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Retail prices of nutritious food rose more in countries with higher COVID-19 case counts

Yan Bai[1,2,3], Leah Costlow[1], Alissa Ebel[1,4], Sarah Laves[1,5], Yurika Ueda[1,6], Natalie Volin[1,7], Maya Zamek[1,8] and William A. Masters[1,9] ✉

The COVID-19 pandemic has curtailed lives and livelihoods, leading to price spikes for some foods and declines for others. We compare monthly retail food prices in up to 181 countries from January 2019 to June 2021, test for differences over time and find that average prices rose significantly, especially for more nutritious food groups in countries with higher COVID-19 case counts. Analysis of retail prices by food group complements data on farm commodity prices and overall consumer price indexes, helping to guide policy for resilience and response to shocks.

COVID-19 has reached all countries of the world, harming lives and livelihoods at unprecedented speed and scale. Throughout the pandemic, news services have reported price spikes and temporary shortages of various kinds of food and other products, but agricultural production and distribution has continued to function without the extremes of food scarcity or government rationing seen during wartime or natural disasters with comparable levels of mass casualties[1]. This article reports on a compilation of national data on consumer prices before and during the pandemic, offering an updated view of global food systems with distinctive implications for policy response and market monitoring.

Previous analyses of world food markets typically focus on wholesale commodities sold in bulk for regional and international trade such as the Food and Agriculture Organization (FAO)'s world food price index or use countries' overall consumer price index (CPI). Commodity prices fluctuated from month to month but remained near historic lows through most of the pandemic and then rose sharply in anticipation of higher incomes after recovery[2]. National studies from such countries as India, China, Brazil and the United States show even larger fluctuations and often declining trends in wholesale prices[3–6], with some suggestive evidence of retail price rises in several European countries[7] and urban India[8].

To inform policies regarding global consumers' access to diverse foods on retail markets, we compiled all available sources of consumer price data from around the world, following a protocol registered in May 2020[9]. In this study we report global average levels of CPIs in up to 181 countries from January 2019 to June 2021 and average prices by food group from early-warning systems (EWSs) for 499 food items in 88 lower- and middle-income countries. The methods and datasets are detailed in the Methods section and supported by the supplementary figures. Our compilation of these data is part of a larger global effort to improve reporting and analysis of consumer food prices and the affordability of healthy diets, funded by the Bill & Melinda Gates Foundation and UKAid[10]. Price reporting by food group could be done in near real time for food system monitoring to inform both long-run development policy and resilience in response to shocks such as the COVID-19 pandemic, climate change and conflict.

COVID-19 in agriculture and food systems

A wide range of evidence reveals that COVID-19 has led to dramatic changes in food demand and supply but has so far done little to slow agricultural production on the farm[11–13]. The disease emerged and spread first in cities, transmitted from person to person through close contact, especially indoors, and was slow to reach farmers whose physical isolation limits exposure to the virus. In more urban areas, fear of infection led individuals to limit their contacts and led many institutions and governments to close public spaces, driving consumers away from restaurants and cafeterias and towards purchase of packaged and retail items[14].

At the start of the pandemic, the sudden switch to food at home led to brief price spikes and low inventory as consumers stocked up in anticipation of limited market access, and processing bottlenecks forced some farmers to dump perishable items such as milk, vegetables and fruits that could not be repurposed for individual sale. Over time, it has become clear that the pandemic's largest effects in food systems have occurred through swings in demand and bottlenecks in off-farm supply chains, as the disease and its aftermath causes waves of illness and loss of life, employment and livelihoods that worsens poverty and food insecurity[15,16].

Among food system workers, the biggest impact has been on employees who live off the farm, including seasonal and migrant workers, who live and travel in groups; meatpacking and greenhouse workers, who labour together in closed spaces; and retail vendors who are in frequent contact with many customers[17,18]. Taken together, the various impacts of COVID-19 in and around the food system could be a new kind of food price crisis in which agricultural production as such is largely unaffected, but there is unusually high price volatility for both agricultural commodities and retail items due to large swings in demand, with higher retail prices on average due to the high cost of maintaining supply chains off the farm.

