

COVID-19's impact on food environment in the Indian states of Telangana, Maharashtra, West Bengal, Tamil Nadu and Punjab: a descriptive qualitative study to build further research in India's food environment resilience building

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To cite: Johnsen JT, Rafaela Lima do Vale M, Bhangaonkar R, *et al.* COVID-19's impact on food environment in the Indian states of Telangana, Maharashtra, West Bengal, Tamil Nadu and Punjab: a descriptive qualitative study to build further research in India's food environment resilience building. *BMJ Nutrition, Prevention & Health* 2024;**0**:e000844. doi:10.1136/bmjnph-2023-000844

► Additional supplemental material is published online only. To view, please visit the journal online (<https://doi.org/10.1136/bmjnph-2023-000844>).

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Received 30 November 2023
Accepted 23 July 2024



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ABSTRACT

Background and aim Globally, COVID-19 has had a profound impact on food and nutrition security. This paper aims to gather the perspective from Transforming India's Green Revolution by Research and Empowerment for Sustainable food Supplies (TIGR2ESS) Flagship Project 6 (FP-6) team on the impact of COVID-19 on the food systems in India. The responses collected will be used for further research projects after TIGR2ESS ends in March 2022.

Method Members of the TIGR2ESS FP-6 team in India were invited to complete an online open-ended questionnaire with 21 questions exploring the impact of the COVID-19 pandemic on food systems and environments in India. The questionnaire and data analysis were guided by the food environment framework developed by Turner *et al* and the adaptations proposed by the United Nations System Standing Committee on Nutrition. Discussions and organisation of codes under the respective themes and subthemes were held online using the virtual platform Miro. 35 individual codes and 65 subcodes were agreed on. Responses were collated and analysed using the template with support from NVivo software and synthesised the relevant themes under Turner *et al*'s framework.

Results The organisation representatives from TIGR2ESS FP-6 (n=16) captured the perceived impact of the COVID-19 on food systems and the environment from the Indian states of Maharashtra, Punjab, Tamil Nadu, Telangana and West Bengal. Negative disruptions were caused by the COVID-19 restrictions across all the themes affecting food actors and consumers. Myths and misconception on dietary intake were reported across the state affecting especially the consumption of poultry. Positive aspects such as home cooking and awareness around healthy food emerged.

Conclusion Potential research areas were identified and involve the effects of supply chain resilience building, farmers selling their produce directly to consumer and the revival of local and traditional food's impact on diets, understanding the harm for consumers by implementing

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ COVID-19 and its measures to contain its spread have profoundly impacted food and nutrition security worldwide.

WHAT THIS STUDY ADDS

⇒ Key insights and break down of COVID-19 impact on food system mechanisms in the Indian states of Telangana, Maharashtra, West Bengal, Tamil Nadu and Punjab.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Future potential action-research areas were identified within supply chain resilience, interstate collaboration for emergency response, price stabilisation strategies, market dynamics, and consumer engagement for future food systems resilience building.

⇒ This study provides key insights into the similarities and differences in the impact of major shocks to food systems across five diverse Indian states spanning different ago-ecological zones.

restrictions, how indigenous and local food may impact peoples' diets, how to build on the encouragement of healthy home cooking during the pandemic, investigate the negative and positive effects of digital environments during the pandemic and dispelling myths and misconception while advocating for healthy diets.

BACKGROUND

The global spread of COVID-19 since early 2020 has profoundly impacted food and nutrition security.¹ Measures to contain its spread led to disruptions in food systems worldwide, affecting various stages from production to distribution. This affected the agricultural workforce, packers, farmers and vendors,

with many having to close or limit their operations. Additionally, global trade disruptions, physical distancing and restrictions in grocery stores resulted in consequences like empty shelves, panic buying and long queues.²⁻⁵ The COVID-19 preventive policies on suspending important social protection programmes were profound and disproportionately affected the poor and marginalised regions and communities.¹⁶

