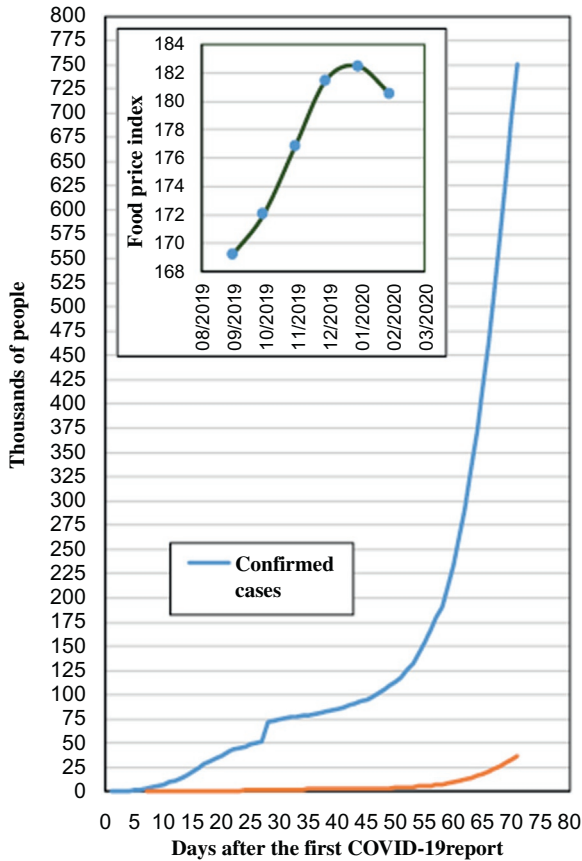


Fig. 2 Globally confirmed cases, deaths, and Food Price Index by the effect of COVID-19.²⁰

restrictions²⁴ in addition to the earlier aspects. Due to the lack of up-to-date surveys in most countries, it is impossible to estimate COVID-19 effects on global poverty and food insecurity accurately. However, the evaluation of simulation models shows that 90 to 150 million people can fall into extreme poverty due to COVID-19.²⁴ Although such estimates are very vague due to the rapid onset of the disease, these projections estimate a significant increase in global poverty between 15 and 24%. The highest increase in poverty is in sub-Saharan Africa and South Asia.²⁴ Poor people do not have enough financial resources to buy food for the prevention of hunger and malnutrition.

For this reason, they tend to buy cheaper and less nutritious foods to meet their needs. Even if the recession is short time, the effects of malnutrition can

be long, especially in young children.²⁴ Of the four dimensions of food security, food availability is probably the most important.²⁷



4. COVID-19 and food hygiene

The food supply chain is a complex global network that includes producers, consumers, agricultural and fishery products, processing and storage, transportation and marketing, etc.²⁸ The more the world as a village connects, the more likely it is that all countries will be exposed to this disease crisis. Therefore not preventing the spread of the disease in one country means that the world is at risk. The consequences of an epidemic disease negatively affect health and lead to unpleasant economic, social, and political crises.²⁹ A recent report by the United Nations Sustainable Development Goals (UNSDGs, 2019) found that about 55% of the world's population, especially in developing countries, lacks social protection. This vulnerability exacerbates socioeconomic harms that, in addition to weakening the diet and promoting malnutrition of the poor people, spread to the human rights and education sectors.²⁹

However, the outbreak of COVID-19 has raised public health concerns, economic and food crises. During the quarantine, the food sector was severely affected, with the greatest impact on vulnerable groups. The agricultural and aquaculture economy in the last quarter of 2020 showed a significant decline that affected millions of people worldwide. This could be because of health concerns about the transmission of the virus through food.¹² Since the effects of this epidemic began in the food market, it is anticipated that food processing and production policies could be revised. Unless new methods of cooperation and action are adopted between government, industry, and individuals, the world will be even less prepared for the next epidemic in the future.¹²

Since the COVID-19 pandemic, the demand for higher nutritional value foods has increased compared to low-value and processed ones. Also, due to the widespread restrictions on food choices, such as the closure of restaurants, families have more opportunities to prepare and consume more healthy and nutritious home-cooked foods. Public and private organizations also present the necessary advice and training through social media to promote healthy behaviors about healthy food according to the limitations of the disease.³⁰ Recent research on COVID-19 has clearly shown that the virus remains active on plastics and stainless steel for up to 72h, compared to 24h on cardboard.³¹⁻³³

Therefore due to the rate and routes of transmission of this virus, it is necessary to provide special health measures for the food industry. Although health concerns are a top priority in the COVID-19 epidemic, livelihoods and food insecurity should not be ignored. The world is currently on the brink of worsening unemployment and food security crises. Policymakers need to keep in mind that the COVID-19 threat still exists worldwide. Therefore they must be careful not to repeat the mistakes that occurred in the food crisis of 2007–08.²⁸ Food factories should take steps to preserve food products and distribute goods properly following WHO recommendations. However, packaging may be a suitable place for virus transmission.³⁴



