

ABSTRACT

SEYMOUR, NATALIE ROSE. Exploring the Use of Grocery Store Audits to Impact Food Safety Behavior (Under the direction of Benjamin Chapman).

Every year, foodborne illness affects one in six people in the United States, posing an economic and public health burden. It is estimated that 70% of foodborne illnesses are acquired from food establishments. With approximately 44% of adults in the United States eating out everyday, the risk of incurring foodborne illness is high. Food companies and establishments operate under food safety risk management systems in an effort to reduce foodborne illness, and third-party audits are sometimes a component of these systems. Though common, the efficacy of the third-party audit is not agreed upon. Food safety education and training programs are another means reduce the risk of foodborne illness, but their ability to influence behavior change is also in question. This thesis sought to analyze the results of third-party audits for insight into violations, as well as research how auditors could be leveraged to promote food safety behavior change.

A systematic literature review was conducted to understand the current knowledge base of safety auditing. Do to scarcity of research on restaurant inspections, little can be concluded about their efficacy. Further research must be conducted to draw definitive conclusions about the factors affecting restaurant inspection scores and their subsequent ability to predict foodborne illnesses. Safety auditing has been successful in healthcare applications when accompanied with immediate feedback. Articles on the application of third-party food safety audits noted audits are frequently employed as a business strategy, not necessarily to ensure safety. Another limitation of audits and inspections was the inconsistency of auditor competency and subsequently, audit quality. The audit system may need to be re-evaluated if promoting food safety is going to be the primary goal.

An exploratory survey-based study was conducted to assess the self-perception of roles and abilities of third-party grocery store auditors. Results showed auditors identified with the roles of teacher and coach, and provide food safety interventions when a violation is observed. Auditors were also confident in their abilities to communicate food safety information and perceived that food workers view them and their interventions favorably. These results suggest the need for further research into leveraging auditors as food safety intervention providers.

In the next study, audit data from six years of grocery store audits in the United States and Canada was analyzed to determine trends in handwashing compliance. This data revealed that there the East North Central division of the United States had higher proportions of non-compliance to handwashing. Deli departments had higher proportions of violations than other grocery store departments. Time of year, day of week and auditor had small effects on compliance. Further analyses must be conducted to include all audit data.

The final chapter of this thesis serves as a response to the three preceding studies. This chapter combines research on mobile, digital and game-based learning with the results from analysis of audit data in a proposed mobile intervention tool. Smartphones and other mobile devices are very popular in the United States, and many adults own and use them. Mobile learning and educational games are also a growing area of research interest. By combining digital learning research with learning theory and results from the big data analysis, a convenient, targeted, engaging intervention tool can be created for grocery store employees.

The studies outlined in this thesis point to the factors that coincide with food safety violations, as well as potential mitigation strategies to improve food safety behavior. Using

auditors as a formal means of food safety education could be a novel and innovative approach. Equipped with a user-friendly tool like a mobile, game-based learning intervention, auditors may be able to positively influence food safety behavior at retail.

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Exploring the Use of Grocery Store Audits to Impact Food Safety Behavior

by
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DEDICATION

To my siblings: Nicole, Joseph, Joshua, Caleb and Zoey Seymour.

Thank you for helping me learn how to care for others and being the
sweetest motivation to work hard.

BIOGRAPHY

Natalie Seymour is the daughter of Julie Seymour and Dion Seymour, and grew up in Maryland as the oldest of six children. Natalie grew up spending countless hours pouring over cookbooks, watching cooking shows and experimenting with new recipes. Natalie was introduced to food science in high school and was surprised to find out that she enjoyed science when it was applied to something she loved—food.

Natalie completed her Bachelor's of Science in Food Science at NC State University in 2014. Food safety allows her to share her passion for food science and helping others understand the world around them, all while working to keep people safe and healthy.

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INTRODUCTION

It is estimated that 48 million cases of foodborne illness are acquired in the United States every year. Of those 48 million, approximately 128,000 will spend time in the hospital and 3,000 will die of illnesses acquired from unsafe food (21, 22). The economic burden of foodborne illnesses is also substantial estimated to be between \$51-77 billion dollars annually (23). The United States Food and Drug Administration (FDA), in conjunction with the Centers for Disease Control and Prevention (CDC) and the United States Department of Agriculture Food Safety Inspection Service (USDA FSIS) recognize that there are five main factors that contribute to foodborne illness. These factors are: supplying food from unsafe sources; poor personal hygiene; inadequate cooking; improper food holding time/temperatures; and contaminated equipment/protection from contamination (9).

It is estimated that the average person in the United States eats out five times per week, resulting in 44% of adults eating out everyday (15). It is also estimated that 52 to 70% of foodborne illnesses are attributed to retail establishments (10, 11, 14, 15). CDC reports that 70% of norovirus outbreaks from contaminated food are traced back to infected food workers, and 64% of norovirus outbreaks are traced to food contamination in a restaurant (3). Norovirus accounts for 58% of foodborne illness cases in the United States annually (22). These factors make the risk of incurring a foodborne illness, especially norovirus, relatively high.

These main risk factors for foodborne illness are directly influenced by food worker behavior (20, 26), and therefore preventable with compliance to food safety standards. Food workers typically receive information about food safety at hire and throughout their time handling food. Food safety education programs may focus on information about food safety

in the form of lectures and printed materials, while training would include hands-on instruction on how to handle food safely (6, 7). Communication about food safety continues past formal training and education and can occur in the form of verbal or written updates and reminders, such as infosheets, posters and manager feedback (4, 13, 18). Current food safety training and education methods can be classroom style, hands-on or computer-based with an post assessment of knowledge change (7, 8, 24). One study of grocery store food workers showed that 78% were receiving electronic presentations delivered in-house (20). Current food safety training and education methods appear to be inadequate in improving the food safety behavior of retail food workers (12, 17, 19).

Hurdles to improving food safety behavior are the many perceived and real barriers to safe food handling, such as time constraints, lack of motivation, inconvenience and inadequate training or resources (13). Research could provide insight into these hurdles and factors around non-compliance. More specific knowledge of what goes on around a food safety violation can influence targeted intervention materials and the removal of barriers in an attempt to promote safe food handling.

Many sectors of the food industry rely on assessments from third-party auditors as part of their food safety management programs (18). Audits and inspections alone are limited, as they are only able to accurately assess the conditions at the point in time that the audit is taking place. Many retail grocery stores obtain third-party audits, which generate a wealth of data on the condition of the store, but most audit data is underutilized. Big data science and the understanding of how to model large data sets has exploded and many industries are using their data in powerful ways (1, 2, 5, 16).

This thesis begins with a study third-party auditors' beliefs, attitudes and values (Chapter 2). To date, no research has been done to determine the attitudes and self-perception of auditors. Behavioral theories point to a person's self-identity as a predictor for planning and executing behaviors. With this in mind, a mixed methods survey was used to evaluate the auditors' self-perception of roles and abilities. Overall, auditors identify with roles of teacher and coach and feel as though helping food workers understand why food safety is important is an integral part of their job. Auditors also place a high value on knowledge and are confident in sharing it with food workers and management. This study provides evidence that these third-party food safety auditors perceive that they have influence over situations and see themselves as conduits for food safety interventions.

A study of third-party food safety audit data was begun in an effort to identify trends and patterns in violations (Chapter 3). By using the data generated from thousands of audits across the United States over six years, this project is piecing together a clearer picture of the factors that surround handwashing non-compliance. Results showed that there is a moderate effect of department on the proportion of handwashing violations, with the largest proportion being in the deli department. Geographic location also has a small-moderate effect, with zip codes in the East North Central division of the United States having higher proportions of violations than other parts of the country. This study serves as the foundation for more research using audit data, which will help identify other factors surrounding food safety violations.

Since auditors already communicate food safety, further research should be conducted to see if leveraging auditors to provide real time training is an effective means to catalyze behavior change and increase compliance. A proposed model for this research is

outlined in Chapter 4. Results from the big data analysis in Chapter 3 could be used to create a convenient, engaging, evidence-based intervention tool designed to be delivered by auditors. The proposed tool would be designed for use on a tablet, and would combine mobile and game learning research with behavior theory and the findings of these studies. Auditors already carry tablets to conduct their audits, and many adults are familiar with portable electronic devices (25).

The studies outlined in this thesis explore new facets of food safety concerns at retail, as well as potential solutions to those concerns. Strategic utilization of audit data has powerful implications for monitoring food safety and understanding the circumstances surrounding food safety violations. Auditors can be leveraged to provide food safety interventions at the site of violations, which could be an effective means of promoting behavior change. The use of technology, specifically game-based learning, could also modernize food safety communication and intervention to engage food workers in a novel way. This research lays the foundation for more studies on the interactions of third-party food safety audits and food worker interventions, with the ultimate goal of increasing safe food handling behavior.

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CHAPTER ONE

The Efficacy of Food Safety Audits and Inspections:

A Review of Selected Literature

INTRODUCTION

Companies throughout the food system utilize third-party audits as an element of their food safety risk management systems. These third-party audits are often conducted by outside industry service providers hired to evaluate the company's food safety system. By the traditional definition, audits include careful evaluations of processes, facilities and relevant plans and documentation. Inspections are generally defined as an examination of a facility and process (8, 19). Inspections are also often conducted by regulatory agencies, such as local public health and federal regulators.

Food suppliers throughout the food system can also be subjected to third-party audits as a means to obtain or maintain industry certifications. These certifications are instituted and regulated by private organizations or buyers themselves, and can be for food safety, quality or labeling claims (2, 23). Many suppliers are required to maintain these certifications in order to sell their product to certain buyers (10, 17, 24). The certification audits may or may not be focused on true compliance to food safety standard. Despite widespread use in the food industry, a third-party audit cannot be the sole metric a company relies on, and recent foodborne illness outbreaks highlight the potential flaws in the system.

Several outbreaks have occurred in cases where the third-party auditor gave a company a high score a short period of time before an outbreak. These outbreaks include: *Salmonella* contaminated peanut butter at Peanut Corporation of America in 2009 (13, 16);

Jensen Farms *Listeria* contaminated cantaloupe in 2011 (18); and *Listeria* contaminated Blue Bell ice cream products in 2015 (22). These outbreaks have caused some to question the efficacy and reliability of third-party food safety auditing (16, 19).

It should be noted that though the audit system is not perfect, food safety is more than just a company or establishment understanding risks and undergoing audits. Food safety comes down to safe food handling behavior to reduce the risk of foodborne illness. While many food safety education and training programs show increase in food safety knowledge, that knowledge may or may not correlate to behavior change (7, 14, 20). A challenge in food safety is promoting behavior change and addressing perceived barriers to safe food handling as another part of the food safety system (7, 21).

It is likely that audits may not be accomplishing the safety goals of a company, but there is very little research into how effective these third-party audits are at affecting food safety. These audits have potential as a method to address food safety in various sectors of the food industry by revealing areas of strength and weakness. Understanding how audits are used and whether they are truly effective is crucial in improving food safety practices at many companies.

The objective of this literature review is to aggregate and analyze the function, efficacy and impact of auditing and inspecting in the area of food safety. Auditing for safety in healthcare settings was also included. Audits can be implemented in some hospital and healthcare settings to monitor the hygiene behaviors of doctors and staff. Audits are also intended to reveal behaviors that may pose risk to patients. Since these audits are also meant to assess risky human behaviors they were included in this review.

METHODS

Article Selection. A systematic review was conducted in order to allow for a more robust analysis of a limited literature base. An initial literature search was conducted using Google Scholar and the following search parameters: “Third party audit” AND (“food safety” OR “healthcare”), which yielded 697 results; "inspection" AND ("food safety" OR "healthcare"), which yielded 221,000 results; and ("audit" OR "inspection) AND ("impact" OR "efficacy") AND ("food safety" OR "healthcare"), which yielded 153,000 results. Articles were first reviewed by title to exclude duplicates and irrelevant studies. Also excluded were papers not available publicly or through North Carolina State University library subscriptions.

Article abstracts were then reviewed to determine final inclusion. The inclusion criteria were as follows: a) primary focus on auditing/inspection for food safety purposes or for safety purposes in healthcare settings; b) focus on the efficacy or impacts of auditing and inspection; and c) peer-reviewed, published literature in English. Article types excluded were: literature reviews, review papers, dissertation theses, conference proceedings, news and feature articles, blogs, reports, lectures, non-peer reviewed work, working papers and letters to editor. Other criteria for exclusion were: a) studies primarily focused on quality audits, or audits for labeling claims; b) papers focused on validating and verifying (spell it out the first time)HACCP plans; c) papers primarily focusing on federal regulatory audits and co-regulation; d) papers primarily focusing on the economic considerations for auditing and inspections; e) papers focusing on non-audit tools and programs for food safety assessment; and f) papers focused on how-to prepare for third-party audits.

Inclusion criteria were designed to identify articles focused on the role of third-party audits and their ability to influence safety behavior change. Articles related to facets of the auditing system that don't affect food safety behavior change, such as economic considerations and quality claims, were excluded. Restaurant inspection studies were included to provide insight into their affect on changing behavior and predicting foodborne illness. Three additional articles were identified from the citations of the included literature (5, 6, 8). Fifteen articles were selected for final analysis.

Article Analysis. Articles were divided into three categories for analysis, as seen in Table 1.1. The first category sought to determine if studies on restaurant inspections were able to predict illness or show positive effects of inspection frequency, food worker education or incentives on final scores. The second category looked at third-party safety auditing efficacy. The third category of articles was coded to provide insight into the motivations for third-party audits, as well as their limitations. NVIVO for Mac 11 (QSR International, 2015) was used for coding and article analysis.

RESULTS

Restaurant Inspections. The results of the seven articles looking at food establishment inspection reports can be seen in Table 1.2. Four studies used existing inspection data, two used existing inspection methods to collect data and one was based on a mailed questionnaire. Jones et al. (2004), concluded that many factors influence inspection scores, but overall scores did not differ significantly between establishments that had a foodborne illness outbreak and those that had not. Cruz, Katz and Suarez (1995) came to a similar conclusion that inspection scores were not able to predict outbreaks. Irwin et al. determined that inspections could identify those establishments at higher risk for food safety issues, and Mathias et al. (1994) found an association between violation rates and foodborne illness, but no association between inspection scores and food worker education. Mathias et al. (1995) did find that food worker education had a positive effect on food handling practices.

Third-Party Safety Auditing. Two papers on auditing in healthcare settings noted that the presence of an auditing program was able to reveal risky behaviors and mistakes (3, 25). When immediate feedback was given, compliance to safety behaviors increased. In the study by Armellino et al. (2012), compliance to hand washing increased with feedback and was sustained over a 75-week period. Full results can be seen in Table 1.3.

