SPECIAL REPORT

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Foodborne Illness Surveillance: A Model for COVID-19 and Other Future Pandemics?

Jim Hartman, MS, REHS

Abstract **Foodborne illness and COVID-19 have obvious differences, but they also have marked similarities. Both conditions cause significant morbidity and mortality and long-term consequences that often are underappreciated by the public and even by public health professionals. Surveillance for both COVID-19 and foodborne illness have passive population-based platforms that have some value but also some problems. The Foodborne Diseases Active Surveillance Network (FoodNet) could be a model for surveillance of COVID-19 (and for other future pandemics) and for refining control strategies. Some activities are more dangerous than others for SARS-CoV-2 transmission, and although contact tracing could shed light on these risks, local health departments in the U.S. have been too overwhelmed to take advantage of the opportunity. Both foodborne illness and COVID-19 could potentially be better controlled through the application of predictive models based on active surveillance.**

Keywords: foodborne illness surveillance, public health surveillance, foodborne outbreaks, COVID-19, pandemics

Impacts

Impact of Foodborne Disease

Surveillance for foodborne disease outbreaks, including enteric illness outbreaks, has been a core function of the Centers for Disease Control and Prevention (CDC) since the 1970s (Wikswo et al., 2022). Moreover, Mead et al. (1999) estimates that foodborne diseases cause approximately 76 million illnesses, 325,000 hospitalizations, and 5,000 deaths in the U.S. each year. One of their data sources was the Cleveland Study (Dingle et al., 1964), which followed 86 families through several years to track gastrointestinal and respiratory diseases. As an example of the methods used by Mead et al. (1999), they used published reports that state only 1 in 38 cases of *Salmonella* is reported because the ill person does not seek medical care, a specimen is not collected for testing, the laboratory does not perform the necessary test, or the result is not reported to the authorities. Their estimates include attribution of 25% of foodborne illnesses to unknown pathogens, which would not be included in the National Outbreak Reporting System as described by Wikswo et al. (2022).

Chronic sequelae

Archer and Kvenberg (1985) reviewed reports of rheumatoid, nutritional, and miscellaneous conditions associated with enteric conditions. Seronegative spondyloarthropathies (a group of inflammatory rheumatic diseases that include reactive arthritis) follow 2–3% of *Salmonella*, *Campylobacter jejuni*, and *Shigella* infections. *Yersinia enterocolitica* serotype O:3 is thought to be the major cause of chronic joint disease in Belgium. Malabsorption problems arise in 2–3% of pediatric acute gastroenteritis patients. Hemolytic uremic syndrome follows 4% of shigellosis cases, sometimes from *E. coli* O157:H7 infections, and infection by potentially any enteric pathogen.

Impact of COVID-19

As of May 2022, COVID-19 had killed 1 million people in the U.S., more than all the U.S. combat deaths in both World Wars, the Korean War, and the Vietnam War (Washington Post Editorial Board, 2022). Life expectancy at birth decreased by almost 1 year in 2021 for the second consecutive year in the U.S., according to CDC provisional data. The last decrease of this size was in the 1940s. One half of the decrease was attributed to COVID-19 (Stobbe, 2022). Drug overdoses, heart disease, suicide, and chronic liver disease also contributed to the decline. Worldwide, "statistical analyses suggest … that in 2021, COVID-19 overtook coronary heart disease to become the world's leading cause of death. This conclusion comes not from official COVID-19 records, but from estimates of excess mortality: that is, deaths that exceed the levels that are expected" ("Missing Data," 2022).

