Relationship Between Employee Food Safety Training and Food Safety Risk Factors at Fort Liberty Military Installation in North Carolina

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Abstract **Preventing foodborne illness within military operations is essential to maintain the security and defense capabilities of units. Fort Liberty (formerly known as Fort Bragg) in North Carolina is the largest Army installation in the U.S. All food service employees at Fort Liberty must have food safety training. Our study evaluated the status of food safety training for the person-in-charge (PIC) and other food service employees. We also evaluated the extent to which training related to the Centers for Disease Control and Prevention (CDC) five foodborne illness risk factors identified during inspections. Our study used Fort Liberty Department of Public Health 2021 data, which consisted of 716 periodic food service sanitation inspections of 124 facilities. Each inspection consisted of 51 inspectable items, aligned with CDC risk factors and an additional factor of PIC responsibilities and food safety training. Missing food safety training was significantly correlated with deficiencies in the ability of personnel to identify CDC risk factors ($p < .05$). The number of deficiencies was significantly higher in facilities that lacked food safety training compared with facilities that received training ($p < .001$). Maintaining food safety training by managers and employees likely reduces deficiencies and the potential for foodborne illnesses.**

Keywords: food safety, sanitation, inspection, food service, person-in-charge

Introduction

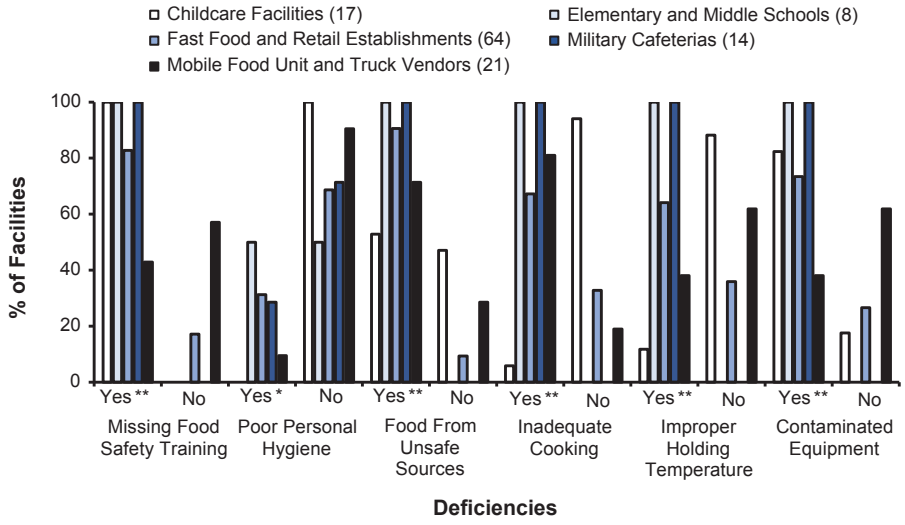
Approximately 48 million people in the U.S. experience foodborne illnesses every year, including 128,000 hospitalizations and 3,000 deaths (Centers for Disease Control and Prevention [CDC], 2018; Scallan et al., 2011). Prevention of foodborne illness is the responsibility of various groups such as government agencies, the food industry, and the public. The Food and Drug Administration (FDA) is one of many entities that provide food safety guidelines. The U.S. Department of Defense (DoD) is also responsible for preventing foodborne illness because protecting health by mitigating illness increases military security, defense, and combat capabilities.

Of the 73 U.S. Army installations, Fort Liberty (formerly known as Fort Bragg) in North Carolina is the largest Army installation by size and population (Military OneSource, 2024). There are approximately 43,414 active-duty soldiers, 98,273 military family members, 10,999 DoD civilians, 5,418 government contractors, and 125,278 retirees and their family members within the area of responsibility of the Fort Liberty Department of Public Health (DPH) (Military OneSource, 2024).

At the end of 2022, the most recent version of the model *Food Code* was released by FDA (2024). The Technical Bulletin Medical 530/Navy Medical P-5010-1/Air Force Medical 48-147_IP, Tri-Service Food Code (TSFC) is based on the 2017 FDA *Food Code*. The TSFC was modified to meet stringent DoD requirements and is the governing regulation for food service sanitation across the DoD (Headquarters, Department of the Army [HQDA], 2019a). The TSFC reinforces mitigation strategies from the *Food Code* for food safety risk factors and identifies five essential public health interventions to protect the health of the DoD population. These interventions include 1) understanding and demonstrating food safety knowledge, 2) worker health controls, 3) regulating hands as a mode of contamination, 4) time and temperature controls to reduce

FIGURE **1**

Percent Difference Between Missing Person-in-Charge and Employee Food Safety Training and Foodborne Illness Risk Factors and Facility Types at Fort Liberty, 2021



* Correlation significant at $p < .05$.
** Correlation significant at $p < .001$.

pathogen growth, and 5) consumer education (HQDA, 2019a).