Third-Party Food Safety Audit Characteristics and Motivations. All articles analyzed noted that third-party food safety auditing is a business and both buyers and suppliers use audits strategically (1, 9, 12, 19). Buyers use third-party audits as a way to push

responsibility on suppliers, and suppliers leverage third-party audits as a marketing tool (9, 12, 19). Hatanaka, Bain and Busch (2008) praised third-party certification, and the audits that come with it, as having the ability to increase the safety of food and secure business leverage. The remaining three articles noted that the quality of the audits is strongly dependent on the auditor that performs them (1, 12, 19). Albersmeier et al. (2009) noted that it is difficult to generalize audit quality because of the discrepancies between auditors. Lytton and McAllister (2014) noted that since outbreaks are rarely traced back to auditor they do not always carry the responsibility of a negligent audit. Negligent audits and discrepancies can be due to perceived financial, social or job security conflicts of interest (12). Powell et al. (2013) highlighted that third-party audits are not a reliable metric for predicting foodborne illness and should only be used as one performance indicator.

DISCUSSION

Due to the dearth in food safety auditing research it is difficult to determine how effective restaurant inspections are at predicting foodborne illness. Some studies indicated that frequency of inspections does not impact the final scores of the inspections (5, 11) or reported foodborne illness (14). Other studies looking at the influence of food worker food safety training did not have conclusive evidence that it consistently improved inspection scores (14, 15). Even if inspection scores were raised, they may be unable to ensure an establishment will go without a foodborne illness incident. Jones et al. (2004) found no significant differences in mean scores from restaurants who had an outbreak and those that did not, and Cruz, Katz and Suarez (1995) found that scores did not predict a foodborne illness outbreak. The inspection model also only gives a snapshot of the situation, so it may

or may not be able to accurately assess the food safety issues in an establishment (19). It should be noted that the studies analyzed were not using the same standards or forms, and may have different scoring systems. The audit tool itself may not be robust enough to identify potential risk factors (19). This analysis suggests that current research on the ability of restaurant inspections to predict foodborne illness is not consistent and audit tools may not be asking the right questions.

There are also many limitations within the third-party auditing system (Table 1.4). Four articles noted that the auditor heavily influences third-party food safety audit quality. The turnout of an audit is dependent on the auditors' technical capabilities, discretion, motivation and potential conflicts of interest (1, 8, 12, 19). Coupled with most companies viewing third-party audits as a business requirement, these limitations are troublesome (1, 4, 9). Inconsistency is a common critique of third-party auditing as well as restaurant inspections, so work to address this limitation could improve the value of these audits.

A potentially impactful change to the audit model would be the continuing the use of risk based auditing (1). By auditing based on risk factors instead of a predetermined checklist, the auditor would be able to make assessments based on risk factors unique to the establishment. Though this would increase the burden on the auditor themselves, especially in the realm of decision-making and technical expertise, this tailored approach could more directly impact the safety of an establishment (1).

Overall, this research indicates that the current state of auditing and inspecting within the food system may need to be re-evaluated. If the end goal is to make a buyer happy, or to achieve a certain score, then perhaps the current system is working. However, if the end goal is to produce and sell safer foods and to ultimately reduce the burden of foodborne illness,

then the current audit and inspection system needs to be reassessed. Regardless of any changes that should be made, audits and inspections will never be a comprehensive solution for food safety problems. As noted in Powell et al. (2013), third-party audits have their place in the food system, but as part of a comprehensive food safety management plan.

Audits and inspections are probably not going away anytime soon, so efforts should be made towards better understanding the current system and identifying ways to improve. More research into the efficacy of third-party audits for food safety could supplement the current literature base and create a more robust knowledge base of the subject. Efforts to standardize metrics and audit protocol could create more consistent and comparable results. Standardizing audit protocol could also help reduce some of the conflicts of interest among auditors, which would hopefully lead to an increase in audit quality.

Table 1.1 Article characteristics and categories for analysis

Category	Studies of Restaurant Inspection	Studies of Third Party Auditing	Overviews of Third Party Auditing
Characteristics and Themes	Purpose	Purpose	Purpose
	Location	Location	Advantages
	Sample size	Sample size	Challenges/Limitations
	Study design	Study design	Critique
	Data collection	Data collection	Key Points
	Key finding	Key finding	

Table 1.1 Article characteristics and categories for analysis

Category	Studies of Restaurant Inspection	Studies of Third Party Auditing	Overviews of Third Party Auditing
Characteristics and Themes	Purpose	Purpose	Purpose
	Location	Location	Advantages
	Sample size	Sample size	Challenges/Limitations
	Study design	Study design	Critique
	Data collection	Data collection	Key Points
	Key finding	Key finding	

Table 1.2 Characteristics and key finding of studies analyzing restaurant inspections (missing Petran paper: <http://www.ncbi.nlm.nih.gov/pubmed/23127710>)

Authors	Purpose	Location	Sample	Study Design	Data Collection	Key Findings
(Corber et.al, 1984)	Determine if sanitary conditions are dependent on inspection frequency	Canada	400 establishments	Single-blind randomized control	Standardized form, trained inspectors	On average, increased frequency of inspections does not significantly decrease violations.
(Cruz, Katz, Suarez, 1995)	Determine ability of inspection reports to predict outbreak	United States	51 cases	Case-control	Existing cases and inspection reports	Inspection reports fail to predict foodborne illness outbreaks.
(Fielding et.al, 2001)	Determine impact of inspection program	United States	Results from one year	Cross-sectional	Environmental health reporting systems	Violations increase with increasing amounts of food handling. New program had positive influence on food handling practices.
(Irwin et.al, 1989)	Determine relationship of inspection results to outbreak	United States	28 outbreak reports/ 56 control	Case-control	Standardized form	Inspection form can identify establishments with increased risk of food safety issues.
(Jones et.al, 2004)	Assessment of inspection system	United States	20,000 inspections	Case Study	Standardized inspectors/ forms	There are many factors that affect the uniformity of inspections. Mean scores were not significantly different between establishments with and without outbreaks.
(Mathias et.al, 1994)	Describe current practices in restaurant inspection, education and foodborne illness	Canada	136 jurisdictions	Cross-sectional	Mailed questionnaire	Evidence of association between foodborne illness and violation rates, but not between inspection scores and food worker education.

Table 1.2 (continued)

Authors	Purpose	Location	Sample	Study Design	Data Collection	Key Findings
(Mathias et.al, 1995)	Effect of length of time between inspections on violations	Canada	610 inspections	Cross-sectional	Standardized form	Inspections should occur annually, there are no restaurant types of higher risk and food service education has positive effect on food handling practices.

Table 1.3 Characteristics and key finding of studies analyzing third-party auditing

Authors	Purpose	Location	Sample	Study Design	Data Collection	Key Findings
(Armellino et.al, 2011)	Evaluate hand washing with remote video TPA	United States	One ICU, continuous two years	Cross-sectional	Video surveillance	Audit feedback can increase and sustain compliance
(Chen, et.al, 2014)	To evaluate the challenges, impacts and motivations of TPA.	New Zealand	115 manufacturers	Cross-sectional	Questionnaire survey	Primary incentives for TPAs: buyer requirements, and improving quality/safety
(Ursprung et.al, 2005)	Study in real-time safety auditing in ICU	United States	One ICU, 13 observation days, 36 days total	Observational study	Standardized forms, one research nurse	Real-time auditing can detect problems and influence immediate change

Table 1.4 Key findings of studies analyzing and critiquing third-party food safety auditing

Authors	Article Purpose	Advantages	Challenges/Limitations	Critique	Key Points
(Albersmeier et.al, 2009)	Evaluate the connection between TPC and framing of standards	Risk oriented auditing can be beneficial	Primarily business motivated Interest geared toward finding/providing easiest and cheapest audit Inconsistencies among auditor competency Difficult to generalize audit quality	Many severe differences between certifications. Many TPC schemes are buyers means of control	There are notable discrepancies within audits, with multiple influencers. Switch focus to risk-oriented auditing
(Griffith, 2005)	Review traditional and innovative inspection strategies	Inspections can provide consumers with valuable information if conducted well; technology can optimize effectiveness	Many factors influence audit quality. Limited resources affect inspection frequency Inconsistency among auditors is problematic	Inconsistent, ineffective, inadequate resources, confusing, too general	Audit and inspection system needs to be reworked to meet needs of food establishments
(Hatanaka, Bain, Busch, 2005)	Highlight factors influencing TPC by examining retailers, suppliers and auditors	TPC transfers monitoring responsibility and liability to auditor/supplier; can be used for marketing	Audits are used as business strategy		TPC are a means to sustain regulation and enter niche markets.

Table 1.4 (continued)

Authors	Article Purpose	Advantages	Challenges/Limitations	Critique	Key Points
(Lytton, McAllister, 2014)	Analyze the sources and types of auditor conflict of interest and assess potential solutions	Private auditors operate outside government regulations	Buyers require audits Audits are expensive Audits depend on auditors' discretion and technical knowledge Outbreaks are rarely traced to auditors	Outbreaks occur at companies with high scores. Conflict of interest may be financial, social or job-related	Conflict of interest arises when auditors are paid by those who are audited
(Powell et.al, 2012)	Identify limitations of audits and inspections and make recommendations for change	Useful if used to make risk-based decisions and changes Can assist regulatory agencies	Effectiveness determined by auditor competency Push responsibility on supplier Only one performance indicator	Not a reliable metric for predicting foodborne illness	There are both strengths and weaknesses Does not determine food safety determined by TPA

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CHAPTER TWO

Evaluating the Self-Perception of Skills and Roles of Third-Party Food Safety Auditors in Grocery Stores

INTRODUCTION

Third-party auditing is used throughout the food system to monitor and manage food safety. These audits are conducted by an entity separate from government, purchaser or the company being inspected, with the intent of providing an unbiased evaluation. Audits verify that policies are being followed and identify activities, processes or behaviors that need improvement (27). Inspections traditionally refer to an examination of an establishment and its operation and are often carried out by government regulatory authorities, such as the local environmental health department (10, 27). Food industry support providers often include auditing as part of their services. In grocery stores, third-party audits evaluate adherence to food safety standards before regulatory inspections and provide insight into whether food is being handled safely, and can be effective means of improvement when results are acted upon (27).

Traditional food safety training for retail food workers, both those in general food handling and management positions, has limited effectiveness, suggesting that alternate strategies should be explored to promote behavior change (9, 28, 31, 39, 40). Utilizing auditors as food safety trainers to assess, deliver and evaluate interventions has potential in engaging retail employees with food safety information and the importance of safe food handling. However, the attitudes of third-party auditors towards their roles in influencing food safety have not been assessed. The self-identity and self-efficacy of auditors can be

important factors in creating interventions, as they can influence whether or not an individual plans to perform a behavior (3, 35). Self-identity includes how individuals view themselves and the roles they assume (29, 35), while self-efficacy is an individual's belief in their ability to succeed at a particular challenge (3). Since both self-identity and self-efficacy influence behavioral intent, an assessment of auditors' self-identity and self-efficacy can provide insight into if and/or how an intervention may be used.

Though third-party auditing and inspection by regulatory agencies are commonplace in the food industry, it is unclear whether they are an effective strategy to mitigate the risk of foodborne illness (2, 18, 19, 27). Third-party audits cannot ensure that food safety practices and protocols are being consistently and properly implemented, as audits only represent a snapshot in time, when an auditor was present (16, 27, 32). Audits can be valuable if action is taken in response to the feedback. Food workers must apply the feedback and make positive changes to increase the safety of the food produced in the establishment, as in the audit and feedback model used in healthcare (12). Without responsive action, audit feedback is of limited value.

Ajzen's Theory of Planned Behavior (TPB) states that there are three factors that influence whether or not a behavior will be planned and carried out. These three factors are attitude, subjective norm and perceived control (1). If these factors are negative, the individual is less likely to follow through with the desired behavior. For example, if a food worker has a negative attitude towards hand washing, does not believe it makes a difference in food safety (perceived control) and/or it is not a priority at the store (subjective norm), then they are less likely to wash their hands. Several applications of the TPB have been made

in food safety and health-related hygiene practices. It has been used to reveal intentions, and to some extent predict hand washing behavior (5, 6, 8, 13, 14, 15, 21, 23, 24, 26, 33, 34, 37).

One of the world's largest equipment and chemical companies (referred to as Company A) conducts food safety audits for grocery store chains in the United States and internationally. Audits are incorporated into store visits conducted by Company A staff who are trained to evaluate and perform maintenance on equipment, sell sanitation and pest control products, and provide insights into compliance with company standards. Company A employs approximately 310 auditors throughout the United States. Auditors are responsible for all locations of one or more grocery store chains within their respective territories. Audits are provided as a service to companies and are often used to validate standards above mandated regulations. Each audit is tailored to a specific client and they differ on various attributes, including: priorities of risk factors; specific behaviors evaluated; focus; length; and frequency of audit. Additionally, companies' positions vary on the auditor's ability to provide an intervention to a food safety infraction when one is observed.

With an outside perspective and *in situ* observations, auditors can play a unique role in food safety training and education. If auditors feel as though they have the resources and ability to influence positive food safety behavior (perceived behavioral control) then perhaps they can effectively reach food workers, a strategy that has been previously recommended (30). This exploratory research aims to provide insight into whether these individuals see themselves as auditing, coaching and/or teaching, and if and how they provide food safety information to store personnel.

METHODS

Survey Development. Due to the large population of auditors and wide geographical spread, an online survey was chosen for data collection. The online survey method allowed for many responses to be collected in a short period of time, while also giving auditors the ability to participate at their convenience and security in the increased confidentiality of their responses. A mixed-methods survey was developed using SurveyMonkey.com (Appendix A). North Carolina State University Institutional Review Board (IRB) determined the survey was exempt from being human subject research (IRB #5982).

Survey Content. The survey included various questions relating to the roles of auditor, teacher and coach. As seen in Appendix A, auditors were asked if they felt their job was to methodically examine and review to find problems (audit), help individuals to learn by giving lessons/instruction (teach) or to instruct or train (coach). Role theory suggests that individuals will behave in ways that are considered normative for the roles with which they identify (4). The role of auditor was chosen because of the food safety audit portion of a store visit. Though the term audit is within their materials, it had not been established as to whether or not the auditors identify with that role. The roles of teacher and coach refer to roles auditors may assume if they were to become conduits for food safety interventions. The Merriam-Webster online dictionary (<http://www.merriam-webster.com/>) was used as the source of definitions for these role terms, to control for different interpretations. Auditors were asked whether they identified with each definition.

In the first portion of the survey, participants were asked to rank nine job activities from greatest to least importance. These activities were gathered from conversations with

upper management within Company A, as well as a posted online job description.

Participants ranked characteristics of a good auditor, teacher and coach in order of their perceived importance. The characteristics were pulled from literature on qualities that make good teachers, coaches, auditors and inspectors (11, 20, 36, 38) Characteristics that were specific to grade school teaching, sports coaching and accounting auditing were deemed inapplicable and omitted. Synonyms pulled from the Merriam-Webster online dictionary (<http://www.merriam-webster.com/>) were listed next to the characteristics to minimize confusion about definitions. Auditors were also asked to rank the roles of auditor, teacher and coach against each other in terms of importance within their jobs.