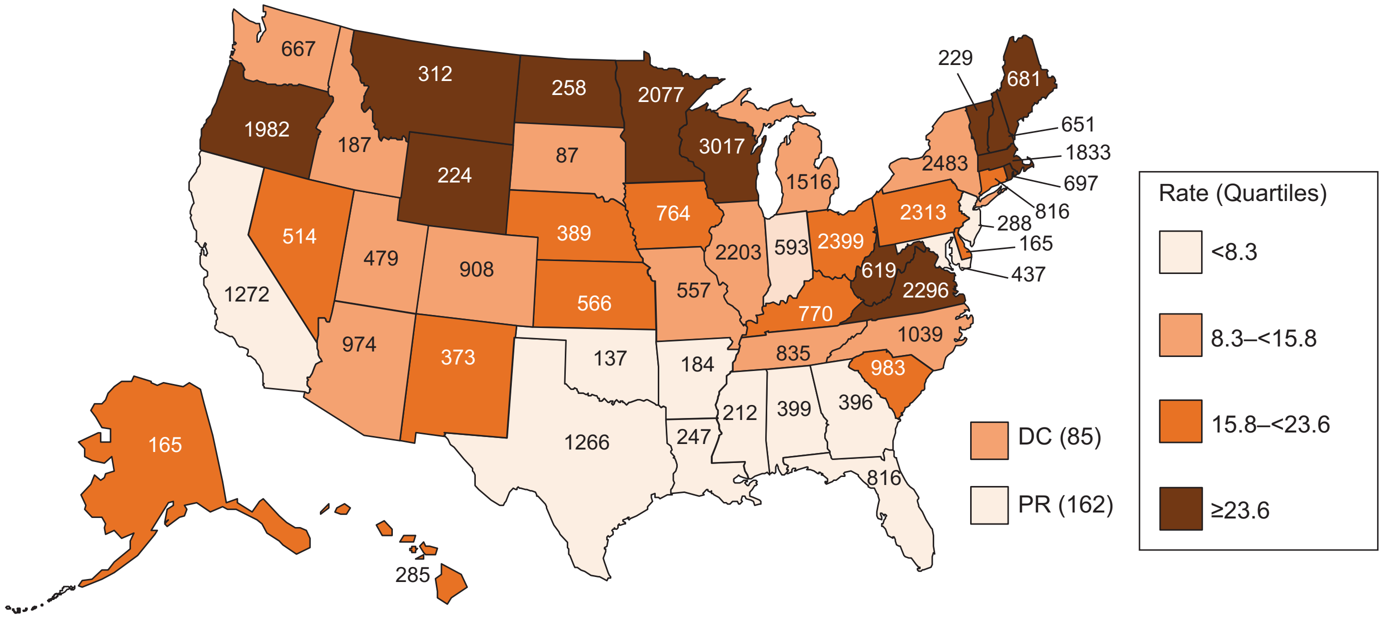
Long COVID

Long COVID—a condition in which people experience symptoms months after an acute SARS-CoV-2 infection seems to have resolved—has been perplexing partly because there are no universally recognized definitions or diagnostic criteria for long COVID, and study designs have been inconsistent (Ledford, 2022). Its prevalence is often reported vaguely as between 15% and

 https://doi.org/10.70387/001c.144000

FIGURE **1**

Rate and Number of Enteric Illness Outbreaks by State, 2009–2019 (*N* = 38,395)



Source: Wikswo et al., 2022.
Note. DC = District of Columbia; PR = Puerto Rico.

50% of unvaccinated COVID-19 cases. Epidemiologist Ziyad Al-Aly has noted, "The public does not react very well to saying 'between 15% and 50%'" (Ledford, 2022).

Misconceptions

Misconceptions About Foodborne Disease

The most widespread misconception about foodborne disease is reflected in the term "food poisoning," which many people use. This term leads to the common misconception that the last meal consumed was the one that caused the illness, leading to erroneous conclusions about the incubation period and implicated food. According to FINDER (Foodborne IllNess DEtector in Real time), a project developed by Google and the Harvard T.H. Chan School of Public Health (Hartman, 2020a; Sadilek et al., 2018), the restaurant most likely to have caused a person's illness was the one they visited most recently only 62% of the time, and furthermore,19.4% of the time it was the second most recently visited, 11.5% of the time it was the third most recently visited, and 7.2% of the time it was the fourth or an even earlier restaurant.

Some misconceptions of foodborne illness on the part of public health professionals appear to show up in the attention given to foodborne disease in different states in the U.S. According to Figure 1 from CDC's population-based National Outbreak Reporting System (NORS), the reported number of outbreaks per million population varies widely, with the highest reporting rate being more than 20 times higher than the lowest reporting rate (Wikswo et al., 2022). Wikswo et al. (2022) attribute much of the difference to the expansion of the surveillance program to include person-to-person spread in 2009. The public, however, has a role to play in reporting their illnesses, such as seeking medical care and providing a stool specimen, which could lead to more accurate reporting of foodborne illness numbers.

Charles Bartleson, then of the Washington State Department of Social and Health Services, reported to the 1986 Conference for Food Protection that possibly because of "untrained or poorly qualified staff" or "lack of concern," some states report foodborne outbreaks at 1/200th the rate of other states (Bartleson, 1987). To provide guidance for environmental public health staff, Torok et al. (2022) published recommendations for training on how to detect, investigate, and respond to foodborne illness outbreaks.

Misconceptions About COVID-19

It is important to acknowledge that there were people across the world who believed the pandemic was a hoax. An article in *HuffPost* discussed "what makes COVID-19 pandemic myths so easy to trust, and who is more likely to believe them" (Ries Wexler, 2020). A *Business Insider* article proclaimed, "Recent study indicated that nearly one third of Americans believe in a conspiracy theory about the coronavirus, such as one that claims the outbreak is linked to 5G internet" (Guzewich, 2020). There is some evidence that political division and partisanship in the U.S., combined with social isolation during the pandemic, set the stage for conspiracy theories about COVID-19 to take root (Allen, 2021).

