

PEER-REVIEWED ARTICLE

Food Protection Trends, Vol 42, No. 6, p. 426–438
https://doi.org/10.4315/FPT-22-006
Copyright © 2022, International Association for Food Protection
2900 100th Street, Suite 309, Des Moines, IA 50322-3855, USA

Ziqian Chen,^{1*} Ece Bulut,² Aljoša Trmčić,³
and Renata Ivanek²

¹College of Human Ecology, Cornell University,
Martha Van Rensselaer Hall, Ithaca, NY 14850, USA

²Dept. of Population Medicine and Diagnostic Sciences,
College of Veterinary Medicine, Cornell University, 602 Tower
Road, Ithaca, NY 14853, USA

³Dept. of Food Science, College of Agriculture and Life
Sciences, Cornell University, Stocking Hall, Ithaca, NY
14850, USA



Rapid Review of Government Issued Documents Relevant to Mitigation of COVID-19 in the U.S. Food Manufacturing and Processing Industry

ABSTRACT

We surveyed publicly available records published by the U.S. government between the start of the coronavirus disease 2019 (COVID-19) pandemic and 30 September 2021 to identify documents containing resources or guidelines about COVID-19 mitigation relevant to the U.S. food manufacturing and processing industry. Among 35 documents identified and reviewed (including 34 from government agencies and 1 from a relevant professional association), we extracted 19 categories of mitigation strategies covering the themes of employee biosafety, surveillance, vaccination, social distancing, and worker education. We concluded that the priority of COVID-19 mitigation in the food processing industry was to protect the health and safety of industry workers while maintaining food supply chain resilience to minimize disturbance in the food market and avoid food crises. This collated list of the identified documents and their comprehensive review will (i) aid researchers and public health workers in interpreting the potential impacts of the recommended mitigations on the epidemiology of the disease among workers in the

food processing industry and (ii) help the food processing industry sort out the most essential strategies to use during a pandemic.

INTRODUCTION

Since the first detected case in the United States in early March 2020, the coronavirus disease 2019 (COVID-19) pandemic has significantly impacted many aspects of society and many sectors of the U.S. economy (67). Specifically, the food manufacturing and processing industry has been heavily affected by labor shortages and supply issues (45), which is a problem of high concern because food is a basic necessity. One of the first documented large COVID-19 outbreaks in the food processing industry occurred at the Smithfield Foods pork processing plant in Sioux Falls, SD, which resulted in 929 cases among its 3,635 employees (26% of employees affected) (39, 51). As of September 2021, >1,400 COVID-19 outbreaks at food processing and meatpacking facilities and >77,900 cases among workers in those facilities had been reported (36). High transmission rates and large numbers of COVID-19 cases in the processing facilities have forced many

*Author for correspondence: Phone: +1 949.508.5454; Email: zc383@cornell.edu

factories into temporary closure due to illness or measures to control the infection (e.g., quarantine) among workers, which has impacted countless employees and their families and threatened the normal functioning of the food supply chain (38). The shortages of labor and closures of processing facilities have also negatively affected the livestock sector. The reduced capacity of the food processing sector resulted in a number of animal production, health, and welfare issues, such as overstocking of farms and the related stress and risk of animal diseases, and efforts to reduce production included drastic measures such as culling of animals and induced abortions (41, 44). The pandemic has placed significant stress on the national food supply chain, and the food processing industry is recognized as a critical infrastructure area for preserving normal societal function.

To help combat the negative effects of the COVID-19 pandemic, the Centers for Disease Control and Prevention (CDC) rapidly responded with a series of documents to help guide mitigation efforts in the community, including in the food processing industry. On 3 April 2020, the CDC (5) published “Cleaning and Disinfecting Your Facility” to provide general guidance regarding cleaning and disinfection at the workplace to prevent the spread of SARS-CoV-2, the virus that causes COVID-19. On 22 April 2020, a memorandum was published based on the CDC investigation of the Smithfield Foods COVID-19 outbreak to provide recommendations for improving health and safety controls at this production plant (39). On 26 April 2020, the CDC (8, 9) and the Occupational Safety and Health Administration (OSHA) jointly published the guidance documents “Meat and Poultry Processing Workers and Employers” and “Protecting Seafood Processing Workers from COVID-19” to help employers and workers identify risks associated with COVID-19 exposure and prevent virus spread at the workplace. A number of other documents were also issued over a relatively short period of time. We constructed a collated list and reviewed those documents issued early in the response to the COVID-19 pandemic (i) to help researchers and public health workers interpret the potential timing for implementation of mitigation strategies and the attributed changes in the epidemiology of the disease in the food processing industry work environment and (ii) to help employers in the food processing industry control COVID-19 exposure risks and maintain facility operations. Thus, the objective of this study was to identify, review, and collate U.S. government documents that contain resources or guidelines about COVID-19 mitigation relevant to the U.S. food manufacturing and processing industry.

MATERIALS AND METHODS

Document collection and search criteria

Rapid Web-based reviews (40) were conducted between 1 June and 30 September 2021 to collect documents that contained resources or guidelines about COVID-19 mitigation from government institutions, including the CDC, OSHA, and

the U.S. Food and Drug Administration (FDA). Each of these three institutions has a dedicated COVID-19 Web page (28, 46, 61), which we reviewed, including all tabs for each page. A complementary snowballing approach was used to identify additional relevant documents from other U.S. government agencies or professional associations where applicable. Collected documents were screened based on the following inclusion criteria: (i) relevance to food manufacturing and processing industry workers (i.e., foodservice and the food retail industry were not within the scope of this review) and (ii) accessible or published between the beginning of the pandemic and the end of the search period (30 September 2021). According to our exclusion criterion, the frequently asked questions (FAQs) pages were excluded from this review. The first author identified the documents, retrieved the publishing date for each document, and read and analyzed each document for content.

Launch date data collection

The original publishing date of each document was retrieved through one of the following two methods. The first method involved going directly to the document web page and retrieving the website source code (52). In the source code, key words “first published” or “published_time” represent the date when the website first went public and became accessible on the Internet. In rare cases when the source code did not contain information regarding publishing date, the second method was used because it provides the publishing date of any website. This method involved use of Carbon Dating the web, a web application that estimates the web page launch date by inputting the URL link of the target web page (49). Therefore, both methods together resulted in complete information about the date when each of the identified documents was first published.

