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Enhancing Response to Foodborne Disease Outbreaks: Findings of the Foodborne Diseases Centers for Outbreak Response Enhancement (FoodCORE), 2010–2019

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Abstract

Context: Each year, foodborne diseases cause an estimated 48 million illnesses resulting in 128 000 hospitalizations and 3000 deaths in the United States. Fast and effective outbreak investigations are needed to identify and remove contaminated food from the market to reduce the number of additional illnesses that occur. Many state and local health departments have insufficient resources to identify, respond to, and control the increasing burden of foodborne illnesses.

Program: The Centers for Disease Control and Prevention (CDC) Foodborne Diseases Centers for Outbreak Response Enhancement (FoodCORE) program provides targeted resources to state and local health departments to improve completeness and timeliness of laboratory, epidemiology, and environmental health activities for foodborne disease surveillance and outbreak response.

Implementation: In 2009, pilot FoodCORE centers were selected through a competitive application process and then implemented work plans to achieve faster and more complete surveillance and outbreak response activities in their jurisdiction. By 2019, 10 centers participated in FoodCORE: Colorado, Connecticut, Minnesota, New York City, Ohio, Oregon, South Carolina, Tennessee, Utah, and Wisconsin.

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Evaluation: CDC and FoodCORE centers collaboratively developed performance metrics to evaluate the impact and effectiveness of FoodCORE activities. Centers used performance metrics to document successes, identify gaps, and set goals for their jurisdiction. CDC used performance metrics to evaluate the implementation of FoodCORE priorities and identify successful strategies to develop replicable model practices. This report provides a description of implementing the FoodCORE program during year 1 (October 2010 to September 2011) through year 9 (January 2019 to December 2019).

Discussion: FoodCORE centers address gaps in foodborne disease response through enhanced capacity to improve timeliness and completeness of surveillance and outbreak response activities. Strategies resulting in faster, more complete surveillance and response are documented as model practices and are shared with state and local foodborne disease programs across the country.

Keywords

foodborne disease; outbreak response; public health capacity

Each year in the United States, foodborne diseases (FBD), including known pathogens and unspecified agents transmitted in food, cause an estimated 48 million illnesses resulting in 128 000 hospitalizations and 3000 deaths.[1] The US Department of Agriculture (USDA) estimates that foodborne illnesses cost more than US $15 billion annually.[2] The evolving food safety landscape poses an ongoing challenge to reducing this burden as food processing becomes increasingly centralized and consumption of imported foods continues to rise[2]; in the United States, an estimated 19% of food consumed is imported.[3] Additional challenges include new and emerging pathogens, antibiotic resistance, unexpected sources of foodborne illness, new routes of contamination, and changing diagnostic tests and subtyping methods.[2] The burden of foodborne illness and the complexity of food safety necessitate a coordinated, multidisciplinary, and multijurisdictional approach to protect consumers and prevent illness.

State and local public health agencies are responsible for conducting disease surveillance and investigating outbreaks.[4,5] An estimated 800 FBD outbreaks are reported annually in the United States through the National Outbreak Reporting System, and public health officials investigate many additional potential clusters of illness or outbreaks.[6] Information collected through investigations provides valuable insights into the pathogens, foods, and settings associated with illness.[7] In addition, timely and effective investigations are necessary to enact control strategies and identify gaps to prevent future outbreaks.[8,9] A 2010 Council of State and Territorial Epidemiologists survey to assess epidemiologic capacity in state and local health agencies identified a need to address shortages in personnel and workforce development opportunities; respondents who investigate FBD outbreaks cited limited staff and resources as barriers to completing investigations.[5,10] To conduct core public health functions, a public health system must maintain structural capacity, which includes all relationships and resources (human and nonhuman) essential for carrying out important public health processes.[11] Insufficient structural capacity can directly affect the ability to conduct investigations in a complete and timely manner.[7,12]

Recognizing these challenges, the US Centers for Disease Control and Prevention (CDC) launched Foodborne Diseases Centers for Outbreak Response Enhancement (FoodCORE)

in 2009 to build structural capacity in select state and local health agencies' FBD programs. FoodCORE aims to improve FBD surveillance and outbreak response in state and local health agencies by funding staff; developing collaborative surveillance and response programs; conducting fast, coordinated, and standardized investigations; developing and implementing performance metrics; and identifying and documenting replicable model practices. In addition, targeted FoodCORE funding can improve capacity and collaboration across laboratory, epidemiology, and environmental health (EH) activities.

This article describes key results and accomplishments of FoodCORE after 8 years of implementation following the 1-year pilot in 2009, including the program's transition to a maintenance phase after rapid improvements achieved during the first 2 years of the program were noted. In addition, this article describes centers' successes and challenges with the development, implementation, and testing of new tools, methods, and technologies to conduct faster and more complete investigations.

