Food Handler Knowledge Retention and Training Effectiveness in the U.S. Retail Food Service: A Comprehensive Analysis of 2,700 Workers

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Abstract **Foodborne illness remains a major public health concern in the U.S., and food handlers serve as a primary point of prevention. The Food Handler Knowledge Retention Study, conducted by the National Environmental Health Association with support from the Food and Drug Administration in collaboration with the Conference for Food Protection and the National Restaurant Association, assessed how well retail food workers retain essential food safety knowledge after training. The survey collected responses from 2,751 food handlers and examined how training type, delivery method, timing, demographics, job duties, and workplace conditions influence knowledge scores.**

Respondents showed high overall knowledge, particularly in handwashing, illness reporting, and personal hygiene. Lower performance was shown in temperature control, food preparation, cleaning and sanitizing, and food storage. Respondents who received their training through a health department or who studied on their own scored higher than respondents who completed standardized certification programs. In-person and blended formats outperformed self-directed or online instructor-led modules. Knowledge was highest among respondents trained within the past year. English speakers scored higher than respondents whose primary language was not English. Respondents who routinely performed high-risk tasks demonstrated greater knowledge in temperature control and cleaning. Older age, higher education, and longer industry experience were associated with higher scores. Workplace support also shaped knowledge retention: supervisor engagement, adequate equipment, and visual reminders contributed positively, whereas limited resources and fewer chances to practice safe food handling created barriers.

These findings show that training effectiveness depends on practical relevance, interactive instruction, language accessibility, and on-the-job reinforcement. Results underscore the need for multilingual materials, regular refresher trainings, and targeted training on preventing foodborne illness.

Keywords: food safety training, knowledge retention, food handlers, retail food service, foodborne illness prevention, training effectiveness, food safety knowledge, workplace factors, training methods, public health

Introduction

Foodborne illness remains a major yet preventable public health issue in the U.S. Estimates from the Centers for Disease Control and Prevention (CDC) indicate that 7 leading pathogens cause 9.9 million domestically acquired illnesses, 53,300 hospitalizations, and 931 deaths each year (Scallan Walter et al., 2025). Norovirus accounts for the most illnesses, estimated at 5.5 million cases annually, followed by *Campylobacter* and *Salmonella*. *Salmonella* causes the most deaths, while *Listeria*, although less common, leads to more severe outcomes.

Food handlers play a central role in interrupting transmission because pathogens such as norovirus are spread easily by contaminated hands, utensils, and surfaces. Research shows that infected food workers account for a large share of outbreaks. Between 2009 and 2012, infected food workers were linked to 70% of foodborne norovirus outbreaks, most often through bare-hand contact with ready-to-eat foods (Hall et al., 2014). Restaurants remain the most common setting for these outbreaks. Hall et al. highlight that behavioral and organizational factors, rather than lack of knowledge, often hinder safe food handling. Consistent hygienic practices, supported by active managerial control, regular monitoring, and ongoing training, are essential for preventing outbreaks.

Training is an essential tool for establishing this foundation and ensuring food handlers understand and apply safe practices. Eight states require food handlers to complete programs accredited by the ANSI National Accreditation Board (ANAB), which sets national quality standards for training (ANSI, 2026). Arizona, California, Georgia, Hawaii, Illinois, New Mexico, Texas, and West Virginia currently require

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ANAB-accredited courses. Evidence shows that training can improve specific behaviors. For example, a study of 141 food service workers found that online food handler training improved temperature control, self-reported hygiene, and cleaning behaviors, although the training did not affect illness-reporting practices (Anding et al., 2025). A systematic review further found that although knowledge-based training boosts test performance, behavior-focused and reinforcement-oriented approaches better support long-term compliance (McFarland et al., 2019). These findings point to the need for ongoing, context-specific training and workplace support rather than reliance on one-time certification.

The literature also points to a gap in understanding how well food handlers retain information over time. Most studies have measured immediate outcomes rather than long-term change (Cotter et al., 2023). Widespread use of standardized training programs has not resolved questions about how much knowledge persists months or years after completion, which groups face the largest barriers, and which training conditions best support long-term retention of knowledge. These unanswered questions limit the ability of regulators, employers, and training providers to design programs that promote sustained safe practices.