The 2017 FDA *Food Code* includes the requirement that the person-in-charge (PIC) of a food service facility maintains a food protection manager certification (FDA, 2022). The PIC must demonstrate food protection knowledge by passing an exam from a course accredited by an agency approved by the Conference for Food Protection (2024). A certified PIC must be present during operating hours of facilities that store, prepare, and serve food. In 2019, the TSFC was updated to include this training requirement for a certified food protection manager (HQDA, 2019a), thereby reducing foodborne illnesses (Brown et al., 2014).

At Fort Liberty, all PICs must be certified food protection managers; additionally, any food service employee (FSE) who engages in food storage, preparation, and service must complete food safety training no later than 30 days after the start of employment as well as 4 hr of refresher food safety training within 12 months (HQDA, 2019a). The Fort Liberty DPH provides food safety training to all FSEs, and certified personnel can provide instruction and proctor the associated certified food protection manager exams from programs accredited by the American National Standards Institute (ANSI) and the Conference for Food Protection (HQDA, 2019a).

The five major foodborne illness risk factors contributing to foodborne illness include: 1) poor personal hygiene, 2) obtaining or using food from unsafe or unapproved sources, 3) contamination of equipment, 4) improper hot or cold holding temperatures, and 5) improper or insufficient cooking (FDA, 2022). Food service facility inspection reports cover these five risk categories. In 2018, foodborne pathogens associated with these five risk factors were responsible for approximately 8.9 million illnesses—including 54,000 hospitalizations and 1,480 deaths—and $14.4 billion in healthcare costs in the U.S. (Hoffman & Ahn, 2021).

Army Food Service Sanitation Program

The Army Food Service Sanitation Program was created to implement Army Regulation (AR) 30-22 (HQDA, 2019b). The U.S. Army Public Health Center has oversight of the program, which is managed by the medical authority of each military installation (Defense Health Agency, 2018). The medical authority of each military installation generally delegates this responsibility to the director of the DPH (i.e., chief of preventive medicine services). The Army Food Service Sanitation Program provides the framework for military public health regulators to establish food safety training, education, and inspection programs to protect personnel who consume food that is stored, prepared, and served on military installations.

Role of Food Service Managers and Food Safety Training Requirements in the Military

The food service manager (FSM) is responsible for actions within the facility during operating hours. The FSM should be the PIC or appoint a PIC who is a certified food protection manager and is at the facility during operating hours. The FSM/PIC demonstrates knowledge of foodborne illness prevention, application of control measures to mitigate illness, and sanitation inspections; this person also provides food safety training to FSEs (HQDA, 2019b).

Importance of Managerial Food Safety Training on Food Service Sanitation

Minimal published research exists on the efficacy of food safety training for military installations. Studies on other types of food facilities, however, support the importance of having a certified food protection manager present during food service operations to mitigate foodborne illness risk factors (Brown et al., 2014). The Environmental Health Specialists Network (EHS-Net) is a cooperative program of partners including CDC, FDA, and the U.S. Department of Agriculture (USDA), with state or local public health departments that investigate sources of foodborne illness (CDC, 2024). EHS-Net investigated the association between FSM and worker food safety certification, training, and knowledge and showed that certified personnel had more food safety knowledge than noncertified personnel (Brown et al., 2014).

Role of Food Service Employees and Food Safety Training Requirements in the Military

Although the FSM/PIC is the first line of defense for food safety, the FSE also plays an important role (Brown et al., 2014). FSEs

TABLE **1**

Correlation Between Deficiencies at Fort Liberty Associated With Foodborne Illness Risk Factor Categories, 2021