Methods

FoodCORE centers were selected through a competitive application process via CDC's Epidemiology and Laboratory Capacity for Prevention and Control of Emerging Infectious Diseases Cooperative Agreement. FoodCORE started as 3 pilot sites in 2009 and expanded over time; the year that each center joined FoodCORE varies.[13] By 2019, 10 centers participated in FoodCORE: Colorado, Connecticut, Minnesota, New York City, Ohio, Oregon, South Carolina, Tennessee, Utah, and Wisconsin. Annual work plans address core FBD program activities, operationalize performance metrics to evaluate progress and identify gaps, demonstrate collaborations with other food safety programs, identify trainings and career development opportunities, and contribute to the development and testing of new tools and technologies. A summary of FoodCORE center-specific work plans is available at https://www.cdc.gov/foodcore/centers.html.

Performance metrics evaluate centers' progress toward program goals by identifying gaps and successes. Core and optional FoodCORE metrics, available at https://www.cdc.gov/foodcore/metrics.html, were collaboratively developed and are reported biannually for *Salmonella*, Shiga toxin-producing *Escherichia coli* (STEC), and *Listeria* (SSL) and Norovirus, Other Etiology, and Unknown Etiology (NOU).[13,14] Other etiologies are enteric illnesses with determined etiology that are not SSL or norovirus. Unknown etiologies are enteric illnesses with no determined/identified etiology from a patient, product, or environmental testing. The SSL metrics are subdivided by isolate/specimen-based, case-based, investigation-based, and outbreak-based metrics. These are used to determine gaps in laboratory isolate handling processes; epidemiologic interviewing practices; cluster and outbreak monitoring, evaluation, and investigation; and outbreak reporting, respectively. *Shigella* and *Campylobacter* were added as optional measures in 2017; data for these pathogens are not included in this analysis. The NOU metrics primarily consist of investigation-based metrics and are used to determine whether gaps exist in investigational activities.

The SSL metrics data were reported for the first half of year 1 (Y0, October 1, 2010, to March 31, 2011); year 1 (Y1, October 1, 2010, to September 30, 2011); year 2 (Y2, October 1, 2011, to December 31, 2012); year 3 (Y3, January 1, 2013, to December 31, 2013); year 4 (Y4, January 1, 2014, to December 31, 2014); year 5 (Y5, January 1, 2015, to December 31, 2015); year 6 (Y6, January 1, 2016, to December 31, 2016); year 7 (Y7, January 1, 2017, to December 31, 2017); year 8 (Y8, January 1, 2018, to December 31, 2018); and year 9 (Y9, January 1, 2019, to December 31, 2019). Metrics data for NOU investigations have been collected since Y2. The midpoint of the FoodCORE program was Y5. A full description of performance metrics and data for Y1 to Y9 is available online.[13]

Metrics data capture the burden, timeliness, and completeness of FBD activities from surveillance through implementation of prevention measures. FoodCORE centers have continually revised them to meet program goals and adapt to changes in methods. For example, public health laboratories (PHLs) across the United States are using whole genome sequencing (WGS), an application of next-generation sequencing (NGS), because it is more precise and detailed than the previous standard technique, pulsed-field gel electrophoresis (PFGE); thus, in Y6, centers pilot-tested and then adopted a set of expanded SSL metrics to evaluate the timeliness and completeness of WGS.

Representative data for the FoodCORE centers are generally not available prior to receipt of FoodCORE funding. Therefore, data from the first half of Y1 were used as a comparative baseline (Y0). Although using this as a comparative baseline underrepresents the full scale of improvements achieved under FoodCORE, it is the most complete representation of performance during program initiation. Analyses were conducted using Microsoft Excel.

Because FoodCORE centers vary substantially in size, structure, and burden, practices that work across all their systems will also likely work in other state and local health departments. These are documented as model practices and are publicly available on the FoodCORE Web site for non-FoodCORE jurisdictions to adopt: https://www.cdc.gov/foodcore/modelpractices.html.[13,15] Successful investigations and projects that advance public health are documented on the FoodCORE Web site as success stories: https://www.cdc.gov/foodcore/successes.html.[13,16]

Results

Results are presented by laboratory, epidemiology, and cross-cutting/EH activities. Figures and tables include data from all 3 areas. See Supplemental Digital Content metrics tables, available at http://links.lww.com/JPHMP/A891, for FoodCORE Y9 metrics data.

Laboratory

The average, or mean, number of SSL isolates and isolate-yielding specimens received or recovered at the PHL in each FoodCORE center more than tripled from Y0 to Y9 (428 and 1 419, respectively).