5. COVID-19 and food production

Globally, it has been estimated that drought and heat can reduce crop production by approximately 10% nationally. According to the Global Food Crisis Report (2020), severe weather events in 2019 have significantly affected food security in the Horn of Africa, South Africa, Central America, and Pakistan. However, the food security crisis still affects the ongoing economic crisis in Venezuela, Haiti, Sudan, and Zimbabwe.³⁵ The COVID-19 pandemic, in addition to the threat to health and the great damage it has done to countries' economies, has clarified other things. In addition to being a serious threat to health, the COVID-19 pandemic has also caused significant damage to countries' economies. The inadequacy of the global food production and distribution system has disrupted food supply in some parts of the world and wasted food in other parts. This is while world hunger is increasing with the COVID-19 crisis.³⁶

The impact of COVID-19 on the food and agriculture parts has revealed the vulnerabilities of the agri-food supply chain, although the extent of disruption varies widely across the world.³⁷ In many developing countries, including Mexico, Peru, India, Thailand, South Africa, Nigeria, Ghana, and Zimbabwe, an important part of the country's economy is associated with the informal preparation and distribution of food. At the micro-level, the economies of many families also depend on this sector, and the challenges facing informal food preparation directly impact the families' economies.³⁸ Although restricting the activities of informal food preparation and distribution centers can be effective in preventing the spread of COVID-19, on the other hand, it creates two major problems in the field of food security. First, the livelihoods of many families involved in food

preparation and distribution are at risk. Second, because the informal food centers provide cheaper foods, the food access of many families living in poorer areas, such as suburbs, villages, and low-income areas, decreases.³⁸

Food security crises often occur due to a sharp decline in food production.²⁶ The prolonged COVID-19 pandemic has delayed the transport of seeds and fertilizers and thus slowed down the global agricultural process. Livestock farmers in the United States and the United Kingdom were forced to discard their food products due to decreasing customer demand, including schools and restaurants.³⁶ In rich countries, major crops, especially corn, wheat, and soybeans, are highly mechanized.²⁶ The presence of COVID-19 up to the planting season could affect the production of major food crops such as wheat, rice, and vegetables, because it is unclear whether agricultural inputs can be distributed promptly. If the production of staple foods is affected, the impact on food security is enormous.³⁹ About 25% of the world's population is directly involved in agriculture. The highest agricultural rates in the world and Asia are for Burundi (92.02%) and Nepal (65%), respectively. In the most populous countries of the world, such as India (42.38%) and China (25%), a high percentage of people are dependent on agriculture.⁴⁰ Many reactions to the epidemic diseases have led to changes in agriculture and food production that may continue for a long time.

In some cases, more emphasis may be placed on the automation of food production and processing to avoid the risks of labor use due to disease transmission or transfer restrictions. This can lead to more investment in mechanization. The mechanization can eliminate food contamination during production.⁴¹

In developing countries, agricultural production is performed with a large labor force. Many processes, such as planting rice and harvesting basic crops, bring workers together. Although farmers in poorer countries are generally younger than in rich countries, the health systems are usually weaker in the poorer ones, and the health challenges may increase individuals' vulnerability to COVID-19.²⁶ In this regard, many agricultural producers face labor shortages. The travel prohibition has led to a shortage of seasonal and informal farmworkers. The International Labor Organization (ILO) estimates that COVID-19 affects about 81% (2.7 billion workers) of the workforce due to full or partial closure of the workplace.^{24,42} Disruption of the aquatic supply chain also occurred due to restrictions on transportation, trade, and labor. Decreases in production due to reducing fishing efforts and delays in aquaculture systems led to reduced availability and consumption of these foods. The reduction in consumers' demand and increase

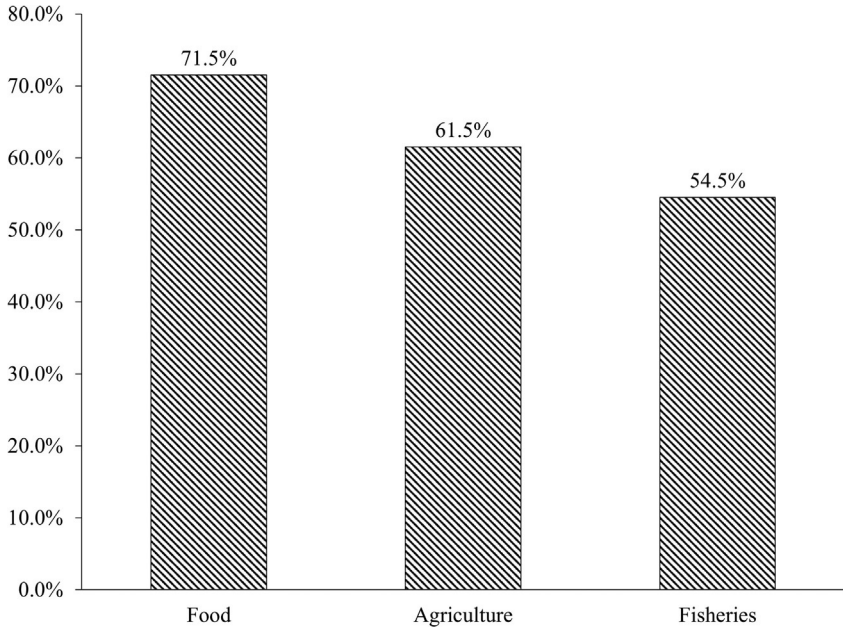


Fig. 3 Impact of COVID-19 lockdown.³⁴

in maintenance costs have enhanced the price of aquaculture and reduced its cost-effectiveness for consumers. In India, fisheries are an important part of nutrition and food security. More than 9 and 14 million people depend directly on fisheries and are employed in this occupation, respectively, contributing to more than 1% of India's GDP.³⁴ Figs. 3 and 4 show the impact of COVID-19 lockdown on food, agriculture, and fisheries and the main factors for food contamination during food processes, factories, and stores, respectively.³⁴ To respond to such crises, food supply chain issues need to be addressed.