Overall food prices and inflation

To identify change in retail food prices relative to all other goods and services, we analysed all available monthly data on each country's overall CPI and their food CPI, including the ratio of food to all prices, which we call the food price index (FPI). Each country's CPI and FPI are computed over many prices observed at diverse

[1]Friedman School of Nutrition, Tufts University, Boston, MA, USA. [2]School of Public Affairs, Zhejiang University, Hangzhou, Zhejiang, P. R. China. [3]The World Bank, Development Data Group, Washington, DC, USA. [4]Somerville Homeless Coalition, Somerville, MA, USA. [5]IPM Institute of North America, Madison, WI, USA. [6]UNICEF, Lilongwe, Malawi. [7]International Food Policy Research Institute, Washington, DC, USA. [8]School of Public Health, University of Califonia, Berkeley, Berkeley, CA, USA. [9]Department of Economics, Tufts University, Medford, MA, USA. ✉e-mail: william.masters@tufts.edu

locations, intended to be nationally representative averages weighted by expenditure shares for each item.

The global averages shown in Fig. 1 are set to 100 in January 2019 so that cumulative changes since then are clearly visible, along with the 95% confidence interval (CI) around the global mean for each month. Figure 1a reveals that the CPI and food CPI rose at almost exactly the same rate from January to October 2019, with no change in the ratio of food prices to the prices of all goods and services (FPI). That FPI ratio rose slightly in November and December before a statistically significant rise from January through May to about 3% above its 2019 level and then sustained at a range between 2% and 3% through June 2021. Those movements in retail prices during the pandemic clearly differ greatly from the FAO's global Food Price Index for traded agricultural commodities that fluctuates widely during this period.

Figure 1b shows the association between food prices and the spread of COVID-19, measured as each month's accumulated number of cases per million people ever recorded in each country. Dots show individual country–month observations, including many at zero before the disease was first reported in that country, and a few observations at the far right show price levels in countries at very high levels of cumulative case counts.

Figure 1 shows that in the months before COVID-19, trends in price levels for food (FCPI) and for all goods and services (CPI) were similar, but then places and times with higher cumulative monthly case counts were associated with significantly higher levels of FCPI than CPI. The ratio between them (FPI) indicates that food prices were more than 5% above the general price level when cumulative monthly cases reached above 8,000 per million people. These are countries' official national statistics, using methods that could potentially be improved with further research. Most importantly, CPIs are calculated with expenditure weights derived from surveys conducted before the pandemic, before consumer spending had shifted towards food and away from categories such as travel, hospitality and other services. The systematically higher price of food shown here reveals the importance of that sector and the monitoring of its prices relative to the cost of other things[6,19,20].

Prices by food group

To compare price changes across different types of food, we assembled all available observations of retail food prices reported by international organizations in their EWSs to guide agricultural aid and food assistance programmes. Historically, these EWSs focused on prices for basic staples (bread and cereal grains; pulses, nuts and seeds) in a few locations, but for 2019–2021, they include many items from diverse food groups (fruits and vegetables; dairy and eggs; meats; fish and seafood; oils and fats; sugar and confectionary) at multiple marketplaces a wide range of mostly low- and middle-income countries (LMICs). In total, we obtained 369,088 individual price observations from three international agencies for 88 mostly LMICs.

Figure 2 for individual items by food group is constructed similarly to Fig. 1 for consumer price indexes, but because different countries report prices for different numbers of foods, we use sample weights to show means and CIs for the average country. Also, item prices may be reported separately for multiple market locations within a country, and differences between places are absorbed using location fixed effects. Global average price rises are lower for the food CPI in Fig. 1 than for the EWS items by food groups in Fig. 2, perhaps due to country selection as the second figure represents about half as many countries as the first, and also selection of items and market locations within countries as CPI data are expenditure-weighted sums of all foods reported in national consumption data from the largest consumer markets, while each food group's average price in Fig. 2 is a simple average over fewer items at more remote locations.

A key similarity between Figs. 1 and 2 concerns the timing of change. Figures 1a and 2a reveal simultaneous acceleration of price rises in April 2020 as the pandemic spread. Figure 2 reveals how price rises for all other food groups outpaced that of breads and cereals, with the highest rise in oils and fats as a basic ingredient for the food industry, perhaps due to low production growth and stronger-than-expected demand from China and India and the biodiesel industry[21]. Figures 1b and 2b show that these higher price levels are robustly associated with the country's cumulative monthly case counts of COVID-19 infection. Comparing the two panels reveals how fruit and vegetable prices spiked in April before the northern hemisphere summer but declined thereafter in seasonal patterns documented elsewhere[22], while dairy and eggs, meats and pulses, nuts and seeds rose later, making them more closely linked with case counts over time. Given the importance of these food groups for low-cost nutritious diets[23], their high prices during COVID-19 is a major threat to nutrition security around the world.