To address gaps in understanding food safety knowledge and behavior, the National Environmental Health Association (NEHA), in partnership with the Conference for Food Protection (CFP) and the National Restaurant Association (NRA), launched the Food Handler Knowledge Retention Study. Supported by the Food and Drug Administration (FDA), this study examined how well food handlers retain and apply key concepts after training and assessed retention differences across worker populations and training environments.

Study Purpose

The study aimed to identify the factors that influence food safety knowledge retention over time. It examined the impacts of training format, time since training, job tasks, and workplace support. It also looked at how characteristics such as language, education, age, and experience relate to performance on a knowledge assessment. Results highlight areas where understanding is strong and where knowledge gaps are most common.

Methods

Design

Survey data were gathered from retail food handlers across the U.S. from January to March 2024, yielding more than 2,700 responses. Participants were recruited through convenience sampling via several outreach channels: direct email, professional listservs, social media, and partner communications distributed by NEHA, NRA, and related networks. Eligible participants included individuals currently or recently employed in retail food establishments as defined by the 2022 FDA *Food Code*, such as restaurants, bars, grocery stores, convenience stores, catering services, and cafeterias. Respondents had the opportunity to enter a gift card drawing as an incentive for participation.

Measures

The survey instrument was developed through a systematic, multiphase process in collaboration with subject-matter experts from NEHA, CFP, and NRA. In total, 24 ANAB-accredited food handler training programs were reviewed to identify common learning objectives, focusing on programs with publicly accessible learning objectives. Overlapping objectives were standardized and grouped into nine main food safety domains:

1. Cleaning and sanitizing food contact surfaces
2. Food safety behaviors (hygiene and handwashing)
3. Temperature control for time/temperature control for safety (TCS) foods
4. Safe food preparation
5. Employee health and illness reporting
6. Food storage and rotation
7. Cross-contamination prevention
8. Allergen cross-contact management
9. Foodborne illness identification and prevention

A panel of experts created a 25-item multiple-choice assessment based on these domains to capture both recall and applied knowledge. The survey collected additional data on demographics, language, training history, job duties, workplace conditions, barriers to using training, and training preferences.

A pilot test with 10 food safety professionals assessed clarity, length, and usability. Feedback led to refinements that improved question wording and reduced respondent burden. The final survey was offered online in English and Spanish via SurveyMonkey.

Data Analysis

Data were analyzed using descriptive, comparative, and relational statistical methods. Descriptive statistics summarized respondent demographics, training characteristics, and knowledge outcomes. Comparative analyses (*t*-tests and analysis of variance [ANOVA]) assessed differences in knowledge retention by training type, format, language, and establishment category. Welch's ANOVA was used when assumptions such as equal variances or normality were violated, with Kruskal–Wallis tests used as a confirmation check. Relational analyses (Spearman correlations and multiple regression) explored links between workplace factors, training variables, and knowledge outcomes. Analyses were conducted in IBM SPSS Statistics for Windows (versions 30.0 and 31.0), with supplementary calculations and visualizations in Excel, using an $\alpha = .05$.