6. COVID-19 and the food crisis

The food crisis caused by COVID-19 does not mean a shortage of basic goods. During the disease pandemic, the share of grocery stores and retail markets has declined; however, large quantities of fresh products on farms have been spoiled and wasted.⁴³ COVID-19 has had many negative economic effects on people, leading to job losses and food insecurity, especially in low-income countries. These effects have led to a global food crisis.⁴⁴ COVID-19 has exacerbated the previous problems in the global food

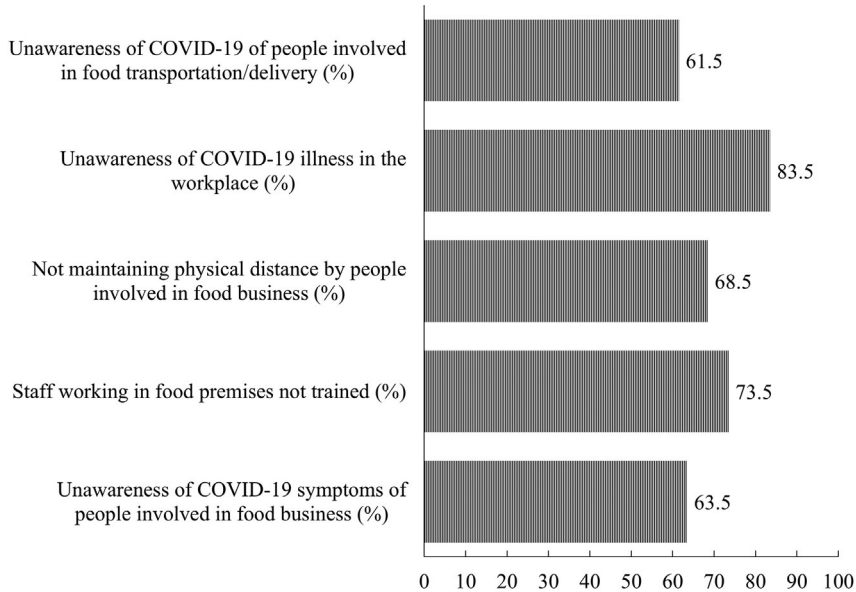


Fig. 4 COVID-19 and main factors for food contamination.³⁴

system. Many of these problems were ignored or modified before the disease. The problems concerned with hunger, food deprivation, and food wastage have long been debated. However, the issue of food supply from farm to fork has never been so important and urgent.³⁶ The limitations of COVID-19 are severe, unfamiliar (for farmers), and completely unexpected to the food supply system.⁴⁵

As reported in various researches, food anxiety and fears from food safety crises can change consumers' sensitivities and beliefs about food health and lead them to use natural and organic diets.⁴⁶ COVID-19 prevention measures such as closure, staying at home, public quarantine, and stopping transportation in communities are very challenging. With the approval of the first case of the disease, many developing countries imposed a short-term state of emergency. In some cases, the movement of imports and exports was slower or even stopped. During this economic crisis, countries must provide citizens with emergency packages that may not be enough to meet the needs of their vulnerable populations.²⁹ During the illness, the transport sector has shut down due to closures of various countries, which can disrupt the supply chain of basic goods, especially food and humanitarian aid. Under these circumstances, the developing countries, mainly dependent on agriculture, will probably run out of food. As a result, hunger and malnutrition put their

health at risk due to poor and unhealthy eating habits. In addition, countries that are highly dependent on food imports and developing countries dependent on exports of raw materials such as oil are also affected.²⁹

The COVID-19 crisis has shown that a coordinated local food distribution system is superior to the organizations that supply and distribute food. In the United States, the emergency food distribution system includes food banks that provide local food warehouses. During the disease, even reputable food banks, which depend on the help of retailers, are involved in this crisis and often fail to provide food stocks due to the slow assistance of retailers. In contrast, the food banks with wholesale suppliers have been better able to maintain access to food.⁴⁷ With the spread of the COVID-19, most countries have imposed higher customs controls on cargo ships, despite the risk of food spoilage as well as disruption of transport activities. Political measures have been taken to prevent the spread of COVID-19, which may globally reduce food production and increase prices.¹⁴ Because the governments have imposed restrictions on food exports and nationwide closures, such reactions can cause food crises. For example, during the global economic downturn of 2007–08, the doubling of world food prices was largely due to trade restrictions imposed by the largest exporters of rice, wheat, and soybeans. These measures, intending to prevent shortages in some countries, helped supply basic foodstuffs in many national markets.¹⁴ Various reports indicate that food insecurity caused by the COVID-19 crisis is rapidly increasing. The vulnerable population is more exposed to food insecurity. A study in the United States shows that 44% of low-income adults do not have food security and are mostly black and Hispanic.^{48,49}