Implications for policy

High consumer prices for many foods during the COVID-19 pandemic reveal the importance of postharvest distribution and retail services, not just agricultural production. Prices depend on the interaction of both demand and supply, with systematically higher prices for all food groups reflecting continued demand but elevated costs associated with the spread of COVID-19 and resulting burden of illness, worker protection and other disruptions and policy responses and other factors. So far, the pandemic has not cut farm production, so agricultural commodity prices fell in anticipation of lower demand during the pandemic and rose in anticipation of recovery but were not systematically elevated during periods of high case counts. This kind of retail food price crisis can be addressed only through attention to off-farm aspects of the food system.

Actions to protect and improve affordability of healthy diets. Appropriate policy responses to COVID-19 begin with disease control. The most important steps to protect food access are the public health measures used to stop the spread of infectious disease and thereby allow people to resume market interactions[11,12]. Disease control is especially important for personal mobility and face-to-face interactions that place many food system workers at high risk of transmission[17,18]. Among consumers, the most important step is to protect consumer incomes and purchasing power, through all elements of the social safety net for those who have lost livelihoods or had low incomes even before the pandemic, with corresponding investments in the infrastructure and technology, institutions and personnel needed to ensure that food supply chains can respond to changing demand[1,16].

Actions to monitor food prices and the cost of healthy diets. Food price monitoring has long focused on wholesale prices for a few commodities but can now be extended to retail prices of all items needed for a healthy diet. This article demonstrates the feasibility of reporting month-to-month changes across all major food groups, using publicly available data. So far, the CPI data for Fig. 1 comes from national statistical offices for 181 countries, while the individual item prices and food group averages reported in Fig. 2 come from international agencies reporting prices for 88 countries. Results from our analyses also show that prices of nutritious food groups might experience higher inflation than what general CPIs and food CPIs indicate, which may further raise the cost estimation for a healthy diet during the COVID-19 pandemic and therefore further reduce the affordability in LMICs[24]. A broader effort could accelerate reporting from these sources, and perhaps also expand coverage to more foods, more market locations and more countries, aggregated by food group as reported here. Future work will make metadata more transparent so that quantities can be compared