The second portion of the survey asked about the auditors' views on performing interventions if they see an infraction during an audit. Auditors were asked if they corrected infractions, what the barriers were for performing interventions, and how they usually perform interventions. Auditors had to self-evaluate their ability to clearly communicate food safety material and their perceptions of employee attitudes to their presence and intervention attempts. Participants' age, sex, length of time in current position and previous audit experience were also recorded.

Survey Testing. The survey was piloted by a convenience sample of four local environmental health specialists who conduct grocery store inspections, as they are familiar with the process of verifying compliance to food safety standards in a retail setting. Feedback on the survey was also provided by Company A resulting in replacing select words with their definitions that reflect Company A's culture and terminology. Both the environmental health specialists and Company A noted that questions 12-15, which asked to rank characteristics in

order of perceived importance, had too many characteristics listed, and that characteristics were potentially ambiguous. To address the ambiguity, synonyms were included next to answer choices. The number of characteristics found in of questions 12-15 were not consolidated unless they had also been paired in the reference literature (11, 20, 36, 38).

Survey Implementation. Participants were recruited through a convenience sample, via emails sent to auditors from supervisors who oversee defined geographical regions. Messages explained the premise of the project, how the data would be used and the study's affiliation with North Carolina State University. Auditors were then asked for their informed consent before participation; auditors were required to agree to participation before proceeding with survey questions. A follow-up email was sent ten days later, via Company A's monthly newsletter. Survey participants were instructed to focus solely on the food safety auditing portion of their job, as many perform a variety of services, such as equipment maintenance during a store visit.

Statistical Methods. One-way Analysis of Variance (ANOVA) tests were performed on each of the ranking questions to determine any significant differences within answer choices. A Tukey's HSD (honest significant test) with an alpha level of 0.05 was used to determine significant differences between each pair of answer choices. Tests were run using JMP® Version 12 for Macintosh, (SAS Institute, Cary, NC).

As seen in questions 17-19, 23 and 25, Likert-type scale questions were asked with a ranking of one being most positive (ex. "*very good*") and five being the least positive (ex. "*very poor*"). Likert-type scale questions were then given a weighted average based on

responses. Free response questions were observed for trends and analyzed for use of positive training terms.

Additional tests were used to determine significant differences between the answers from auditors in different groups. Microsoft Excel (2011) was used for Chi-square tests to determine significant differences between responses to questions 12-15. Unpaired t tests were run to compare the means of responses to Likert-type scale questions using www.graphpad.com. Conditional probabilities were calculated for the responses to questions 20 and 24. A Chi-square test was then used to determine if there were any significant differences present.

RESULTS

Response, Demographics and Characteristics. There were 121 responses out of the approximately 310 auditors to which the survey was sent. Sample distribution of work experience was compared with data from human resources. Unpaired t test determined no significant difference in the distributions ($p=0.373$). Demographic data of study auditors is shown in Table 2.1. Data shows the majority of auditors have one to five years of experience working as an auditor with Company A (49%, $n=121$), didn't have experience coming into the position (83.5%) and are responsible for 3 or more (84%) national and regional chains (80%).

Self-Perception and Job Priorities. Ninety percent ($n=121$) of auditors identified with the role of coach, 91% identified as a teacher of food safety and 74% identified with the role of auditor (multiple responses allowed). There were significant differences in responses

to priority of job activities (F Ratio=59.27, $p<0.0001$). The top three most important activities were: identify problems, protect public health and teach food safety practices (Figure 2.2, Table 2.1). Significant differences were also observed between auditors' rankings of characteristics needed for all three roles: auditors (F Ratio=41.08, $p<0.0001$), teachers (F Ratio=33.75, $p<0.0001$) and coaches (F Ratio=25.42, $p<0.0001$). Knowledge was ranked as the most important characteristic, but was not significantly different from the following: respect and honesty, support and understanding (Figures 2.3-2.5, Tables).

When asked to rank coaching, teaching and auditing, coaching was listed as highest importance and significantly different than teaching ($p=0.0156$) and auditing ($p=0.038$). There was no significant difference between the rankings for coaching and teaching ($p=0.962$).

There were no significant differences between the rankings of auditors with previous experience and auditors without, or between auditors with one chain and auditors with multiple chains ($p=0.999$).

Auditors' Self-Assessment. Auditors' self-assessment can be seen in Table 2.7. The results showed that the auditors are very confident in their abilities to explain and relay food safety information. They also perceived that food workers view them and their intervention efforts positively.

Interventions. Ninety-two percent ($n=121$) of participants indicated that yes, they provide interventions when an infraction is observed and 8% indicated that they sometimes provide them. Those auditors that indicated they sometimes provide intervention were asked

select all factors that prohibited them from performing interventions. Of the 8% (10 auditors) who indicated they sometimes provide interventions, two cited that specific clients did not allow reactive interventions, five cited concerns about time and eight selected 'other' factors as to why they do not always provide interventions. Auditors frequently use verbiage such as 'explain' (62), 'risk' (39) and 'solution' (13) when describing how they perform interventions. Frequency data can be is shown in Table 2.6. Results of rating questions can be seen in Table 2.7.

Forty-six percent (46%) of auditors said they always use previous food safety audits to influence the interventions they provide. Another 46% said they sometimes use previous audits, while 8% said they did not. There were no significant differences between the ratings of auditors with previous experience and auditors without, or between auditors with one chain and auditors with multiple ($p>0.05$). Tests of conditional probability showed that experienced auditors are eight percent (8%) more likely to pull from previous audits when providing an intervention ($p=0.027$), no other tests were significant.

DISCUSSION

When looking at auditors' self-perception of roles within the job, auditors strongly identify with their job being to teach and coach, by definition. Fewer auditors felt their job was to audit. However, when asked to rank the activities in their job in order of importance, identifying problems was listed at the top, along with protecting public health. The action of identifying a problem fits in with the definition of an auditor. This suggests that auditors' self-identities are dictated by what they think they do as opposed to what their job tells them

they do (perform an audit). There is strong evidence that self-identity plays into the Theory of Planned Behavior and can be used as a predictor of behavioral intent (29).

Teaching food safety behaviors was listed as one of the top three most important activities, but coaching was listed as one of the bottom three. From the previous questions it was observed that the auditors identify as teachers and coaches more strongly than they do as auditors when presented with the definitions. This suggests that the words themselves may be carrying a different connotation than their actual meaning. In conversation with Company A it was mentioned that some grocery chains have their own definitions for some of the terms used, so auditors could have been thinking of those definitions instead of those traditionally used. Though auditors may not use those terms to describe themselves they do feel as though the actions that come along with those terms encapsulate what they do.

Scoring as the lowest overall priority for the auditors was helping the store obtain a good score and enforcing compliance. This follows along with the idea that the third-party auditing is meant to act as an assessment. However, it is worth noting that a small subset of the population (5%) did rank helping the store obtain a good score as top priority. When asked to rank the importance of the characteristics of a good coach, teacher or auditor, knowledge of the subject matter was consistently listed as the most important characteristic. The auditors value the subject matter and feel confident in their ability to effectively translate that information. Auditors report frequently staging forms of interventions as opportunities to help transmit knowledge and improve behavior. These responses usually include the auditor explaining using words like risk, reason and solution. Example interventions include: *“I explain why the behavior is a risk, present a solution, and focus on the positive of changing the habit to prevent future risk vs. dwelling on a mistake”* and *“I explain possible outcomes*

and relate it to their own lives, families, and include anecdotal info to add a more credible touch.”

Additionally, auditors feel as though the food workers in the grocery stores overall view them positively. This indicates that auditors have a positive sense of self-efficacy, which inclines them to perform such interventions (3). According to the Theory of Planned Behavior (TPB), when approaching a particular behavior, a person’s attitude, the subjective norm, and their perceived level of control over the situation influence what they do (17). When analyzed through the Theory of Planned Behavior, the survey results suggest several positive outcomes. One, auditors overall have a positive attitude towards providing and delivering interventions. Two, if this positive attitude is shared throughout Company A, it has become the subjective norm. Three, the results suggest that auditors perceive that they have the knowledge and skills needed to effectively relay food safety information. This also points to strong self-efficacy. According to the TPB, this level of perceived behavioral control, along with the attitude and subjective norm, are indicative of the behavior being performed. Also, a meta-analysis of self-identity and TPB concluded that self-identity is a strong predictor of behavioral intent (29). The results showing that auditors identify with the roles of teacher and coach could also indicate their readiness to perform interventions.

Results demonstrate that auditors are willing to provide food safety interventions when they see risky behavior. Current literature debates the effectiveness of education and of inspecting (18, 25, 30), but one study noted that inspections and education together can increase compliance to food safety when improved scores are the desired outcome (19). The literature also suggests that food workers prefer short, interactive trainings (22, 31), and that informal training can be done during inspections (30). Armed with evidence-based materials

in these formats, auditors could be effective means of delivering training to food workers at the time of infraction with the goal of changing behavior.

Limitations. Limitations to this study include the inability to secure higher participation without perceived coercion, as well as the inability to collect more demographic and characteristic data due to IRB constraints. Also, social-desirability or response bias (7) could have led auditors to respond more positively than accurate, and self-selection bias could have caused only those who are enthusiastic about their job to complete the survey. The definitions of coach used in the survey align more closely with that of an athletic coach than a business coach. This may have influenced the answers by muddling the distinction between teacher and coach.

CONCLUSION

Overall, the third-party food safety auditors identify with the roles of teacher and coach and feel as though an integral part of their job is to help food workers understand why food safety is important. These auditors place a high value on knowledge and are confident in sharing it with food workers and management. This study provides evidence that these third-party food safety auditors perceive that they have influence over situations and see themselves as avenues for food safety interventions. Therefore, research should continue and explore methods by which to maximize auditors and their potential during audits.

Table 2.1 Auditors' demographic and characteristic data

Gender		Age		Years experience with Company A	
Male	88%	20-30	20%	<1	61-70
Female	6%	31-40	34%	1-5	49%
Prefer not to answer	6%	41-50	27%	6-10	24%
		51-60	16%	11-16	12%
			3%	16-20	5%
Prior food safety auditing experience		Experience Gained		Years previous experience	
Yes	16.5%	85% (n=20)	Processing facilities Restaurant management Government/military food auditing	1-5	45%
No	83.5%	20% (n=20)	Other private auditing firm	6-10	35%
				11-20	20%
Chains in territory		National Distribution			
1	14%	Regional only	13%		
2	2%	National only	8%		
3+	84%	Both regional and national	80%		
Percentage of chains allowing interventions			94%		

Table 2.2 Tukey's HSD in responses to ranking importance of job activities

Answer Choice	Significant Difference ^a	Mean
Identify problems	A	3.38
Protect public health	A B	3.41
Teach food safety practices	B C	4.26
Prevent problems	C	4.40
Address problems	C	4.41
Prevent and address hazards	C D	4.94
Coach managers and associates	D	5.62
Enforce compliance	E	6.57
Help store obtain a good score	F	8.01

^aSame letters indicate items that are not significantly different

Table 2.3 Tukey's HSD ranking importance of characteristics of a good auditor

Answer Choice	Significant Difference ^a	Mean
Overall food safety knowledge	A	4.08
Conscientiousness (honesty, ethics, scrupulousness)	A B	5.31
Responsibility (reliability, trustworthiness)	B C	5.66
Oral communication skills	B C D	5.98
Sound judgment	B C D	6.18
Respect (consideration, regard)	B C D E	6.54
Problem solving ability	C D E	7.04
Precision and order (accuracy/exactitude, systemization/organization)	D E F	7.21
Self-confidence (stability, security)	E F	7.75
Client awareness	F G	8.66
Participating and outgoing (socially uninhibited, friendly, responsive)	G H	9.75
Sensitivity and humanistic (perceptiveness, acuteness, delicacy)	G H	10.03
Critical (suspicious, opinionated)	H	10.29
Enthusiasm and spontaneity	H	10.50

^aSame letters indicate items that are not significantly different

Table 2.2 Tukey's HSD in responses to ranking importance of job activities

Answer Choice	Significant Difference ^a	Mean
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Address problems	C	4.41
Prevent and address hazards	C D	4.94
Coach managers and associates	D	5.62
Enforce compliance	E	6.57
Help store obtain a good score	F	8.01

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Table 2.3 Tukey's HSD ranking importance of characteristics of a good auditor

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Oral communication skills	B C D	5.98
Sound judgment	B C D	6.18
Respect (consideration, regard)	B C D E	6.54
Problem solving ability	C D E	7.04
Precision and order (accuracy/exactitude, systemization/organization)	D E F	7.21
Self-confidence (stability, security)	E F	7.75
Client awareness	F G	8.66
Participating and outgoing (socially uninhibited, friendly, responsive)	G H	9.75
Sensitivity and humanistic (perceptiveness, acuteness, delicacy)	G H	10.03
Critical (suspicious, opinionated)	H	10.29
Enthusiasm and spontaneity	H	10.50

^aSame letters indicate items that are not significantly different

Table 2.4 Tukey's HSD ranking characteristics of a good teacher

Answer Choice	Significant Difference ^a	Mean
Knowledge/proficiency in subject	A	2.50
Patience (forbearance, tolerance)	B	4.94
Good disposition and consistent behavior	B C	5.28
Fairness (impartiality, justice, objectivity)	B C	5.72
Encouraging (optimistic, heartening)	B C	6.04
Cooperation (collaboration, partnership)	B C D	6.09
Kindness and consideration (courtesy, thoughtfulness)	B C D	6.47
Flexibility (adaptability, adjustability)	C D	6.63
Use of recognition (praise, encouragement)	D	6.75
Interest in individuals	D	7.16
Sense of humor	E	8.45

^aSame letters indicate items that are not significantly different

Table 2.5 Tukey's HSD ranking characteristics of a good coach

Answer Choice	Significant Difference ^a	Mean
Knowledge (smarts, learning)	A	4.05
Respect and honesty (consideration, regard, truthfulness)	A	4.12
Support (advocate, back, endorse)	A B	5.20
Understanding (accord, disposition)	A B	5.21
Help with improving skills and performance	B C	5.78
Positive feedback	B C	6.15
Fairness (impartiality, justice, objectivity)	C	6.41
Care (conscientiousness, heedfulness)	C	6.76
Enthusiasm (passion, fervor, zeal)	C	6.81
Organization (order, systemization)	C	6.88
High expectations	D	8.63

^aSame letters indicate items that are not significantly different

Table 2.6 Frequency of positive terms used in describing food safety interventions

Word	Frequency	Percentage
Explain	62	51.24%
Discuss	10	8.26%
Demonstrate	10	8.26%
Show	9	7.44%
Review	3	2.48%
Reason	13	10.74%
Risk	39	32.23%
Consequence	6	4.96%
Example	4	3.31%
Solution	13	10.74%