Results

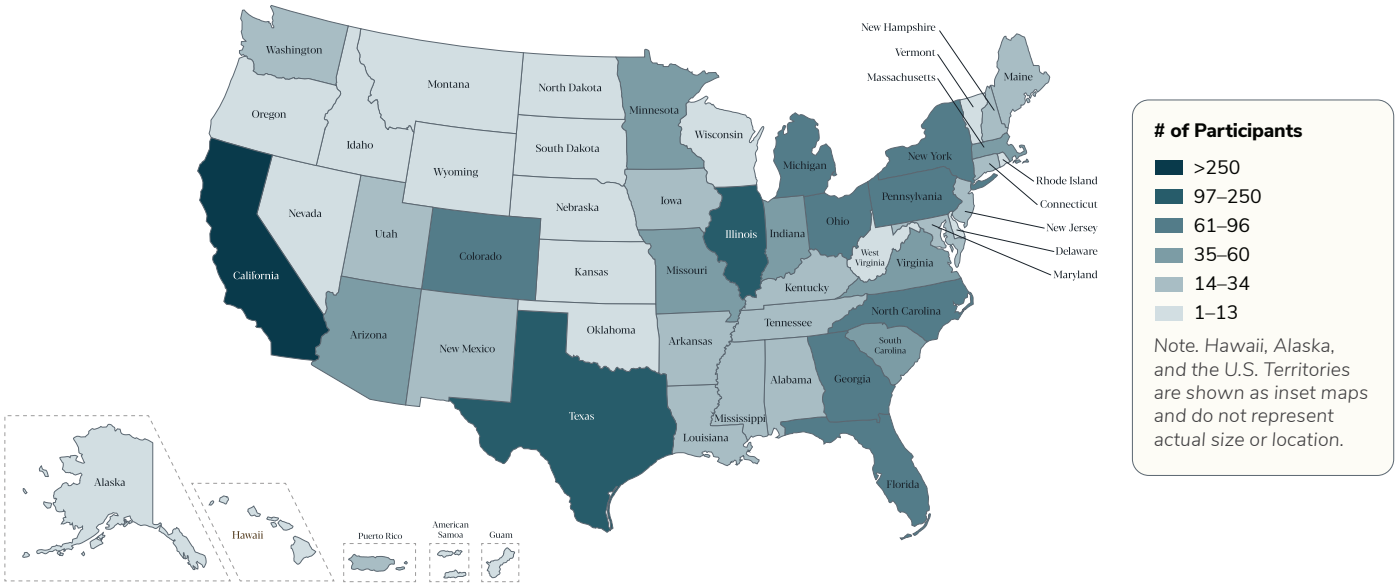
Participant Characteristics

A total of 2,751 retail food handlers from across the U.S. were included in the analytic sample (Figure 1). Of these, 367 (13%) completed the survey in Spanish. Participants represented a diverse range of food service settings, with restaurants (67%) and quick-service or fast-food establishments (42%) being the most common. Other settings included catering (33%); cafeterias in schools, offices, hospitals, or universities (30%); concessions such as those at sporting events or festivals (24%); hotel, resort, or club food service (21%); and grocery stores (21%).

Respondents were distributed across all age groups, with the largest proportion ages 35–44 years (22%), followed by 45–54 years (19%), 55–64 years (18%), 25–34 years (17%), 18–24 years (13%), ≥65 years (7%), and <18 years (2%). Nearly one half of respondents identified as White (49%), followed by Hispanic or Latino (29%) and Black or African American (14%). English was the most common native language (72%), followed by Spanish (20%).

FIGURE **1**

Geographic Location of the Food Handler Survey Participants



Educational attainment varied: 29% had some college attendance but no degree, 23% held a high school diploma or GED, 19% held a bachelor's degree, 12% had an associate's degree, 7% held a master's degree, and <1% held a doctoral degree. Industry experience ranged widely: the most common tenure was 11–15 years (12%), followed by 5–6 years (11%), and then 21–30 years (11%). Participants with <1 year (7%), 2 years (10%), 16–20 years (9%), and >30 years (7%) of experience were represented.

Training History

Most respondents (88%) completed an ANAB-accredited food handler training program; 74% completed it within the past 2 years, and 86% completed their training in English. The remaining respondents received employer-based or local health department training, studied independently, learned from coworkers, or had no formal training. Among those trained through an employer or health department (n = 194), 69% had completed their training within the previous 2 years, and 92% completed their training in English.

Knowledge Retention

Respondents demonstrated strong food safety knowledge, with an average score of 84%, a median of 88%, and a mode of 92% (range = 16–100%). Performance varied across food safety knowledge domains (Table 1).