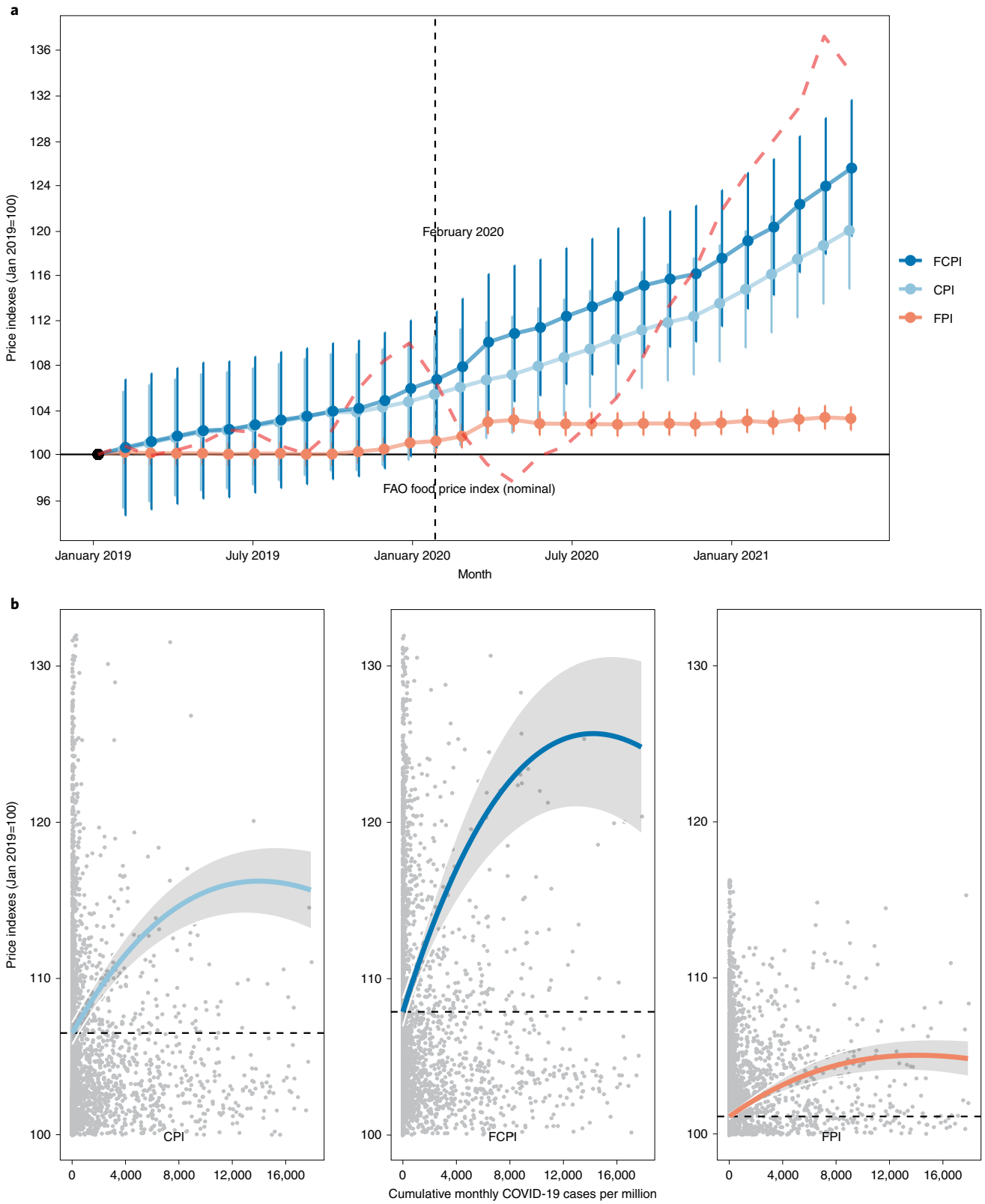
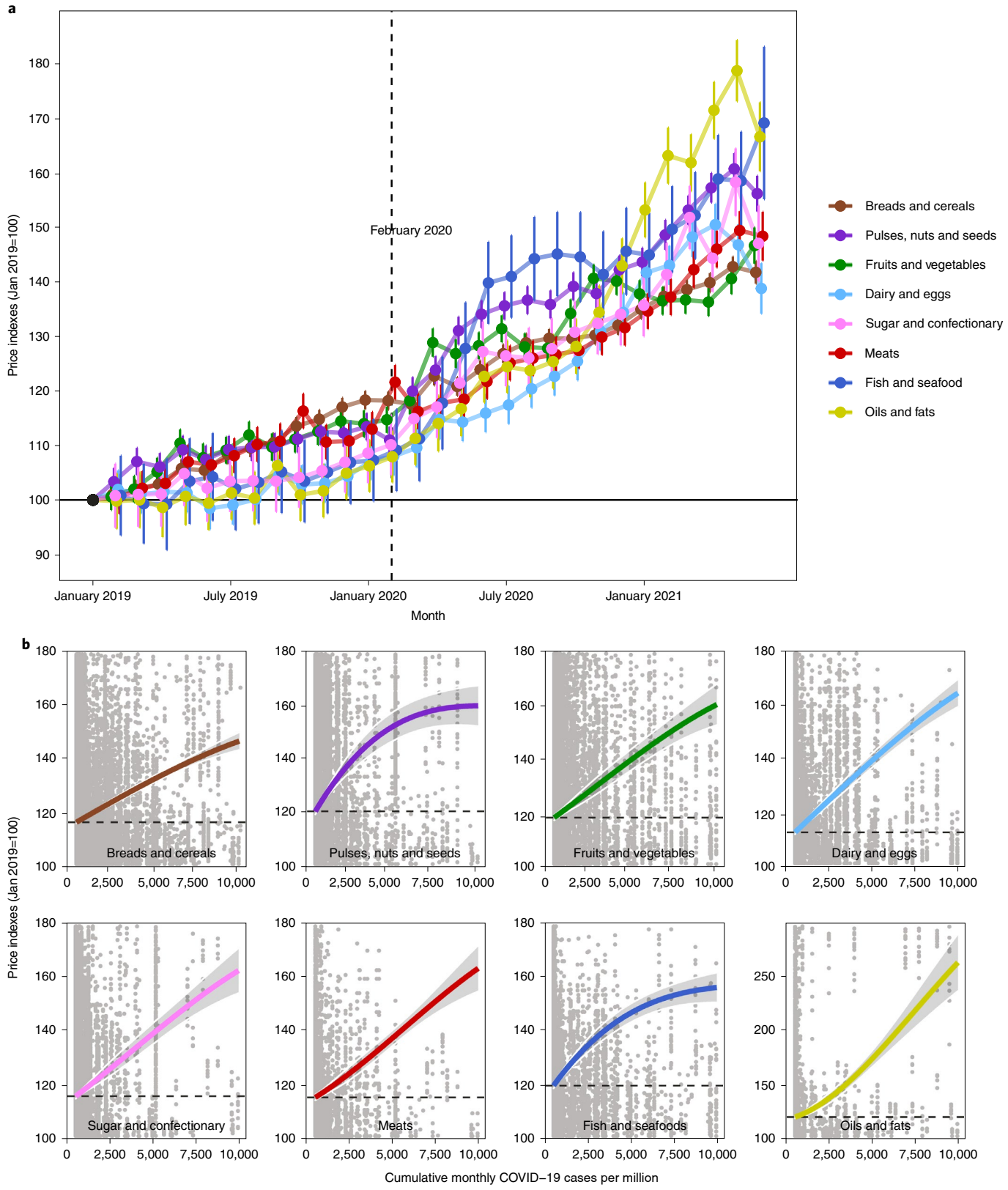