In India, COVID-19 restrictions disrupted agricultural production and supply.⁷ Strict mobility limits led to labour shortages, impacting production and food distribution.⁸ Many agricultural workers were compelled to return to their home villages in some states, intensifying strains on local food systems.⁹ The discontinuity in transportation led to dumping of food produce with an estimated 10%–20% drop in fruit and vegetable availability.⁷ Reduced market hours have reportedly further exacerbated food waste. Misinformation, largely from social media, claiming that poultry carried COVID-19 was reported to be widespread by the media.¹⁰ The restrictions also impacted the economic activity of consumers² considering a widespread loss of jobs and incomes,¹¹ especially for informal workers, the poor,^{2 12} women¹³ and small-holder farmers, which constitute around 86% of India's agricultural sector.¹⁴ Changes in food prices further restricted food affordability for consumers. Changes in food prices hindered affordability, with declines for some crops but increases for items like lentils, vegetables, fish and meat.^{2 7} There were reports of consumers prioritising essential products followed by a focus on healthy products.¹¹ The Indian government responded to the COVID-19 pandemic with relief packages, including food and cash transfers.²

It is essential for countries to monitor the situation closely, gather lessons learnt and data to avert the worst outcomes with respect to food security and malnutrition and protect the human right to food. The former United Nations System Standing Committee on Nutrition (UNSCN), now United Nations (UN) Nutrition, argued that there was a need to understand better the impact of the COVID-19 pandemic on both external and personal domains of food environments. The external domain includes aspects related to food availability, prices and vendors—while the personal dimension includes geographical access, affordability, convenience and desirability.¹⁵

Using the UN Nutrition framework, this paper aims to gather the perspective from Transforming India's Green Revolution by Research and Empowerment for Sustainable Food Supplies (TIGR2ESS) Flagship Project 6 (FP-6) team on the impact of the COVID-19 on the food systems in India. The responses collected will be used for further research projects after TIGR2ESS ends in March 2022.

METHODS

An open-ended structured online survey was conducted to gather information on the perception of relevant

stakeholders on the impact of the COVID-19 pandemic on food systems and environments in their respective Indian states. The data were collected once by the respective organisations between May and September 2020 using Qualtrics, an online survey software hosted by the University of Cambridge. The survey was designed to capture the current situation in the respective states.

Sample of key stakeholders

Relevant information on the potential impact of COVID-19 on food systems and environments was collected through individuals engaged in the TIGR2ESS project. TIGR2ESS is organised around six FPs. The FP-6: Impacting Well-being in Rural and Urban Communities consists of a multidisciplinary group of social scientists, land economists, basic scientists and a nutrition think tank,¹⁶ thus hosting vast knowledge of Indian food systems and environments. Table 1 presents more detailed characteristics of TIGR2ESS and its FP-6 study participant organisations.

Food environments in the COVID-19 pandemic framework

The research team designed a 21-question open-ended questionnaire to explore the potential disruption in food systems and environments in the TIGR2ESS FP-6 operated states and regions (see online supplemental material 1 for more details). The open-ended structured questionnaire was informed by the food environment framework developed by Turner *et al*¹⁷ and the adaptations proposed by the UNSCN to describe potential COVID-19's impact on food systems and environments.¹⁵ This framework divides the food environment into external and personal domains. The external domain considers aspects such as availability, food prices, vendors, markets and regulation while the personal domain considers affordability, accessibility, convenience and desirability. The questions enclosed the potential impact of COVID-19 on food production, availability, access and waste in the respective organisation's region/state. The responses could be informed by existing published materials or personal experiences of the respective team. The questions enclosed the background information about the members of the respective team and COVID-19 impact on food production, food availability, food access and consumer behaviours. The questionnaire was reviewed by volunteers from the NNEdPro virtual core, consisting of over 70 individuals globally with scientific experiences across the nutrition field.