Content analysis

After the initial collection and screening of documents, content analysis was conducted on all identified documents, and a codebook was developed in Excel (Microsoft, Redmond, WA) to record the mitigation strategies mentioned in each document. Specifically, the entire content of each document was extracted and coded based on the category of mitigation strategy. For that purpose, we adapted a list of categories of mitigation strategies from a recent needs assessment survey of COVID-19 perceptions in the food processing industry (43) and added to the original list any new category that we came across in the documents. The list of considered categories and their detailed explanations are given in the Supplemental Material (Table S1). After generating a list of categories of mitigations, the frequency of each category was also determined in terms of the number of reviewed documents mentioning a given category. Excel spreadsheets used to organize and analyze the reviewed documents can be accessed at <https://github.com/IvanekLab/Control-of-COVID-19-in-the-US-food-industry>.

RESULTS AND DISCUSSION

This study was conducted to survey documents published by U.S. government institutions regarding COVID-19 mitigation in the U.S. food manufacturing and processing industry. A total of 35 publicly available documents were identified through a rapid review of the CDC, OSHA, and FDA Web pages, including two documents identified through snowballing: one from a relevant government agency (the Federal Emergency Management Agency [FEMA]) and one from a professional agency (the American Society of Heating, Refrigerating and Air-Conditioning Engineers [ASHRAE]). As a primary regulatory agency for the agriculture industry, the U.S. Department of Agriculture (USDA) would be a major source of information for the food processing industry, and their documents were considered for review. However, after preliminary research, the identified USDA documents were excluded from the study based on the inclusion criteria. Specifically, industry-specific COVID-19 information published by the USDA is in the form of FAQs (57, 59), which was one of the exclusion criterion. The document “USDA COVID-19 Workplace Safety Plan” (58) is addressed to USDA employees (rather than to industry workers), which was another exclusion criterion. This document provides guidance for employees of USDA agencies, including inspectors for the Food Safety and Inspection Service (FSIS) (56). Because FSIS inspectors interact with food industry workers, the USDA document provides indirect protection to the health of the employees in FSIS-regulated commercial establishments by protecting the health of FSIS inspectors.

A timeline was created listing when the 35 documents were published (Fig. 1). A cluster of documents was published in April 2020 following the World Health Organization’s declaration of COVID-19 as a global pandemic (35) and coinciding with the outbreak at Smithfield Foods (37, 51). In December 2020, a second cluster of documents was published when a large spike in COVID-19 cases occurred in the United States during the winter (53). Among the 35 documents, five themes and 19 categories of mitigation strategies were identified and extracted through content analysis (Table 1). The five broad themes are employee biosafety, surveillance, vaccination, social distancing (also described a physical distancing) (6), and worker education. The first document addressing the employee biosafety theme was published in October 2018 (Fig. 1), i.e., before the pandemic has started, but it was included in this review because of its relevance to COVID-19 control. In April 2020, surveillance, social distancing, and worker education mitigation themes were first mentioned in the reviewed documents, and the vaccination theme was first mentioned in a document published in October 2020 (Fig. 1).

Overall, information provided by each agency was consistent. Regarding employee biosafety, guidelines for the food industry generally recommended that employers inspect and maintain facility heating, ventilation, and air conditioning systems (31, 47, 50), improve air filtration by installing MERV-13 filters (47, 50), increase natural ventilation (47), ensure the demand-controlled ventilation is off (31, 50), promote hand washing and install hand sanitizer dispensers (3, 7, 9, 34,

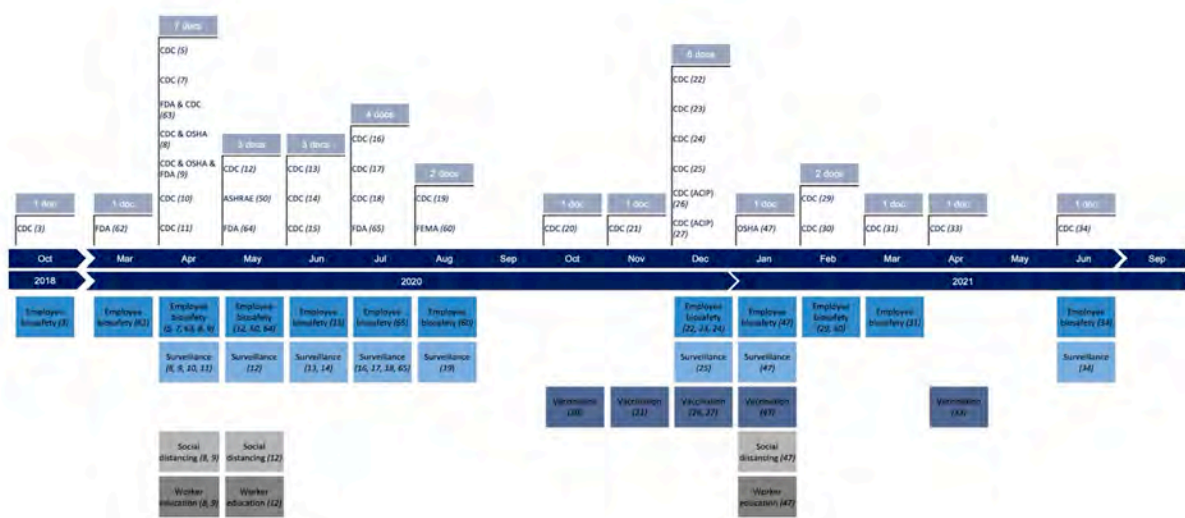


Figure 1. Timeline of the documents published by the U.S. government and one professional association about mitigation of coronavirus disease 2019 (COVID-19) relevant to U.S. food manufacturing and processing industry workers. Above the timeline axis are individual documents by their publishing entities (and reference number); below the axis are the themes of mitigation strategies extracted from all documents published in a given month (ordered by row from the most to least frequently appearing theme).

62), require a minimum of cloth mask wearing (8, 9, 15, 24, 47, 63, 64), and enhance workspace cleaning (8, 9, 12, 47). Under the surveillance theme, the agencies recommended that facility operators temperature screen workers before entry into the facility and identify individuals with a body temperature of $\geq 100.4^{\circ}\text{F}$ (38°C) (8, 9, 12, 65), implement COVID-19 screening tests at least once per week (9–13, 17, 25, 47, 65), and establish a COVID-19 coordinator and a contact tracing system (8, 9, 12, 14, 19, 65). Under the social distancing theme, the reviewed documents generally suggested that employers engineer the work environment to space workers >6 ft (1.8 m) or install physical barriers to separate workers at the production line when physical distancing cannot be maintained (8, 9, 12, 47), cohort workers and stagger their shifts and break times (8, 9), minimize workers at worksites (8, 12), and modify leave policies to ensure they are nonpunitive (8, 9, 12, 47). Under the worker education theme, agencies recommended that employers provide education and training sessions to inform employees about COVID-19 and prevention measures (8, 9, 12, 47). Under

the vaccination theme, documents provided guidance on facilitating vaccination among workers through measures such as providing transportation and offering paid leave (21, 33, 47). No contradictions were found across sources.