The highest scores were observed in the food safety domains of handwashing (98%), illness reporting (96%), and personal hygiene (88%). Moderate performance was seen in allergen cross-contact (86%) and cross-contamination prevention (84%), while lower scores were noted in time/temperature control (80%), safe food preparation (77%), cleaning and sanitizing (66%), and food storage (61%). The weakest items involved reheating requirements for chicken soup (62%), proper food storage order (61%), cooking temperature for ground beef (56%), and required cleaning frequency for equipment (48%).

Several food safety knowledge domains showed strong associations with overall knowledge retention. Safe food preparation correlated most strongly with total knowledge (r = .71), followed by food contamination (r = .56), handwashing (r = .53), and food storage (r = .38).

Training

Knowledge scores varied by training type (Figure 2). Respondents trained through state or local health departments achieved the highest average score (88.7%), followed by self-study (88.2%), company-provided training (86.3%), learning from coworkers (85.3%), certified training (84.1%), and no formal training (79.8%).

A Welch's ANOVA confirmed training type was related to total knowledge scores, $F(5, 82.31) = 6.34$, $p < .001$, although the effect size was small at $\eta^2 = .01$, 95% confidence interval (CI) [0.003, 0.016]. Additionally, Games–Howell comparisons showed that self-study and state or local health department training produced significantly higher scores than certified training. The no-training group's wide CIs and high variability limited the ability to detect differences.

The mode of training delivery also influenced performance. A Welch's ANOVA revealed that training format was related to total knowledge scores, $F(3, 309.8) = 17.5$, $p < .001$. The effect size was small ($\eta^2 = .024$, 95% CI [.013, .036]). The Games–How-

TABLE **1**

Knowledge Assessment Score by Food Safety Domain

Domain	Knowledge Assessment Questions	Average Score (%)
Handwashing	• After using the restroom and before returning to work, you must first [do what]? • You just walked into the kitchen to prepare food after taking your lunch break. What do you need to do first?	98
Illness reporting	• What should you do if your doctor tells you that you have norovirus? • What are some of the symptoms of foodborne illness you must report to your manager? • What should you do if you are throwing up (vomiting) before your scheduled shift at work?	96
Personal hygiene	• How does good personal hygiene help prevent foodborne illnesses?	88
Allergen cross-contact	• You are getting ready to cook an order for a guest who has a soy allergy. What is one practice you should do to prevent allergen cross-contact? • Which of the following can result in an allergen cross-contact?	86
Cross-contamination	• Which of the following is an example of cross-contamination? • A serving spoon fell into a long pan of macaroni salad on the customer buffet. What is the best way to prevent this kind of contamination? • You are very busy and accidentally drop a steak on the floor. What should you do?	84
Temperature control	• Hot foods that require temperature control to be safe must be kept at what temperature? • Cold foods that require temperature control to be safe must be kept at what temperature?	80
Safe food preparation	• You are preparing 100 sandwiches for a large order. To make them, you need to mix diced chicken with mayonnaise and seasonings, and cut up lettuce, tomatoes, and onions. What is the SAFEST way to prepare these sandwiches? • What is the best way to cool down a large pot of sauce or soup? • What temperature should beef hamburgers be cooked to? • Which of these options is the best way to thaw frozen chicken? • How hot should chicken soup get when you are reheating it before you can place it on the hot buffet?	77
Cleaning and sanitizing	• What are the correct steps for washing dishes? • If a slicer or pizza cutter is being used at room temperature all day, how often should it be cleaned and sanitized?	66
Food storage	• From top to bottom, in what order should the following foods (raw ground pork, raw chicken, raw steaks, vegetables) be stored?	61

ell comparisons showed that respondents who trained in person scored significantly higher than did respondents in all other groups, including online-recorded, online with a live instructor, and hybrid. Hybrid scores did not differ from the two online formats. The online formats produced the lowest scores.

Time since training showed a clear relationship with knowledge outcomes. A Welch's ANOVA showed significant differences in knowledge scores across the time-since-training groups (past year, 1–2 years ago, 3–5 years ago, and >5 years ago), $F(3, 354.17) = 19.5$, $p < .001$. The effect size was small ($\eta^2 = .017$, 95% CI [.008, .028]). Moreover, the Games–Howell comparisons showed that respondents who trained within the past year scored significantly higher than respondents who trained 1–2 years ago and 3–5 years ago. Respondents who trained 1–2 years ago, however, scored significantly lower than respondents who trained 3–5 years ago.