Data collection

Initial discussions to participate were held with all FP-6 stakeholders. Five organisations agreed to partake in the study and formed respective teams to answer the questionnaire. The following organisations participated: the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) (Telangana) (n=5), Indian Institute of Technology (IIT-Bombay) (Maharashtra) (n=3), MS Swaminathan Research Foundation (Tamil Nadu) (n=3), NNEdPro-Kolkata office (West Bengal) (n=3) and

Table 1 Description of participant organisations from TIGR2ESS FP-6

TIGR2ESS aims to ‘develop and strengthen alliances across a wide-ranging network of UK and Indian experts in crop science, hydrology, social science and policy, creating a two-way knowledge exchange partnership’ and works towards ‘defining the requirements for advancing the Green Revolution in India, set the necessary policy agenda and define a collaborative research programme focused on sustainable crop production and sustainable resource use’.⁴⁰

Name of FP-6 organisation	Organisation description
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) (Telangana)	Aims: ICRISAT is a non-profit, non-political organisation that conducts agricultural research for development in the drylands of Asia and sub-Saharan Africa. ICRISAT and its partners help to empower poor people to overcome poverty, hunger and a degraded environment through better agriculture. ICRISAT conducts research on five highly nutritious drought-tolerant crops: chickpea, pigeon pea, pearl millet, sorghum and groundnut. Location: ICRISAT is headquartered in Hyderabad, Telangana State, in India, with two regional hubs (Nairobi, Kenya and Bamako, Mali) and country offices in Niger, Nigeria, Zimbabwe, Malawi, Ethiopia and Mozambique.
Indian Institute of Technology (IIT-Bombay) (Maharashtra)	Aim: The IIT Bombay is recognised worldwide as a leader in the field of engineering education and research. Location: IIT Bombay is located in the city of Mumbai, Maharashtra, is a Public Technical Institution under the aegis of the Ministry of Education.
NNEdPro Regional Network in India (West Bengal)	Aims: The members of the Indian NNEdPro Network include dietitians, medical doctors, academics, medical and health educators, researchers, students, professional associations and other key stakeholders across India. NNEdPro manages its key activities in India via the Laketown Scientific Research and Clinicians Association (Remedy Clinic Study Group (RCSG)). The RCSG is a non-governmental organisation with independent governance and in an exclusive partnership as the principal Indian agency of the NNEdPro Global Institute. Location: The Laketown Scientific Research and Clinicians Association (Remedy Clinic Study Group (RCSG)) is based in Kolkata, India. NNEdPro Global Institute is headquartered in the UK.
MS Swaminathan Research Foundation (MSSRF) (Tamil Nadu)	Aims: MSSRF was envisioned and founded by Professor MS Swaminathan, an agriculture scientist, with proceeds from the First World Food Prize that he received in 1987. In 1988, MSSRF was established as a not-for-profit trust. The Foundation aims to accelerate the use of modern science for sustainable agricultural and rural development. MSSRF focuses specifically on tribal and rural communities with a pro-poor, pro-women and pro-nature approach. The Foundation applies appropriate science and technology options to address practical problems faced by rural populations in agriculture, food and nutrition. Location: Chennai, Tamil Nadu
Panjab University (Punjab)	Aims: Panjab University (Established in 1882) is a Central and State government-funded university. The Panjab University has a long tradition of pursuing excellence in teaching and research in science and technology, humanities, social sciences, performing arts and sports. Location: The university is located in Chandigarh, Punjab.

FP-6, Flagship Project 6; TIGR2ESS, Transforming India's Green Revolution by Research and Empowerment for Sustainable food Supplies.

Panjab University (Punjab) (n=2) (see [table 1](#)). Team leaders within the respective organisations were asked to compile responses from their respective teams, which could be achieved by holding a workshop, interviews or capturing the perceptions of all its members. While IIT-Bombay, MSSRF, NNEdPro-Kolkata office and Panjab University relied on published materials and personal experiences of their respective teams, the ICRISAT team chose to undertake a telephonic survey to understand the different perspectives of the COVID-19 crisis. They used a translated version of the questionnaire and phoned 40 randomly selected households between July and August 2020 in the urban, periurban, tribal and rural locations of Telangana. The households were recruited as respondents from previous surveys and 10 households from urban, periurban, tribal and rural location, respectively, within Telangana were randomly selected. Two women and 38 men responded to the telephone survey.

ICRISAT then synthesised the responses among the team and summarised the respective answers for the authors to analyse.