Primary isolates and isolate-yielding specimens are the subset of all received specimens limited to the first or representative SSL isolate or sample for each case or testing unit

for nonhuman isolates. The average proportion of *Salmonella* primary isolates that were serotyped during Y0, Y5, and Y9 was 99%, 98%, and 98%, respectively, whereas the average proportion of STEC primary isolates that were serotyped during these periods was 86%, 87%, and 77%, respectively. The average proportion of primary SSL isolates with PFGE information decreased from 83% (82%, 93%, and 82% for *Salmonella*, STEC, and *Listeria*, respectively) at Y0 to 43% (45%, 37%, and 19% for *Salmonella*, STEC, and *Listeria*, respectively) at Y9. The average proportion of primary SSL isolates with WGS information increased from 45% (40%, 64%, and 98% for *Salmonella*, STEC, and *Listeria*, respectively) in Y6, to 82% (81%, 82%, and 83% for *Salmonella*, STEC, and *Listeria*, respectively) in Y7, to 91% (91%, 93%, and 100% for *Salmonella*, STEC, and *Listeria*, respectively) in Y8, and further expanded to 99% (98%, 99%, and 99% for *Salmonella*, STEC, and *Listeria*, respectively) in Y9 (Figure 1).

The average median turnaround time (TAT) to complete serotyping, the number of days from receipt of an isolate until serotyping is completed, decreased from 7 days (8 and 5 days for *Salmonella* and STEC, respectively) in Y0 to a median of 4 days (4 and 4 days for *Salmonella* and STEC, respectively) in Y9 (Table). On average, each center completed PFGE for SSL isolates within a median of 12 days (13, 5, and 6 days for *Salmonella*, STEC, and *Listeria*, respectively) in Y0 compared with a median of 5 days (5, 5, and 3 days for *Salmonella*, STEC, and *Listeria*, respectively) in Y9 (Table). Starting in Y8 of the program, reporting PFGE metrics for *Listeria* became optional. The average TAT to complete WGS decreased from a median of 22 days (23, 18, and 12 days for *Salmonella*, STEC, and *Listeria*, respectively) in Y6 to a median of 8 days (8, 8, and 6 days for *Salmonella*, STEC, and *Listeria*, respectively) in Y9 (Figure 2).

Epidemiology

From baseline to Y9, the average number of laboratory-confirmed SSL cases reported to epidemiology staff in each center tripled from 370 confirmed cases (325, 39, and 6 cases of *Salmonella*, STEC, and *Listeria*, respectively) in Y0 to 1100 confirmed cases (864, 218, and 18 cases of *Salmonella*, STEC, and *Listeria*, respectively). FoodCORE uses the National Notifiable Diseases Surveillance System for surveillance case definitions for each pathogen.[17]

Overall, the proportion of laboratory-confirmed case-patients with an attempted interview increased from an average of 88% (88%, 90%, and 100% for *Salmonella*, STEC, and *Listeria*, respectively) at Y0 to an average of 98% (99%, 99%, and 98% for *Salmonella*, STEC, and *Listeria*, respectively) during Y9 (Figure 1). The average proportion of SSL case-patients with an exposure history also increased from 61% (59%, 71%, and 77% for *Salmonella*, STEC, and *Listeria*, respectively) at Y0 to 85% (84%, 90%, and 87% for *Salmonella*, STEC, and *Listeria*, respectively) at Y9.

On average, the TAT in days from report to attempted interviews of laboratory-confirmed SSL case-patients was maintained from a median of 1 day (1, 1, and 1 days for *Salmonella*, STEC, and *Listeria*, respectively) in Y5 compared with a median of 1 day (1, 1, and 1 days for *Salmonella*, STEC, and *Listeria*, respectively) in Y9 (Table). Centers completed

interviews in an average of less than 3 days from notification in Y6, Y7, Y8, and Y9. The TAT data for interviewing were unavailable prior to Y6.

Cross-cutting/EH

The average number of SSL cluster and outbreak investigations in each center remained stable. In Y1, each center conducted an average of 74 SSL investigations (64, 8, and 2 investigations for *Salmonella*, STEC, and *Listeria*, respectively) compared with an average of 72 SSL investigations (56, 14, and 2 investigations for *Salmonella*, STEC, and *Listeria*, respectively) in Y9 (Figure 3). The average number of NOU investigations increased from 64 NOU investigations (37, 16, and 11 investigations for Norovirus, Other Etiology, and Unknown Etiology, respectively) in Y2 to 151 NOU investigations (109, 18, and 24 investigations for Norovirus, Other Etiology, and Unknown Etiology, respectively) in Y9 (Figure 3).