Table 2.7 Rating averages in response to Likert scale questions

Question Prompt	Rating Average
Ability to translate information clearly	1.44
Confidence explaining food safety	1.48
Perception of employees' attitude towards auditor	2.12
Employees' response to interventions	1.93
Employees' perception of food safety rules	2.25

Figure 2.1 – Auditors’ ranking importance of job activities

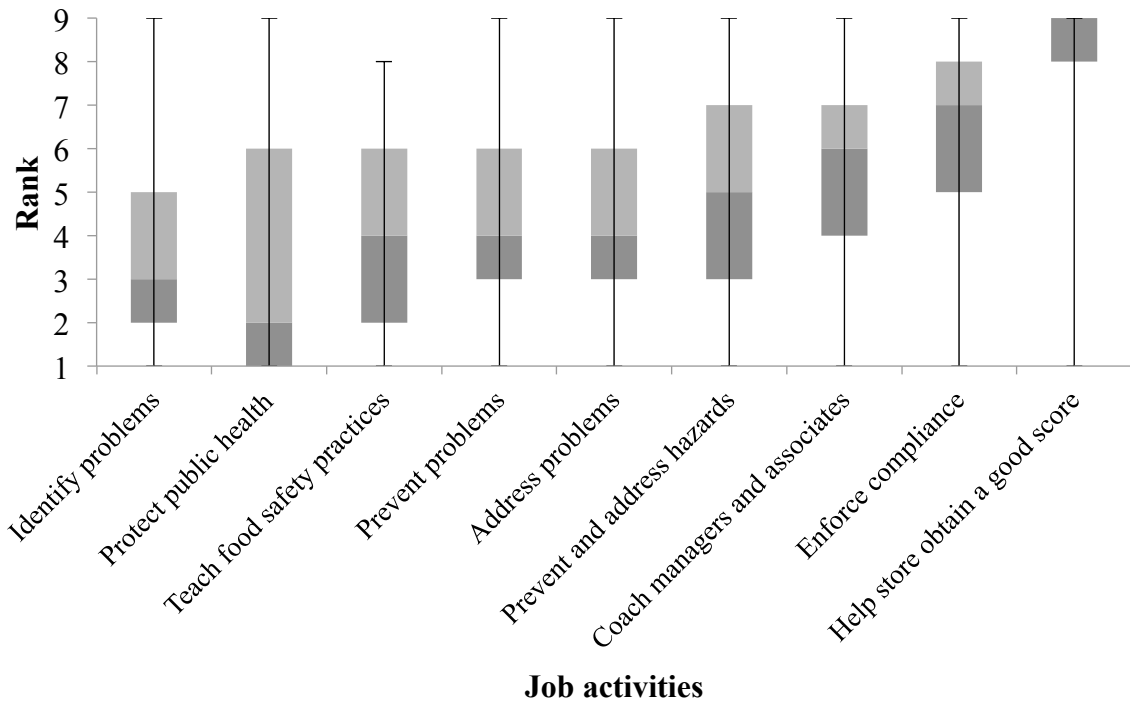


Figure 2.2 – Auditors’ ranking importance of characteristics of a good auditor

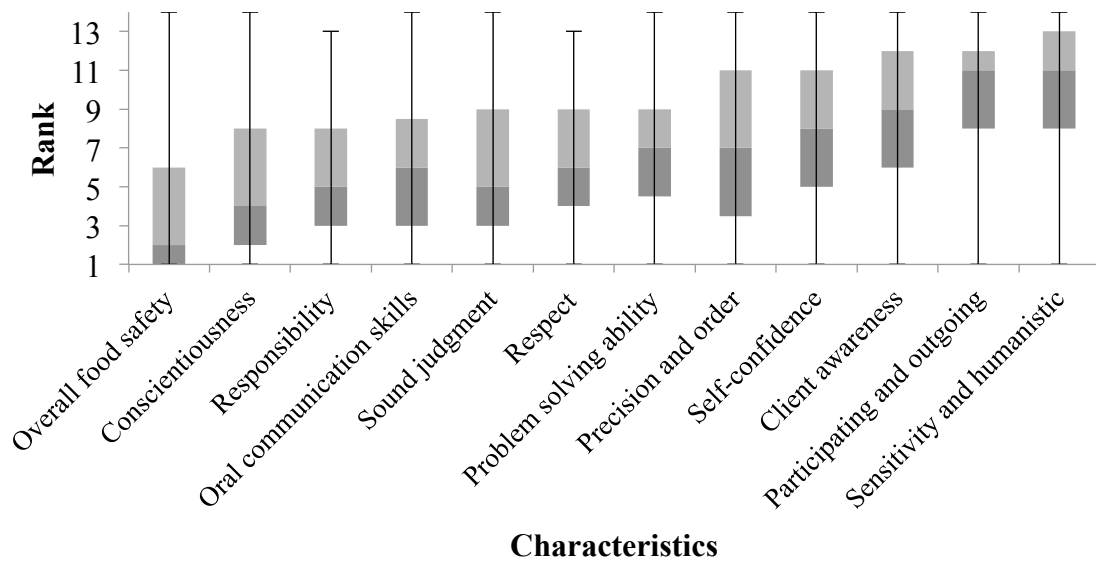


Figure 2.3 – Auditors’ ranking importance of characteristics of a good teacher

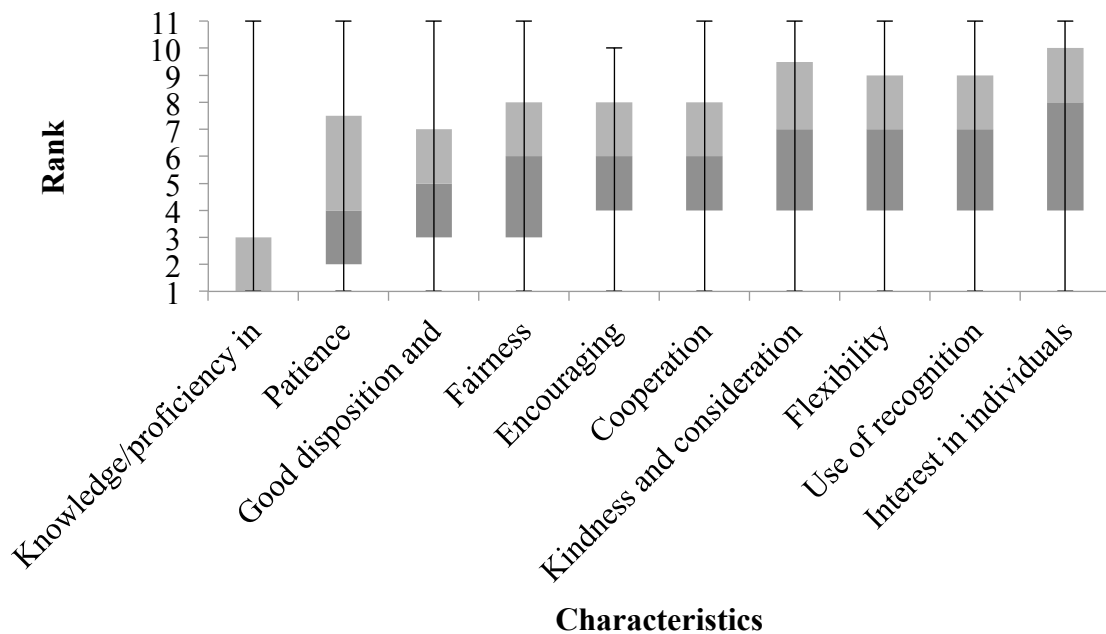
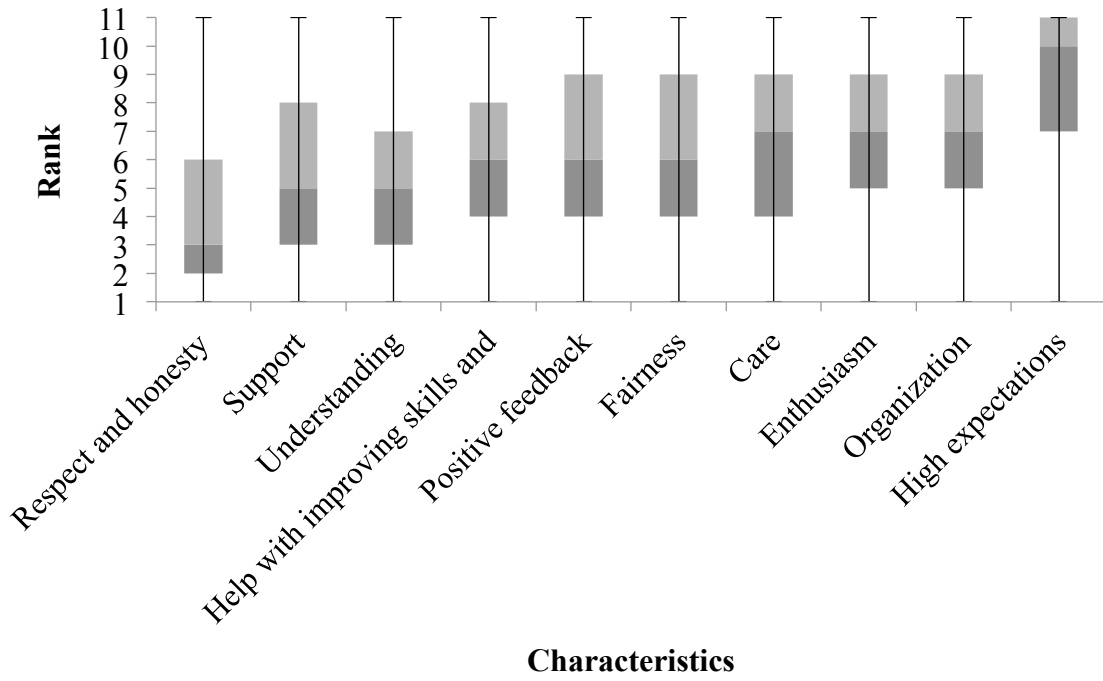


Figure 2.4 – Auditors’ ranking importance of characteristics of a good coach



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CHAPTER THREE

Evaluation of Grocery Store Food Safety Audits for Patterns in Handwashing

Compliance

INTRODUCTION

Data is constantly being generated and collected from everyday activities ranging from trips to the grocery store and Internet searches to social media platforms, smart device applications and activity trackers (3, 22, 24, 26). These aggregate data sets fall under the term 'big data,' which originated with data sets too voluminous for normal computers to handle. With modern advances in computing capabilities this big data has been harnessed by many industries and organizations (2, 3, 8, 16, 24, 27). The collection and analysis of big data sets has become a powerful tool with wide applications.

The McKinsey Global Institute, an international management consulting firm, categorized the big data application and potential into five main categories: healthcare, retail, personal location, public sector and manufacturing (20). Retailers often use big data sets to track their customers purchasing habits (8, 26). Analysis of purchasing habits can provide insight into product stocking as well as targeted advertisements and promotions for individual customers. For example, Walmart used big data to not only show that when hurricanes are projected they sell more strawberry flavored Pop-Tarts®, but that the sales were seven times the normal rate (16, 24). This application of big data helps retailers know what products and at what volumes to stock during certain conditions. Another example of big data utilization is Target, which uses algorithms applied to purchasing data to track a woman's pregnancy and offer relevant specials and coupons based on trimester (8).

In the public health realm, Google uses big data from Internet search terms to track seasonal influenza. In conjunction with the Centers for Disease Control and Prevention (CDC), the Google Flu Trends program tracks relevant search terms and correlates them with reported illnesses (23, 27). In the years that Google Flu Trends has been in use, it has been relatively reliable at predicting cases of the flu, and is a faster reporting method than the CDC database (19, 23). Though issues with the algorithm caused some over reporting, this novel application of big data analysis is still noteworthy (19), and similar algorithms are being successfully applied to Twitter (1, 27).

Another public health application of big data is the use of online reviews from restaurant patrons. One study by Columbia University, Yelp and the New York City Department of Health and Mental Hygiene analyzed online reviews of restaurants from Yelp.com. Reviews that noted foodborne illness symptoms were further analyzed and later revealed three previously unreported outbreaks (14). Another project used surveillance of Twitter activity to identify cases of foodborne illness (15). Other public health initiatives research utilizing changes in cell phone usage to track domestic and international outbreaks, as well as predicting small disease outbreaks by following highly socially connected individuals (27).

One advantage of big data is that it is often riddled with multiple variables, and as such can also be challenging to work with for research purposes (24, 26). With traditional data collection, researchers usually have the ability to know, and sometimes control, variables. Without this control the data sets can become messy. Some also critique that big data is not representative or random, and therefore should not be used to draw widespread conclusions (2, 24). Researchers that use big data sets must be responsible with its analysis.

This study explores the use of big data from third-party grocery store food safety audits. This project was in partnership with one of the world's largest food safety third-party audit companies (Company A). Auditors from Company A visit grocery stores at regular intervals to provide maintenance checks for equipment, sell cleaning and pest control products and check for compliance to food safety based on the chain's unique audit. Food safety auditing at the retail level is often solicited by the grocery store as a means of assessing compliance to food safety standards before inspection by environmental health officials. Audits are tailored to the grocery store chains' needs and priorities; questions, duration of audit and departments visited may differ from one chain to another. Company A audits typically generate 100 to 200 data points per visit, depending on the intensity of the audit.

Company A approached grocery store clients for permission to use their audit data for research purposes. Third-party audit data from eight companies, with presence in the continental United States and Canada, were included in this study. Included data spanned six years, from 2009 to 2015. Big data sets were analyzed to test the hypothesis of significant differences in compliance based on day of week, time of year, geographic location, auditor and store department. The goal of this first phase of research was to find trends and patterns that answer the questions on where and when handwashing violations occur.

METHODS

Data preparation. All identifying information was removed from audit data files before receipt to protect the participating companies, and auditors were assigned a random number to protect their identity. Data submitted for analysis included: date, account number,

time of audit, length of audit, zip code, auditor number, overall score, survey ID, department and all question responses and comments.

Data was initially analyzed using an iterative approach. Survey IDs were used to determine the number of the food safety audit (FSA) versions; there were 19 unique audits in the aggregate. Analysis of audit question content revealed 17 food safety audits and two safety audits; safety audits were excluded. All FSAs were compared to identify the questions that asked for similar information. In the aggregate analysis, all questions targeting the same category of violation were analyzed as a unit. In addition to isolating the FSA questions, the number of data points and individual audits were also assessed. The data yielded 72,278 unique audits and 9,561,615 total data points.

Cleaning, merging and assembling the data for statistical analysis was non-trivial. Each zip code was geocoded with latitude and longitude information using Google Maps API. This was done to allow for computation of approximate distances between locations. While distances for all locations were identified, most analyses in this document only included the approximately 87% of observations that are in the continental United States.