Data analysis

Data were analysed using template analysis.¹⁸ All five transcripts provided by the team leaders of the respective organisations were initially coded by one researcher (RB) using a deductive approach with predefined codes based on the framework developed by Turner *et al.*¹⁷ Another researcher (MRLdV) used an inductive approach introducing further codes. The two (RB and MRLdV) researchers met with the lead author (JTJ) to compare the codes and agree on the codes that should be applied to subsequent transcripts. Discussions and organisation of codes under the respective themes (availability and consumer accessibility; food prices and consumer affordability; vendors, markets, regulations and consumer

convenience; and consumer desirability) were held online using the virtual platform Miro.¹⁹ 35 individual codes and 64 subcodes were agreed on. Various examples of the codes were product shelf-life, food waste, food ration, online shopping/delivery services and gardening behaviour while examples of subcodes were fast food, waiting time, production and trade restrictions (see online supplemental material 2 for more details). The agreed template was then applied to all transcripts by three researchers (MRLdV, WN and SA) using NVivo and further verified by the lead author (JTJ). The template created was used to descriptively summarise the information provided by participants. The senior researcher (SR) discussed the summaries and way forward with the lead author (JTJ). The present the results, the researchers decided to synthesise the relevant themes under the Turner *et al*¹⁷ framework.

RESULTS

The perceived impact of COVID-19 on food systems and environments in India was captured and presented by the following categories under Turner *et al*¹⁷ framework: availability and consumer accessibility; food prices and consumer affordability; vendors, markets, regulations and consumer convenience and consumer desirability. Negative disruptions were caused by the COVID-19 restrictions across all the themes affecting food actors and consumers. Myths and misconceptions on dietary intake were reported across the states, affecting especially the consumption of poultry. However, some positive aspects emerged, such as home cooking and awareness of healthy food. The representation from TIGR2ESS FP-6 participants (n=16) captured perspectives from the states of Maharashtra, Punjab, Tamil Nadu, Telangana and West Bengal. The respective organisation quotations were given individual numbers at random to keep the anonymity of the participants.

Availability and consumer accessibility

During the COVID-19 lockdown, the organisations noted a marked shortage of fresh produce, especially vegetables, poultry and fish. Despite this, local vendors managed to maintain limited supplies in certain areas. The agricultural sector faced labour shortages, leading to crops standing unharvested. Transportation breakdowns inflated costs and hindered market access. Early on, panic buying led to shortages of staple foods at the beginning of the COVID-19 implemented restrictions.

For consumers, fish and fruits were hardest hit, with limited access to vegetables, animal products and pulses. While high-income groups leaned towards fresh produce, the less affluent turned to cereal-based diets. One organisation also reported consumers had limited access to markets and an increased consumption of local and indigenous products. Efforts to address food scarcity included local kitchens and government-supported meal schemes, but manpower constraints due to movement restrictions

were a major bottleneck in implementation and posed challenges.

Social protection programmes (such as the mid-day meal programme and community kitchens) initially struggled but quickly adapted, providing dry rations and doorstep delivery of mid-day meals. Financial aid, fuel support and free food kits were established. Youth club volunteers and institutions were crucial in providing for vulnerable populations. Essential items were distributed through the public distribution system. These combined efforts, though facing initial challenges, played a vital role in alleviating food scarcity during the pandemic.

Free food kit (rice, oil, sugar and pulses) was distributed to the BPL (below the poverty line) household through ration card along with Rs.1000 for other necessities. In many places, local formal and informal institutions including panchayat, youth clubs and other volunteers join together to meet the food needs of older people as well as the people who reside at the roadside. Organisation 4

The organisations described curfew affecting individuals' accessibility to markets by restricting mobility to access diverse foods. These restrictions were reported to influence diets across socioeconomic categories differently, yet one of the organisations reported no apparent changes in individuals' dietary intake.

Digital food ordering increased among high-income groups, and the pandemic encouraged more people to shop online. Reportedly, only a small section of society procured food through mobile-based applications.

... the pandemic is causing more people to shop for groceries online. The demand for local products, digital commerce and omnichannel services such as home delivery, chat features and virtual consultations is surging, and is likely to endure beyond this crisis. Organisation 2

Food prices and consumers' affordability

Participants universally reported increased food prices nationwide, particularly for vegetables, fruits, greens, meat and seafood. In some states, there was an initial surge in vegetable and fruit prices at the start of the pandemic, followed by a return to prepandemic levels. Interestingly, despite farmers selling their products at lower rates, consumers often paid higher prices at the point of purchase. Price disparities were also observed based on the place of purchase, with wholesalers offering lower prices than retailers.