Environmental health assessments provide information needed to recommend effective short- and long-term interventions to stop ongoing foodborne outbreaks and prevent them in the future. Each center conducted more EH assessments as part of SSL investigations from an average of 2 (15%) EH assessments in Y1 to 6 (31%) EH assessments in Y9. In addition, centers increased the number of SSL investigations where food or environmental samples were collected for testing from an average of 4 (4%) SSL investigations in Y1 to 6 (11%) SSL investigations in Y9. The proportion of NOU foodborne or point-source investigations where an EH assessment was conducted was maintained from an average of 22 (80%) in Y2 to 19 (78%) in Y9. The proportion of NOU foodborne or point-source investigations where food or environmental samples were collected for testing decreased from an average of 5 (21%) in Y4 to 3 (14%) NOU investigations in Y9. Data for the number and proportion of foodborne or point-source investigations where food or environmental samples were collected for testing were unavailable prior to Y4.

From Y2 through Y9, centers implemented public health actions in response to SSL and NOU investigations with an identified vehicle or source, including exclusion of ill person(s) (n = 794), remediation or closure of an establishment (n = 604), educational campaigns (n = 454), media or public messaging (n = 442), and food product recalls (n = 317).[13]

The FoodCORE Web site has 17 success stories that highlight the effect targeted resources have had on improving centers' capacities to detect and respond to outbreaks, train professionals and strengthen health systems, and create programs that increase the safety of people's food, water, and environment.[16] Four model practices have also been published, describing FoodCORE centers' approaches to *Initial Case-Patient Interviewing, Laboratory Timeliness and Completeness, Student Interview Teams, and Communication and Collaboration*.[15]

Discussion

Since 2009, FoodCORE centers have demonstrated that targeted investments can improve and subsequently maintain the timeliness and completeness of laboratory, epidemiology, and EH surveillance and outbreak response activities. A previous article described the

implementation of the FoodCORE program, including the use of process-based performance metrics to identify areas of improvement.[18] Performance metrics continue to be a valuable tool to evaluate the impact and effectiveness of foodborne surveillance activities, document successes, identify gaps, and quantify the scope of work and resources needed to have a comprehensive FBD program.

Improving laboratory capacity

Using FoodCORE funding, centers hired additional staff to complete laboratory testing and communicate timely results to epidemiology staff and national surveillance systems. In addition, centers purchased and maintained equipment and reagents necessary for faster, more complete testing. Despite an increase in the average number of isolates and isolate-yielding specimens received or recovered at the PHL, FoodCORE centers also increased their capacity to conduct molecular subtyping and communicate results rapidly to investigative partners, allowing for outbreaks to be identified sooner and epidemiologists to identify and interview ill persons more quickly.

Public health laboratories were able to increase and then maintain the proportion of isolates subtyped while improving TAT. However, completeness and timeliness of serotyping was not maintained; by Y4, fewer isolates were serotyped and the TAT increased. Centers reported that these trends in serotyping were attributable to the ability of PHLs to complete PFGE faster and on more isolates, making serotyping less valuable for *Salmonella* and STEC outbreak detection. While the difference in the proportion of SSL isolates with complete serotype information from Y3 (98%) to Y9 (94%) is small, it likely indicates advancements in DNA testing and a transition in laboratory methodology to WGS. With NGS, PHLs are able to access information on species, serotype, and subtype of bacteria in just one test.[19]

While FoodCORE PHLs documented successes with NGS implementation, they also faced challenges. Public health laboratories were tasked with training microbiologists, ordering new supplies and equipment, upgrading technology, and performing PFGE and WGS simultaneously during the implementation and transition period, while also prioritizing investigations as WGS detected a greater number of clusters. High WGS supply costs might have also prevented centers from sequencing 100% of their isolates during Y6-Y8. To minimize costs per isolate sequenced, some centers batched isolates rather than performing sequencing as soon as possible after isolation; this increase in the proportion of primary isolates with WGS results came at the cost of timeliness, with WGStaking more than 4 times as long as PFGE.

The greatest improvements in PFGE subtypingwere observed prior to Y7. In January 2018 (Y8),CDC discontinued PFGE subtyping for *Listeria* in support of the full transition to WGS. In 2019, PulseNet fully transitioned all enteric pathogens to WGS as the national and international standard subtyping method, which is reflected in the sharp decline in the average proportion of SSL primary isolates with PFGE results in Y9. Centers anticipate continuing to improveWGS timeliness and completeness now that PFGE has been discontinued and laboratory time and resources are fully dedicated to NGS.

Improving epidemiology capacity

Patient interviews provide critical data for developing hypotheses; conducting detailed interviews as soon as possible after illness is vital for obtaining critical information about food consumption histories and other exposures. FoodCORE centers used funding to increase the number of dedicated epidemiology staff and improve data sharing, outbreak and cluster surveillance, and activity tracking. Specifically, the addition of student interviewers and regional staff enhanced capacity to complete rapid interviews, perform data entry, and conduct analytic studies.