Although the effects of COVID-19 on food security in developed countries have been relatively minor so far, more serious problems are emerging in developing countries. In developed countries, the demand for some staple foods, such as rice, was initially very high, and the consumers bought many supplies due to the fear of food shortages. Some food consumption patterns have changed due to people being restricted to eating at home rather than in restaurants. In many developing countries, COVID-19 had a severe impact on employment and income, creating a major food crisis for many people who could not afford food.⁴¹ With this crisis that led to unprecedented unemployment, people who had never experienced hunger before became vulnerable. It is estimated that 40% of people receiving services from food banks in recent weeks are first-time customers.⁴⁷ The studies have reported that about one-fifth of Africa's population (256 million people) is malnourished, and the number of hungry people increases. It is expected that Africa's

population will double by 2050, and their food demand will triple. Therefore, to provide food to expand and have a healthy life and increase welfare based on the sustainable development goals (SDGs), it is necessary to preserve ecosystems and reduce inequalities.¹¹ Thus increasing the food stocks, especially in the agricultural off-season, may help reduce unpredictable shocks.



7. The impact of the COVID-19 epidemic on countries around the world

The impact of the COVID-19 epidemic on food insecurity and its health consequences in the world is very complex, multilevel (structural, familial, and individual levels), and two-dimensional.^{50–52} After December 2019, the outbreak of COVID-19 increased the responsibilities of tackling global food insecurity. Given that most agricultural products are perishable in nature, this has led to changes in the amount of planting, harvesting, and storage of agricultural products, resulting in reduced food quality and increased production costs.⁵³

From a macroeconomic point of view, the IMF estimates the loss of global GDP (GDP) caused by the COVID-19 epidemic at \$ 9 trillion, a small portion of which could be highly cost-effective in preparing for an epidemic.⁵⁴ In a recent study (2020), Mauro and Baldwin reported that the outbreak of the coronavirus would cause economic collapse in countries such as the G-7, which has a 65% stake in the world's manufacturing units, as well as a 60% drop in global supply and demand. Forty-one percent of world exports are also affected by this outbreak.⁵⁵

In 2020 UNICEF reported that approximately 820 million people were chronically hungry, and 113 million were experiencing severe insecurity.^{42,53} More than 1.4 million people (14% of the population) in Bolivia suffer from food shortages due to financial constraints, and 7% suffer from chronic hunger. In India, approximately 16,500 farmers committed suicide even before the epidemic, for which the psychological and economic impact of COVID-19 could not be estimated (Fig. 5).⁵⁶

UNICEF reports from the early months of the COVID-19 epidemic showed a 30% reduction in coverage of essential nutrition services in middle-income countries.⁵⁷ Researchers believe global trade in goods has fallen by 13%–22% due to COVID-19.⁴² Kansiiime et al.⁵⁸ online assessed the effects of the COVID-19 epidemic on household income and food security in Kenya and Uganda. This study showed that more than 67% of the

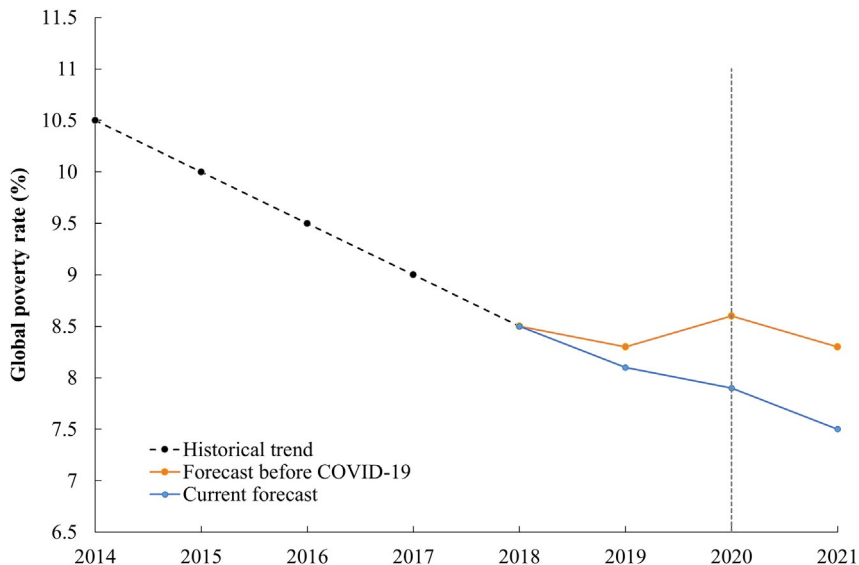


Fig. 5 Impact of COVID-19 on global poverty.⁵⁶

participants were shocked by their income due to the COVID-19 crisis. Participants estimated that food insecurity increased by 38% and 44% in Kenya and Uganda, respectively, and that in both countries, regular fruit consumption decreased by about 30% compared to the normal preepidemic period.⁵⁸