The uptick in food prices coupled with reduced income and earning opportunities had varying impacts on different socioeconomic groups. Those reliant on the informal sector were hit hardest, experiencing job loss and significant income reduction, pushing them into debt and food insecurity. Consumers generally bought smaller quantities and shifted towards predominantly consuming cereals and coarse grains. Notably, the rise in food prices,

along with limited food accessibility, prompted a resurgence in locally produced and traditional foods.

Vendors, markets, regulations and consumer convenience

The organisations detailed how shortages of fruits and vegetables, stemming from harvest and supply chain restrictions, significantly impacted vendors and markets. With road and rail closures due to movement restrictions, producers faced challenges in reaching markets. Interstate transportation disruptions particularly affected vendors reliant on supplies from other states, affecting a range of products, including vegetables, fruits, poultry and marine items, leading to losses for poultry and milk farmers.

As it was the harvesting period, there were delays in harvesting due to shortage of labour and transportation to market. Also, the traders who were involved in the value chain were missed out during the crisis. Farmers fetched low prices for their grain crops. In case of perishables (fruits and vegetables) they incurred heavy losses as they couldn't find proper markets to sell their produce. There were serious implications on the export market as the fresh products such as fruits and sea food could not timely have marketed due to COVID restrictions. Organisation 1.

Food shortages and high prices, alongside movement restrictions, resulted in reduced customer turnout, prompting vendors and markets to shorten business hours or close altogether. Some organisations reported the emergence of small farmer groups directly trading with consumers. Grocers and supermarkets implemented purchasing limits on select products.

All organisations noted a surge in food loss and waste as closures left vendors unable to sell perishable items, resulting in significant losses of crops, poultry, meat and seafood. Two of the organisations reported losses of poultry, meat and seafood, which had to be thrown.

Vegetables, fruits, and greens diversity as well as animal and seafood had decreased hugely, which mainly due to lack of financial capability among middle/low-income/BPL populations, thereby reducing the demand for these produces overall. Along with this, the factor of availability and price also matters a lot here. Organisation 3.

Consumer experiences were marked by long queues, especially at local supermarkets, necessitating multiple visits for a single item. However, those shopping at local groceries or neighbourhood shops encountered shorter queues.

Most organisations reported an uptick in home cooking due to food outlet closures. While there was a positive shift towards healthier options like nuts, salads and fruits, some states observed an increased burden on women for household cooking responsibilities. A positive trend emerged with family members sharing cooking duties. One organisation noted an emphasis on more hygienic

food preparation methods, including vegetable washing in salt or turmeric solution before cooking and storing.

Consumer desirability

The organisations noted a surge in demand for local produce, seasonal items and hot meals in their respective states. Two organisations mentioned a shift away from ready-made and fast foods, with a reluctance towards roadside and mobile kitchens. One organisation highlighted increased efforts to bolster local food systems, leading to a rise in terrace and home gardening. Another organisation reported increased consumption of fruits, vegetables, poultry, eggs and spices among urban consumers, as they perceived them as protective foods. The consumers preferred locally produced produce in these cases.

More of poultry and meat were consumed as protein-rich foods were advocated through the social media, and newspapers by the local government. There was an increase in the consumption of fruits and vegetables and also spices. Outside food was completely avoided. Organisation 1

Consumers were observed to prefer locally produced fruits, vegetables, poultry, eggs and spices, perceiving them as protective foods. However, myths and misconceptions play a role in purchasing decisions. For instance, misinformation about COVID-19 spreading through poultry significantly impacted consumption in one state, while in another, consumers believed poultry, meat and eggs to boost immunity.

Further misconceptions included a belief that non-vegetarian foods lowered immunity and increased susceptibility to COVID-19. Some consumers viewed ginger, garlic, turmeric and fruits as immunity boosters. Additionally, there was an increase in the consumption of warm water, lemon, spices, herbal teas and citrus fruits. Boiling and cooling portable water was considered necessary to ensure sterilisation from the COVID-19 virus.