Another popular but baseless theory is that doctors and hospitals were exaggerating deaths due to COVID-19 for profit (Fichera, 2020). Even setting aside conspiracy theories, disagreements abound regarding COVID-19 death rates. Physician Dr. Leana Wen, for example, suggested that death certificates might be exaggerating COVID deaths (Wen, 2023). Whereas epidemiologist Dr. Michael Osterholm (2023) commented:

> The idea that someone is already going to die due to an underlying condition is flawed. We are all human and we're all going to die someday. With that line of reasoning, one could argue that the only valid underlying cause of death to list on a death certificate would be birth. If COVID-19 truly played no role, that would not have been included in the death certificate.

In other words, as William Shakespeare put it in *Sonnet 60*:

> Like as the waves make towards the pebbled shore,
> So do our minutes hasten to their end;
> Each changing place with that which goes before,
> In sequent toil all forwards do contend.

Surveillance

Public health surveillance systems can be passive or active. Passive surveillance refers to data generated without solicitation, intervention, or contact, whereas active surveillance requires some sort of regular outreach by the agency (Mausner & Kramer, 1985).

Foodborne Illness Surveillance

Passive Surveillance

CDC has been conducting population-based surveillance for foodborne and waterborne diseases since the 1970s; more specifically, CDC uses NORS to captures data on foodborne, waterborne, and enteric illness outbreaks in the U.S. (Wikswo et al., 2022). State, local, and territorial public health agencies report outbreaks voluntarily. In stark contrast to the estimates by Mead et al. (1999) and Archer and Kvenberg (1985), NORS received a median of 100,563 illness reports per year between 2009 and 2019. NORS was expanded in 2009 to include person-to-person spread and other modes of transmission. Now 62% of reported outbreaks have been attributed to person-to-person spread and 24% to foodborne transmission. *E. coli* outbreaks have the highest case fatality and hospitalization rates, but the highest absolute number of deaths and hospitalizations are caused by norovirus because it causes more outbreaks.

Active Surveillance

The CDC, Food and Drug Administration (FDA), U.S. Department of Agriculture's Food Safety and Inspection Service (USDA FSIS), and 10 state health departments established in July 1995 the Foodborne Diseases Active Surveillance Network (FoodNet), an active, population-based sentinel surveillance system to track trends for infections commonly transmitted through food (Centers for Disease Control and Prevention [CDC], 2024). Its surveillance area eventually included 50 million people, which is 15% of the U.S. population.

Features of FoodNet include:

- Contacting clinical laboratories regularly to report out findings and to ascertain what percentage of laboratories are testing for each enteric pathogen.
- Contacting physicians to understand practices regarding the diagnosis of acute diarrheal diseases.
- Conducting population surveys, including random digit dialing and address-based sampling.

FoodNet also publishes an online toolbox to let users search and download data and see results displayed on interactive graphs, maps, and charts (www.cdc.gov/FoodNetFast).

Surveillance for COVID-19 and Other Viral Respiratory Diseases

Currently, surveillance for COVID-19 is all or almost all passive. Individual at-home test results are rarely reported to authorities or governing agencies.

Recommended Consolidation

Six former advisers to former President Joe Biden provided an opinion on a National Public Radio (NPR) program (Mosley & McMahon, 2022) about what it would take to make the pandemic manageable and to "create a new normal." NPR cited three articles the former advisers published in *JAMA* (Borio et al., 2022; Emanuel et al., 2022; Michaels et al., 2022).

Emanuel et al. (2022) stated:

> The "new normal" requires recognizing that SARS-CoV-2 is but one of several circulating respiratory viruses that include influenza, respiratory syncytial virus (RSV), and more. COVID-19 must now be considered among the risks posed by all respiratory viral illnesses combined. Many of the measures to reduce transmission of SARS-CoV-2 (e.g., ventilation) will also reduce transmission of other respiratory viruses. Thus, policy makers should retire previous public health categorizations, including deaths from pneumonia and influenza or pneumonia, influenza, and COVID-19, and focus on a new category: the aggregate risk of all respiratory virus infections.

Flu Estimates With a "Multiplier"

The Influenza Hospitalization Surveillance Network (FluSurv-NET) is a population-based surveillance system that collects data on laboratory-confirmed influenza-associated hospitalizations among children and adults through a network of acute care hospitals in 14 states (CDC, 2023). According to CDC (2021):

> First, national rates of flu-related hospitalizations and in-hospital death were adjusted for the frequency of flu testing and the sensitivity of flu diagnostic assays, using a multiplier approach. However, flu testing practices at sites that contribute to our FluSurv-NET surveillance system may not be representative of flu testing practices for the entire United States.