Measure	Missing Food Safety Training	Poor Personal Hygiene	Food From Unsafe Sources	Inadequate Cooking	Improper Holding Temperature	Contaminated Equipment
Missing food safety training	1.00	0.20* ($p = .02$)	0.56** ($p < .001$)	0.43** ($p < .001$)	0.45** ($p < .001$)	0.49** ($p < .001$)
Poor personal hygiene	0.20* ($p = .02$)	1.00	0.42** ($p < .001$)	0.31** ($p < .001$)	0.34** ($p < .001$)	0.40** ($p < .001$)
Food from unsafe sources	0.56** ($p < .001$)	0.42** ($p < .001$)	1.00	0.60** ($p < .001$)	0.60** ($p < .001$)	0.75** ($p < .001$)
Inadequate cooking	0.43** ($p < .001$)	0.31** ($p < .001$)	0.60** ($p < .001$)	1.00	0.86** ($p < .001$)	0.36** ($p < .001$)
Improper holding temperature	0.45** ($p < .001$)	0.34** ($p < .001$)	0.60** ($p < .001$)	0.86** ($p < .001$)	1.00	0.46** ($p < .001$)
Contaminated equipment	0.49** ($p < .001$)	0.40** ($p < .001$)	0.75** ($p < .001$)	0.36** ($p < .001$)	0.46** ($p < .001$)	1.00

* Correlation significant at $p < .05$ (2-tailed).
** Correlation significant at $p < .01$ (2-tailed).

must report personal health information (e.g., diarrhea, vomiting) to the FSM/PIC, use personal hygiene techniques regarding their hands or exposed body parts, and maintain cleanliness of clothing and uniforms (HQDA, 2019a). FSEs must obtain a minimum of 4 hr of initial food safety training within 30 days of starting work and an additional 4 hr of training annually related to the five foodborne illness risk factors identified by CDC. All FSEs must complete a food safety training course and maintain a certificate of completion (HQDA, 2019a).

One study determined inconsistencies in food safety knowledge related to foodborne illness risk factors among facilities in suburban Chicago (Manes et al., 2013). A baseline knowledge questionnaire was administered to 729 FSEs from 211 facilities to gather information on knowledge, personal hygiene, and behaviors. The results showed that 39% of respondents had never participated in a food safety training course (Manes et al., 2013). Further, the most commonly identified knowledge gaps were related to optimal bacterial growth temperatures during refrigeration, holding and cooking, hygiene, and cross-contamination. According to CDC, a 10% reduction in foodborne illness risk factors would prevent 5 million illnesses annually in the U.S. (National Center for Emerging and Zoonotic Infectious Diseases, 2012).

In our study, we examined the relationship between the foodborne illness risk factors identified via inspection reports and the extent to which Fort Liberty PICs and FSEs were trained in food safety training. Our main objectives were to 1) examine the extent to which insufficient food safety training related to deficiencies associated with CDC foodborne illness risk factors among five facility categories and 2) compare deficiencies between facilities with and without food safety training. Other than internal reports from the Fort Liberty DPH, we know of no other studies that have investigated food safety training at a military installation.

Methods

Our study used internal 2021 inspection reports from the DPH for each facility within Fort Liberty. We received a review waiver from the East Carolina University Medical Center Institutional Review Board, as existing data had no identifiers and no interaction with participants was required. Inspection reports are accessible to the public on request, but internal data are primarily used for trend analyses. Our study analyzed 716 food service sanitation inspections of 124 facilities: 17 childcare facilities, 8 elementary and middle schools, 64 fast food and retail establishments, 14 military cafeterias, and 21 mobile food units and trucks. Each sanitation inspection consisted of 51 inspectable items ranging from proper handwashing and the use of disposable gloves to proper internal product cooking temperatures and hot/cold holding temperatures (Supplementary Figure 1, www.neha.org/jeh-supplementals). Inspectable items align with CDC foodborne illness risk factors, as well as PIC duties, responsibilities, and food safety training.

Deficiencies identified from sanitation inspections during the study period (except for missing food safety training) were assigned to one of the five CDC categories. Deficiencies incurred by each food service facility within each category and the status of food safety training for each employee were tabulated by category.