The number of food handler courses completed during the past 5 years (0, 1 course, 2 courses, 3 courses, 4 courses, and ≥5 courses) did not significantly affect knowledge scores, as shown by an ANOVA test, $F(5, 2613) = 1.18$, $p = .319$. Similarly, an independent samples *t*-test revealed that respondents who received supplemental training outside of a food handler course (e.g., company-led sessions or coworker instruction on another food safety topic) did not differ in their score on the knowledge assessment from respondents who did not have additional training, $t(1705) = 0.38$, $p = .706$.

Language Factors

Language played a notable role. More than one half of the 730 respondents who reported a native language other than English completed their training in English ($n = 380$, 52%). Further, the primary language respondents spoke significantly affected their knowledge scores. A Welch's independent samples *t*-test showed that English speakers scored higher than did respondents who spoke a primary language other than English, $t(130.04) = 3.21$, $p = .002$. The effect size was small ($d = .38$, 95% CI [0.19, 0.56]).

Job Role and Task Frequency

Job responsibilities significantly affected knowledge retention. Independent samples *t*-tests revealed that respondents performing

high-risk tasks (e.g., cooking, cooling, cleaning) scored higher than those doing low-risk tasks (e.g., stocking, supervision) in both time/temperature control, $t(98) = 10.75$, $p < .001$, $d = 2.15$, 95% CI [1.66, 2.64], and cleaning and sanitizing, $t(98) = 6.08$, $p < .001$, $d = 1.22$, 95% CI [0.79, 1.64], both reflecting a large effect size. All other knowledge domains showed no significant differences.

Demographic Influences

Knowledge retention varied significantly by age, education, and industry experience, as shown by separate Welch ANOVA tests, $F(7, 308.96) = 10.53$, $p < .001$, $\eta^2 = .023$, 95% CI [0.012, 0.033]; $F(9, 167.64) = 14.75$, $p < .001$, $\eta^2 = .046$, 95% CI [0.029, 0.059]; and $F(6, 954.29) = 38.20$, $p < .001$, $\eta^2 = .070$, 95% CI [0.051, 0.088], respectively. The effect sizes for these analyses were small. Games–Howell post hoc comparisons indicated that individuals with higher levels of education (doctoral-level respondents did not differ significantly from other groups, likely due to limited representation), greater industry experience, and older age tended to demonstrate higher knowledge scores.

Predictors of Knowledge Retention

A multiple regression analysis was conducted to examine if individual characteristics moderate the relationship between training type and knowledge retention. Education level had a marginally significant positive effect on knowledge scores ($\beta = .026$, $p = .092$), indicating a slight advantage associated with higher education. Training type ($p = .365$), work experience ($p = .673$), and all interaction terms ($p > .05$) were nonsignificant (Table 2). These findings suggest that education modestly enhances training outcomes, whereas training type and experience alone do not meaningfully affect knowledge retention.

Application of Training and Barriers

After training, several workplace factors influenced the ability of respondents to apply and retain food safety knowledge. Top facilitators included:

- Having the right equipment (65.6%)
- Opportunities to apply training on the job (59.3%)
- Job tasks requiring use of training (55.2%)
- Visual reminders such as posters or signs (40.1%)
- Supervisor support (35.0%)
- Additional employer-led training (30.8%)
- Coworker support (27.1%)