DISCUSSION

In this study, five organisations across five state in India reported profound COVID-19 disruption in the food systems in their respective states in four ways: (1) disruption in market-open hours and access to vendors and markets, (2) reduction in consumer affordability due to increased food prices, (3) the constraints on availability and consumer accessibility of food and (4) change in consumer desirability. In this section, we will discuss the effects of each theme and consider further research which can be done by the respective organisations post-TIGR2ESS FP-6. A clear cascade effect from food actors influencing consumers and vice versa could be seen in the results as many statements overlap the respective themes.

The observations in this study reinforce previous assumptions that vendors and markets were heavily affected by regulations, resulting in disruption in food supply chains. Movement restrictions between states

particularly affected vendors relying on produce from other states. This dependency on interstate trade and centralised production poses challenges for future food system resilience.²⁰⁻²³ Exploring strategies to mitigate such dependencies is crucial for ensuring access to essential and nutritious produce during emergencies. Further research in this area is imperative for building robust systems resilient to future disruptions.

Access restrictions due to COVID-19 resulted in long queues for the consumers, a phenomenon observed globally.¹ Interestingly, participants noted instances where consumers turned to local shops, experiencing shorter wait times. A study from Italy also highlighted a similar shift towards local and local agri-food.²⁴ A seeming natural shift due to the restrictions in market access was described as smallholder farmers self-organised to trade directly with consumers. This shift prompted smallholder farmers to trade independently with consumers. Future investigations on the factors behind varying customer traffic in different shops could provide insights for supporting short-chain suppliers and promoting decentralised food access.

While studies have shown a shift during COVID-19 in consumer waste patterns leading to a reduction of food waste at the household level,²⁵ one concern raised in our study was the waste generated by marketplaces that were unable to sell their perishable products. This points to the lack of measures in place to effectively use perishable products and should be brought to future attention in future resilience building. Further research and mitigations can be built on existing studies and guidance like the six priority areas for action report by the Global Panel on Agriculture and Food Systems for Nutrition.²⁶

Understanding the health implications, particularly among socioeconomic groups, requires further exploration. The reported shift towards less diverse, cereal-dominant diets, rather than nutritionally balanced options is of concern. A study from Gujarat and Maharashtra, India, also observed a similar trend towards more unhealthy food choices.²⁷ While many factors are in play for this change, one organisation notably reported an initial increase in fruit and vegetable prices at the onset of the pandemic, which later returned to pre-pandemic levels. Another study from the early stages of the pandemic noted rising vegetable prices but highlighted a reduction in poultry and egg prices due to misinformation surrounding COVID-19 and these food groups,²⁸ of which could serve as important food groups against malnutrition.

Our study acknowledges the increased reliance on food aid yet does not delve into its operational details or impact on dietary patterns. This indicates a need for further research into the role of food banks and distribution centres in promoting and sustaining a healthy diet within the Indian context. One avenue to explore is the development of evidence-based nutrition standards for food distribution,²⁹ applicable at both national and local levels. The approach outlined in the study by Macaninch

*et al*³⁰ could serve as a valuable guide for conducting such assessments. Additionally, a crucial preventative measure lies in school/mid-day meal programmes. Social programmes like school/mid-day meals play a vital role for vulnerable populations, particularly during a pandemic. Another study clearly demonstrates the negative impact of these disruptions on decades of efforts to combat malnutrition.³¹

Consumers reportedly shifted to online shopping, and a small section of the society used mobile-based applications to order food. However, this was mainly observed in high-income groups in our findings. This is not unique to India as multiple observations have been reported elsewhere,³² especially for food delivery from restaurants.³³ There is a need for a better understanding of this shift in diets for Indians and to prevent unhealthy food marketing. For example, the shift to digital environments promoted unhealthy food consumption in Brazil.³⁴ Digital food environment can positively and negatively impact peoples' diets,³⁵ especially for children and adolescents.³⁶ Research on the diet impact of increased utilisation of the digital food environment is needed in an Indian context.