Risks of hunger and food security have also existed in Brazil since 2016 and are now exacerbated by the onset of the COVID-19 epidemic. This situation requires awareness of the scope and importance of the issue and the expression of measures in three government areas (federal, municipal, and state) to ensure access to adequate and healthy food and reduce the adverse effects of disease on diet, health, and nutrition among the most vulnerable.⁵⁹ A study conducted by UNICEF and the Brazilian Institute of Public Opinion and Statistics from July 3, 2020, to July 18, 2020, found that during the epidemic, one in five Brazilians aged 18 or over (33 million) has had no experience with money to buy food due to running out of income. The study also reported that about 9 million Brazilians could not even eat a meal due to a lack of money or food.⁶⁰

According to the latest World Food Program (WFP) data, more than 368 million children are currently missing school meals due to the closure of schools in about 200 countries worldwide due to COVID-19.⁶¹ About 25% of meat processing plants in the United States closed due to COVID-19 in 2 weeks in April 2020, and thousands of workers lost their

jobs due to compliance with health protocols.³⁶ Recent two national surveys from the United States have shown that COVID-19 has led to increased food insecurity rates in families with children compared to previous years. The study of the effects of COVID-19 showed that 34.5% of households with children under 18 years of age and 34.4% of households with children under 12 years of age were food insecure by the end of April 2020, while these percentages were 14.7% and 15.1%, respectively.¹ Before COVID-19 pandemic, 1 in 9 households in the United States had food insecurity or limited or unreliable access to adequate food.^{62,63}

In a survey, the Bangladesh Rural Advancement Committee reported that extreme poverty had increased by about 60% and that 14% of people had no food at home.²³ Also, the results of a study conducted on Romanian students showed that food wastage during the corona was significantly reduced in the study sample. Their awareness of the environmental consequences of food waste has also increased.⁶⁴ Hence, various studies have shown that COVID-19 has influenced people's behaviors to food preparation and consumption. Buying certain types of food that have a longer shelf life and higher nutritional value, storing food at home, as well as the tendency to consume home-cooked food are examples of these behaviors. This behavior led to higher food prices, and as a result, poor people were less able to buy these items. This is more evident in developing countries.⁶⁵

The impact of the COVID-19 epidemic on food insecurity and poor health outcomes is due to previous economic and health inequalities, which are mainly driven by systemic racial discrimination.^{51,66} Before COVID-19, black, Hispanic, and low-income households experienced food insecurity and chronic illness.⁶⁷ In 2018 the prevalence of food insecurity was highest among low-income households at 29.1%, non-Hispanic blacks at 21.2%, and Hispanics at 16.2%, while in the general population, it was 11.1%. Such disputes result from unequal access to resources, including employment, food, housing, education, and healthcare.^{66,68}

Across Africa, high levels of malnutrition among women, children, and the elderly will be exacerbated by declining incomes in low-income families. Also, the livelihoods of farmers and suppliers are at greater risk due to restrictions and disruptions such as the closure of transportation routes.⁴ However, most African countries have seen a steady decline in the prevalence of malnutrition since 2000. For example, the prevalence of malnutrition in Algeria, Morocco, Senegal, Cameroon, Togo, and Ethiopia increased from 10.7%, 6.8%, 28.7%, 30.8%, 31.1%, and 52% in 2000 to 3.9%, 3.4%, 11.3, respectively, 9.9%, 16.1%, and 21.4% in 2019. However, in countries such as

Uganda, Nigeria, and Madagascar, the prevalence rate of malnutrition increased from 27.7%, 9.3%, and 34.4% in 2000 to 41%, 13.4%, and 44.4% in 2019, respectively (Fig. 6).⁶⁹

During the COVID-19 epidemic, India’s economic loss is estimated at \$ 234.4 billion, or 8.1% of GDP, assuming that India remains quarantined at least until the end of May 2020.³⁴ Figs. 7 and 8 show changes in GDP during the 5 weeks of quarantine in Nigeria and 7 weeks in Ethiopia.⁷⁰