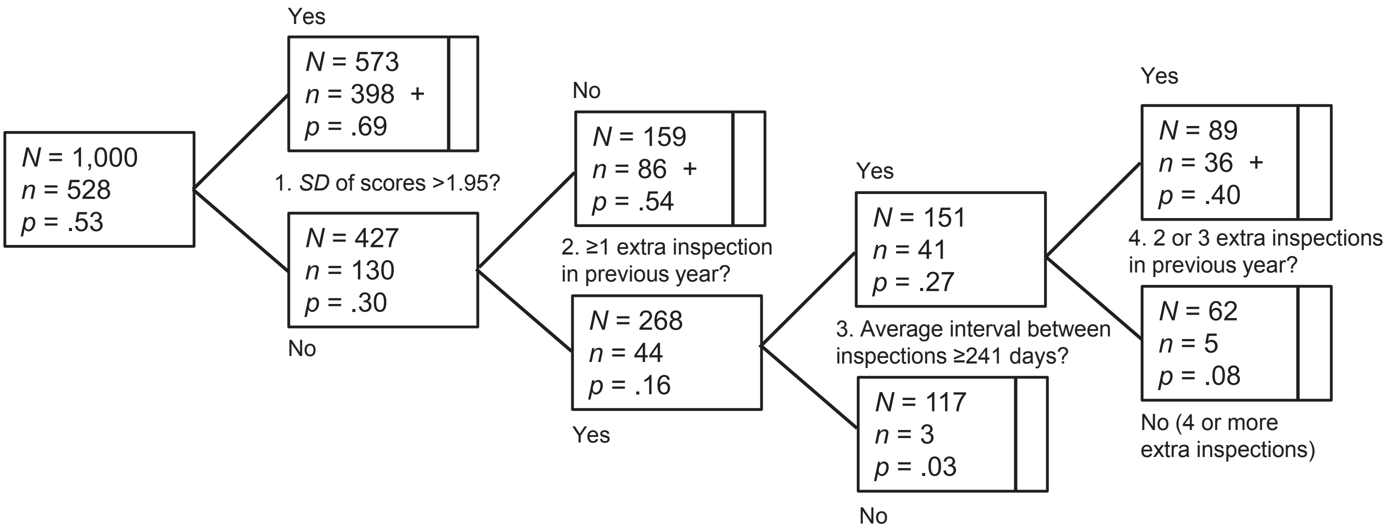
This methodology means CDC tracks positive tests for influenza, then multiplies that out to estimate flu-like hospitalizations. This methodology would never capture rising numbers of COVID-19. Similar methods were in use for the 2022–2023 U.S. flu season (as of November 26, 2024, this information is at https://www.cdc.gov/flu-burden/php/data-vis/).

Other Strategies in Use

Much of the surveillance for influenza and COVID-19 is done separately, but it looks as if many of the recommendations from Emanuel et al. (2022) are in progress. The National Center for Immunization and Respiratory Diseases (NCIRD) conducts virologic and outpatient illness surveillance, tracks positive COVID-19 and influenza test results at long-term care facilities as well as hospitalizations for laboratory-confirmed influenza, and conducts mortality surveillance (CDC, 2023). Of note:

FIGURE **2**

Example of CART (Classification and Regression Tree) Output for Food Safety Inspection Data



Source: Hartman, 1992.

- All public health and clinical laboratories report each week to CDC the total number of respiratory specimens tested for influenza.
- All influenza-positive surveillance samples received at CDC undergo next-generation sequencing.
- A total of 85 million patient visits for influenza-like illnesses (ILI) for any respiratory pathogen were reported by >3,000 outpatient care providers in the 2020–2021 flu season.
- For patient visits to healthcare professionals, CDC compares visits for ILI in "non-influenza weeks" and "influenza weeks." They add 2 standard deviations to the average percentage of patient visits to healthcare professionals in "non-influenza weeks."
- Each year, approximately 15,000 nursing homes report positive ILI test results for patients and staff.
- All death certificates in the U.S. are tabulated by the National Center for Health Statistics. Pneumonia, influenza, and/or COVID-19 (PIC) deaths currently are combined into a new PIC category, and an increase of 1.645 standard deviations above the seasonal baseline of pneumonia and influenza deaths is considered the epidemic threshold.

One big difference between these other types of surveillance and FoodNet is the latter conducts a population survey by U.S. Postal Service mail and random digit dialing—whereas for ILI, surveillance is not done for cases that do not result in a visit to a healthcare practitioner. As such, CDC states that their surveillance "does not directly provide the number of influenza illnesses" (CDC, 2023).

Risk Characterization and Predictive Modeling

A distinction can be made, according to Wikipedia, between risk factors and risk markers, both of which can have predictive power:

> A risk marker is a variable that is quantitatively associated with a disease or other outcome, but direct alteration of the risk marker does not necessarily alter the risk of the outcome. For example, driving-while-intoxicated (DWI) history is a risk marker for pilots as epidemiologic studies indicate that pilots with a DWI history are significantly more likely than their counterparts without a DWI history to be involved in aviation crashes (Risk Factor, 2022).

Risk Characterization and Predictive Modeling for Foodborne Disease

Risk Characterization for Foodborne Disease

The risk factors for foodborne illness are well-known (see Sidebar, page 23, at right).