Statistical analysis. Initial statistical analysis of the audit data tested the hypothesis used questions surrounding handwashing compliance, as personal hygiene is one of the FDA's list of top five factors contributing to foodborne illness (9) and handwashing is a major factor in controlling the spread of human norovirus (4). Handwashing data included questions on properly equipped handwashing stations, properly demonstrated handwashing behavior and observation of appropriate handwashing. The preliminary analyses outlined here serve as the foundation for broader and more complex research questions, as detailed at

the end of this chapter.

Geocoding information was used to plot data to show geographic location of audits by year. Data was plotted again to show proportion of handwashing violations based on geographic locations. These plots also included audit data from Canada.

The data was fit with pairwise associations between the handwashing violations and geographical, temporal and departmental differences. Geographic locations, as determined by zip code, were broken into divisions as dictated by the United States Census Bureau. A map of the divisions can be seen in Figure 3.1. These analyses did not include Canadian data.

A logistic regression model was also fit to study the affect of auditor. There were 336 unique auditor IDs, which when combined with the preceding predictors, led to 359 total predictors. To avoid over fitting and to induce a more parsimonious model, a penalized maximum likelihood was used to estimate coefficients indexing the logistic regression model. Let $\{X_i, Y_i\}_{i=1}^n$ denote the observed data, where: $X \in \mathbb{R}^p$ denote the predictors and $Y \in \{0, 1\}$ denotes an indicator of a violation with 1 indicating a violation. Assumed model is $P(Y = 1|X = x) = \frac{\exp(x \gamma \beta)}{\{1 + \exp(x \gamma \beta)\}}$. Let $l_n(\beta)$ denote the log-likelihood and the maximum likelihood estimator, β_{λ} , to be the solution to

$$\min_{\beta \in \mathbb{R}^p} [-l_n(\beta) + \lambda \{ \|\beta\|_2^2 + \|\beta\|_1 \}]$$

where $\|\beta\|_2^2 = \sum_{j=1}^p \beta_j^2$ and $\|\beta\|_1 = \sum_{j=1}^p |\beta_j|$ and $\lambda \geq 0$ is a tuning parameter.

RESULTS

Distribution of data and handwashing violations. Distribution of data points by year can be seen in Figures 3.2-3.8. Over the six year time period, audit data coverage expands

across the country and into Canada. Proportion of handwashing violations by year can be seen in Figures 3.9-3.15. Certain regions of the map show high proportions of handwashing violations than others.

Handwashing by department. Departments were divided into the following categories: bakery, deli, deli/bakery, general, meat, meat/seafood, produce, seafood, and other, as seen in the FSAs. Table 3.1 shows the number and proportion of inspections with a violation by department. Test of no difference in probability of violation across departments yielded a p-value less than $10e^{-16}$. The difference in proportions between the deli (largest proportion, 0.0745) and general (smallest proportion, 0.00480) showed a Cohen's h of 0.40, which is considered a moderate effect size.

Handwashing by day of week. Table 3.2 shows a breakdown of violations by day of week. No practically significant differences were observed among the rates of violations on the weekdays (Monday-Friday), as opposed to whereas the rates appear to drop slightly on the weekend days (Saturday-Sunday). Test of equality of rates across all days of weeks was p-value equal to 0.015. The difference in proportions between Sunday (lowest proportion, 0.0115) and Monday (highest proportion, 0.0347) showed a Cohen's h of 0.160, which is considered to be a small effect size.

Handwashing by proximity to a major US holiday. Rate of handwashing violation broken down by whether or not it was observed within the three days before and after a major United States holiday (New Years, Memorial Day, Independence Day, Labor Day,

Thanksgiving, Christmas) can be seen in Table 3.3. These holidays represent six of the ten federal holidays and exclude those not traditionally associated with large food-based gatherings. Test of independence of obtaining a violation and being near a holiday is p-value equal to $3.81e^{-6}$; however, Cohen's h of 0.07 indicates the treatment effect is small.

Handwashing by geographic region. Handwashing violations by geographic division (Figure 3.1) are reported in Table 3.4. Test of no difference in rate of violation across the geographic divisions yielded a p-value less than $1e^{-16}$. The difference in proportion of violations in the East North Central division (largest proportion, 0.0622) and the Mid-Atlantic division (smallest proportion, 0.0104) showed a Cohen's h of 0.30, which indicates a small-moderate effect size.

DISCUSSION

This preliminary analysis of grocery store audit data showed differences in handwashing compliance, most notably between departments. As seen in Table 3.1, 7% of visits to the deli find handwashing violations, in contrast to the 3% of visits that find violations in bakery and meat, and the 4% of visits that find violations in produce and seafood. The lowest proportion, 0.5%, was found in the general area of the store, where most of the shelf stable products are kept.

Outbreak surveillance has consistently implicated foods from restaurants and delicatessens in foodborne illness outbreaks (6, 11, 13, 17, 18, 21). The difference in handwashing compliance found in this study could be a possible factor for why these areas have higher rates of foodborne illness. Another explanation lies in the types of foods

prepared and served in the deli department of a grocery store. Most deli foods are considered ready-to-eat, meaning they don't require further washing or heat treatments before consumption (28). Preparation using both raw and cooked ingredients, as well as the handling of a ready-to-eat product, present many situations where handwashing is required; many outbreaks have been traced back to foods that require multi-step preparation (12). Lack of proper handwashing could also lead to the spread of a disease-causing microorganism, especially if foods are not then held at appropriate temperatures (9).

While analysis of individual handwashing questions is not available, it is possible that violations occurred due to failure to wash hands or incomplete handwashing procedures. One study utilizing observations of grocery store deli and bakery workers found that handwashing attempts averaged once every 2.02 hours, less than half of the attempts met all requirements of proper handwashing and most frequent non-compliance was failure to wash hands before putting on gloves (25). Another study that observed restaurant workers found an average of 1.57 handwashing attempts per hour, with only 11% of them being correct and most common reason for non-compliance being failure to dry hands with a paper towel (5). Higher rates of non-compliance in this data set could be attributed to issues similar to what was observed in the aforementioned studies.

There appear to be minimal effects of day of week on proportion of violations. There is much less data for weekend (Saturday and Sunday) violations than for weekdays (Monday-Friday), likely because most audits are conducted during normal business days. However, due to the small effect size of 0.16, further analyses would need to be expanded to other categories of questions to determine if there truly are higher proportions of violations on some days than others. Similar analyses would also be needed to test for a true affect of

proportion of violations in proximity to a major United States holiday, as the treatment effect observed was small.

A small-moderate size effect was observed between proportions of violations by geographical divisions. This effect showed the highest proportion of violations in the East North Central division, as seen in the plotted data in Figures 3.12-3.16. The United States Food and Drug Administration (FDA) published a guidance document of food safety standard operating procedures for food establishments every four years. States adopt versions of the food code as they see fit. As of 2015, Michigan, Wisconsin and Ohio operate under the 2009 FDA Food Code, Illinois operates under the 2005 code and Indiana operates under the 2001 Code (10). When viewing Figures 3.9-3.15, it appears as though many of the zip codes with higher proportions of handwashing violations hover over Indiana, which is operating under an older version of the FDA Food Code. The handwashing provisions in Section 2-301.11-16 of the 2001 Food Code (7) vary slightly from those outlined in Section 2-301.11-16 of the 2013 Food Code (28), but there may also be other state-level factors at play.

When looking at the overall effect of auditor on proportion of violations, results show that the majority of auditors are no more or less likely to record a violation. The right side of Figure 3.16 shows that out of 336 total auditors, 92 are less likely to report a violation and 98 are more likely to report a handwashing violation. These numbers are small in comparison to the overall body of auditors. Results from a survey of Company A auditors (Chapter 2) show that small percentages of auditors have different priorities and role identities for their positions. Part of the survey asked auditors to rank certain job activities by order of perceived importance. A small percentage of auditors (5%) reported that their most important job activity was to help a store obtain a good score, which may mean they are

less likely to report a violation. On the contrast, 50% of auditors reported their most importance activity was protecting public health, which may lend to a higher likelihood of recording a violation.

Future Work. The data set used in this study has the potential to be utilized for many more analyses. One future direction could look at correlations between violation categories to answer questions such as ‘if the prevalence of violation A increases, will the prevalence of violation B also increase?’ or ‘do violations increase in all departments at the same time?’ This type of correlation could provide insight into all areas where control measures should be taken in the event that a certain violation is detected. Another study would look at the distribution of violations and potential trends when overlaid with socioeconomic and epidemiological data. Results from public health inspections could also be added to determine ties with public health and outbreak findings. Another comparison with public information would include looking at audit data based on the version of the FDA Food Code under which the establishment is running.

With six years of data it could also be feasible to test whether past audit results can predict the outcome of future audits. If a reliable model for predicting audit results could be created and verified, grocery stores would be able to see forecasted problems and better plan for interventions. The addition of a predictive model for outbreaks and public health inspections could be used to create a tool with the ability to predict violations and their potential impact on public health.

Finally, using all models developed, research could be expanded to analyze third-party restaurant audits in the United States and Canada to see if trends are comparable. The

models could also be used on Company A's international grocery and restaurant audit data so that comparisons could be made on a global scale.

CONCLUSION

The results of this study provide more insight into handwashing violations in grocery stores and support previous research. Priority attention should be given to creating interventions to address handwashing in deli departments. This analysis should also serve as the springboard for continued research into third-party audit data. The results from this small subset of the data available suggest that there is more to be found and analyzed. Future analyses have the potential to influence food safety intervention strategies, as well as the future of the audit process.

Table 3.1 Violations by department

Department	Bakery	Deli	Deli/ Bakery	General	Meat	Meat/ Seafood	Produce	Seafood	Other
Violation	50339	46081	25090	29171	66963	6927	71399	39319	1402
Pass	1703	3431	494	140	1869	85	2486	1402	249
Prop. of violation	0.0338	0.0745	0.0197	0.0048	0.0279	0.0123	0.0348	0.0357	0.0177

Table 3.2 Violations by day of week

Day	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Violation	68338	74478	76628	75081	53742	694	347
Pass	2368	2561	2499	2610	1803	14	4
Prop. of violation	0.0347	0.0343	0.0326	0.0347	0.0335	0.0201	0.0115

Table 3.3 Violations by proximity to a major United States holiday

Near Holiday	No	Yes
Violation	343591	5717
Pass	11730	129
Prop. of violation	0.0341	0.0225

Table 3.4 Violations by geographic division

Division	E. N. Cent.	W. N. Cent.	Mid- Atlant.	N. Eng	E. S. Cent.	S. Atlant.	W. S. Cent.	Mtn.	Pacific
Violation	47750	9841	7486	10132	27739	115337	19216	48014	63793
Pass	2973	377	78	282	1079	2596	765	1653	2056
Prop. of violation	0.0622	0.0383	0.0104	0.0278	0.0388	0.0225	0.0398	0.0344	0.0322