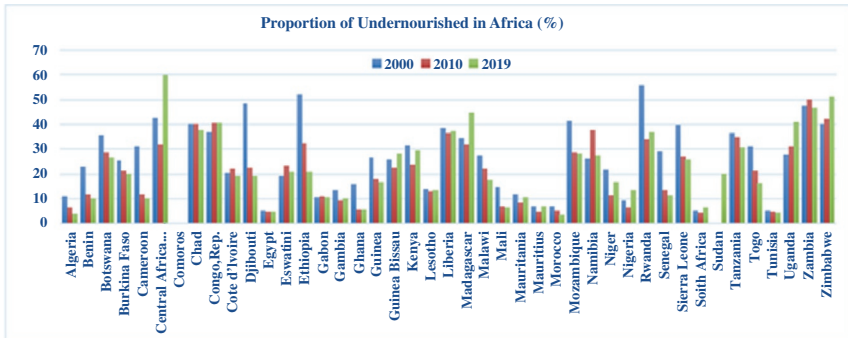


Fig. 6 Prevalence of Undernourished in African Population (%) 2000–19.⁶⁹

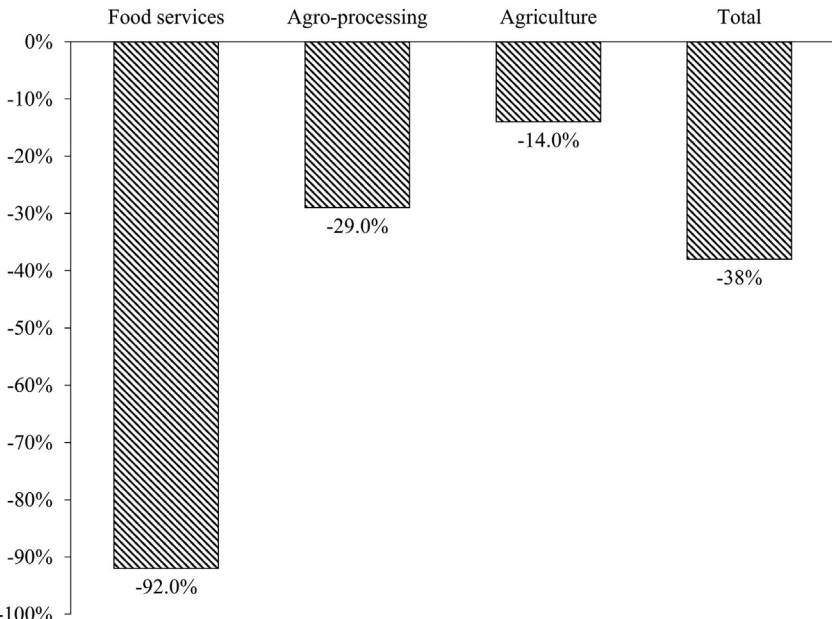


Fig. 7 GDP during the 5 weeks of quarantine in Nigeria.⁷⁰

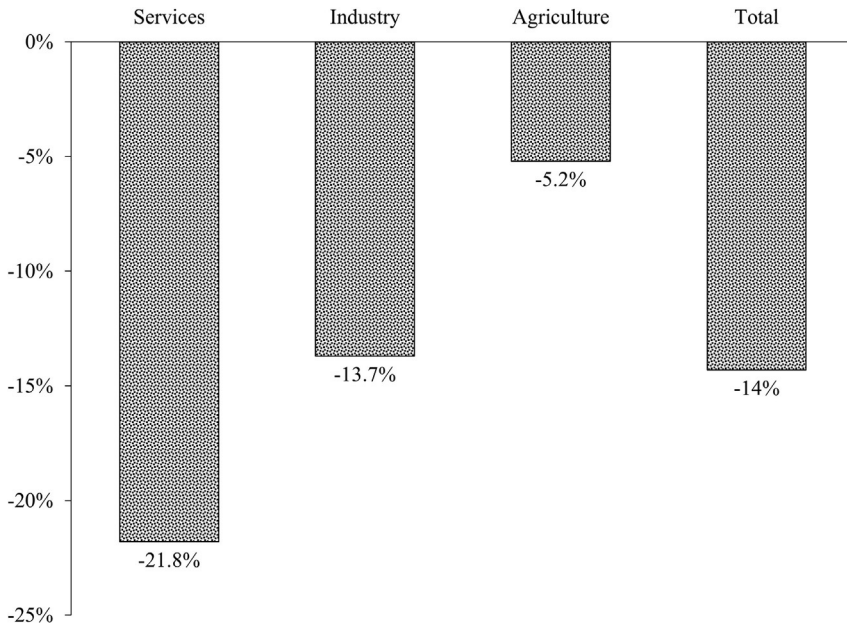


Fig. 8 GDP during the 7 weeks in Ethiopia.⁷⁰



8. COVID-19, food insecurity, and its consequences

Food insecurity with cognitive and behavioral consequences such as skipping meals due to financial constraints, food hoarding, pressuring, or overfeeding children while preparing food due to concerns about food shortages, etc., has negative effects in child's health through family conflicts.⁴⁹ Although the distribution of food parcels by local and national governments and private donors among poor communities can help prevent acute starvation, the quality of food parcels should be evaluated as it may meet long-term nutritional needs. It is not enough and therefore has long-term negative effects on households that rely more on these food packages. In these packages, in addition to the amount of food, their type and number of calories are also very important.⁷¹ The experience of food insecurity is stressful and, in the short and long term, is associated with many harmful physical and psychological consequences. Among children, food insecurity is also associated with adverse behavioral and educational outcomes.⁷²

Short-term shortages of basic foodstuffs in shops, inability to access shops due to personal quarantine, and economic reasons were the three main factors in food insecurity. In particular, people from ethnic groups of blacks, Asians and minorities, unemployed adults, childcare charities, and people with health and disabilities were at higher risk.^{13,73}

Previous research has shown that the health of older people is particularly endangered due to food insecurity, and given their vulnerability to the COVID-19 outbreak, this population needs to understand how food hardships occur. The elderly are generally not eligible for unemployment insurance, and the nutrition assistance program for the elderly is much smaller than for young adults.⁷⁴ Although the effects of food insecurity are heterogeneous within and across countries, the FAO believes that the consequences are for the unemployed, informal sector workers, families with children under 6, female-headed households, adults living alone, and adults. There will be more black families and low-income households.^{75,76} Therefore, in conditions of food insecurity, children and adolescents with dietary deficiencies are exposed to developmental disorders, cognitive deficits, chronic physical and mental problems, and death.⁷⁷

In the United States, about 38% of adults had experienced an increase in food insecurity since mid-March 2020, when COVID-19 was declared a national emergency.⁷⁸ This rate is likely to increase as the economic crisis continues and housekeeping orders continue. As a result of unemployment and declining incomes from the COVID-19 epidemic, millions of Americans struggled with the quantity and quality of food needed and the price of in-store food, accompanied by rising prices.⁷⁹ In addition, food insecurity in populations vulnerable to COVID-19 (for example, people with chronic illnesses and the elderly) increased due to fears of exposure to the virus.