Top 5 Risk Factors That Contribute to Foodborne Illness

- Food from unsafe sources
- Inadequate cooking
- Improper hot/cold holding temperatures
- Contaminated equipment
- Poor personal hygiene

Source: Florida Department of Agriculture and Consumer Services (https://www.fdacs.gov/Consumer-Resources/Health-and-Safety/Foodborne-Illnesses -FAQ/What-are-the-risk-factors-that-contribute-to-foodborne-illness).

This situation has persisted for many years mostly unchanged (Bryan, 1978). None of the risk factors requires much elaboration here because all levels of government in the U.S. and around the world have programs to address foodborne illness and are striving to improve the processes to control it.

These controls, however, have not always been in place. The novel *The Jungle*, written by Upton Sinclair and published in 1906, was intended to expose the dangerous labor practices and cruel treatment of animals in the Chicago stockyards and U.S. slaughterhouses. According to Lohnes (2022), when *The Jungle* was published, “its readers were outraged—but not in the way Sinclair had hoped. Their primary concern was food quality.”

Because of the public response, the Pure Food and Drug Act of 1906, which ensured that meatpacking plants processed their products in a sanitary manner, and the Federal Meat Inspection Act of 1906, which required that the USDA inspect all livestock before slaughter, were passed in 1906 (Lohnes, 2022). The findings by Mead et al. (1999), however, bring the overall effectiveness of these programs into question.

Predictive Modeling for Foodborne Disease

Hartman (2020a) described a variety of predictive models for scheduling facility inspections based on the facilities’ probability of food code violations; the violations can be thought of as both risk factors and risk markers for foodborne illness. One early model (Hartman, 1992) used past inspection results to predict future ones by applying classification and regression trees (CART) software (Breiman et al., 1984) to food safety inspection data provided by the city of Columbus, Ohio, to develop a new predictive model. This “tree-structured approach” is an example of artificial intelligence (AI): machine learning without specification of the variables to use. The class intervals of the continuous random variables were selected by the software.

The results from one classification tree (Hartman, 1992) are shown in Figure 2. A learning sample of 1,000 full-menu restaurants contained 528 restaurants that failed a standard inspection at least once in 5 years. CART made its first split with the question: “Was the standard deviation of scores in the previous year above 1.95?” Of the 573 establishments included, 398 indicated they had failed at least once. The bar at the right end of the box indicates that this was a “terminal node” and was not split further. Of the 427 for which the first answer was no, 159 establishments that did not have an extra inspection included 86 failures and could not be split further. Another split of the 268 establishments that had an extra inspection identified 41 failures by asking if the average interval between inspections was ≥241 days. Of those establishments, 36 had 2 or 3 extra inspections in the previous year.

This procedure was self-updating, in the sense that after the results from inspections were entered, CART could be rerun to predict the next batch of inspection results.

TABLE 1

Example of a Restart Inspection Form

Requirement	Yes	No
No self-service, including straws, stir sticks, buffets, and condiments. Self-service beverage stations are allowable.		
Employees must perform daily symptom assessments. Require employees to stay home if symptomatic of COVID-19.		
Ensure handwashing by employees when changing tasks, when hands become contaminated, and at a minimum once every 2 hr.		
Ensure social distancing between employees. Provide COVID-19-compliant floor plan for the kitchen.		
Post COVID-19-compliant seating plan that ensures social distancing and states maximum dining capacity.		
Number of employees permitted in break room limited to 10.		
Compliance with OAC training requirements for person in charge (PIC) and manager certification.		
Provide training for all staff on COVID-19 prevention.		
Have a plan to immediately isolate and seek medical care for any person who develops symptoms of COVID-19 while at the facility. Shut down areas affected for deep sanitation if possible.		
Perform enhanced cleaning of commonly touched surfaces such as doorknobs, railings, and countertops at least every 2 hr.		
Ensure high-volume shared surfaces in congregate areas, including playing cards, arcade controllers, and pool cues, are cleaned between customers.		
Clean and sanitize tables, chairs, and menus between customers.		
Ensure online and remote access reflects changes in response to COVID-19.		
Provide access to hand sanitizer for customers.		
Reservations for no more than 10 people per party.		
Ensure distancing of 6 ft between parties, otherwise use barriers. Barriers must meet all applicable building and fire code requirements.		
Maintain compliance with ODH sanitation and food safety regulations.		

Note. OAC = Ohio Administrative Code; ODH = Ohio Department of Health.
Source: Recreated from the Delaware General Health District, 2020.

Another predictive model for scheduling facility inspections is FINDER (Hartman, 2020a; Sadilek et al., 2018), mentioned previously (see Misconceptions section). In this strategy, anonymous visitors to restaurants had their smart phones set to share their location data. The entire sequence of locations each one visited within 3 days prior to the user performing a Google search of web pages about foodborne illness were included—pages such as Wikipedia articles and the CDC website about foodborne illness. FINDER classified the web searchers as “sick” or “not sick.” The result was that 52.3% of restaurants identified by FINDER had serious health code violations, compared with 22.7% for other restaurants.