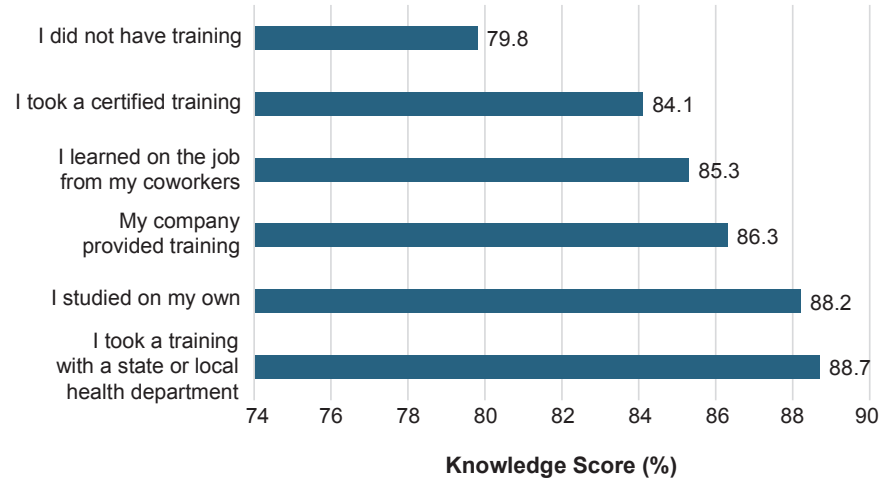
A multiple regression analysis confirmed that workplace resources significantly contributed to knowledge retention ($p < .05$) (Table 3). Among predictors, supervisor support ($\beta = .15$, $p < .01$) was the strongest contributor, followed by equipment availability ($\beta = .12$, $p < .01$) and instructional posters ($\beta = .10$, $p < .05$).

Respondents also named barriers that limited their ability to use the training content:

- Conflicting job information (12.6%)
- Need for additional training (10.0%)
- Job irrelevance of course content (9.6%)
- Forgetting course material (9.3%)
- Lack of necessary equipment (9.1%)
- Few opportunities to practice (8.6%)
- Limited coworker support (7.0%)
- Time constraints (6.1%)
- Lack of supervisory support (5.2%)

FIGURE **2**

Average Knowledge Assessment Score by Training Type



Training Preferences and Needs

Survey results indicate that food handlers favor flexible, engaging, and practical training that combines convenience with hands-on experience. Preferred formats included prerecorded online classes (47%), in-person sessions (44%), and on-the-job instruction (35%). Respondents valued videos (61%), fact sheets (48%), and live demonstrations (48%) as the most helpful resources, emphasizing interactive methods such as quizzes and demonstrations. Training preferences did not differ significantly by age. Many respondents expressed interest in additional training on specialized food processes (40%), allergen management (34%), and core procedures such as reheating and cooling (10–20%).

Discussion and Conclusion

The results of this study offer valuable insights and several patterns about the current state of food safety knowledge among retail food handlers. Some outcomes aligned with expectations, while others challenged assumptions about training effectiveness and knowledge retention. The following discussion examines these themes in detail.

Training Effectiveness Hierarchy

Training type emerged as an important factor. Respondents who trained by state and local health departments, as well as through self-guided study, were more effective than standardized certification programs. It is unclear whether these state and local courses or self-guided materials were ANAB-accredited or based on other accredited content. Public health education research indicates that practical, hands-on instruction enhances competence, especially when training mirrors real workplace demands and community priorities (Lee et al., 2021). This finding supports the idea that locally relevant, context-based

TABLE **2**

Regression Results: Influence of Characteristics on Training Type and Knowledge Retention

Predictor	Coefficient	*p*-Value
Training type	-0.006	.365
Education level	0.026	.092
Work experience	0.009	.673
Training type × education	-0.001	.714

TABLE **3**

Regression Analysis: Predicting Knowledge Score From Supportive Resources

Resource Availability	Coefficient	*p*-Value
Posters	0.10	<.05
Equipment	0.12	<.01
Supervisor support	0.15	<.01

learning and self-directed study can deepen understanding and strengthen long-term retention of knowledge by linking content to respondents' real experiences. Experts emphasize this point, noting that training rooted in everyday practice, explaining the why, and including personal accountability tends to lead to more meaningful behavioral improvements (Emond, 2019).

Although lecture-style formats remain common (Reynolds & Dolasinski, 2019), broader certification programs might struggle to incorporate innovative, flexible teaching methods that meet the diverse needs of food workers. Locally managed training programs and self-directed learners could have an advantage because they take an active role in learning and tailor the material to regional food safety issues, community practices, and workplace conditions, helping participants apply their knowledge with greater confidence. These concepts are central to adult learning theory (Knowles, 1975).