With these added resources, centers increased the proportion of laboratory-confirmed cases with a corresponding interview, providing more epidemiologic data for routine surveillance as well as cluster and outbreak investigations. The greatest improvements in the proportion of cases with attempted interviews and complete exposure history occurred within the first few years of the program. Rapid TAT from case notification to attempted interview helps ensure the most accurate recall. As with attempted interviews, substantial improvements in reducing STEC TAT from case notification to attempted interview occurred within the first few years of participation in FoodCORE; TAT for *Salmonella* and *Listeria* was maintained at 1 day.

After Y3, centers shifted from making improvements in epidemiologic performance to maintaining the high level of performance they had achieved. In Y4, 3 of 10 centers attempted to interview 100% (range: 94.8%−100%) of their cases in a median of 1 day; this level of performance requires persistent effort and innovation to preserve timeliness and completeness. For some performance metrics, improvements in completeness are indicated by smaller ranges among centers as minimum values increased. For example, the range in the proportion of SSL cases with complete exposure history was 76.8% to 91.8% in Y9, an improvement from a range of 23.9% to 79.5% at baseline indicating that all jurisdictions showed improvements over time.

Improving cross-cutting outbreak response activities

Consistent communication and collaboration among laboratory, epidemiology, and EH partners ensure that critical information is shared in a timely manner throughout an investigation. Delays or interruptions in communication and data sharing between team members can impede investigations; a coordinated team can work together to quickly solve and stop outbreaks, preventing additional illnesses.

FoodCORE resources were used to support the addition of EH staff and cross-cutting trainings that enhance collaboration and coordination with internal and external partners in food safety programs at the federal, state, and local levels to build comprehensive outbreak response programs. Even with an increase in the number of SSL and NOU investigations, FoodCORE centers leveraged their capacity to conduct rapid EH assessments that incorporate laboratory and epidemiologic data to help focus investigations, collect data for and participate in traceback efforts to help identify food vehicles and sources of contamination, and provide training for local EH specialists to standardize EH activities. The availability of EH information in conjunction with laboratory and epidemiologic

information during an investigation can support additional public health actions, including public messaging and food product recalls.

Documenting practices and lessons learned

Model practices and success stories allow non-FoodCORE jurisdictions to build their capacity and improve their performance by using the methodologies and practices that have been shown to be successful in FoodCORE centers. Since the model practice *Initial Case-Patient Interviewing* was originally published, new investigation methods have emerged, including the use of text messaging to reach case-patients and online questionnaires. Laboratory methodologies have also changed since the model practice for *Laboratory Timeliness and Completeness* was published and this model practice will be revised to reflect current recommendations, most notably, the implementation of NGS as the primary subtyping method for enteric pathogens. FoodCORE centers updated the *Initial Case-Patient Interviewing* model practice in response to advancements in epidemiologic investigation methods. FoodCORE will continue to document, update, and share model practices and success stories to inform efforts to improve outbreak response.

Conclusion

As documented in the previously published FoodCORE paper, considerable improvements in the completeness and timeliness of outbreak response activities occurred within the first 2 years of the program.[18] As the program reaches a decade of implementation, centers continue to maintain the high level of timeliness and completeness achieved in early years while demonstrating improvements in performance using new methods and technologies, including WGS and interviewing techniques.