A study of students in Texas found that 34.5% of them had experienced food insecurity over the past 30 days due to COVID-19, which is 15% more than food insecurity reported in previous US student reports.^{15,48,80} Current lifestyle changes and the loss of part-time jobs were the most important predictors of food insecurity in students due to COVID-19. Also, in the Philippines, many industries have lost their incomes and purchasing power since the outbreak of the epidemic. As many as 7.3 million Filipinos are unemployed.⁷¹ Since the epidemic, the Ministry of Welfare and Social Development has identified approximately 21 million low-income Filipino families needing immediate financial and food assistance from the government.⁷¹

In addition, students living with one parent were more than twice as likely as other students to experience food insecurity. This finding suggests

that family support plays an important role in protecting students' food security in facing crises such as COVID-19. Family support increases food purchasing power and helps maintain a balanced diet, especially for students with lower nutritional literacy or lower cooking skills.^{80–82}

Widespread food insecurity during the COVID-19 epidemic can have serious and long-term consequences for the health of low-income households. Food insecurity is associated with an increased risk of chronic diseases such as HIV,^{83–86} type 2 diabetes,^{87,88} cardiovascular disease,^{89,90} hyperlipidemia, hypertension,⁹¹ and high rate mortality.⁹² In addition, given that chronic diseases such as diabetes and cardiovascular disease are risk factors for COVID-19 complications,⁹³ food insecurity can increase the risk of COVID-19 with a worse outcome.

The study of the impact of the first wave of COVID-19 on food insecurity during the epidemic crisis in the first week (April 20–26) of 2020 shows that a large proportion of respondents in April 2020 experienced food insecurity in the COVID-19 health emergency. Compared to March rates, food insecurity generally doubled in April and tripled among children. The rate of increase in food insecurity was higher than the projected increase in unemployment in April, especially for families with children. As a result, the number of economic problems families have experienced has increased and required an immediate and sustained response from the government.⁹⁴

Therefore it is necessary to pay more attention to the relationship between eating pathology and food insecurity, especially in children and adolescents during pandemics. Although these times are uncertain, there are issues such as identifying the factors that exacerbate income and job inequality in the economic crisis that we must consider to protect the food security of children and adolescents now and shortly. Food security determines dignity, justice, life, and sustainable development.¹



9. COVID-19 epidemic and food system

The world population is estimated to reach 10 billion by 2050, which raises significant concerns about food safety and adequate supply, hence the demand for foods such as meat, dairy products, as well as processed foods.¹² Before the epidemic, more than 80% of the Yemeni population was dependent on food aid and faced severe food insecurity. In Syria, 9.3 million people are insecure due to unprecedented inflation in food prices. Sudan is

currently facing a strict travel ban, while food prices rose 82% in April from a month earlier. This will make it less likely to achieve the zero hunger target by 2030.¹²

Social justice and the goals of environmentally sustainable development are focused on reducing hunger, but the COVID-19 crisis has unprecedentedly affected these goals and disrupted the global food system. COVID-19 has tested the depth of global commitment to social justice and food sustainability and security.³⁶

In addition, there is no specific system for the proper distribution of food in pandemic conditions. The COVID-19 pandemic made the defect more apparent. In general, based on food consumption, there are two types of food systems: one system that deals with the preparation and consumption of home food from grocery stores, farmer markets, and food centers, and the other system that is for consumption in institutions and outside the home like restaurants, schools, and businesses. The closure of restaurants, businesses, schools, and many institutions due to COVID-19 increased the demand for food at home, disrupting food supply in grocery stores.⁹⁵ Because food was originally prepared for use by farmers outside the home, and the consumption pattern changed due to COVID-19, large amounts of food were wasted.⁹⁶

The food industry is a very important sector economically. However, the food sector faces various challenges compared to other areas of daily life, including tourism and aviation. The epidemic could lead to \$ 113 billion in aviation losses and \$ 80 billion in tourism.⁹⁷ Some food companies face various challenges due to declining revenues, while others work hard to meet retailers' growing demand. The fact is that this epidemic clearly shows that different companies from different industries around the world are closely related to each other. Hence, supply management strategies are also important to meet consumer needs. Maintaining the flow of food and goods across the supply chain must be ensured with the participation of all stakeholders. Ensuring consumer confidence is also essential for food safety and security.⁹⁷

A study by Adhikari et al.⁹⁸ in Nepal showed that the COVID-19 pandemic had reduced the achievements of the SDGs as well as the negative impact on agricultural systems, food access, food consumption, and food security stability.⁹⁸ During an epidemic, continued supply flows in the agricultural and food sectors, are critical strategies to preventing a food crisis and

reducing the negative impact on the global economy. As a result, every country has to realize the deterioration of the situation and sometimes, it has to tighten measures due to the prevalence of the epidemic. The supply chain must also be flexible enough to meet the challenges of the food supply chain.⁹⁷