Critical Timing Window and Quantity

This study also highlights the role of timing. Knowledge retention peaked among respondents who trained within the past year, decreased among those who trained 1–2 years ago, and appeared higher among those who trained 3–5 years ago. This later increase likely is due to cohort differences, such as greater experience, rather than a true rebound in retention. The performance decline observed after initial training aligns with learning research on how memory fades without later reinforcement. Findings from Carpenter et al. (2022) explain this pattern by demonstrating that people remember information far better when they revisit it after a delay and practice recalling it, rather than reviewing it repeatedly in one sitting. Their work shows that spaced retrieval—revisiting material at intervals—creates deeper, longer-lasting learning than massed study or simple re-reading. This evidence explains why additional training hours in our sample did not produce higher knowledge scores: additional training must involve retrieval practice, application, or booster sessions delivered at well-spaced intervals. Programs that rely on a one-time course or certification could fail to support the long-term memory processes that food handlers need to apply concepts consistently.

Task–Knowledge Alignment

A notable pattern in the data is the link between individuals who perform high-risk job tasks and greater knowledge of temperature control, cleaning, and sanitization. The review of studies by McFarland et al. (2019) showed that food safety concepts tied to frequent, simple tasks—such as handwashing or equipment cleaning—improve more quickly after training, whereas technical skills with limited routine exposure, such as thermometer use or time–temperature controls, show weaker gains.

These results indicate that direct exposure to high-risk tasks strengthens technical knowledge. The large effect sizes observed in the data partly reflect how the groups were defined, because respondents with frequent hands-on responsibilities differ substantially from respondents with primarily supportive roles. Respondents who do not regularly perform high-risk tasks have fewer opportunities to practice and reinforce critical procedures. These patterns highlight the value of repeated, task-based practice and suggest that scenario-based or practical exercises could help strengthen skills used less often and promote more consistent food safety behaviors.

Knowledge Gap Analysis

Notable knowledge gaps were observed in time/temperature control, food preparation, cleaning and sanitizing, and storage. These domains stand out as priorities for targeted intervention and reflect notable public health vulnerabilities, as they align directly with two of the FDA's Five Major Risk Factors (Food and Drug Administration, 2023) for foodborne illness: 1) improper holding/time–temperature control and 2) contaminated equipment or inadequate cleaning and sanitization. The combination of limited exposure, technical complexity, and inconsistent reinforcement might explain these deficiencies. These areas represent high-value targets for future training and on-the-job support.

Conversely, high scores in handwashing and illness reporting align with broader evidence that clear, behavior-focused messages supported by policy and practice can be effective. Evidence from CDC (2024) indicates that workers wash their hands more consistently when cues, signage, and accessible sinks are present and when illness policies are clearly communicated and reinforced by managers. Taken together, the current study results and this prior work suggest that when safety protocols are visible, consistent, and actionable, workers are more likely to remember and follow them. Similar communication

and policy strategies could help strengthen weaker areas of food safety knowledge.

Access Considerations

Language emerged as a meaningful factor. Many respondents who spoke a primary language other than English completed their training in English, which likely contributed to lower scores among non-native speakers. Evidence from a review from Alkhaldi et al. (2025) indicates that non-native-speaking food workers find it difficult to understand safety requirements when training is provided only in the host country's language. The review also showed that providing instructions in workers' native languages greatly improves knowledge, attitudes, and practices, which emphasizes the benefits of culturally tailored, multilingual materials. Our findings support the need for expanded language access, translated materials, and culturally responsive instruction. Further, clear communication is a foundational requirement for effective training.

Higher performance among respondents in in-person environments emphasizes the value of interactive, hands-on instruction over fully online courses. Practical skill development benefits from active engagement, demonstration, and immediate feedback—features that are less common in self-directed digital formats. A review by McFarland et al. (2019) supports this emphasis, showing that hands-on demonstrations and supervised practice lead to more effective behavioral outcomes than online or lecture-only food safety training.