Targeted investments coupled with process evaluations are effective in evaluating performance; identifying areas for improvement; and implementing and documenting successful strategies as model practices to improve the timeliness and completeness of outbreak surveillance and response activities. The centers will continue to revise performance metrics as needed to meet program goals and adapt to advancements in surveillance and response methods and technologies. Continued support of the FoodCORE program is necessary to maintain improved outbreak response activities and continue contributing critical information to the identification and control of local and multistate FBD outbreaks, as well as sharing successful practices that can improve FBD surveillance and outbreak response in other jurisdictions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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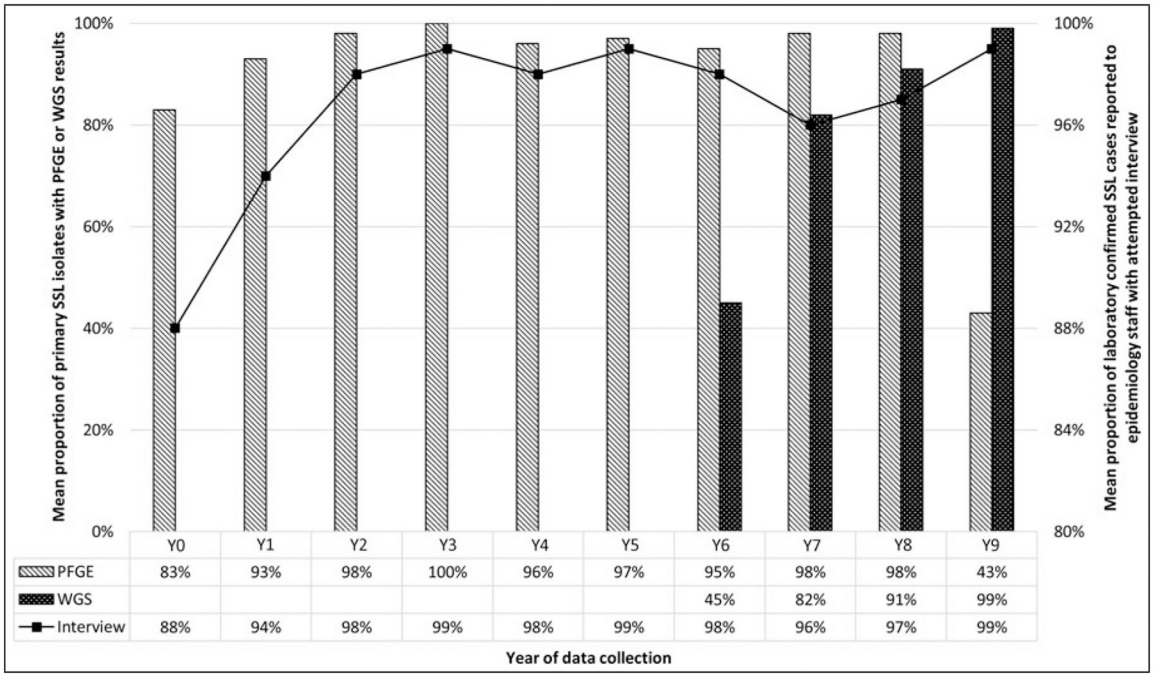
Implications for Policy & Practice

- Targeted investments allow FoodCORE centers to improve the timeliness and completeness of FBD surveillance and outbreak response activities.
- FoodCORE centers work to increase collaboration and strengthen partnerships across laboratory scientists, epidemiologists, and EH specialists. With increased coordination, centers detect more outbreaks, conduct thorough investigations, control outbreaks faster, and prevent people from getting sick.
- FoodCORE collaborates with other federal and state food safety programs, including CDC's PulseNet, Environmental Health Specialists Network (EHS-Net), FoodNet, CalicNet, NoroSTAT, and the Integrated Food Safety Centers of Excellence. FoodCORE also works with the Association of Public Health Laboratories, US Department of Agriculture's Food Safety and Inspection Service, and the US Food and Drug Administration's Rapid Response Teams. Cross-program collaborations enhance and complement FoodCORE's internal capacity-building efforts.
- Performance metrics allow for continual evaluation of investigation, response, control, and prevention activities, including the implementation of newer laboratory subtyping methods such as WGS.
- FoodCORE centers document successful strategies as model practices and share these with other state and local FBD programs to implement within their own jurisdictions.
- OutbreakNet Enhanced (OBNE), a complementary CDC program based on the FoodCORE model, supports epidemiologic capacity to investigate and respond to foodborne disease outbreaks in 29 sites. For more information, visit https://www.cdc.gov/foodsafety/outbreaknetenhanced/index.html.



	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9
PFGE	83%	93%	98%	100%	96%	97%	95%	98%	98%	43%
WGS							45%	82%	91%	99%
Interview	88%	94%	98%	99%	98%	99%	98%	96%	97%	99%

FIGURE 1.

Mean Proportion of *Salmonella*, Shiga Toxin-Producing *Escherichia coli*, and *Listeria* Primary Isolates With Pulsed-Field Gel Electrophoresis and Whole Genome Sequencing[a] Results and Average Proportion of Laboratory-Confirmed Cases Reported to Epidemiology Staff With Attempted Interview in FoodCORE Centers From Baseline Through Year 9[b]

Abbreviations: PFGE, pulsed-field gel electrophoresis; SSL, *Salmonella*, Shiga toxin-producing *Escherichia coli*, and *Listeria*; WGS, whole genome sequencing.

[a]In Y6, centers pilot-tested and then adopted a set of expanded SSL metrics to evaluate the completeness of WGS. Data prior to Y6 are unavailable and are intentionally left blank.

[b]Baseline (Y0) = October 2010 to March 2011; year 1 (Y1) = October 2010 to September 2011; year 2 (Y2) = October 2011 to December 2012; year 3 (Y3) = January 2013 to December 2013; year 4 (Y4) = January 2014 to December 2014; year 5 (Y5) = January 2015 to December 2015; year 6 (Y6) = January 2016 to December 2016; year 7 (Y7) = January 2017 to December 2017; year 8 (Y8) = January 2018 to December 2018; and year 9 (Y9) = January 2019 to December 2019.