The frequency of each of the 19 categories of mitigation strategies in the 35 documents is depicted in *Figure 2*. The frequency of appearance can be influenced by many factors, such as but not limited to changes in the scientific understanding of SARS-CoV-2, ease and cost of implementation, or lack of compliance with certain infection controls (48, 69). Among the 19 categories, “Face mask, face shields, goggles,” “Test for infection and isolation,” and “Workplace cleaning and disinfection” were each mentioned in 13, 10, and 7 of the 35 documents, respectively, making these the top three most frequently mentioned mitigation strategies. A high frequency of appearance may make it more difficult for industry employees to keep track of the information about the mitigation strategies. Therefore, this study may provide a more organized and convenient means for readers to locate relevant documents of interest.

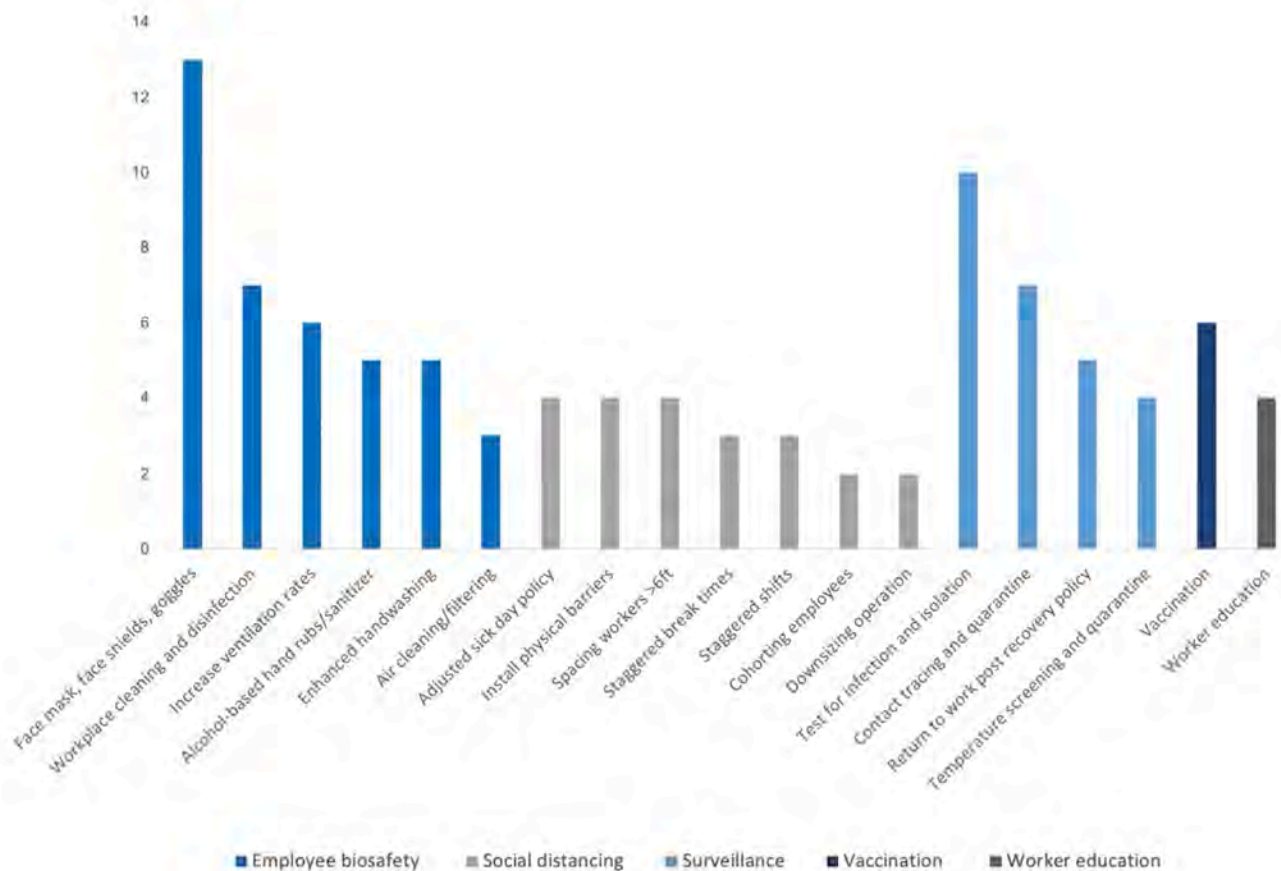


Figure 2. Frequency in the reviewed documents of 19 categories of mitigation strategies against COVID-19 in the U.S. food manufacturing and processing industry.

Multiple government institutions have issued documents relevant to the mitigation of COVID-19 among workers in the food processing industry

Since the start of COVID-19 outbreak in the United States in early March 2020, the CDC and other government institutions have acted quickly through responding and providing numerous documents containing resources or guidelines about COVID-19 mitigation to the general public and various industries. Specifically for the food processing industry, the FDA published a dedicated site for the food and agriculture sectors on 17 March 2020 (61), and the CDC and OSHA jointly published the guidance documents “Meat and Poultry Processing Workers and Employers” and “Protecting Seafood Processing Workers from COVID-19” on 26 April 2020 (8, 9).

Overall, the CDC has been at the forefront of responding to the pandemic and served two major roles in COVID-19 mitigation. First, the CDC is the main platform for providing COVID-19 information, from disease surveillance and summaries of scientific studies to mitigation strategies. This leadership is expected because the mandate of the CDC is to protect the nation from health threats (4). Thus, the CDC provides detailed resources and guidelines in all aspects of disease control (32). In addition to general mitigation strategies such as face masking (8, 9, 12, 15, 22–24, 29, 30, 34), virus testing (9–13, 16, 17, 25), vaccination (20, 21, 26, 27, 33), contact tracing (8, 9, 12, 14, 16, 19), quarantine (8, 9, 14), and temperature screening (8, 9, 12) (Table 1), the CDC has also suggested workplace-specific strategies to help combat virus spread at food processing facilities, including increased ventilation (8, 9, 12, 31), production line distancing, adjusted sick day policy, and physical barriers (8, 9, 12), and staggered break time and shifts and worker cohorting (8, 9). The CDC’s second role is to serve as a reference point for other agencies to further develop more specialized guidelines. For example, OSHA built industry-specific guidelines covering agriculture, dentistry, emergency response and public safety, food manufacturing and processing, health care, manufacturing, meat and poultry processing, postmortem care, retail, and seafood processing based upon the evidence-based documents that the CDC had developed (47). Specifically for the food processing industry, these guidelines were critically important for employers, who relied on this information to implement and incorporate the mitigation strategies into their processing facilities’ daily routine to control COVID-19 infection in the workplace.