Data Analysis

Spearman's rank correlation coefficient and Fisher's exact test ($p < .05$) were used to examine the relationship between missing food safety training and deficiencies associated with the five CDC foodborne illness risk factor categories found during inspections. Fisher's exact test ($p < .05$) was used to show

TABLE **2**

Relationship Between Missing Food Safety Training and Deficiencies at Fort Liberty Associated With Foodborne Illness Risk Factor Categories, 2021

Foodborne Illness Risk Factor	Missing Food Safety Training			
	Yes (n = 101)		No (n = 23)	
	#	%	#	%
Poor personal hygiene				
Deficiencies	28	27.7	2	8.7
No deficiencies	73	72.3	21	91.3
Food from unsafe sources*				
Deficiencies	91	90.1	13	56.5
No deficiencies	10	9.9	10	43.5
Inadequate cooking*				
Deficiencies	72	71.3	11	47.8
No deficiencies	29	28.7	12	52.2
Improper holding temperature*				
Deficiencies	69	68.3	4	17.4
No deficiencies	32	31.7	19	82.6
Contaminated equipment*				
Deficiencies	84	83.2	7	30.4
No deficiencies	17	16.8	16	69.6

* Fisher's exact test shows significant differences in food safety training status between facilities with deficiencies and facilities with no deficiencies for each factor at $p < .05$.

differences between missing food safety training, the five CDC foodborne illness risk factors, and the five facility types. One-way analysis of variance (ANOVA, $p < .001$) was used to compare the means of differences between food safety training, risk factor deficiency categories, and facility types.

The frequency of deficiencies by each facility type in each category was also analyzed. An independent samples t-test ($p < .05$) was used to compare the total number of facilities with and without sufficient food safety training and with or without deficiencies in CDC foodborne illness risk factors for each category (data coded dichotomously where 1 = yes and 0 = no). This process allowed for the comparison of facilities with insufficient/sufficient food safety training versus facilities that did or did not show deficiencies in at least one of the five CDC foodborne illness risk factors. We calculated the total number of deficiencies related to the five foodborne illness risk factors and used IBM SPSS (version 28.0.1.1) for our data analysis.

Results

Food Safety Training and Risk Factors

Our study examined 716 inspection reports from 124 food service units and facilities collected in 2021 at Fort Liberty. All CDC foodborne illness risk factor categories (i.e., $p < .001$: food from unsafe sources, inadequate cooking, improper hot/cold holding temperatures, contaminated equipment; $p = .02$: poor personal hygiene) were significantly correlated with missing food safety training (Table 1). Fisher's exact test showed significant association ($p < .05$) in food safety training status between facilities with deficiencies compared with no deficiencies for three of the five CDC foodborne illness risk factor categories (i.e., food from unsafe sources, improper hot/cold holding temperature, contaminated equipment; Table 2). There was no significant association between missing food safety training and poor personal hygiene ($p = .06$) or inadequate cooking ($p = .05$).

Food Safety Training and Risk Factors by Facility Type

Figure 1 shows differences between food safety training status and CDC foodborne illness risk factors at the five different facility types. Five deficiency categories—missing food safety training, food from unsafe sources, inadequate cooking, improper holding temperatures, and contaminated equipment—were significantly correlated with each other (all $p < .001$). Poor personal hygiene was significantly correlated with missing food safety training across all facility types ($p = .005$). There was a significant difference ($p < .001$) among military cafeterias and elementary and middle school facilities compared with the other three facility types in all deficiency categories.

Figure 2 shows the variance in the means of differences between missing food safety training, CDC foodborne illness risk factors, and facility types. Five deficiency categories showed significant differences between facility types: missing food safety training ($F = 8.06$, $p < .001$); food from unsafe sources ($F = 13.14$, $p < .001$); inadequate cooking ($F = 11.25$, $p < .001$); improper holding temperatures ($F = 10.60$, $p < .001$); and contaminated equipment ($F = 7.18$, $p < .001$). Poor personal hygiene showed no significant difference between facility types ($F = 0.84$, $p = .50$). Compared with other types of facilities, military cafeterias showed significantly higher ($p < .05$) deficiencies in the five food safety risk categories.