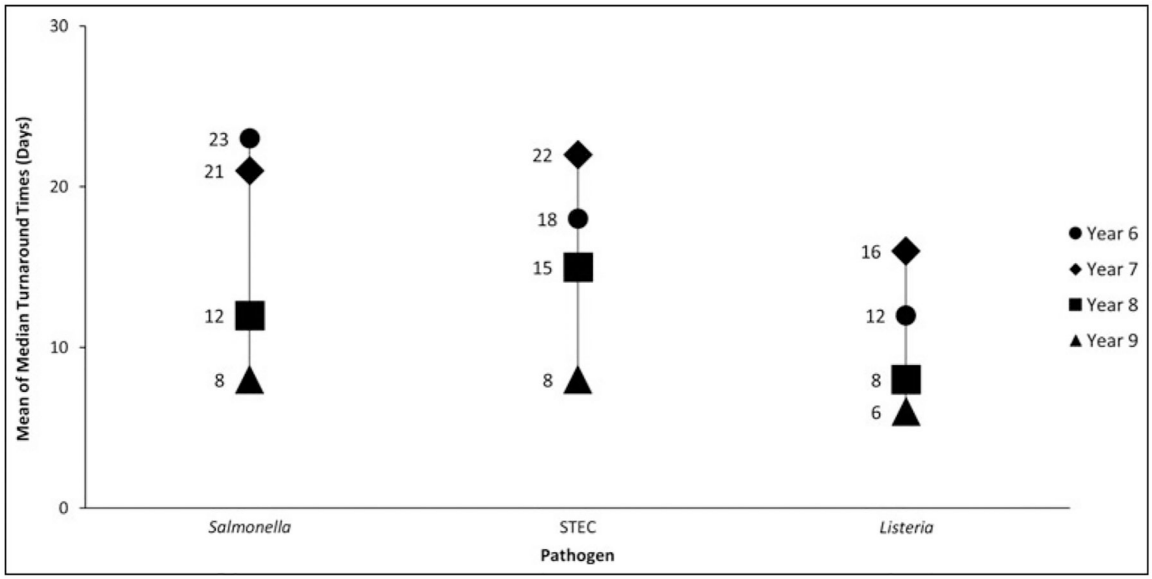


FIGURE 2.

Mean of Median Turnaround Times[a] for *Salmonella*, Shiga Toxin-Producing *Escherichia coli*, and *Listeria*, From Isolate Receipt (or Recovery) at the Public Health Laboratory to Whole Genome Sequence Being Shared With the National Database in FoodCORE Centers at Year 6[b], Year 7[c], Year 8[d], and Year 9[e]

Abbreviation: STEC, Shiga toxin-producing *Escherichia coli*.

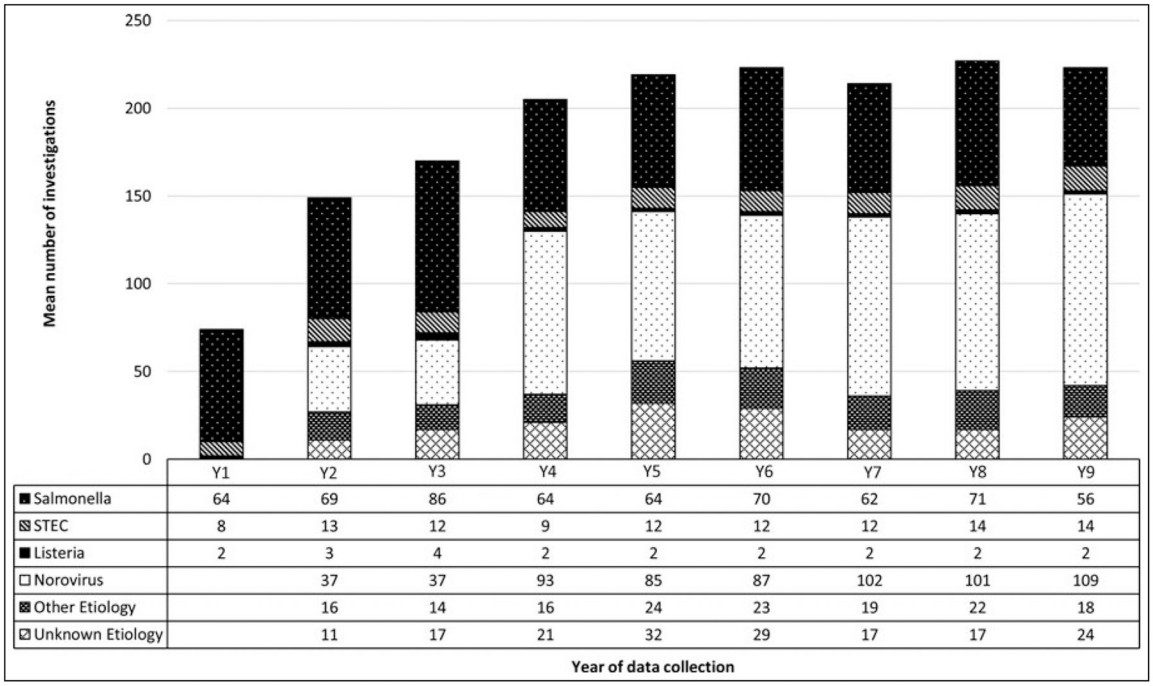
[a]Time in days.