Because numerous documents have been released by various government agencies, our organized timeline of when each relevant document was published and the themes and categories of mitigations covered can be helpful for interpreting the corresponding changes in the epidemiology of COVID-19 in the food processing industry work environment. Epidemiological research on COVID-19 in the United States, including studies involving the food processing industry, has included timing of interventions (mitigation strategies) to illustrate the relation between disease transmission and

specific interventions (51, 66, 70). In a previous study, the adoption speed of nonpharmaceutical interventions was found to be associated with lower COVID-19 infection and death rates (1). Because adoption of interventions is typically preceded by publication of guidelines by government agencies and presuming that the industry followed the guidelines, the publishing time can be used as a proxy for the intervention implementation time to study the impacts (e.g., COVID-19 relevant cases, deaths, and hospitalizations) of the various interventions recommended in these guidelines.

In addition to the intended purpose to reduce the spread of infection, some of these short-term mitigation strategies, such as workplace disinfection and ventilation improvement, can have long-term benefits for the food processing industry because they could further improve the hygiene standards at facilities and promote establishment of effective strategies that reduce contamination with foodborne pathogens during the food production process (54). Additionally, the presence of a plan developed for infectious diseases at the workplace can help food processing facilities prepare for similar pandemics in the future (43).

Overall goals were to ensure the safety of workers and maintain the food supply

Because the food and agriculture sectors were identified as critical infrastructure sectors during the COVID-19 pandemic (55), the two overarching goals of COVID-19 mitigation in the food processing industry workplace have been (i) to ensure the safety of the workers and (ii) to maintain the operation of food processing facilities as part of critical infrastructure. In one of the reviewed documents “COVID-19 Critical Infrastructure Sector Response Planning,” the CDC (12) requires critical infrastructure workers who have potentially been exposed to a person with confirmed COVID-19 but are nonclose contacts to get tested but allows them to continue working as long as they remain asymptomatic and have not tested positive. In the face of a global pandemic, it is critically important to put the health of food processing industry employees at the highest priority and to maintain facility operations to meet public needs and to keep societal order. As the National Infrastructure Simulation and Analysis Center modeled in a previous study, a severe pandemic with 25% reduction in labor can reduce food production by almost 50%, causing food shortages (42). With SARS-CoV-2, a major practice to slow the spread of infection has been social distancing at home, which would result in modified daily activities and potentially increased food demand (2). Any imbalance between demand and supply can cause food price inflation, food shortage, and consequently food insecurity if no action is taken (68). Therefore, as employers develop COVID-19 mitigation programs for their facilities, it is important to ensure the safety of the workers and maintain food processing operations to strengthen the food supply chain and avoid nationwide or, even worse, worldwide food crises.

TABLE 1. Identified documents published before 30 September 2021 by the U.S. government and one professional association on COVID-19 mitigation strategies relevant to the food manufacturing and processing industry (cont.)

Document title	Publishing date	Entity	Theme(s)	Mitigation strategies	Reference
When and how to wash your hands	4 Oct 2018	CDC	Employee biosafety	Alcohol-based hand rubs and sanitizer; enhanced hand washing	3
Safely using hand sanitizer	28 Mar 2020	FDA	Employee biosafety	Alcohol-based hand rubs, sanitizers	62
Cleaning and disinfecting your facility	3 Apr 2020	CDC	Employee biosafety	Workplace cleaning and disinfection	5
Hand sanitizer use out and about	15 Apr 2020	CDC	Employee biosafety	Alcohol-based hand rubs, sanitizers	7
Use of respirators, facemasks, and cloth face coverings in the food and agriculture sector during coronavirus disease (COVID-19) pandemic	24 Apr 2020	FDA, CDC	Employee biosafety	Face mask, face shields, goggles	63
Meat and poultry processing workers and employers	26 Apr 2020	CDC, OSHA	Employee biosafety, social distancing, surveillance, worker education	Adjusted sick day policy; cohorting employees; contact tracing and quarantine; downsizing operations; enhanced hand washing; face mask, face shields, goggles; increase ventilation rates; install physical barriers; return to work postrecovery policy; spacing workers >6 ft (1.8 m); staggered shifts; staggered break times; temperature screening and quarantine; worker education; workplace cleaning and disinfection	8
Protecting seafood processing workers from COVID-19	26 Apr 2020	CDC, OSHA, FDA	Employee biosafety, social distancing, surveillance, worker education	Adjusted sick day policy; alcohol-based hand rubs, sanitizers; cohorting employees; contact tracing and quarantine; enhanced hand washing; face mask, face shields, goggles; increase ventilation rates; install physical barriers; return to work postrecovery policy; spacing workers >6 ft; staggered shifts; staggered break times; temperature screening and quarantine; test for infection and isolation; worker education; workplace cleaning and disinfection	9
Test for current infection	28 Apr 2020	CDC	Surveillance	Test for infection and isolation	10
Test for past infection	28 Apr 2020	CDC	Surveillance	Test for infection and isolation	11
COVID-19 critical infrastructure sector response planning	6 May 2020	CDC	Employee biosafety, social distancing, surveillance, worker education	Adjusted sick day policy; contact tracing and quarantine; downsizing operation; enhanced hand washing; face mask, face shields, goggles; increase ventilation rates; install physical barriers; return to work postrecovery policy; spacing workers >6 ft; temperature screening and quarantine; test for infection and isolation; worker education; workplace cleaning and disinfection	12
Guidance for building operations during the COVID-19 pandemic	15 May 2020	ASHRAE	Employee biosafety	Air cleaning, filtering; increase ventilation rates	50

Continued on the next page.

TABLE 1. Identified documents published before 30 September 2021 by the U.S. government and one professional association on COVID-19 mitigation strategies relevant to the food manufacturing and processing industry (cont.)