Figure 3.1 United States Census Bureau divisions

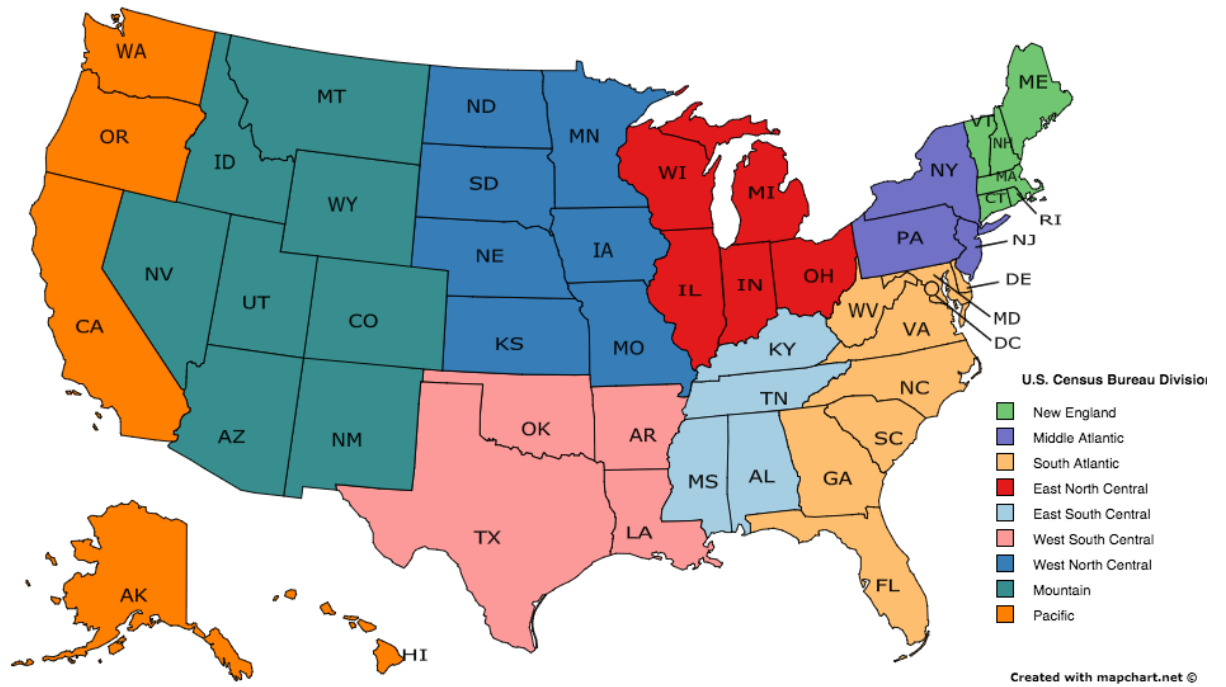


Figure 3.2 Audit sampling location distributions, 2009

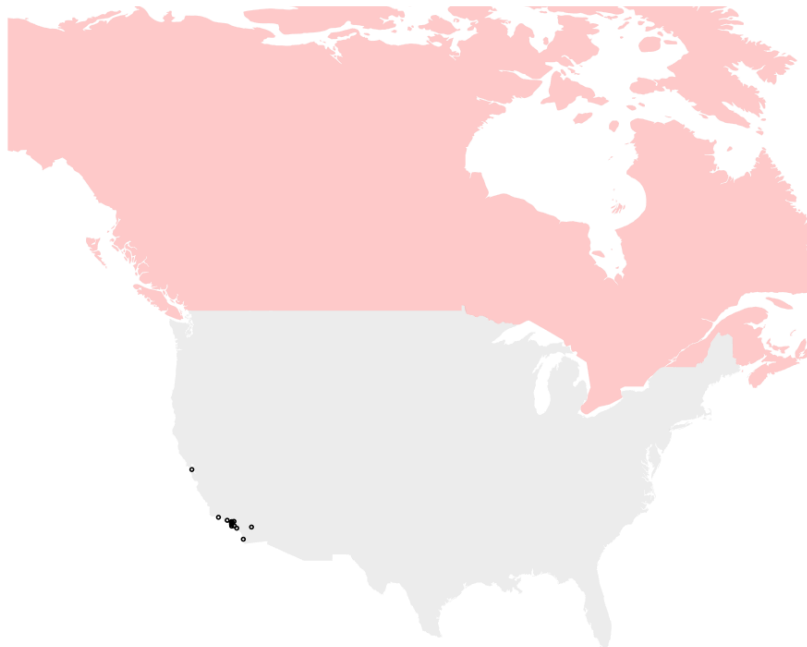


Figure 3.3 Audit sampling location distributions, 2010

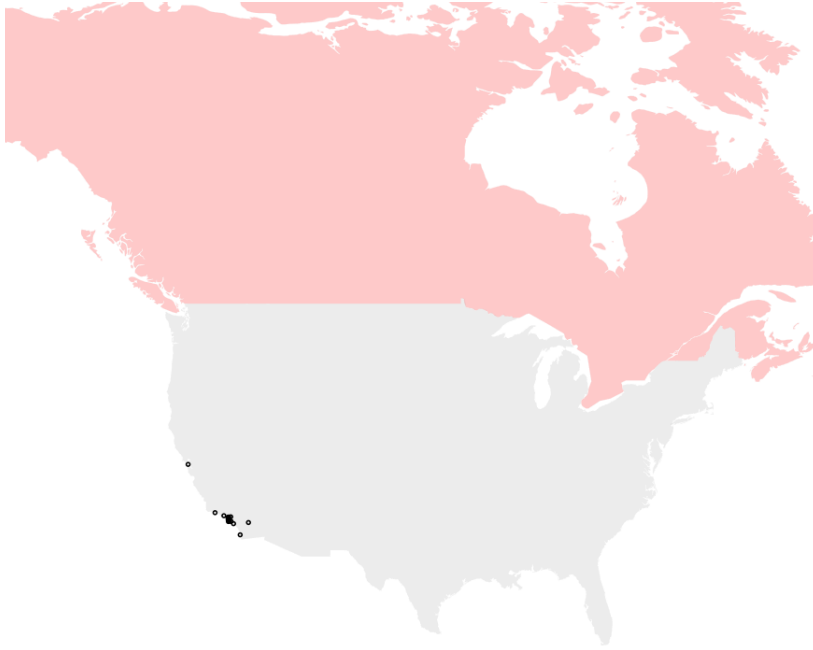


Figure 3.4 Audit sampling location distributions, 2011

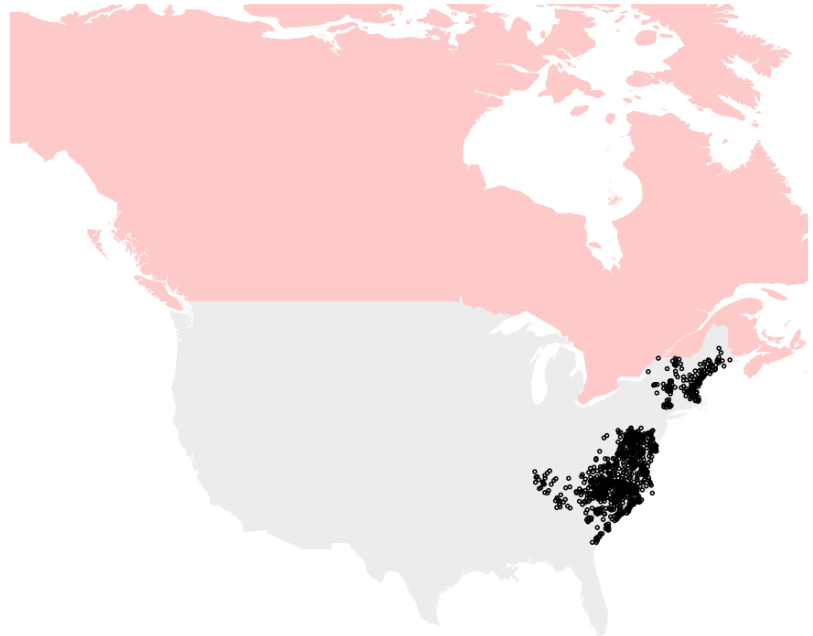


Figure 3.5 Audit sampling location distributions, 2012

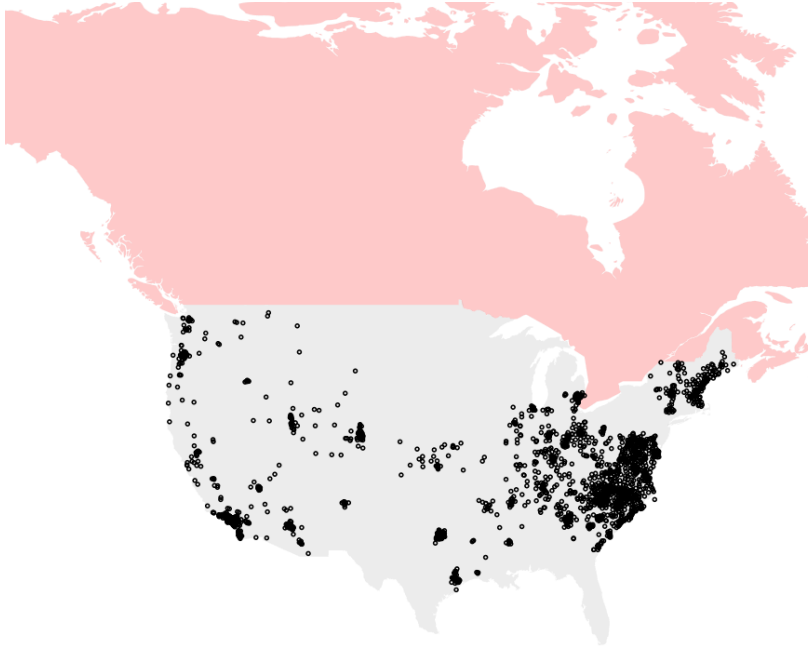


Figure 3.6 Audit sampling location distributions, 2013

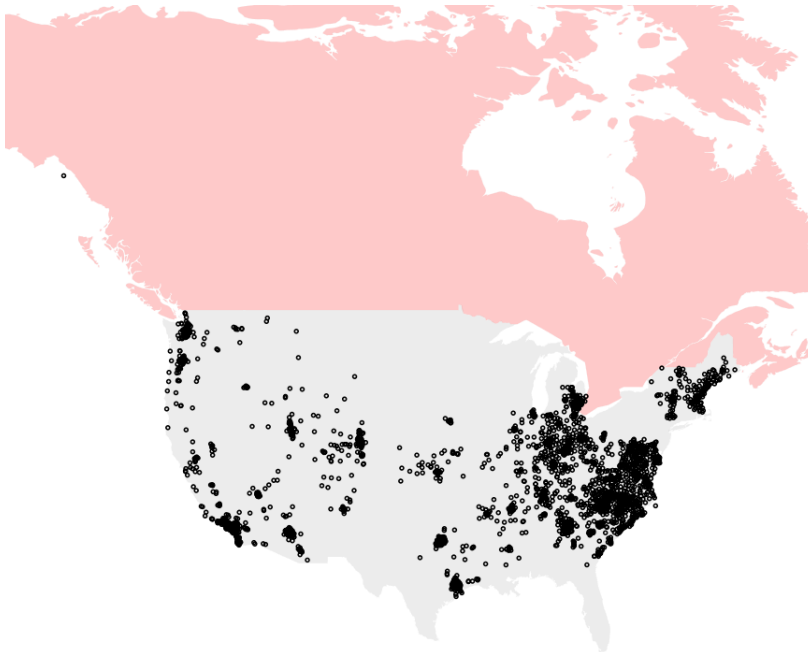


Figure 3.7 Audit sampling location distributions, 2014

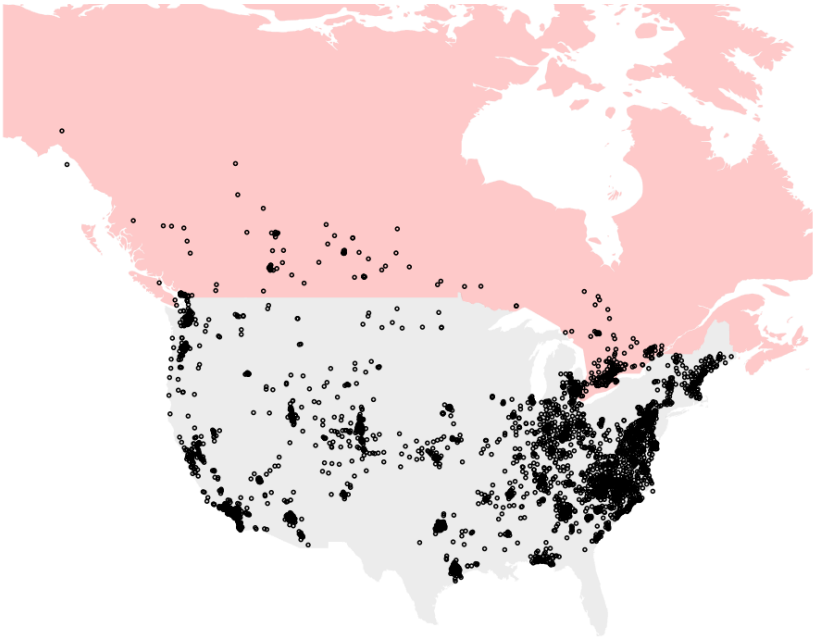


Figure 3.8 Audit sampling location distributions, 2015

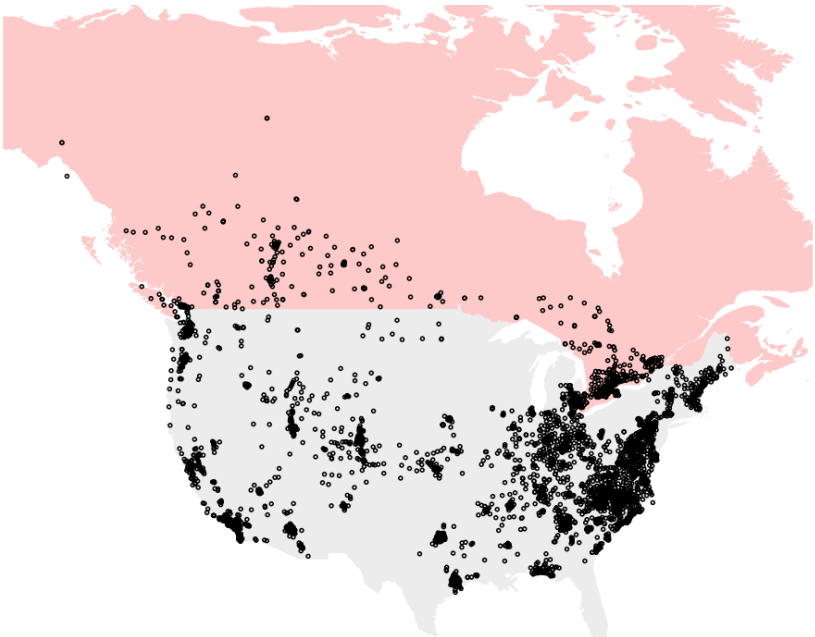


Figure 3.9 Proportion of handwashing violations by zip code, 2009

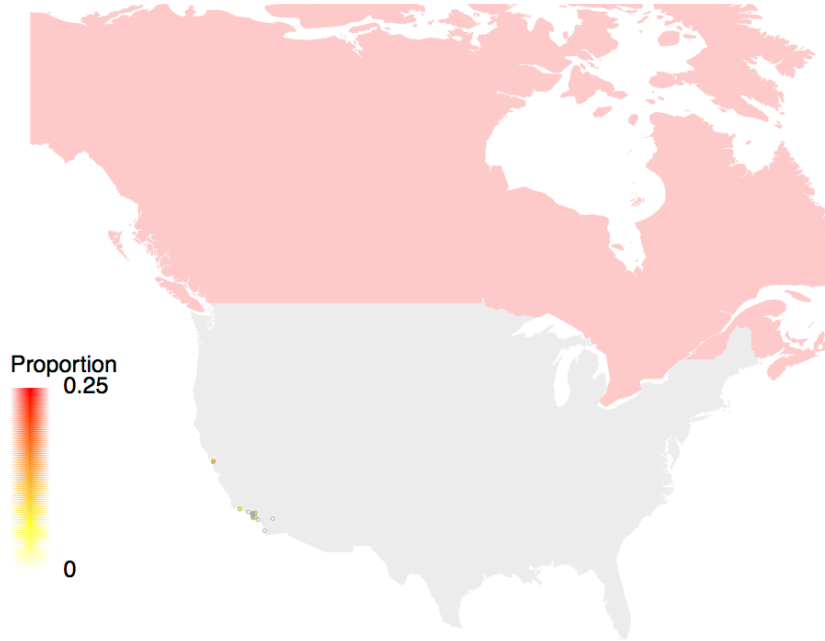


Figure 3.10 Proportion of handwashing violations by zip code, 2010

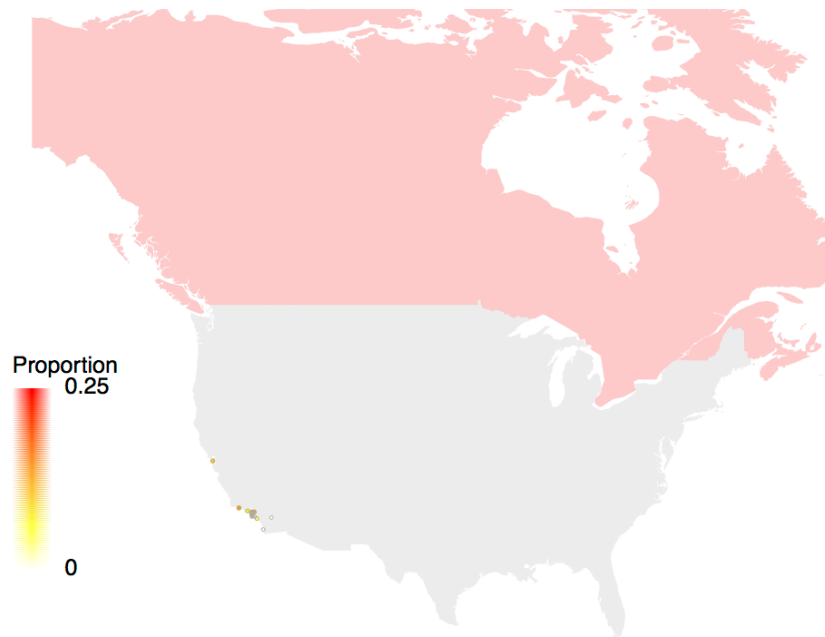


Figure 3.11 Proportion of handwashing violations by zip code, 2011

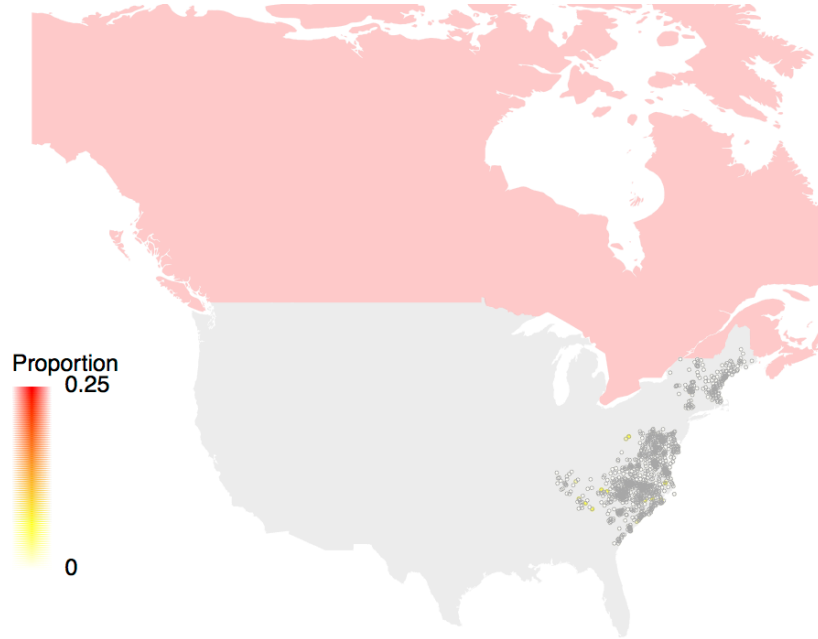


Figure 3.12 Proportion of handwashing violations by zip code, 2012

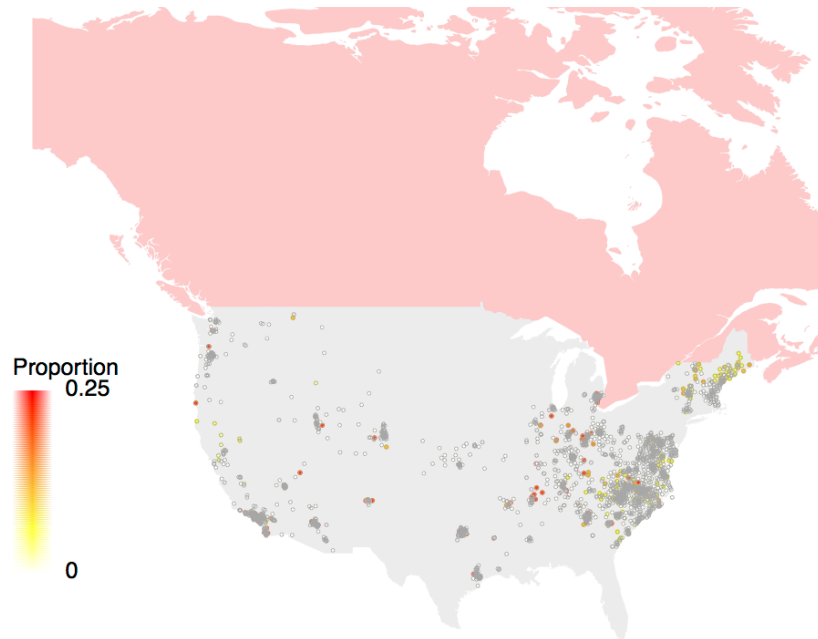


Figure 3.13 Proportion of handwashing violations by zip code, 2013

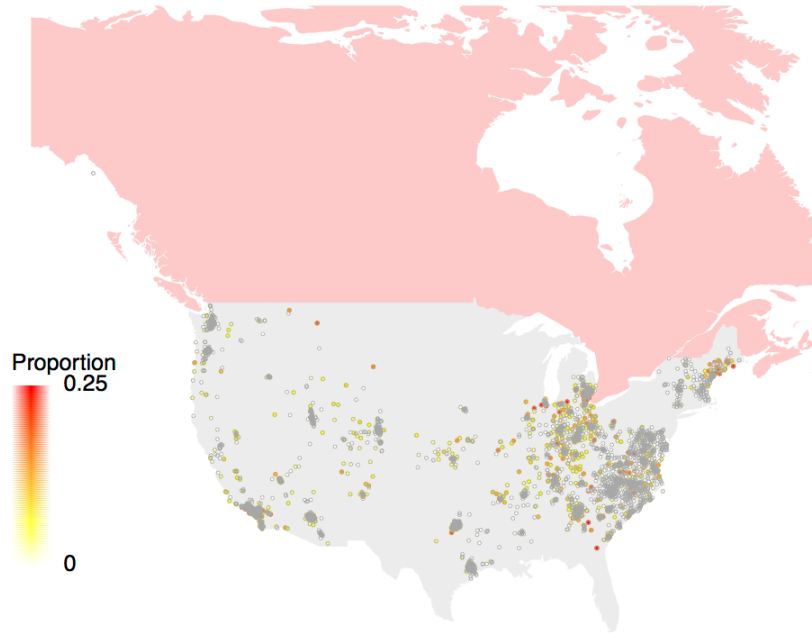


Figure 3.14 Proportion of handwashing violations by zip code, 2014

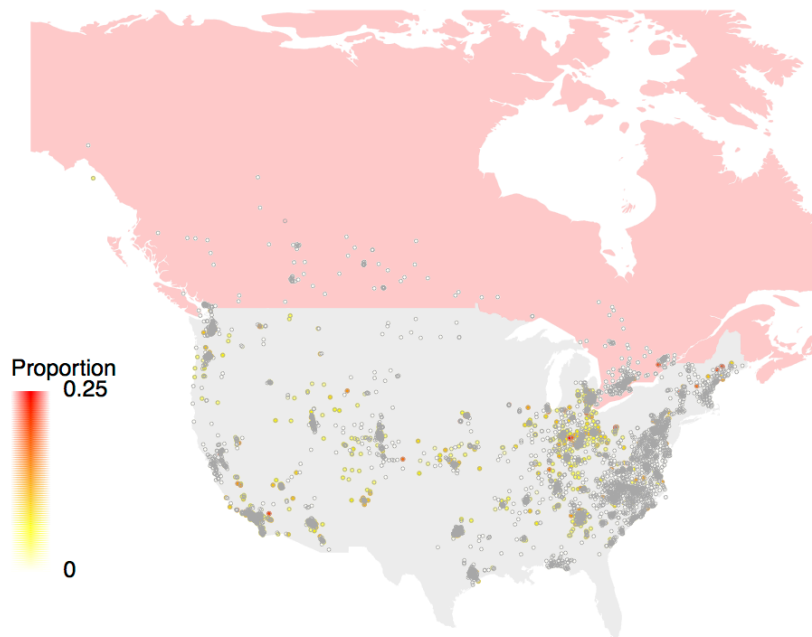


Figure 3.15 Proportion of handwashing violations by zip code, 2015

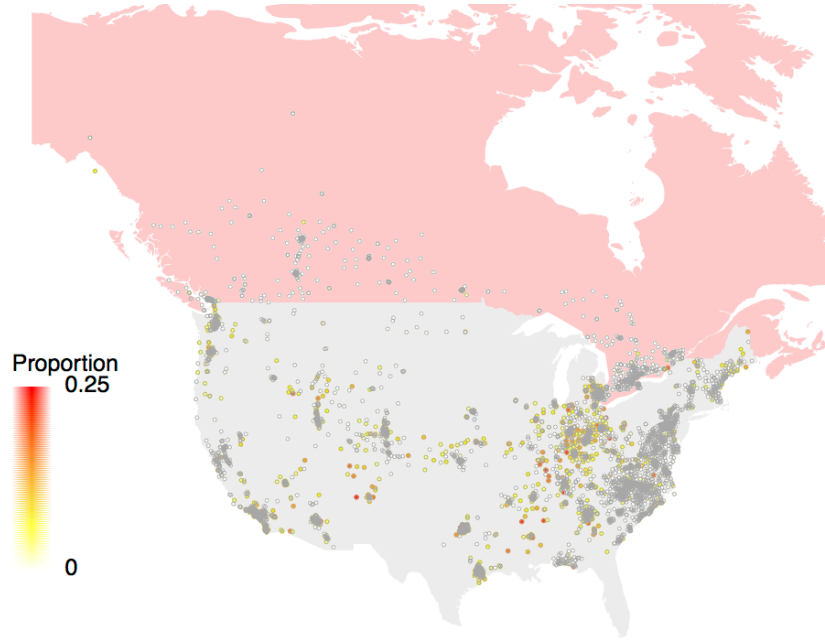
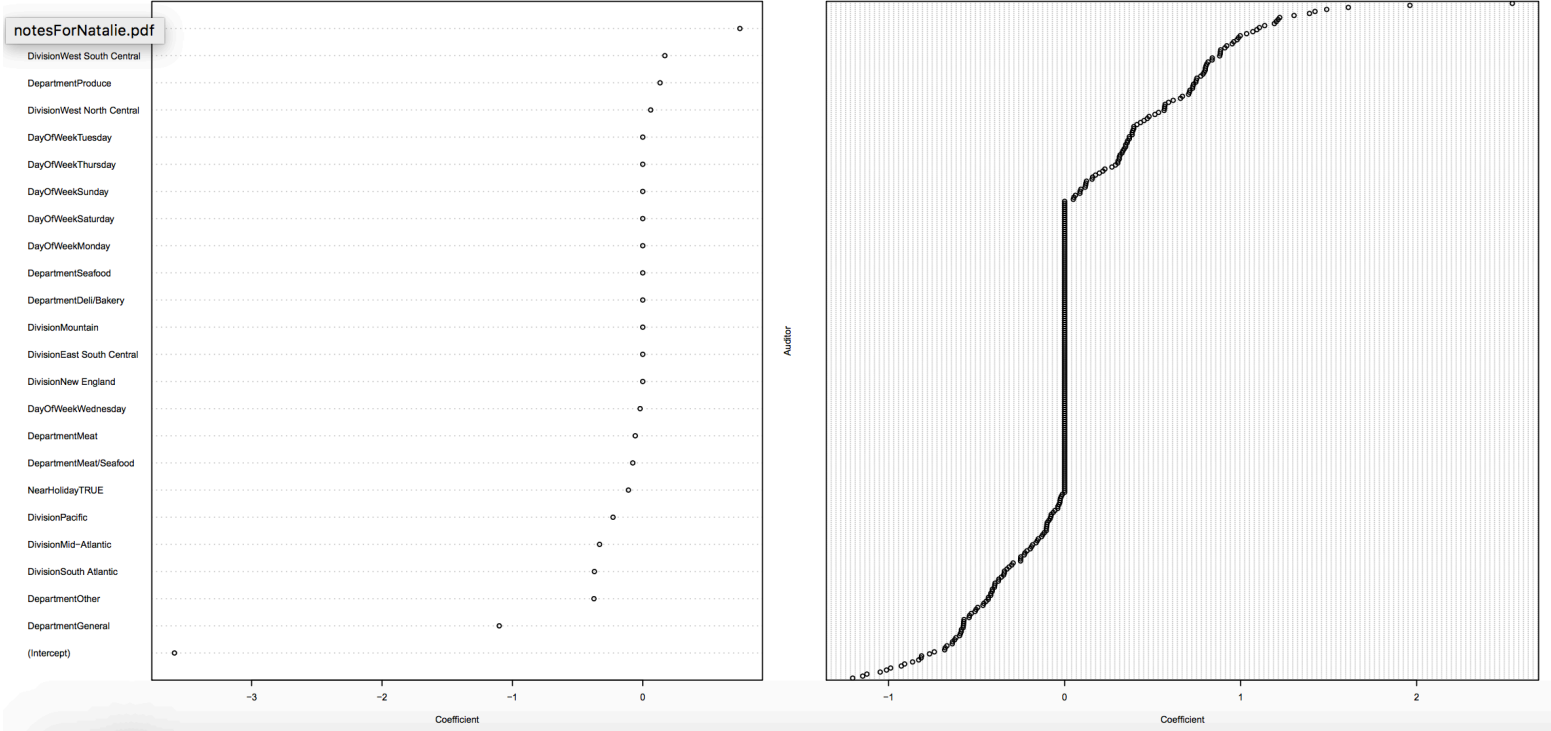


Figure 3.16 Left: Estimated coefficients indexing non-auditor coefficients. Right: estimated coefficients indexing auditor coefficients.



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CHAPTER FOUR

Mobile and Game Based Learning and its Application in a Proposed Food Safety

Intervention Tool

Introduction

With an estimated 52 to 70% of foodborne illness cases originating in retail food establishments (10, 11, 14, 15), much attention is given to creating and evaluating food safety training and education programs for food workers (4, 7, 18, 22, 24, 29, 30). Government standards and/or the employing establishment often mandate food safety training and education for food workers before and during their time in a food handling capacity. Many approaches have been taken ranging from in person classes, online learning platforms, videos, instructional books and more (4, 23, 24, 30). Current research has shown that the education and training strategies are effective for increasing knowledge, but that knowledge change may or may not correlate to behavior change (12, 17, 22). In order to increase compliance to food safety standards and affect positive change on behavior, the factors surrounding violations must be better understood and educational training strategies should be reassessed.