Risk Characterization and Predictive Modeling for COVID-19

Risk Characterization for COVID-19

After the first three suspected cases of 2019 novel coronavirus (initially known as 2019-nCoV or severe acute respiratory syndrome coronavirus-2 [SARS-CoV-2] and renamed by the World Health Organization as coronavirus disease 2019 [COVID-19]) in Ohio were confirmed on March 9, 2020, the State of Ohio closed restaurants and bars except for carryout

TABLE **2**

COVID-19 Mitigation Strategies Used in Food Industrial Facilities in the United States Before Vaccine Availability

Intervention Type and Mitigation Strategy	Definition of Mitigation Strategy
Physical Distancing	
Installed 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
Staggered break times	Groups of employees have different break times
Staggered arrival and departure times (staggered shifts)	Groups of employees have a set number of hours to work during the day, but they have different start and finish times
Downsizing operations	Reduction of a facility's production capacity accompanied by a reduction in the number of employees
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) whose school or childcare provided is closed or unavailable for reasons related to COVID-19 (definition adapted from U.S Dept. of Labor "Families First Coronavirus Response Act: Employee Paid Leave Rights")
Spacing workers >6 ft (1.8 m) during production	Keeping a space at least 6 ft between employees
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
Biosafety	
Enhanced hand washing	Implementation of a set of instructions for employees about when and how to wash hands that goes above and beyond instructions that were in place pre-COVID-19
Alcohol-based hand rubs	Implementation of a set of instructions for employees about when and how to use hand rubs
Face mask, face shields, and/or goggles	Implementation of a set of instructions about how and when to use face masks, face shields, and goggles. Face masks: often referred to as surgical masks or procedure masks, cover the nose and mouth, secured under the chin, fit snugly against the side of the face, do not have gaps. Face shields: secondary protectors intended to protect the entire face against exposure. Goggles: shield the eyes against hazards.
Increased air ventilation rates	Increase in the rate at which external air (fresh air) flows into the building
Air cleaning and/or filtering	Destroying or removing hazards such as virus particles from the air
Surveillance	
Temperature screening and quarantine	Screen for employees with a body temp >99.5 °F (37.5 °C) (or other cutoff value), and keep identified employees away from the workplace to determine whether they develop COVID-19 symptoms or test positive for the disease
Test for infection and isolation	Test employees for COVID-19 (virus test); isolation: keep an employee who is sick with COVID-19 or tested positive for COVID-19 without symptoms away from the workplace
Contact tracing and quarantine	Contact tracing: identify individuals who may have been exposed to a person with COVID-19; quarantine: separate individuals who have had close contact with someone with COVID-19 to determine whether they develop symptoms or test positive for the disease
Return to work post-recovery policy	Strategy implemented for employees returning to work following a COVID-19 case based on symptoms or doctor's recommendation

Note. Used with permission of the International Association of Food Protection and adapted from "Survey of Implemented Mitigation Strategies and Further Needs of the U.S. Food Industry to Control COVID-19 in the Work Environment in Early 2021," by S. Llanos-Soto, E. Bulut, S.I. Murphy, C.J. Henry, C. Zoellner, M. Wiedmann, D. Wetherington, A. Adalja, S.D. Alcaine, and R. Ivanek, 2023, *Food Protection Trends, 43*(1), 40–60 (https://doi.org/10.4315/FPT-22-012). Permission conveyed through the Copyright Clearance Center, Inc.

and delivery and issued stay-at-home orders, bans on large gatherings, and other business closures. These actions were met with resistance and protests (Hartman, 2020b). Masking and social distancing were imposed. In May 2020, the Ohio Department of Health issued a reopening guide for businesses and required COVID-19 control inspections for restaurants. The guide is no longer available, but an article addressing it is (Hartman, 2020b). Table 1 was used in Delaware County, Ohio, for these inspections after a cautious reopening (Delaware General Health District, 2020). Table 2 shows some COVID-19 mitigation strategies in use in U.S. food industrial facilities before vaccine availability (Llanos-Soto et al., 2023). A case-control study by Fisher et al. (2020) shows the potential for these interventions.

As Schnake-Mahl et al. (2022) point out, closing indoor dining caused lots of resistance and might not be viable over the long term. Improving ventilation might be more successful and does not have to be expensive (LaPook, 2024; Pequignot, 2022). Contact tracing, already in place for other communicable diseases, was expanded to help control COVID-19. There is evidence that these actions and similar ones around the world prevented millions of infections and deaths (Capon et al., 2021; Hernandez, 2020; Schnake-Mahl et al., 2022).

China went through drastic lockdowns early in the pandemic, but after widespread protests, the government relaxed all the protocols, and in late 2022 were poised to experience the disaster they had avoided (Rammeloo, 2022).

Predictive Modeling for COVID-19

As of early spring 2023, predictive modeling for COVID-19 analogous to models described previously in this article for foodborne diseases was impossible because no inspections were being carried out to enforce COVID-19 restrictions, even though these inspections had saved as many as 590,902 lives (Bollyky et al., 2023).