Document title	Publishing date	Entity	Theme(s)	Mitigation strategies	Reference
Food and agriculture: considerations for prioritization of PPE, cloth face coverings, disinfectants, and sanitation supplies during the COVID-19 pandemic	25 May 2020	FDA	Employee biosafety	Face mask, face shields, goggles	64
Testing strategy for coronavirus (COVID-19) in high-density critical infrastructure workplaces after a COVID-19 case is identified	13 Jun 2020	CDC	Surveillance	Test for infection and isolation	13
Contact tracing	23 Jun 2020	CDC	Surveillance	Contact tracing and quarantine	14
Guidance for wearing masks	28 Jun 2020	CDC	Employee biosafety	Face mask, face shields, goggles	15
Quarantine and isolation	2 Jul 2020	CDC	Surveillance	Contact tracing and quarantine, test for infection and isolation	16
Interim guidance for SARS-CoV-2 testing in non-healthcare workplaces	3 Jul 2020	CDC	Surveillance	Test for infection and isolation	17
Ending home isolation for persons with COVID-19 not in healthcare settings	17 Jul 2020	CDC	Surveillance	Return to work postrecovery policy	18
What to do if you have a COVID-19 confirmed positive worker or workers who have been exposed to a confirmed case of COVID-19	17 Jul 2020	FDA	Employee biosafety, surveillance	Contact tracing and quarantine, return to work postrecovery policy, temperature screening and quarantine, test for infection and isolation, workplace cleaning and disinfection	65
Case investigation and contact tracing in non-healthcare workplaces: information for employers	4 Aug 2020	CDC	Surveillance	Contact tracing and quarantine	19
Addressing PPE needs in non-healthcare setting	7 Aug 2020	FEMA	Employee biosafety	Face mask, face shields, goggles	60
How CDC is making COVID-19 vaccine recommendations	14 Oct 2020	CDC	Vaccination	Vaccination	20
Workplace COVID-19 vaccine toolkit	9 Nov 2020	CDC	Vaccination	Vaccination	21
How to store and wash masks	15 Dec 2020	CDC	Employee biosafety	Face mask, face shields, goggles	22
How to wear masks	15 Dec 2020	CDC	Employee biosafety	Face mask, face shields, goggles	23
Your guide to masks	15 Dec 2020	CDC	Employee biosafety	Face mask, face shields, goggles	24
Self-testing	18 Dec 2020	CDC	Surveillance	Test for infection and isolation	25
Interim list of categories of essential workers mapped to standardized industry codes and titles	22 Dec 2020	CDC (ACIP) ^b	Vaccination	Vaccination	26
The Advisory Committee on Immunization Practices' updated interim recommendation for allocation of COVID-19 vaccine	31 Dec 2020	CDC (ACIP)	Vaccination	Vaccination	27

Continued on the next page.

TABLE 1. Identified documents published before 30 September 2021 by the U.S. government and one professional association on COVID-19 mitigation strategies relevant to the food manufacturing and processing industry (cont.)

Document title	Publishing date	Entity	Theme(s)	Mitigation strategies	Reference
Protecting workers: guidance on mitigating and preventing the spread of COVID-19 in the workplace	29 Jan 2021	OSHA	Employee biosafety, social distancing, surveillance, vaccination, worker education	Adjusted sick day policy; air cleaning, filtering; face mask, face shields, goggles; increase ventilation rates; install physical barriers; spacing workers >6 ft; staggered shifts; staggered break times; test for infection and isolation; vaccination; worker education; workplace cleaning and disinfection	47
Improve how your mask protects you	10 Feb 2021	CDC	Employee biosafety	Face mask, face shields, goggles	29
Types of masks	10 Feb 2021	CDC	Employee biosafety	Face mask, face shields, goggles	30
Ventilation in buildings	23 Mar 2021	CDC	Employee biosafety	Increase ventilation rates	31
Post-vaccination considerations for workplaces	5 Apr 2021	CDC	Vaccination	Vaccination	33
Hand hygiene at work	3 Jun 2021	CDC	Employee biosafety, surveillance	Alcohol-based hand rubs, sanitizers; enhanced hand washing; workplace cleaning and disinfection	34

^aThis document was identified and accessed during the study's document collection period (1 June to 30 September 2021) under the CDC's COVID-19 Web page. Retrieval of its original publishing date revealed that the Web page was originally published in 2018. However, it was included in this review because the Web page contained information relevant to our study topic of COVID-19 mitigation.

^bACIP, Advisory Committee on Immunization Practices.

Study limitation

Documents identified in this review were limited to the period before October 2021. Consistent with the practice for rapid reviews (40), we focused on a specific segment of the food industry and adapted the search methodology to enable a rapid review process. Specifically, we thoroughly searched the CDC, OSHA, and FDA websites for relevant food manufacturing and processing industry COVID-19 information because we presumed that these three government agencies would be the most prominent authorities relied upon for guidance during the pandemic in the United States. The preliminary review also included the USDA website because the USDA is the primary regulatory agency for meat and poultry processing industries. However, the identified USDA documents were in the form of FAQs or were directed to USDA employees and thus did not meet the review inclusion criteria. Because the search methodology was not intended to provide an exhaustive review of all documents concerning COVID-19 mitigation published on the Internet, relevant documents published by other government agencies and corresponding additional mitigation strategies might have been missed. To address this limitation, we expanded the search process with snowballing, which revealed a few additional documents,

in an effort to reduce the potential bias associated with the search methodology. Although the information synthesized in this review is expected to be useful to researchers who study the epidemiology of COVID-19 by aiding interpretation of the potential timing of implementation of mitigation strategies, the synthesized information alone does not allow tracking the impact of recommendations on the epidemiology of the disease, which would require longitudinal field investigation tracking that impact and could be the subject of future research.

CONCLUSION

This article provides a summary of the common types of COVID-19 mitigation strategies that have been recommended for implementation in the U.S. food manufacturing and processing industry. The documents collected in this review indicate that the government was able to respond to the pandemic within a couple of weeks by providing evidence-based resources and guidelines for the industry. "Face mask, face shields, goggles," "Test for infection and isolation," and "Workplace cleaning and disinfection" were the three most frequently mentioned mitigation strategies of relevance to the food processing industry.

The summarized timeline of published documents can serve as a useful resource for public health researchers studying the implications of the implementation of various mitigation strategies in the food processing industry workplace and for food processing facilities for developing their COVID-19 management policies. During a pandemic, food processing facilities must protect their workers' health and safety and maintain operations to ensure an uninterrupted food supply chain and food security. Thus, facility management must make both engineering and policy changes to help adjust to the situation. These changes can have positive long-term impacts on the food processing industry and prepare food processing facilities for similar situations in the future.

ACKNOWLEDGMENTS

This study was funded by the USDA, National Institute of Food and Agriculture award 2020-68006-32875 to R.I. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript. The authors thank Brianna Dumas (Health Scientist, National Center for Chronic Disease Prevention and Health Promotion, CDC), Capt. John D. Gibbins (Team Lead, National Institute for Occupational Safety and Health, CDC), Cdr. Adam Kramer (Environmental Health Officer, National Center for Environmental Health, CDC), and Arthur P. Liang (Special Advisor on Food Industry Relations, National Center for Emerging and Zoonotic Infectious Diseases, CDC) for providing helpful comments on the manuscript.