A study of grocery store food safety audit data from a leading retail third-party audit provider (Company A) was used to explore trends around food safety violations. Analysis of the audit data revealed that hand washing violations occur in high proportions in certain areas of the United States, as well as in certain grocery store departments (Chapter 3). In another study, auditors from Company A were surveyed to determine self-perception of roles and abilities. Results showed auditors see themselves as coaches and teachers and report

providing food safety interventions when they see violations (Chapter 2). Auditors also reported that they were confident in their abilities to communicate food safety information, and that food workers appear to be receptive to intervention efforts. These insights into food safety violations lend to the exploration of a more targeted approach to food safety interventions.

One such intervention tactic would be equipping auditors with education and training materials based in this research. A novel approach in education is the use of digital technology for mobile and game based learning (8, 9, 20, 25, 28). According to Company A, tablets are used to conduct audits in grocery stores, making an electronic tool an appealing option. This chapter seeks to combine the research outlined in Chapters 2 and 3 with literature on learning and behavior, as well as digital and mobile learning technology in a proposed mobile food safety education tool.

INTERVENTION TOOL

Learning on Digital Platforms. Mobile learning refers broadly to self-paced education that can occur at any time or place using a portable electronic device (8, 19, 28). The prevalence of mobile learning has increased along with distance education and the insurgence of mobile devices. Distance education allows learners to access information and interact with instructors without being in the same geographic location (19). Mobile devices, including smart phones, tablets, laptops, electronic readers and audio file players, are a popular means to access information (8). According to a study conducted in 2015, it is estimated that 65% of adults in the United States own a smartphone, and many report using it to access important information, ranging from health advice to personal banking (26). It was

also reported that smartphone ownership increases to 85% in young adults (ages 18-29 years old). Thirty percent of grocery store employees are 16-24 years old, and 37% are 25-44 years old (5), combined with US smartphone use data this suggests that most grocery store employees have some familiarity with some mobile devices.