Further, also as of early spring 2023, COVID-19 and other viral respiratory diseases appeared to be on the wane, and it might have been unrealistic to expect much cooperation from the public with any mitigation strategies. According to Bracken (2023), as of March 8, 2023, a record low share of Americans (53%) were concerned about the new Omicron variant, which was down 3 percentage points from February and represented an all-time low for tracking concern. Also in March 2023, *The New York Times* ended its daily COVID-19 data collection, although at that time, the disease was still causing deaths across the U.S. (Andrews & Jones, 2023). Furthermore, the COVID Tracking Project and Johns Hopkins University online databases also closed. On April 10, 2023, President Joe Biden signed a bipartisan congressional resolution to end the COVID-19 national emergency ("Biden Ends," 2023). The week before, ending April 5, 2023, 1,773 people in the U.S. died of COVID-19. The national emergency was first declared on January 31, 2020, and ended on May 11, 2023.

TABLE **3**

Phases Toward Standardized Data Processes and Systems

Phase 1	Phase 2	Phase 3
• Paper and pencil field data collection, multiple points of data transfer • Minimal data entry quality controls • Manual cleaning of data • Multiple points of data collection, entry, and transfer • Data fields not yet standardized	• Electronic field data collection • Defined data fields and data types, including a data dictionary (i.e., a set of information describing the contents, format, and structure of a database and the relationship between its elements) • Data required to be synchronized or uploaded into the system database once an inspector reaches their office or home office • Reports available to the public • Data systems siloed and restricted data sharing • Some analysis of the data	• Automatic synchronization from electric field collection to database • Integration of data from other sources (e.g., pictures, GIS information) • Automated data cleaning and reconciliation • Custom reports available to the public, the ability for the public to query data • Share data across systems • Data sharing agreements with other agencies • Use of data to analyze, interpret, and drive actions and provide real-time insights

Source: Coleman et al., 2022.

In a review of the Cleveland Study (Dingle et al., 1964) mentioned previously in this article (see Impacts section), Banks (2022) says:

> After such mountainous labour it is sad to learn that the data do not at present lead to conclusions on practical methods of prevention and control, largely because the aetiology of most of the illnesses was not determinable at the time. In other words the labour seems to have been premature. It is hoped that the voluminous data accumulated at such cost, especially on the common respiratory diseases, may be of value in future when more is known about causative agents.

If these restrictions and specialized inspections are ever resumed should another pandemic occurs, predictive modeling could help focus inspections. The Delaware County, Ohio, inspection report (Table 1) and the mitigation strategies in use in U.S. food industrial facilities before vaccine availability (Table 2) could be adapted.

Contact tracing could help identify COVID-19 or other disease risks in various venues. This process would have to be done early in a pandemic when the caseload is light (Capon et al., 2021; Hartman, 2020b; Hernandez, 2020). A strategy such as FINDER could also be used.

Conclusion and Recommendations

We have seen that both foodborne illness and COVID-19 and other respiratory pathogens continue to be public health problems despite surveillance and control efforts. We offer some recommendations arising from this article specifically, as well as some from external sources.

Some may question the utility of offering more recommendations about COVID-19 when the public generally believes the pandemic is over. But surely there is still a reason to offer the USDA's Food Guide Pyramid or to recommend smoking cessation or seatbelt use. This case is no different.

Foodborne Disease

A symposium at the International Association for Food Protection (IAFP) 2019 Annual Meeting asked, "Why are we still having food safety failures if we all have food safety systems?" (Prince, 2019). The first speaker, Gale Prince, answered this question by saying it was because of an ongoing failure with so-called HACCP (hazard analysis critical control point) prerequisites such as floors, walls and ceilings, and equipment design and cleaning.

For environmental health professionals, the article by Torok et al. (2022) might be helpful in addressing some of the foodborne illness surveillance issues discussed previously in this article (Wikswo et al., 2022). But a survey of the environmental health workforce (Gerding et al., 2019) seems to suggest challenges ahead because of deficiencies in staff education and work backgrounds. For example, IAFP published the *Procedures to Implement the Hazard Analysis Critical Control Point System* (IAMFES, 1991) and *Procedures to Investigate Foodborne Illness* (IAFP, 1999) booklets between 1991 and 1999 (there are many other publications about HACCP now), but they might be too technical for the general environmental public health professional.

Hartman (2020a) described a wide variety of predictive models and surveillance tools for foodborne diseases. Friedlander and Zoellner (2020) introduced AI concepts for retail food operations. Then in November 2022, the consumer software application ChatGPT (2023) was released, prompting raves (Pelley, 2023) and warnings (Bremmer, 2023) of the generative AI platform.