REFERENCES

- Amuedo-Dorantes, C., N. Kaushal, and A. N. Muchow. 2021. Timing of social distancing policies and COVID-19 mortality: county-level evidence from the U.S. *J. Popul. Econ.* 34:1445–1472.
- Barman, A., R. Das, and P. De. 2021. Impact of COVID-19 in food supply chain: disruptions and recovery strategy. *Curr. Res. Behav. Sci.* 2:100017.
- Centers for Disease Control and Prevention. 2018. When and how to wash your hands. Available at: <https://www.cdc.gov/handwashing/when-how-handwashing.html>. Accessed 6 June 2021.
- Centers for Disease Control and Prevention. 2019. Mission, role and pledge. Available at: <https://www.cdc.gov/about/organization/mission.htm>. Accessed 28 January 2022.
- Centers for Disease Control and Prevention. 2020. Cleaning and disinfecting your facility. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/community/disinfecting-building-facility.html>. Accessed 17 August 2021.
- Centers for Disease Control and Prevention. 2020. Tribal community life during COVID-19. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/community/tribal/social-distancing.html>. Accessed 28 January 2022.
- Centers for Disease Control and Prevention. 2020. Hand sanitizer use out and about. Available at: <https://www.cdc.gov/handwashing/hand-sanitizer-use.html>. Accessed 6 June 2021.
- Centers for Disease Control and Prevention. 2020. Meat and poultry processing workers and employers. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/community/organizations/meat-poultry-processing-workers-employers.html>. Accessed 1 June 2021.
- Centers for Disease Control and Prevention. 2020. Protecting seafood processing workers from COVID-19. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/community/guidance-seafood-processing.html>. Accessed 16 September 2021.
- Centers for Disease Control and Prevention. 2020. Test for current infection. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/testing/diagnostic-testing.html>. Accessed 28 July 2021.
- Centers for Disease Control and Prevention. 2020. Test for past infection. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/testing/serology-overview.html>. Accessed 28 July 2021.
- Centers for Disease Control and Prevention. 2020. COVID-19 critical infrastructure sector response planning. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/community/critical-infrastructure-sectors.html>. Accessed 5 June 2021.
- Centers for Disease Control and Prevention. 2020. Testing strategy for coronavirus (COVID-19) in high-density critical infrastructure workplaces after a COVID-19 case is identified. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/community/worker-safety-support/hd-testing.html>. Accessed 23 August 2021.
- Centers for Disease Control and Prevention. 2020. Contact tracing. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/daily-life-coping/contact-tracing.html>. Accessed 7 August 2021.
- Centers for Disease Control and Prevention. 2020. Guidance for wearing masks. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/cloth-face-cover-guidance.html>. Accessed 8 June 2021.
- Centers for Disease Control and Prevention. 2020. Quarantine and isolation. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/if-you-are-sick/isolation.html>. Accessed 7 August 2021.
- Centers for Disease Control and Prevention. 2020. Interim guidance for SARS-CoV-2 testing in non-healthcare workplaces. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/community/organizations/testing-non-healthcare-workplaces.html>. Accessed 4 June 2021.
- Centers for Disease Control and Prevention. 2020. Ending home isolation for persons with COVID-19 not in healthcare settings. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/hcp/disposition-in-home-patients.html>. Accessed 7 August 2021.
- Centers for Disease Control and Prevention. 2020. Case investigation and contact tracing in non-healthcare workplaces: information for employers. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/community/contact-tracing-nonhealthcare-workplaces.html>. Accessed 7 August 2021.
- Centers for Disease Control and Prevention. 2020. How CDC is making COVID-19 vaccine recommendations. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/vaccines/recommendations-process.html>. Accessed 18 July 2021.
- Centers for Disease Control and Prevention. 2020. Workplace COVID-19 vaccine toolkit. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/vaccines/toolkits/essential-workers.html>. Accessed 18 July 2021.
- Centers for Disease Control and Prevention. 2020. How to store and wash masks. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/how-to-wash-cloth-face-coverings.html>. Accessed 8 June 2021.