Fig. 1 | Consumer price indexes for food and other items, January 2019–June 2021. Data shown refer to national CPI from 181 countries, CPI for food and non-alcoholic beverages (FCPI) and FPI ratio of food to overall price level from 179 countries since January 2019 (=100) with missing data in Central African Republic and Guyana. **a**, The global mean (coloured dot) and 95% CI (coloured bar) in each month for those indexes, with the FAO world food commodity price index (orange dashed line) for comparison. February 2020 is shown as a black vertical dashed line. **b**, The global mean (coloured line) and its 95% CI (grey shading) at each level of reported cumulative monthly COVID-19 cases per million. The *x* axis of **b** is truncated at the far right to show 99% of the observations, although the regression line was estimated using all data, including the 1% of prices observed with COVID-19 rates that are off the charts to the right for each food group. The black dashed horizontal line shows the intercept of the regression model, representing the estimated prices indexes at the COVID-19 case number of zero.



within and across countries and permit global monitoring of retail prices for all major food groups in nearly real time.

Conclusions

This study uses month-to-month changes in average retail food prices to measure the degree of resilience in global food supply chains. Our principal finding is a higher average food CPI relative to overall CPI after March 2020, especially for some food groups, and especially in countries with higher COVID-19 case counts. Results demonstrate that food prices can now be systematically monitored using many hundreds of retail items and market locations, giving a very different picture from the handful of widely traded

Fig. 2 | Average prices by food group, January 2019–June 2021. This figure shows results from 369,088 price observations for 1,344 unique country-items in up to 88 countries. Each price is normalized to 100 in January 2019. A total of 87 countries report prices for breads and cereals; 55 for fruits and vegetables; 51 for pulses, nuts and seeds; 50 for meats; 46 for oils and fats; 41 for sugar and confectionery; 30 for dairy and eggs; and 24 for fish and seafood. Tubers, such as potatoes and sweet potatoes, are categorized as fruits and vegetables in the analysis. **a**, The global mean (coloured dot) and 95% CI (coloured bar) in each month. February 2020 is shown as a vertical dashed black line. The solid black horizontal line indicates a price level of 100 as of January 2019. **b**, The global mean (coloured line) and its 95% CI (grey shading) at each level of cumulative monthly COVID-19 cases per million. The horizontal axis of **b** is truncated at the far right to show 99% of the individual observations, although the regression line was estimated using all data, including the 1% of prices observed with COVID-19 rates that are off the charts to the right for each food group. The black dashed horizontal line shows the intercept of the regression model, representing the estimated normalized prices at the COVID-19 case number of zero.

commodities whose prices at major port cities were previously the only available measure of world food market conditions.

The use of retail food item prices as opposed to agricultural commodity prices requires close attention to national government reporting of CPI data and international agency collection of item prices for EWS purposes. Since October 2020, a new project at Tufts University working with the World Bank and the International Food Policy Research Institute is working to expand use of the food prices shown here, computing the cost and affordability of healthy diets to guide agricultural and nutrition policy[10]. For this article, we responded to the pandemic by repurposing our food price project's travel budget to employ multi-lingual research assistants for a pre-registered analysis plan[9]. New work on food prices and diet costs commissioned by United Nations agencies is being used to guide agricultural and food system investments[25] in ways that could be particularly valuable for pandemic response.