The recommendation, therefore, is for organizations such as FDA, CDC, or the National Environmental Health Association (NEHA) to develop AI models to facilitate foodborne illness outbreak investigations, development of HACCP plans, and food safety root cause analyses (RCA) for state and local health departments and food businesses. (For RCA, see The Pew Charitable Trusts, 2020, and Guzewich, 2021). Some models of this type have already begun to appear. For a general AI-assisted (i.e., machine learning) RCA (not specifically for food), see Papageorgiou et al. (2022). For an AI-powered HACCP plan builder, see https://bitrebels.com/business/ai-powered-haccp-plan-vs-consultant/ and https://www.fooddocs.com/haccp-plan (information only, not an endorsement). Furthermore, Hartman (2025) describes the development of AI applications for retail food.

COVID-19

According to Halperin et al. (2021), COVID-19 is the second major respiratory viral pandemic in just over one decade and the third coronavirus pandemic within two decades. These authors also predict that more pandemics are likely in the coming years, whether from new coronaviruses or from other pathogens. CDC has reviewed this history (Jernigan, 2018).

We have seen that misconceptions and conspiracy theories abound regarding COVID-19. There might be no way to change people's minds about matters such as vaccinations or masks after their minds have been made up, so the best hope for the next pandemic might be to intercede with school children beforehand. Dr. Michael Jensen, a domestic terrorism expert at the University of Maryland, has pointed out that the Proud Boys—the right-wing extremist group that helped push the January 6, 2021, attack on the U.S. Capitol—started as a protest against mask mandates and business closures.

He contrasts the law enforcement responses to terrorism with a public health response that might begin in schools and might focus on combating misinformation and extremism with critical thinking skills (Young, 2023). Such a public health response could include attitudinal inoculation, which involves suggesting that an attempt to change the audiences' beliefs or attitudes might be coming, followed by the issuing of information to refute such an attempt (Braddock, 2019). Research along these lines is underway at PERIL (www.american.edu/spa/peril), a research lab at American University that is doing the kind of early intervention work Dr. Jensen was referring to.

NEHA could begin to prepare people for the next pandemic through school curricula and professional in-services. A national public health agency such as the National Institutes of Health, CDC, or the World Health Organization should begin now to study ways that the public might be convinced to tolerate the types of measures that were successful in limiting the spread of viral respiratory diseases during the COVID-19 pandemic.

Llanos-Soto et al. (2023) listed four federal laws aimed at relieving economic pressure due to COVID-19. A uniform inspection report form should be devised (Table 1), and data systems, such as the recommendations in Table 3, should be put in place.

One of the references in Torok et al. (2022) describes critical thinking skills, which would also help address and eradicate many of these conspiracy theories (Willingham, 2008).

Moreover, some of the former COVID-19 pandemic mandates have been institutionalized. For example, physical distancing in many offices has become permanent, resulting in a possible commercial real estate and banking crisis ("Why Empty Offices," 2023) and a disruption of related services.

There are several things Emanuel et al. (2022) called for that have not happened. For example, we have no tracking for at-home COVID-19 test results, and no national paid sick and family medical leave. A risk threshold to trigger mitigation strategies could be implemented, but no agreement has been reached regarding such a threshold. The threshold could be based on surveillance conducted by CDC (2025) through its COVID Data Tracker.

Additionally, individual states and cities should conduct their own real-time surveillance for respiratory diseases, preferably using common definitions. Including case

Lessons to Learn

- Need a renaissance in our public health system (e.g., invest in it; align world, federal, state, city, and county responses; engage with all communities)
- Need a robust primary health system (e.g., prompt detection, diagnosis, and treatment; get up-to-date with vaccinations)
- Need a resilient population (e.g., control chronic diseases such as hypertension; diabetes control; curb tobacco use; rebuild the public's trust and our "common platform of understanding")
- The Centers for Disease Control and Prevention (CDC) needs to reestablish its identity as separate from our government in Washington, DC (e.g., be first, be right, be empathetic, and give practical advice; have successes and publicize them)
- No lockdowns (e.g., keep schools open for education and the economy; do not stay at home, outdoors is not a risk; better, smarter lockdowns and closures could have prevented one half of COVID-19 deaths in the U.S.)

Source: Lessons we need to learn according to Dr. Tom Frieden, former director of the Centers for Disease Control and Prevention (GZERO WORLD, 2022).

definitions from the Cleveland Study (Dingle et al.,1964) would enable historical comparisons. Voluntary registration of worksites, data sharing with the Occupational Safety and Health Administration, and union cooperation could be implemented.

Thomas Frieden, former director of CDC, has discussed measures (Bremmer, 2022) that could shore up the nation's public health system (see Sidebar, page 27). Primary care physicians have a crucial role in restoring the resilience of the U.S. population by encouraging smoking cessation, treating hypertension, and encouraging vaccination (Unger, 2022).

Disclaimer: This article was created with 100% human content and not written with ChatGPT or other AI programs, except Google. Further, the content in this article was drafted in 2023 with minor additions in 2025.

Corresponding Author: Jim Hartman, MS, REHS, 196 South Grant Avenue, Apartment 608, Columbus, OH 43215-8366.
Email: jimh117@earthlink.net

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