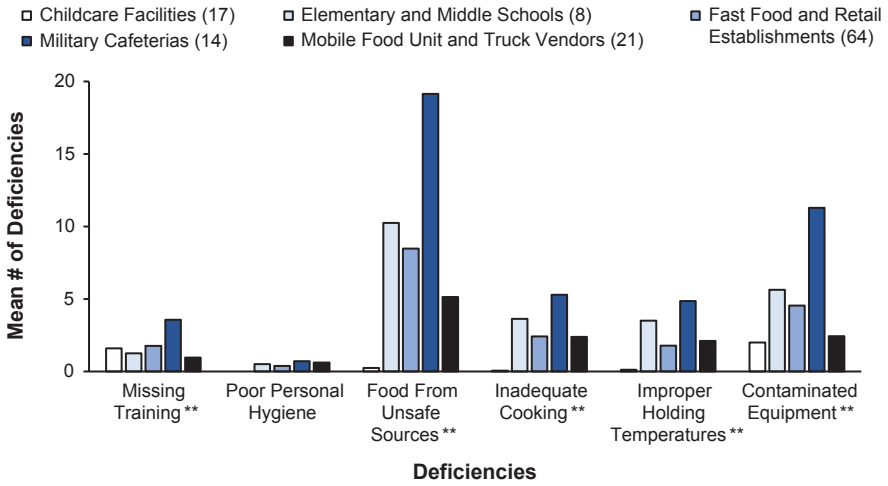
Figure 3 shows the means of total deficiencies by facility type in each category. Fast food and retail facilities had the most deficiencies among all categories: missing food safety training ($n = 924$), poor personal hygiene ($n = 23$), food from unsafe sources ($n = 308$), inadequate cooking ($n = 154$), improper hot/cold holding temperature ($n = 114$), and contaminated equipment ($n = 371$). Military cafeterias showed the second highest number of deficiencies in four categories: food from unsafe sources ($n = 165$), inadequate cooking ($n = 74$), improper holding temperature ($n = 68$), and contaminated equipment ($n = 158$). Childcare facilities ranked second highest in

missing food safety training (n = 204), and mobile food unit and truck vendors ranked second in poor personal hygiene (n = 13).

Of 124 facilities surveyed, 101 facilities (81%) had at least 1 employee and/or a PIC who were missing the mandated food safety training, and only 23 facilities (19%) were not missing food safety training. There was a significant difference (t = 4.184, p < .001) between the mean number of deficiencies in the missing food safety training group ($M \pm SD$: 20.75 ± 17.49) and the group that had the required food safety training ($M \pm SD$: 5.17 ± 7.04). These results show there was a higher mean number of deficiencies in facilities that were missing food safety training compared with facilities that were not missing food safety training.

FIGURE **2**

Differences in Mean Numbers of Deficiencies Between Facility Types at Fort Liberty, 2021



** Correlation significant at p < .001 between food safety training and risk factors identified via inspections.

Note. Further explanation of the deficiencies: missing training (e.g., did not meet the training requirement); poor personal hygiene (e.g., bare-hand or arm contact with food, unkept hair); food from unsafe sources (e.g., suppliers with insufficient certificate of analysis); inadequate cooking (e.g., cooking and reheating time insufficient); improper holding temperatures (e.g., cold or hot holding temperatures insufficient); and contaminated equipment (e.g., drying, storage, and handling of utensils and equipment insufficient).

Discussion

Food Safety Training and Risk Factors

As expected, facilities with employees who were missing the required food safety training showed significant correlations with all five CDC foodborne illness risk factors identified on inspection reports. Our study results show that food safety training might help reduce foodborne illness risk factor deficiencies in military installation food establishments. Although the TSFC requires the FSM/PIC to be a certified food protection manager and that all FSEs have food safety training, it has been documented that this training is not necessarily obtained, and refresher food safety training is not consistently being conducted or maintained by the FSM/PIC (HQDA, 2019a).

Unmet food safety training requirements could be due to a lack of and/or low retention of personnel, lack of food safety training opportunities, or the failure of the PIC to establish or maintain an internal continuous food safety training program. The Food Safety and Inspection Service (2024) within USDA determined that FSEs trained in proper food safety sanitation techniques can lead to a 60% reduction in foodborne illness outbreaks. Continuous food safety training is crucial to maintaining knowledge and procedures in food service sanitation (McFarland et al., 2019).