Workplace Environment

Workplace conditions played a central role in retention. Supervisor engagement, equipment availability, and visual reminders predicted higher knowledge scores. These results reinforce the idea that safe food handling depends not only on what workers learn but also on the environments in which they work. Pai et al. (2024) found that organizational factors—including leadership involvement, communication systems, and resource availability—shape if workers consistently follow safe practices. Our findings show that workers need functional tools, supportive supervision, and environmental cues to apply their training effectively. Limited resources, unclear communication, and few opportunities for practice hinder skill use and weaken knowledge retention.

Training Preferences and Needs

The preferences reported by respondents indicate an interest in flexible, interactive, and practical learning formats, including prerecorded classes and visual and hands-on methods such as videos, live demonstrations, and on-the-job training. These preferences align with evidence that active learning methods, particularly ones combined with face-to-face interaction, are more effective than purely online formats for developing skills and improving knowledge retention (Beimel et al., 2024). The lack of significant age differences in these preferences indicates that experiential and blended approaches have broad appeal across the workforce. Furthermore, respondent requests for additional training on specialized processes, allergens, and core operational procedures highlight the importance of ongoing, targeted education in areas most directly related to foodborne illness prevention.

Limitations

Several limitations should be considered when interpreting these findings. The convenience sampling approach in our study allowed for a wide geographic reach but may not reflect the full diversity of the U.S. food handler workforce. The overrepresentation of ANAB-trained participants, likely due to recruitment through national restaurant networks, could limit the applicability of the findings. Additionally, self-selection bias might have inflated knowledge scores if more motivated workers chose to participate. The survey was offered only in English and Spanish, which could introduce selection bias, as individuals with limited proficiency in either language might be less likely to participate or might interpret the questions differently. The study design prevents causal conclusions; additionally, unmeasured factors, such as workplace culture or management expectations, could influence both training participation and performance outcomes. Lastly, the analysis also identified some small yet statistically significant effects. The large sample enabled the detection of subtle patterns that offer useful insight into fine-grained relationships and can help guide future research.

Recommendations

Our study findings suggest several improvements related to the program design of food handler training, strategies, and workplace implementation.

Training Program Design

- Embed practical, locally relevant content aligned with daily responsibilities.
- Provide multilingual, culturally adapted materials that support equitable learning.
- Reinforce high-risk domains such as food storage and cleaning and sanitizing through applied exercises.
- Incorporate refresher or booster sessions at regular intervals to counteract knowledge decay.

Regulatory and System-Level Strategies

- Require regular refresher training to maintain competency and promote accountability.
- Evaluate learning outcomes using demonstrated competency rather than course completion.
- Support local and state training initiatives through funding and technical assistance.
- Develop adaptive learning systems tailored to employee role and experience level.

Workplace Implementation

- Train supervisors as active reinforcement agents and mentors.
- Maintain functional equipment and visual job aids to support daily safe practices.
- Integrate ongoing feedback and on-the-job coaching into standard operating procedures.

Practice and Policy Implications

Programs succeed when training mirrors real workplace conditions and supports long-term learning. Our study recommendations highlight intentional program design, policies that promote consistent performance, and workplace structures that help staff turn knowledge into meaningful action. Together, these elements can guide the food industry toward higher skill levels, stronger public health protections, and a learning culture that treats safe food handling as a core responsibility at every stage.

Effective food safety training depends on far more than information delivery. Context, reinforcement, and accessible resources

shape long-term improvement. Regular refresher trainings, interactive methods, and environments that position food safety as a central operational standard help maintain competency. Our findings point to a shift from high-volume training toward approaches focused on quality, relevance, and measurable results.

Future research should use longitudinal designs to monitor knowledge retention over time and connect training methods and knowledge to observed food safety behaviors. Intervention studies should focus on areas with low performance, and economic analyses can measure the return on investment from decreased foodborne illness. Additional priorities include creating brief, competency-based assessment tools for industry use and examining how aligning training delivery with learner preferences affects long-term behavior change.

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