23. Centers for Disease Control and Prevention. 2020. How to wear masks. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/how-to-wear-cloth-face-coverings.html>. Accessed 8 June 2021.
24. Centers for Disease Control and Prevention. 2020. Your guide to masks. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/about-face-coverings.html>. Accessed 8 June 2021.
25. Centers for Disease Control and Prevention. 2020. Self-testing. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/testing/self-testing.html>. Accessed 23 August 2021.
26. Centers for Disease Control and Prevention. 2020. Interim list of categories of essential workers mapped to standardized industry codes and titles. Available at: <https://www.cdc.gov/vaccines/covid-19/categories-essential-workers.html>. Accessed 28 June 2021.
27. Centers for Disease Control and Prevention. 2020. The Advisory Committee on Immunization Practices' updated interim recommendation for allocation of COVID-19 vaccine. Available at: https://www.cdc.gov/mmwr/volumes/69/wr/mm695152e2.htm?cid=mm695152e2_w. Accessed 28 June 2021.
28. Centers for Disease Control and Prevention. 2021. Coronavirus disease 2019 (COVID-19). Available at: <https://www.cdc.gov/coronavirus/2019-nCoV/index.html>. Accessed 1 June 2021.
29. Centers for Disease Control and Prevention. 2021. Improve how your mask protects you. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/your-health/effective-masks.html>. Accessed 8 June 2021.
30. Centers for Disease Control and Prevention. 2021. Types of masks. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/types-of-masks.html>. Accessed 8 June 2021.
31. Centers for Disease Control and Prevention. 2021. Ventilation in buildings. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html>. Accessed 15 July 2021.
32. Centers for Disease Control and Prevention. 2021. CDC public health science agenda for COVID-19. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/science/science-agenda-covid19.html>. Accessed 16 January 2022.
33. Centers for Disease Control and Prevention. 2021. Post-vaccination considerations for workplaces. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/community/workplaces-businesses/vaccination-considerations-for-workplaces.html>. Accessed 16 September 2021.
34. Centers for Disease Control and Prevention. 2021. Hand hygiene at work. Available at: <https://www.cdc.gov/handwashing/handwashing-corporate.html>. Accessed 6 June 2021.
35. Cucinotta, D., and M. Vanelli. 2020. WHO declares COVID-19 a pandemic. *Acta Biomed.* 91:157–160.
36. Douglas, L. 2020. Mapping Covid-19 outbreaks in the food system. Available at: <https://thefern.org/2020/04/mapping-covid-19-in-meat-and-food-processing-plants/>. Accessed 20 December 2021.
37. Dyal, J. W., M. P. Grant, K. Broadwater, A. Bjork, M. A. Waltenburg, J. D. Gibbins, C. Hale, M. Silver, M. Fischer, J. Steinberg, C. A. Basler, J. R. Jacobs, E. D. Kennedy, S. Tomasi, D. Trout, J. Hornsby-Myers, N. L. Oussayef, L. J. Delaney, K. Patel, V. Shetty, K. E. Kline, B. Schroeder, R. K. Herlihy, J. House, R. Jarvis, J. L. Clayton, D. Ortbahn, C. Austin, E. Berl, Z. Moore, B. F. Buss, D. Stover, R. Westergaard, I. Pray, M. DeBolt, A. Person, J. Gabel, T. S. Kittle, P. Hendren, C. Rhea, C. Holsinger, J. Dunn, G. Turabelidze, F. S. Ahmed, S. deFijter, C. S. Pedati, K. Rattay, E. E. Smith, C. Luna-Pinto, L. A. Cooley, S. Saydah, N. D. Precely, R. A. Maddox, E. Lundeen, B. Goodwin, S. E. Karpathy, S. Griffing, M. M. Jenkins, G. Lowry, R. D. Schwarz, J. Yoder, G. Peacock, H. T. Walke, Dale A. Rose, and M. A. Honein. 2020. COVID-19 among workers in meat and poultry processing facilities—19 states, April 2020. *Morb. Mortal. Wkly. Rep.* 69:557–561.
38. Food Dive. 2020. Tracking coronavirus closures at food and beverage factories. Available at: <https://www.fooddive.com/news/tracking-coronavirus-closures-at-food-and-beverage-factories/576559/>. Accessed 20 December 2021.
39. Grant, M., C. Basler, J. Jacobs, E. Kennedy, J. Osburn, J. Steinberg, and S. Tomasi. 2020. Memorandum: strategies to reduce COVID-19 transmission at the Smithfield Foods Sioux Falls pork plant. 22 April. Available at: https://covid.sd.gov/docs/smithfield_recs.pdf. Accessed 14 February 2022.
40. Grant, M. J., and A. Booth. 2009. A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Info. Libr. J.* 2:91–108.
41. Hashem, N. M., A. González-Bulnes, and A. J. Rodriguez-Morales. 2020. Animal welfare and livestock supply chain sustainability under the COVID-19 outbreak: an overview. *Front. Vet. Sci.* 7:582528.
42. Huff, A. G., W. E. Beyeler, N. S. Kelley, and J. A. McNitt. 2015. How resilient is the United States food system to pandemics? *J. Environ. Stud. Sci.* 5:337–347.
43. Llanos-Soto, S., E. Bulut, S. I. Murphy, C. J. Henry, C. Zoellner, M. Wiedmann, D. Wetherington, A. Adalja, S. D. Alcaine, and R. Ivanek. 2021. Ongoing mitigation strategies and further needs of the United States food industry to control COVID-19 in the work environment. medRxiv. [Preprint.] Available at: <https://doi.org/10.1101/2021.08.06.21261702>. Accessed 1 September 2021.
44. Marchant-Forde, J. N., and L. A. Boyle. 2020. COVID-19 effects on livestock production: a One Welfare issue. *Front. Vet. Sci.* 7:585787.
45. Nakat, Z., and C. Bou-Mitri. 2021. COVID-19 and the food industry: readiness assessment. *Food Control* 121:107661.
46. Occupational Safety and Health Administration. 2020. Coronavirus disease (COVID-19). Available at: <https://www.osha.gov/coronavirus>. Accessed 1 June 2021.
47. Occupational Safety and Health Administration. 2021. Protecting workers: guidance on mitigating and preventing the spread of COVID-19 in the workplace. Available at: <https://www.osha.gov/coronavirus/safework>. Accessed 1 June 2021.
48. Petherick, A., R. Goldszmidt, E. B. Andrade, R. Furst, T. Hale, A. Pott, and A. Wood. 2021. A worldwide assessment of changes in adherence to COVID-19 protective behaviours and hypothesized pandemic fatigue. *Nat. Hum. Behav.* 5:1145–1160.
49. SalahEldeen, H. M., and M. L. Nelson. 2013. Carbon dating the Web: estimating the age of Web resources, p. 1075–1082. In D. Schwabe, V. Almeida, and H. Glaser (chairs), WWW'13 Companion: Proceedings of the 22nd International Conference on World Wide Web. Association for Computing Machinery, New York.
50. Schown, L. J. 2020. Guidance for building operations during the COVID-19 pandemic. ASHRAE J. Available at: https://www.ashrae.org/file%20library/technical%20resources/ashrae%20journal/2020journaldocuments/72-74_ieq_schoen.pdf. Accessed 15 July 2021.
51. Steinberg, J., E. D. Kennedy, C. Basler, M. P. Grant, J. R. Jacobs, D. Ortbahn, J. Osburn, S. Saydah, S. Tomasi, and J. L. Clayton. 2020. COVID-19 outbreak among employees at a meat processing facility—South Dakota, March–April 2020. *Morb. Mortal. Wkly. Rep.* 69:1015–1019.
52. Taylor, C., and T. Boylls. 2021. How to find the publication date of a Website. Available at: <https://www.wikihow.com/Find-the-Publication-Date-of-a-Website>. Accessed 28 June 2021.
53. The New York Times. 2020. Coronavirus in the U.S.: latest map and case count. Available at: <https://www.nytimes.com/interactive/2021/us/covid-cases.html>. Accessed 28 January 2022.
54. Trmčić, A., E. Demmings, K. Kniel, M. Wiedmann, and S. Alcaine. 2021. Food safety and employee health implications of COVID-19: a review. *J. Food Prot.* 84:1973–1989.