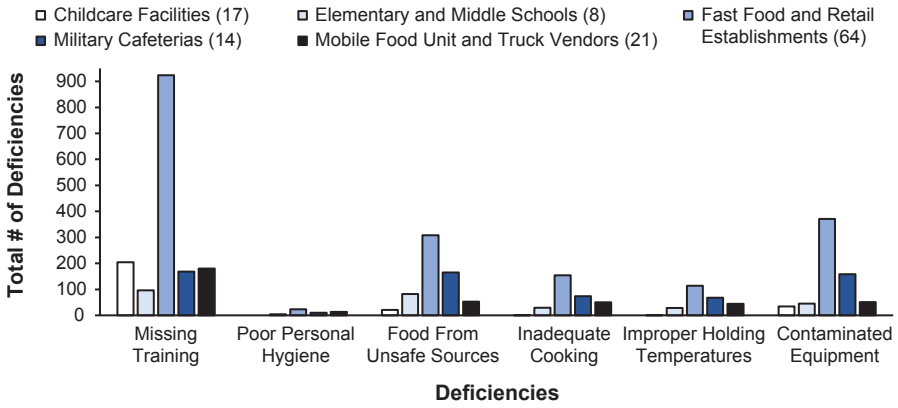
Of the 124 facilities we surveyed, 101 were missing food safety training for at least 1 or more employees and were found to have an average of 344 deficiencies in CDC foodborne illness risk factor categories during the period of study. In comparison, 23 facilities had the required food safety training and were found to have an average of 37 deficiencies in CDC foodborne illness risk factor categories. Although these data do not definitively show that having the required food safety training eliminates identified deficiencies, they do indicate reduced deficiencies related to food safety training—which shows that having food safety training could reduce the potential for foodborne illness outbreaks.

Another study surveyed more than 900 Florida restaurants to examine the relationship between inspection results of chain and independent restaurants and mandatory food safety certification and safety training via the restaurants' documented food service sanitation and safety inspection results (Murphy et al., 2011). The findings of the same study indicated that nearly 400 chain restaurants showed significantly lower mean critical deficiency violations compared with the other more than 500 independent restaurants. Hence, chain restaurants emphasize food safety training to reduce identified deficiencies, possibly due to corporate liability associated with foodborne illness outbreaks (Murphy et al., 2011). The requirement of and adherence to food safety training has been shown to reduce deficiencies and/or violations found among various facilities, thus reducing the potential for the occurrence of foodborne illness outbreaks.

Our results from Fort Liberty show a significant relationship between missing employee food safety training and deficiencies associated with all CDC foodborne illness risk factors identified via inspection. Facilities with a greater number of identified foodborne illness risk factors due to incorrect practices also had a lack of food safety training. When food service facilities maintained the required food safety training, they exhibited fewer identified deficiencies (e.g., food from unsafe sources, inadequate cooking, improper holding temperature, contaminated equipment). Having the required food safety training, however, did not eliminate deficiencies, likely due to various factors among FSEs.

FIGURE **3**

Deficiencies in Food Safety Training and Foodborne Illness Risk Factors by Facility Type at Fort Liberty, 2021



Limitations

Limitations of our study include using a fixed sample from Fort Liberty. Our study was cross-sectional rather than longitudinal in that inspections in a specific year were included. Data were collected from facilities at a specific point in time versus collecting data repeatedly from the same population over an extended period. Our study also relied on secondary data from standardized inspection reports, and thus there could be variations in the interpretation of individual inspectors who collected the data. Furthermore, our study observed the quantity (i.e., presence or absence) rather than severity of deficiencies. If the severity of each deficiency was rated, analyses could determine the number of deficiencies with a more severe impact on food safety and sanitation and the potential for foodborne illness outbreaks.

Recommendations and Conclusion

Food safety training requires reinforcement and hands-on application. If FSEs are not continuously observed and provided hands-on training with opportunities to apply what they have learned, they might not adhere to training, guidelines, and regulations for reducing deficiencies. Additional work should be done to improve behavioral-based food safety training to encourage implementing, retaining, and applying food safety training among DoD food facilities in the U.S. Moreover, existing food safety training programs across other military installations should be compared to evaluate the extent to which trends and potential mitigation could overlap. Maintenance of the required food safety training by FSMs and FSEs could minimize the number of deficiencies linked to CDC foodborne illness risk factors and reduce foodborne illness on military installations.

Future research could use ratings of deficiency severity (i.e., critical or noncritical) to determine a more detailed level of food service sanitation and safety operations. Fort Liberty could reinforce food safety training requirements by meeting with directors of all major food service facility categories to discuss deficiency findings and food safety training shortcomings. This meeting could include food safety training templates or programs the facilities could implement to reinforce food safety knowledge among PICs and FSEs. Fort Liberty could also implement standard operating procedures for facilities inspected by DPH and/or establish a policy to publish food facility inspection ratings to the military installation population.

These actions could incentivize facilities to increase their food safety knowledge, potentially reducing identified deficiencies within their facilities. A facility with repeated deficiencies in missing food safety training or other deficiencies could be temporarily mandated to cease operations until the facility rectifies the issues.

Acknowledgment: We thank the Fort Liberty DPH for its cooperation in granting access to the data inspection reports used in our study.

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