[b]Year 6 (Y6): January 1, 2016 to December 31, 2016.

[c]Year 7 (Y7): January 1, 2017 to December 31, 2017.

[d]Year 8 (Y8): January 1, 2018 to December 31, 2018.

[e]Year 9 (Y9): January 1, 2019 to December 31, 2019.



	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9
Salmonella	64	69	86	64	64	70	62	71	56
STEC	8	13	12	9	12	12	12	14	14
Listeria	2	3	4	2	2	2	2	2	2
Norovirus		37	37	93	85	87	102	101	109
Other Etiology		16	14	16	24	23	19	22	18
Unknown Etiology		11	17	21	32	29	17	17	24

FIGURE 3.

Mean Number of *Salmonella*, Shiga Toxin-Producing *Escherichia coli*, *Listeria*, Norovirus,Other Etiology, and Unknown Etiology[a] Investigations in FoodCORE Centers From Year 1 Through Year 9[b]

Abbreviation: STEC, Shiga toxin-producing *Escherichia coli*.

[a]Metrics data for Norovirus, Other Etiology, and Unknown Etiology investigations have been collected since Y2. Other etiologies are enteric illnesses with determined etiology that are not *Salmonella*, STEC, *Listeria*, or norovirus. Unknown etiologies are enteric illnesses with no determined/identified etiology from a patient, product, or environmental testing. Data prior to Y2 are unavailable and are intentionally left blank.

[b]Year 1 (Y1) = October 2010 to September 2011; year 2 (Y2) = October 2011 to December 2012; year 3 (Y3) = January 2013 to December 2013; year 4 (Y4) = January 2014 to December 2014; year 5 (Y5) = January 2015 to December 2015; year 6 (Y6) = January 2016 to December 2016; year 7 (Y7) = January 2017 to December 2017; year 8 (Y8) = January 2018 to December 2018; and year 9 (Y9) = January 2019 to December 2019.

TABLE

Mean and Range of Median Turnaround Times[a] From Receipt or Recovery of Isolate to Completion of Serotyping, PFGE Subtyping, and WGS, and From Notification to Attempt of an Interview With a Case-Patient for the Baseline Period of Year 1[b], Year 5—the Mid-Point Between the Baseline Period of Year 1 and Year 9[c], and Year 9[d]

	Salmonella			**STEC**			***Listeria***		
	Baseline	**Year 5 (Mid-Point)**	**Year 9**	**Baseline**	**Year 5 (Mid-Point)**	**Year 9**	**Baseline**	**Year 5 (Mid-Point)**	**Year 9**
Serotype	8 (4–14)	3 (1–5)	4 (2–6)	5 (4–8)	4 (0–6)	4 (1–8)	N/A	N/A	N/A
PFGE[e]	13 (4–40)	5 (2–10)	5 (2–7)	5 (3–8)	5 (2–8)	5 (2–9)	6 (2–16)	3 (1–4)	3 (0–5)
WGS	U[f]	U[f]	8 (4–17)	U[f]	U[f]	8 (5–13)	U[f]	U[f]	6 (0–10)
Interview attempt	1 (0–3)	1 (0–4)	1 (0–3)	3 (1–5)	1 (0–4)	1 (0–3)	U[g]	1 (0–2)	1 (0–7)

Abbreviations: N/A, not applicable; PFGE, pulsed-field gel electrophoresis; STEC, Shiga toxin-producing Escherichia coli; U, unavailable; WGS, whole genome sequencing.

[a] Mean (range) of median turnaround times in days.

[b] Baseline period: October 1, 2010 to March 31, 2011.

[c] Year 5: January 1, 2015 to December 31, 2015. Year 5 of the FoodCORE program represents the mid–point between the baseline period of year 1 and year 9.

[d] Year 9: January 1, 2019 to December 31, 2019.

[e] FoodCORE centers discontinued reporting of PFGE metrics for Listeria starting in year 8 (January 1, 2018 to December 31, 2018) of the program as public health laboratories in the United States fully implemented WGS as the primary subtyping method.

[f] WGS metrics were unavailable until year 6 (January 1, 2016 to December 31, 2016) of the FoodCORE program.

[g] Data are reported only when available from 3 or more FoodCORE centers.