Mobile devices are also used for recreation and game play, and mobile learning games are gaining popularity as educational tools (19). Using games as educational tools is not a new concept; games have structure, rules and motivation to engage players (2). Video and computer games can also provide virtual reality experiences and simulations, allowing players to practice skills in a low-risk, immediate feedback setting (6, 8, 25, 28).

Game Based Learning. Video and computer games comprise a \$30 billion industry worldwide, engaging players of all ages (3). Gaming has made a cultural impact, and researchers have begun to explore the effects of gaming on behavior and the human brain. Highlighted conclusions can be seen in Table 4.1. The impact of gaming on the brain and learning has led some researchers to study the potential use of games for education. One use of gaming for education has been in supplementary and learning games and mobile applications. Highlighted results can be seen in Table 4.2. These studies on learning games have shown positive feedback from participants, and researchers promote further exploration to optimize this platform.

Describing the Need for an Innovative Approach. Preliminary analysis of audit data showed that there is an increased proportion of violations in certain departments and areas of the country. Further analysis of this data will be able to expand upon this knowledge

and fill in the gaps around factors contributing to increased proportions of violations. This information will allow for targeted approaches to food safety concerns.

Third-party auditors have the unique advantage of interacting with food workers in their job settings, which allows them to directly relate intervention efforts to the tasks, equipment and food products the employees are working with. Context-dependent memory refers to the effect of environment triggering a memory made in the same or a similar environment, and can affect recall of information (13, 27). Auditor delivered interventions would occur at the job location and time of a violation, which could help food workers tie concepts to particular activities.

The results from the survey outlined in Chapter 2 show that auditors identify with the roles of food safety teacher and coach. Auditors report to be confident in their ability to explain and deliver interventions. According to Ajzen's Theory of Planned Behavior, whether or not a person will perform a behavior is determined by their behavioral intention, which is influenced by their perceived behavioral control, attitude and the social norm (1, 16). Self-identity and the belief that the individual is equipped with the necessary resources to perform the behavior are also predictors (21). Auditor confidence and self-identity, supplemented with a convenient intervention tool and ideal delivery setting make leveraging auditors as food safety educators an innovative and potentially effective strategy.

Tablet-Based Intervention Tool. The development of a mobile learning tool, such as an application or software program, could provide auditors with innovative food safety training and education materials. The tool would provide engaging intervention materials based in the best available science and behavior theory, and potentially contribute to

auditors' confidence in providing a quality intervention to the food worker. The potential increase in confidence and resources may increase the likelihood of auditors performing interventions, per the Theory of Planned Behavior (1, 16).

A proposed tablet-based tool would be engaging and user friendly for the auditor and food worker. The tool would be created for use on tablets in order to eliminate the need for auditors to carry additional materials. Preliminary ideation and design flow for user experience can be seen in Figure 4.1. The home screen of the tool would allow the auditor to select the appropriate grocery store department and then proceed to select the violation to reveal the intervention material.

Proposed interventions would be in the form of interactive games, videos or simulations. Interventions would be five minutes or less in order to not interfere with auditors' store visits or food workers' tasks. Research on education for grocery store food workers showed that food workers want short, regular, hands-on trainings (23). The activities on the tool would be as hands-on as possible, allowing the food worker to practice proper behavior.

An example activity could be a short game to serve as a reminder for when to wash hands. The game would track images that represent foods or activities across the screen. Food workers would be instructed to tap a button whenever contact with a passing object would require handwashing. As the game progresses, images would get trickier and move faster. After a short period of game play the foodworker would be presented with their score and the chance to play again.

Pilot Testing. Multiple rounds of pilot testing would be needed to assess the usability and practicality of the tool. First round of testing would include a focus group with auditors to gain their overall feedback on the tool. After feedback was applied another round of focus groups would be conducted with grocery store food workers to determine the perception on the receiving end of the tool. Feedback would be applied again, and then a small-scale piloting would occur with auditors using the tool during store visits. Any final edits would be made and then a larger scale study would be conducted comparing scores in selected categories of questions before and after the intervention tool was used.

CONCLUSION

Game based learning and mobile learning are increasingly popular areas of research with potential applications for food safety. Short, engaging interventions designed with behavior theory and game based learning could help auditors effectively explain food safety to a food worker. From the food worker's perspective this mobile learning tool could provide a clear and engaging format for food safety information. From the auditors' perspective this tool could provide an easy to use intervention resource. Most food workers are required to have some level of training before they handle food. A tool like this would not replace the initial training program, but would serve as a reminder for information that food workers already know and relate that information to their work environment and create contextual memories. If shown to be successful, variations of this tool could be developed for store and restaurant managers to provide interventions to food workers on a regular basis.

Table 4.1 Highlighted advantages of gaming on brain function

Author	Advantages
(Bavelier & Davidson, 2013)	Long-term game play has measurable impacts on brain function, attention and behavior. Gaming should be used strategically for education
(Prensky, 2003)	Video games grab and keep attention, teaching complex strategy and reasoning; develop multi-tasking and parallel processing.
(Siang & Rao, 2003)	Computer and video games engage behavior theory, cognitive learning theory and motivation theory. These theories should be used to develop learning games.

Table 4.2 Highlighted usages of mobile applications and games for educational purposes

Author	Application	Results
(Batson & Feinburg, 2008)	Web-based game for teenagers	Students were motivated to play game and found it helpful Further research to test if learning actually occurred
(Ebner & Holzinger, 2007)	Web-based game to teach graduate level engineering	Student game-based learning was comparable to traditional lecture-based learning. Game provide motivation to master concepts
(Huang & Cappel, 2005)	Web-based game to supplement undergraduate university course	Students found game helpful and entertaining; preferred game to standard review questions
(Papastergiou, 2009)	Web-based game application for highschool students	Game learning was more effective than the non-game based control Game learning provided more motivation for students.
(Teri et al., 2013)	Mobile app to supplement undergraduate university course	Many students found app useful and convenient No significant difference in test scores

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CONCLUSION

The current literature base on the efficacy of third-party audits and restaurant inspections is inconclusive at best. To date, research has not been able to consistently show a decreased risk for foodborne illness outbreaks based on restaurant inspections. Outbreak events in food processing facilities have shown that the audit score is not necessarily indicative of safe food either. Limitations in other audit and inspection applications suggest that there may also be limitations at the retail level, but targeted research is needed to confirm. There are hurdles in the audit system, both with the auditor and the company being audited. The audit and inspection system needs to be reassessed in order to determine limitations and strengths. Limitations should be addressed in order to optimize the audit process. Third-party audits have their place in the food system, but only as part of a comprehensive food safety management plan.

The studies outlined in this thesis sought to learn more about the third-party audits in grocery stores through understanding how auditors see themselves and their roles, as well as geographical and temporal differences in observed violations. The studies showed that auditors report they currently provide interventions and they value food safety knowledge. These results, interpreted through behavior theories, suggest auditors could be useful to provide strategic food safety interventions. Research should continue to explore methods by which to maximize auditors' influence during an audit.

One specific way auditors could be used to influence food safety compliance is through the delivery of targeted intervention materials. The results from the big data analysis outlined in Chapter Three revealed some geographical and departmental differences in

handwashing violations. More analysis in this direction could reveal stronger effects with different test and different categories of violations. Armed with this knowledge and evidence-based tools, auditors could be prepared to look for specific violations and provide quality interventions when they are observed.

It is well established that though food workers often know correct food safety information they do not always follow through with best practices. Innovative approaches to food safety communication should be created with the intent of addressing perceived barriers and the factors that influence violations. The use of digital and mobile technology could allow food workers to have interventions delivered to them in the work environment. Concise, engaging tools could be used to help food workers recall food safety standards, understand their importance and immediately implement them while at work. Game based learning activities, as well as the mobile device platform, may make the tools more appealing to food workers and more convenient to auditors. The presence of the auditor may also have a positive effect, as they are enthusiastic and confident.

The overarching goal of the studies outlined in this thesis was to explore third-party food safety audits in grocery stores with the intent of understanding the factors around violations and how auditors could intervene. Analysis of third-party food safety audit data should be continued and findings should be applied to improve the audit process as well as food safety interventions and communication.

APPENDICES

APPENDIX A

Company A Auditor Survey

This survey is a part of a collaboration with Ecolab and North Carolina State University to improve foodhandler compliance to food safety standards through the development of new assessment and resolution tools. Your participation in this survey is greatly appreciated. This survey should take about 20-30 minutes to complete and your identity will remain anonymous. There will be no collection of identifying information, geographical location or IP address.

This survey specifically targets the food safety component of being a [Company A Auditor]. While we realize that you have many other components to your job, please focus your responses to the food safety activities that occur during store visits. Thank you for your time.

1. Do you consent to completing this survey and having your answers used for this research?

SELECT: yes, no

Demographics & Work Experience:

2. How many [chains] do you have in your territory?
 - a. SELECT: 1, 2, 3+
3. Are your [chains] national or regional?
 - a. SELECT: National, Regional, Both
4. Within the scope of the contract, with what percentage of your [chains] can you perform teaching and training activities? Please enter an estimate below.
 - a. FILL IN
5. How many years have you been a territory representative with [Company A]?
 - a. SELECT: Less than 1, 1-5, 6-10, 11-15, 16-20, 20+
6. Did you have food safety audit experience before joining [Company A]?
 - a. Yes/No (If yes, then route to questions 10 & 11; If no, route to question 11)
7. Where was your previous food safety audit experience?
 - a. PLEASE SELECT ALL THAT APPLY: Local Health Department, State Health Department, private auditing firm (Diversey, NSF, etc)
8. How many years did you work in the roles previously mentioned?
 - a. SELECT: Less than 1, 1-5, 6-10, 11-15, 16-20, 21-25, 26+

Job Description

9. As a [auditor], do you feel like your job is to instruct or train individuals in food safety?
 - a. Yes/No
10. As a [auditor], do you feel like your job is to cause or help individuals to learn about food safety by giving lessons/instruction?
 - a. Yes/No

11. As a [auditor], do you feel like your job is to methodically examine and review to find problems?
 - a. *Yes/No*
12. Please rank the following activities within your job from greatest to least importance.
 - a. *RANKING: Prevent problems, Identify problems, Address problems, prevent and address hazards, enforce compliance, teach food safety practices, coach managers and associates, help store obtain a good score, protect public health*
13. Please rank the following characteristics/skills needed to be a good at performing assessments and audits. 1 being most important, 14 being least important.
 - a. *Precision and order* (accuracy/exactitude, systemization/organization)
 - b. *Conscientiousness* (honesty, ethics, scrupulousness)
 - c. *Enthusiasm* and spontaneity
 - d. *Participating and outgoing* (socially uninhibited, friendly, responsive)
 - e. *Sensitive and humanistic* (perceptiveness, acuteness, delicacy)
 - f. *Critical (opinionated, suspicious)* (11)
 - g. *Problem solving ability*
 - h. *Overall food safety knowledge*
 - i. *Self-confident (stable, secure)*
 - j. *Responsible* (reliability, trustworthiness)
 - k. *Client awareness*
 - l. *Sound judgment*
 - m. *Respect* (consideration, regard)
 - n. *Oral communication skills, (20)*
14. Please rank the following characteristics/skills need to be good at teaching and training. 1 being most important, 11 being least important.
 - a. *Kindness* and consideration (courtesy, thoughtfulness)
 - b. *Cooperation* (collaboration, partnership, democratic)
 - c. *Flexibility* (adaptability, adjustability)
 - d. *Patience* (forbearance, tolerance)
 - e. *Good disposition and consistent behavior*
 - f. *Fairness* (impartiality, justice, objectivity)
 - g. *Sense of humor*
 - h. *Encouraging* (optimistic, heartening)
 - i. *Interest in individuals*
 - j. *Use of recognition (praise, encouragement)*
 - k. *Knowledge/proficiency in subject (38)*
15. Please rank the following characteristics/ skills needed to be good at helping individuals improve behavior. 1 being most important, 11 being least important.
 - a. *Care* (conscientiousness, heedfulness)
 - b. *Support* (advocate, back, endorse)
 - c. *Understanding* (accord, disposition)
 - d. *Respect* and honesty (consideration, regard, truthfulness)
 - e. *Enthusiasm* (passion, fervor, zeal)
 - f. *Fairness* (impartial, democratic behavior, objectivity)

- g. *Help improve skills and performance*
 - h. *Knowledgeable (smart)*
 - i. *Organization (order, systemization)*
 - j. *High expectations*
 - k. *Positive feedback (36)*
16. Please rank the following. 1 being most important, 3 being least important.
- a. *Performing an accurate assessment according to the pre-determined food safety standards*
 - b. *Sharing and explaining knowledge about the importance of food safety and safe food handling behaviors.*
 - c. *Helping employees understand the risks associated with their behaviors and how they implement strategies to help minimize those risks.*

Intervention Questions

17. Please rank your ability to translate food safety information clearly.
- a. *Likert Scale (1-5), 1: very good, 2: good, 3: neutral, 4: poor, and 5: very poor*
18. If a manager or employee asked a question about why a food safety practice was important, how would you feel about explaining it?
- a. *Likert Scale (1-5), 1: very good, 2: good, 3: neutral, 4: poor, and 5: very poor*
19. From your perspective, please rank the attitudes employees tend to have towards you being present as a food safety auditor.
- a. *Likert Scale (1-5), 1: very good, 2: good, 3: neutral, 4: poor, and 5: very poor*
20. Do you provide and explain resolutions to foodhandlers when you see them perform a risky behavior? (i.e. not wash hands correctly, fail to change gloves, etc)
- a. *Yes, Sometimes, No (if yes, direct to 25, if sometimes or no, direct to 24)*
21. What prevents you from providing and explaining resolutions to a foodhandler when you see a risky behavior (violation)?
- a. *The account doesn't allow for on-the-spot resolutions*
 - b. *Concern about time constraints*
 - c. *Please share other barriers providing resolutions to a foodhandler (fill in)*
22. Please describe how you provide and explain resolutions to a foodhandler performing risky behavior (violation).
- a. *Free response*
23. How do employees typically respond to your resolutions?
- a. *Likert Scale (1-5), 1: very favorably, 2: favorably, 3: neutral, 4: poorly, and 5: very poorly*
24. Do you use previous food safety audits to influence teaching and training moments and resolutions?
- a. *SELECT: Yes, Sometimes, No*
25. How do you think the employees view the food safety rules (i.e. handwashing, no bare hand contact, sanitation, etc)?
- a. *Likert Scale (1-5), 1: very favorably, 2: favorably, 3: neutral, 4: poorly, and 5: very poorly*
26. What is your age?

- a. *SELECT: 20-25, 26-30, 31-35, 36-40, 41-45, 46-50, 51-60, 61-70, 70+*
27. What is your gender?
a. *SELECT: male, female, prefer not to answer*
28. If you want to share any positive or negative stories you have about teaching and coaching during food safety audits, please fill record it below.
(fill in)

End of Survey

Thank you for taking the time to complete this survey. Your participation is greatly appreciated!

APPENDIX B

Preliminary intervention tool ideation and design flow