55. U.S. Cybersecurity and Infrastructure Security Agency. 2020. Identifying critical infrastructure during COVID-19. Available at: <https://www.cisa.gov/identifying-critical-infrastructure-during-covid-19>. Accessed 20 December 2021.
56. U.S. Department of Agriculture. 2012. Food inspector. Available at: <https://www.fsis.usda.gov/careers/job-opportunities/career-profiles/food-inspector>. Accessed 23 June 2022.
57. U.S. Department of Agriculture. 2020. Coronavirus disease (COVID-19). Available at: <https://www.usda.gov/coronavirus>. Accessed 23 June 2022.
58. U.S. Department of Agriculture. 2021. USDA COVID-19 workplace safety plan. Available at: <https://www.usda.gov/sites/default/files/documents/usda-covid-19-workplace-safety-plan.pdf>. Accessed 2 September 2021.
59. U.S. Department of Agriculture. 2021. Frequently asked questions (FAQs) on USDA's response to COVID-19 workplace safety. Available at: <https://www.usda.gov/sites/default/files/documents/usda-future-work-faqs.pdf>. Accessed 23 June 2022.
60. U.S. Federal Emergency Management Agency. 2020. Addressing PPE needs in non-healthcare setting. Available at: <https://www.fema.gov/fact-sheet/addressing-ppe-needs-non-healthcare-setting>. Accessed 13 August 2021.
61. U.S. Food and Drug Administration. 2020. Food safety and the coronavirus disease 2019 (COVID-19). Available at: <https://www.fda.gov/food/food-safety-during-emergencies/food-safety-and-coronavirus-disease-2019-covid-19>. Accessed 1 June 2021.
62. U.S. Food and Drug Administration. 2020. Safely using hand sanitizer. Available at: <https://www.fda.gov/consumers/consumer-updates/safely-using-hand-sanitizer>. Accessed 6 June 2021.
63. U.S. Food and Drug Administration. 2020. Use of respirators, facemasks, and cloth face coverings in the food and agriculture sector during coronavirus disease (COVID-19) pandemic. Available at: <https://www.fda.gov/food/food-safety-during-emergencies/use-respirators-facemasks-and-cloth-face-coverings-food-and-agriculture-sector-during-coronavirus>. Accessed 2 July 2021.
64. U.S. Food and Drug Administration. 2020. Food and agriculture: considerations for prioritization of PPE, cloth face coverings, disinfectants, and sanitation supplies during the COVID-19 pandemic. Available at: <https://www.fda.gov/food/food-safety-during-emergencies/food-and-agriculture-considerations-prioritization-ppe-cloth-face-coverings-disinfectants-and>. Accessed 2 July 2021.
65. U.S. Food and Drug Administration. 2020. What to do if you have a COVID-19 confirmed positive worker or workers who have been exposed to a confirmed case of COVID-19. Available at: <https://www.fda.gov/food/food-safety-during-emergencies/what-do-if-you-have-covid-19-confirmed-positive-worker-or-workers-who-have-been-exposed-confirmed>. Accessed 7 August 2021.
66. Wang, X., E. G. Ferro, G. Zhou, D. Hashimoto, and D.L. Bhatt. 2020. Association between universal masking in a health care system and SARS-CoV-2 positivity among health care workers. *JAMA* 324:703–704.
67. Welfens, P. J. J. 2020. Macroeconomic and health care aspects of the coronavirus epidemic: EU, US and global perspectives. *Int. Econ. Econ. Policy* 17:295–362.
68. World Bank Group. 2022. Food security and Covid-19. Available at: <https://www.worldbank.org/en/topic/agriculture/brief/food-security-and-covid-19>. Accessed 2 February 2022.
69. Wright, L., A. Steptoe, H. W. Mak, and D. Fancourt. 2022. Do people reduce compliance with COVID-19 guidelines following vaccination? A longitudinal analysis of matched UK adults. *J. Epidemiol. Community Health* 76:109–115.
70. Zachariah, P., C. L. Johnson, K. C. Halabi, D. Ahn, A. I. Sen, A. Fischer, S. L. Banker, M. Giordano, C. S. Manice, R. Diamond, T. B. Sewell, A. J. Schweickert, J. R. Babineau, R. C. Carter, D. B. Fenster, J. S. Orange, T. A. McCann, S. G. Kernie, and L. Saiman. 2020. Epidemiology, clinical features, and disease severity in patients with coronavirus disease 2019 (COVID-19) in a children's hospital in New York City, New York. *JAMA Pediatr.* 174(10):e202430.

SUPPLEMENTAL MATERIAL

TABLE S1. Definitions of themes and categories of COVID-19 mitigation strategies considered in the content analysis

No.	Theme	Category	Definition ^a
1	Employee biosafety	Air cleaning, filtering	Destroying or removing hazards such as viral particles from air
2	Employee biosafety	Alcohol-based hand rubs, sanitizers	Implementation of a set of instructions for employees about when and how to use alcohol-based hand rubs and sanitizers
3	Employee biosafety	Enhanced hand washing	Implementation of a set of instructions for employees about when and how to wash hands that go above and beyond instructions that were in place before COVID-19
4	Employee biosafety	Face mask, face shields, goggles	Implementation of a set of instructions about how and when to use face masks, face shields, and goggles
5	Employee biosafety	Increase ventilation rates	Increase in the rate at which external air (fresh air) flows into the building
6	Employee biosafety	Workplace cleaning and disinfection	Instructions on how to clean and disinfect the facilities as a daily routine or when there are workers diagnosed with COVID-19
7	Social distancing	Adjusted sick day policy	Employee benefits include a paid sick leave granted when an employee is unable to work because the employee is quarantined or isolated due to COVID-19, because of a bona fide need to care for an individual subject to quarantine or isolation, or to care for a child (<18 years of age) whose school or childcare provider is closed or unavailable for reasons related to COVID-19
8	Social distancing	Cohorting employees	Establishing groups of employees based on their risk of infection in the company, where each cohort remains as separated from the other cohorts as possible
9	Social distancing	Downsizing operation	Reduction of a facility's production capacity accompanied by a reduction in the number of employees
10	Social distancing	Install physical barriers	Clear plastic partitions preventing employees from getting too close and preventing particles or droplets exhaled by one person from entering the breathing zone of another
11	Social distancing	Spacing workers >6 ft	Keeping a space at least 6 ft between employees
12	Social distancing	Staggered shifts	Groups of employees have a set number of hours to work during the day, but they have different start and finish times
13	Social distancing	Staggered break times	Groups of employees have different break times

Continued on the next page.

TABLE S1. Definitions of themes and categories of COVID-19 mitigation strategies considered in the content analysis (cont.)

No.	Theme	Category	Definition ^a
14	Surveillance	Contact tracing and quarantine	Contact tracing to identify individuals who may have been exposed to a person with COVID-19; quarantine to separate individuals who have had close contact with someone with COVID-19 to determine whether they develop symptoms or test positive for the disease
15	Surveillance	Return to work postrecovery policy	Any strategy implemented for employees returning to work following a COVID-19 case based on symptoms or a doctor's recommendation
16	Surveillance	Temperature screening and quarantine	Screen for employees with temperature >99.5°F (or other cutoff value) and keep identified employees away from workplace to determine whether they develop COVID-19 symptoms or test positive for the disease
17	Surveillance	Test for infection and isolation	Test employees for COVID-19 (virus test); isolation keeps an employee who is sick with COVID-19 or tested positive for COVID-19 without symptoms away from workplace
18	Vaccination	Vaccination	Any recommendation regarding vaccination of employees against COVID-19
19	Worker education	Worker education	Employers educate and train workers and supervisors about how they can reduce the spread of COVID-19

^aDefinitions of mitigation categories were adapted from those of Llanos-Soto et al. (43).