Methods

We use national CPIs and retail food prices from international agencies to describe changes in average consumer prices paid during the COVID-19 pandemic. We begin with changes from one calendar month to the next as categorical variable, and for correlation with the timing of each country's epidemic, we use a cubic function of the country's cumulative monthly case count. Analyses control for fixed effects associated with each country in its CPI and each market location for the food price data, to adjust for differences over space. In addition, because different countries report prices for different numbers of foods, we use sample weights in the regression models to show means and CIs for the average country. The weight is defined as the reciprocal of the price observation number of country i in time t for food group fg divided by the total price observation number in time t for food group fg. This ensures that each country is equally represented in the regression results, as prices from countries with fewer observations are given greater weight and vice versa. All analyses and data visualizations were conducted using Stata/SE version 17.1 and R version 4.1.0. Descriptions of the datasets are detailed below.

CPIs. Our price index data were downloaded from the FAO, which disseminates food and agriculture data for all countries and territories of the world through FAOSTAT at http://www.fao.org/faostat/en/#home. We downloaded the CPI and FCPI in September 2021 for 203 and 200 countries, respectively. We then downloaded the COVID-19 data from Johns Hopkins University (https://raw.githubusercontent.com/owid/covid-19-data/master/public/data/jhu/new_cases.csv), complemented with data before January 2020 from European Centre for Disease Prevention and Control (https://www.ecdc.europa.eu/en/covid-19/data), and merged it with the CPI database. After deleting countries without COVID-19 information and dropping Venezuela and Zimbabwe, which had multiple currencies in use due to hyperinflation, the resulting dataset spans 181 and 179 countries with CPI and FCPI data, respectively, from January 2019 to June 2021 (Supplementary Fig. 1).

Individual item prices. Our food item prices come from the international EWS data assembled by three different organizations: the World Food Programme (WFP)'s Vulnerability Analysis and Mapping programme (https://data.humdata.org/dataset/wfp-food-prices), the FAO's Global Information and Early Warning System data for Food Price Monitoring and Analysis (https://fpma.apps.fao.org/giews/food-prices/tool/public) and the United States Agency for International Development (USAID)-funded Famine Early Warning System Network (FEWS NET) (https://fews.net). Each of these provides monthly food price reporting for specific market locations in LMICs. Unlike CPI data, the EWS prices are not intended to be nationally representative of all consumer expenditures. Instead, their aim is to cover the cost of basic foods needed by people at risk of undernutrition, primarily in more remote towns and open markets than the high-volume markets captured by CPI.

We compiled all available EWS data in September 2021, initially including 789 food items and 109 countries. We then categorized those food items into 8 food groups of breads and cereals; pulses, nuts and seeds; fruits and vegetables; dairy and eggs; sugar and confectionary; meats, fish and seafood; and oils and fats. We kept observations for which prices were reported for January 2019 to June 2021. To focus on percentage changes, we normalized each price to be 100 in January 2019. To remove extreme outliers that are almost certainly caused by data-entry errors, we trimmed the top and bottom 0.5% of normalized prices by food group and dropped observations with missing COVID-19 or normalized prices, leaving a total of 369,088 observations in the final dataset.

Supplementary Figs. 2, 3 and 4 provide a visual summary of the price dataset, which contains 1,344 country-items for 499 food items from 88 countries. As shown in Supplementary Fig. 2, a total of 52 countries (59%) have prices for 10 or more food items. A majority of country items (63%) and countries (an average 70% for various food groups) have prices updated through September 2020, and food groups are well represented over time as shown in Supplementary Figs. 3 and 4.

The country and item coverage described in this annex reveals some risk of selection bias in global averages. To the extent that non-reporting is most common for the places and nutritious food items whose supply chains are most stressed, leading to scarcity and high prices, our global averages over the observed data are a lower bound that understates the actual rise in food prices associated with COVID-19. Future work will examine patterns of non-reporting and changes in observed prices, with respect to a variety of country characteristics including COVID-19 exposure and policy responses.

Data availability

All data are in the public domain and available for download with code for replication of the study's figures and results at the project website: https://sites.tufts.edu/foodpricesfornutrition/methods/data-code.

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Author contributions

W.A.M. conceived the study and obtained funding. Y.B. led the analysis and data visualization. L.C., A.E., S.L., Y.U., N.V. and M.Z. assembled data and conducted analyses as students before graduation and employment at the affiliations shown. W.A.M. and Y.B. wrote the paper.

Competing interests

The authors declare no competing interests.

Additional information

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Correspondence and requests for materials should be addressed to William A. Masters.

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