Interestingly, the organisations in this study described some positive trends in consumer desirability that occurred and should be further explored. The increase in home cooking, with proper knowledge and ingredients, can positively impact peoples' diets.^{37,38} However, as pointed out in this study, there is a risk of shifting these types of household responsibilities to women, burdening them with more responsibilities. Proper education and encouragement to share these responsibilities are important to lessen further burdens on women during emergencies.

The findings underscore how myths and misconceptions can significantly impact perceptions of certain food products. Items believed to be linked to diseases, like poultry, tend to suffer from negative consumer sentiment. This not only affects the income of vendors and farmers but also leads to a reduction in the consumption of nutritious foods, especially among groups that rely on them. The sudden exclusion of certain food groups can result in a drop in essential nutrients in people's diets. Interestingly, there was an uptick in vegetable consumption as they were believed to boost the immune system. However, health-promoting products like herbal teas and ginger can be wrongly marketed as preventive or curative foods for diseases. Myth-busting is an essential preventative measure. The Indian Government, media and the WHO promptly took action to debunk such myths, which either affected the sales of nutritious produce or led to unnecessary product sales.^{10,39} However, a more in-depth understanding of how to swiftly identify and counter instances of myths and misconceptions would be invaluable for prompt action in the face of disruptive misinformation.

Strengths, limitations and assumptions

This analysis is limited in scope. It draws from key stakeholders within the TIGR2ESS FP-6 group, with additional

input from ICRSIAT providing household-level data summaries. The findings reflect a specific group's experiences and perspectives. While the strengths lie in participants' expertise in nutrition and food systems, their insights are often secondhand, which can lead to potential misinterpretation. Additionally, recall bias may influence their reflections. The study's primary objective is not to discuss the nutritional impact of COVID-19-related food system shocks but to gather insights for future research on food environment disruption and resilience-building projects.

CONCLUSION

The COVID-19 pandemic has illustrated the vulnerabilities of food systems and environments in India. This descriptive analysis highlights several critical themes for future exploration and research by FP-6 stakeholders after the conclusion of the TIGR2ESS project.

For actors in food and nutrition security, potential action-research areas include supply chain resilience, interstate collaboration for emergency response, price stabilisation strategies and a more nuanced understanding of market and vendor policies, particularly for indigenous communities. Examining direct farmer-to-consumer sales and the resurgence of local and traditional foods on dietary patterns, as well as understanding how local decentralised shops can enhance consumer access, are key topics for further investigation.

From the consumer perspective, potential research areas encompass understanding the impact of restrictions on consumers, safeguarding and operating social security programmes during emergencies, assessing the influence of indigenous and local foods on dietary habits, leveraging the promotion of healthy home cooking during the pandemic, exploring both positive and negative effects of digital environments and addressing myths and misconceptions while advocating for nutritious diets.

These insights extend beyond the COVID-19 context, contributing to the ongoing pursuit of building robust food systems capable of withstanding future disruption.

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Funding This research was supported by TIGR2ESS through the Global Challenges Research Fund, UK

Competing interests None declared.

Patient consent for publication Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request. Please contact the main author to request the data material.

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Annex 1:

Questions for India's food system and food environment and its possible impacts of COVID-19

Objective: this questionnaire aims to gather the perspective of your team on the impact of the COVID-19 on different aspects of the food systems and environments in your state/region. The responses collected will be used to create a platform for further discussions, projects and research.

Submission of responses: Please, submit your responses by _____.

Background

Please, provide some background information about the members of your team.

- What institution(s) is your team part of?
- What are the work locations of the members of your team (locality/district/state)?
- What are the physical locations of the members of your team (locality/district/state)?
- What are the areas of interest of your team (including emerging areas post COVID-19)?

The following questions are about the potential impact of COVID-19 on food production, availability, access and waste in your region/State. The responses can be informed by existing published materials, or personal experiences of your team. When using information from published materials, please do include sources/references.

Food Production

- 1) How has agricultural value chains been affected? Which implications does it have on the proportion of (good) fresh products entering the export market?
- 2) Which food/food groups have been affected by agricultural losses?
- 3) Which factors contributed to agricultural losses? (for example, food outlets/markets closures)
- 4) How are the agricultural losses expected to influence cropping in the short (e.g., this year) and medium term (e.g., next year)?
- 5) How would agricultural losses influence individuals' diets?