The vulnerability of food supply chains in food systems varies according to their priorities and structure. Their four important features can be as follows:

- (i) Governments worldwide have made it a priority to ensure the delivery of staple foods to consumers.
- (ii) In developing countries, traditional labor-focused food supply chains are more affected than modern ones.
- (iii) Even modern food supply chains and systems can be severely affected by the closure or unemployment of labor and the severance of international connections.
- (iv) COVID-19 has affected public food distribution systems. School closures, for example, deprive many poor children in the United States of public meals. Farmers and other suppliers struggle to find markets to replace institutions such as restaurants and schools, resulting in a significant amount of wasted milk and other micronutrient-fortified foods. Other food supply networks are also affected, including general nutrition programs for pregnant and lactating mothers.²⁴

In high-income countries, perishable foods and their products have been significantly affected by COVID-19 due to their short shelf life and reliance on workers for storage and processing. Many farms employing migrant labor have faced labor shortages due to government restrictions on transportation to prevent the release of COVID-19, and the agricultural production cycle has been disrupted.³⁶ In summary, four major issues in the food industry and food supply chain have been addressed during the outbreak of COVID-19. First, people tend to follow a healthy diet to protect themselves and their immune systems. Second, food safety has received increasing attention among manufacturers, retailers, and consumers to prevent coronavirus transmission. Third, food security concerns have arisen due to traffic restrictions. Fourth, concerns about food stability have emerged during the epidemic.⁹⁷

Thus the coronavirus (COVID-19) epidemic has shown how global food systems can become vulnerable, leading to increased food insecurity, malnutrition, and poverty, especially among vulnerable groups.⁹⁸



10. Strategies to deal with the food crisis in the COVID-19 epidemic

Creating a global response to the impact of the COVID-19 pandemic on food insecurity and its consequences, including prolonged starvation and malnutrition, requires science-based solutions, informing policymakers, including governments, global organizations, and stakeholders.¹ However, various factors such as climate, geography, socioeconomic systems, healthcare systems, educational systems, and political structures must be considered for epidemics.¹

However, being prepared for these patients, such as COVID-19, requires planning, organizing, investing, spending time and resources, as well as coordination between government agencies and the public. In addition, ensuring food availability, basic food supplies, and communicating with the public and teaching personal hygiene practices such as hand washing, masking, and physical distance are critical to COVID-19.^{1,31,32}

Selective government policies to reduce the effects of COVID-19 on food security can include programs for food production, estimating food demand, appropriate methods of food distribution and storage, food processing and preparation, and a global food supply chain.⁴

Given that various issues affect food security, it is recommended to use the following approaches to create a food-resistant system against various threats:

- Provide innovation and low-cost or cost-effective methods to produce agricultural products that can increase production flexibility to be used against shocks and unpredictable consequences such as crop loss, epidemic conditions, market failure, etc.
- Creating associations of individuals and communities to effectively manage various innovations in agriculture.
- Interacting with decision-makers to support the implementation of robust political mechanisms that support appropriate agricultural solutions can increase flexibility in food systems.
- Support research that raises awareness of producers and consumers to strengthen the flexibility of food systems because it can, in addition to farmers' livelihoods and promote sustainable agricultural approaches, make healthy and nutritious food available to the community.⁹⁹



11. Conclusion

COVID-19 showed that global food systems can become vulnerable, resulting in increased food insecurity, malnutrition, and poverty, especially among vulnerable groups. Therefore it is necessary to link the pathology of access to food and food insecurity, especially in children and adolescents during pandemics. In poor countries, agricultural production, from planting to harvesting, is done by labor. In these countries, health systems are usually weaker, and existing health challenges may increase people's vulnerability to epidemics such as COVID-19. Therefore many agricultural producers face labor shortages.

Due to the fact that in severe poverty there is not enough income to buy food to prevent hunger and malnutrition, poor people close to the poverty line turn to cheaper and less nutritious food. Although access to sources of income is short lived, the effects of malnutrition can be long lasting, especially for young children and adolescents. However, in these circumstances, among the four dimensions of food security, access to food is the most important.

International Labor Organization (ILO) surveys show that COVID-19 has affected more than 80% of the workforce due to complete or partial closure of the workplace. Although the timing of the epidemics is unclear, the identification of factors that exacerbate inequality in income, employment, and thus access to food should be considered to protect the food security of children and adolescents now and in the future.

Also, better management of food supply and demand can prevent an immediate food crisis for millions. During the crisis, various restrictions forced farmers to sell their products and dairy products while food banks faced shortages. Food distribution channels designed to bring fresh farm food to commercial customers could not easily feed the food banks, leaving farmers discarding the crop for not selling and leaving people hungry.

In an epidemic, the cooperation of most organizations in the distribution system and access to food is also very important. As the crisis has clarified, cooperation is much more vital in areas that are on the outskirts of cities or in rural areas. Because of these collaborations, the rate of food waste will reduce.

Responding to the impact of the COVID-19 pandemic on food insecurity and its consequences, including poverty, prolonged starvation and malnutrition, seems to require science-based solutions, informing policymakers,

including governments and global organizations as well as stakeholders. However, various factors such as climate, geography, socioeconomic systems, healthcare systems, educational systems, and political structures must be considered for epidemics.

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