Food Availability

- 6) Which shifts in food supply have been observed?
- 7) Which shifts in food demand have been observed?
- 8) How different factors have been contributing to shifts in supply and demand?
- 9) Which foods or food groups have been facing shortages? How has it been affecting the diversity of food options available?
- 10) How would food shortages affect individuals' diets?

Food Access

- 11) Which food/food groups have been facing inflation or shift in prices? Which implications does these limitations in food access have on individuals' diets?
- 12) Which factors have been limiting individuals' access to foods? (for example, reduced income and earning opportunities, restrictions in access to markets, restriction on food items limits, long queues)?
- 13) How have school meals and other social protection mechanisms "e.g. mid-day meal and the public distribution system" been affected?
- 14) How have food emergency solutions, such as food banks, been affected? (for example, are they experiencing a reduction in donation? increase in demand? what is their capacity to cope with demand?)

Consumer behaviours

- 15) How has consumer behaviours been affected? (for example, use digital/phone food ordering, increase in ultra-processed food products) Which implications might these changes in consumer behaviours have on individuals' diets?
- 16) Which concerns or misconceptions around food have emerged?
- 17) How has home cooking been affected?

Annex 2:

Themes	Categories	Codes	Subcodes
Food environment external domain	Availability: presence of food sources or products	Agricultural inputs	Uncertainty
		Agricultural losses, inequalities, geography	Animal foods
			Fruits and vegetables
		Animal foods	
		Fresh produce	
		Fruits and vegetables	
		Food in general	
		Livestock inputs	
		Production, processing or transportation	Cost
			Disruption or delays
			Access
			Competition
			Continuation
Recovery, food supply chain			

Themes	Categories	Codes	Subcodes
		Trade and procurement	Disruption
			Uncertainty
Food environment external domain	Vendors properties: vendor typology, opening hours, services	New food vendors	
		Vendor properties	Centralization
			Organisation
			Services
			Inequity
			Size
		Hours of operation	
	Product properties: intrinsic compositional assets of foods, food quality, composition, safety, level of processing, shelf-life, packaging	Product properties	Safety
			Shelf-life
			Labour intensity
	Prices: monetary value of food products	Food prices	Challenges
			Changes

Themes	Categories	Codes	Subcodes
		Food prices for consumers	Fruits and vegetables
	Marketing and Regulation: promotional information, branding, advertising, sponsorship, labelling, and policy regulations pertaining to the sale of foods.	Marketing and regulations	Food sales
Food environment internal domain	Affordability: Prices interact with individual purchasing power to determine affordability within the personal food environment domain.	Affordability of foods	Animal
			Fresh
			Healthy
			Inequality
			Number of people to be fed
		Income	
	Accessibility: include distance, time, space and place, daily mobility, and modes of transport	Space and place	Centralization
Density of food outlets			

Themes	Categories	Codes	Subcodes
	that collectively shape individual activity spaces.	Waiting time	
	Convenience: time and effort of preparing, cooking and consuming food products, time allocation	Convenience	Support
			Time and efforts
	Desirability: preferences, acceptability, taste, desire, attitudes, culture, knowledge and skills	Desirability	Sustainability of change
			Change
			Cropping choices
			Essential items
			Fear
			Food environments
			Food systems
			Healthy fresh and or local foods
			Home cooking
			Convenience
	Inequality	Gender	
Income			

Themes	Categories	Codes	Subcodes
		Migration	
		Misconceptions	
		Vendor	Product property
			Shelf life
			Services
Food consumption	Consumer food consumption	Food consumption	Animal foods
			Change
			Diet diversity
			Nutrient value
			Quantity
			Ultra-processed foods
Interventions	Government actions	Government measures	Hospitality sector
			Market closure
			Movement restriction
			Food services

Themes	Categories	Codes	Subcodes
			Food provision
			Cash transfer
			Continuity
		Government programmes	Disruption
			School meals / midday meals
		Recovery	Economy
			Financial support and incentives
		Community actions	Education support
	Support citizen groups, length food chain		
	Food services or provision		
	Healthcare support		
	Resources		