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Temporary Restaurant Closures and Food Handling Violations: Inspection Reports in British Columbia

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This is to certify that the doctoral dissertation by

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Abstract

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MS, Royal Roads University, 2008

BS, University of Guelph, 1995

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

Unsafe food handling practices are implicated in many restaurant-associated foodborne disease outbreaks. Factors that contribute to unsafe food handling in restaurants include inadequate food safety knowledge, employees who perceive that safe food handling is not under their control, and restaurant cultures that do not prioritize food safety. The purpose of this study was to determine whether temporary restaurant closures were associated with reduced food handling violations after closure in restaurants from the Vancouver Coastal Health Authority and the Fraser Health Authority, in British Columbia, Canada. The theoretical foundations used were the health action process approach and the theory of planned behavior. Mixed-effects Poisson regression analyses showed that the typical restaurant had an estimated 16% increase in the average number of overall food handling violations per inspection after temporary closure, compared with before closure. Restaurant- and employee-related factors responsible for unsafe food handling practices likely result in the continuation of unsafe food handling practices, despite temporary restaurant closures. This study may contribute to positive social change by challenging the assumption that temporary restaurant closures motivate food handlers to improve their food handling practices. To protect the public's health, additional interventions must follow temporary restaurant closures for reasons such as insanitary conditions and improper food handling. Suggested interventions include the provision of targeted learning resources to restaurant managers, the issuing of directives requiring food handlers to attend recognized food safety training courses, and environmental health managers requiring a reduction in problematic menu items.

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Dedication

To Samantha, Joe, Ellen, and Dorothy.

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Chapter 1: Introduction to the Study

Introduction

Restaurant inspections are in place to prevent foodborne illness and to license establishments (U.S. Food and Drug Administration, 2013). Environmental health officers (EHOs) enforce standards based on risk assessment and management principles and provide food safety information to the food service industry (Federal/Provincial/Territorial Food Safety Committee, 2016). In British Columbia, Canada, the Public Health Act gives EHOs inspection powers to monitor restaurants and confirm compliance with food safety regulations (British Columbia, 2008). Employees of health authorities with the required training qualifications, which include 2 years of training in environmental health and passing the Canadian Institute of Public Health Inspector's certification exam, are designated as EHOs (British Columbia, 2008). EHOs conduct routine inspections of restaurants and assign them risk ratings of low, moderate, or high: high is based on a history of noncompliance, complex food preparation processes, and a lack of control over risks associated with the foods prepared. High-risk categorized restaurants are inspected more frequently (Almanza, 2014); routine inspections are typically scheduled three times a year (Cates et al., 2009). Furthermore, to protect the public from foodborne disease, an EHO may issue a temporary closure order when he/she believes there is a substantial public health risk (Almanza, 2014). EHOs use enforcement measures in cases where they believe a health hazard is likely or definitely going to occur (Lundén, 2013).

The purpose of this study was to determine whether temporary restaurant closures were associated with reductions in food handling violations postclosure in the groups under study. Restaurant closures have been presumed to be an effective mechanism for protecting the public from health hazards; however, no evidence supports the effectiveness of temporary restaurant closures in reducing critical violations in restaurants. In the Literature Review, I will discuss three possible reasons why restaurant employees do not discontinue unsafe food handling practices despite temporary restaurant closures: (a) lack of knowledge and understanding of safe food handling behaviors, (b) food handler perceptions of safe food handling as not being under their control, and (c) restaurant cultures in which food safety is not a priority. EHOs often debate the reasons why employees working in high-risk categorized restaurants exhibit such low levels of compliance with food safety regulations. Conventional wisdom holds that lack of compliance is primarily attributable to restaurant employees' lack of knowledge and understanding of safe food handling practices. Supporting this viewpoint, restaurant managers self-reported in a study by Läikkö-Roto and Nevas (2014) that they did not always understand the required behavioral corrections and the reasons for them (36.5%). In addition, in Clayton, Clegg Smith, Neff, Pollack, and Ensminger's (2015) study, several restaurant food handlers suggested unsafe food handling practices were related to inadequate knowledge and understanding; however, other employees disagreed. This illustrates that more information is needed about the association between food handlers' food safety knowledge and inspection scores or numbers of critical violations.

It is logical that food handlers' lack of knowledge and understanding might indeed translate into unsafe food handling practices. A second viewpoint, however, is that violations primarily happen in restaurant cultures in which food safety is not a priority. Several researchers' findings support this claim. Waters et al. (2015) found increased odds (odds ratio [OR] range, 1.85–3.42) existed for holding temperature, personal hygiene, equipment cleanliness, cross contamination, and sanitizer violations, if the same violation had been cited in the previous routine inspection. Furthermore, Kettunen, Nevas, and Lundén (2015) observed that enforcement measures did not result in violations being completely corrected in 31.8% of cases, and enforcement measures had to be used recurrently for 15.7% of violations. In Clayton et al.'s (2015) study, respondents agreed that restaurant employees were unlikely to perform safe food handling practices consistently without management oversight. In this study, I found that, in the groups under study, temporary restaurant closures were not associated with overall reductions in food handling violations postclosure. My findings support the latter viewpoint that a positive restaurant food safety culture reduces food handling violations.

As I found that the restaurant employees studied did not generally improve their food handling practices following temporary restaurant closures, I have concluded that EHOs should develop additional strategies to protect the public's health. With this research, I have contributed to positive social change by using scholarship to encourage EHOs to think differently about temporary restaurant closures and how to strengthen food handlers' intentions to perform safe food handling practices. Only a few researchers have investigated enforcement measure outcomes (see Kettunen et al., 2015). In this study, therefore, I contribute to this research gap.

In this chapter, I will focus on introducing the study and highlighting why my findings are relevant for EHOs. Major sections of this chapter include: the background, problem statement, purpose of the study, research questions, theoretical foundations, nature of the study, definitions, assumptions, scope and parameters, limitations, relevance, and summary.

Background

In this section, I will highlight potential outcomes of foodborne illness and food handling issues in restaurants. In Canada, foodborne transmission is the main route of transmission for *Campylobacter* spp., *Clostridium perfringens*, *Escherichia coli* subsp., and *Salmonella* spp. (Butler, Thomas, & Pintar, 2015). Foodborne pathogens most commonly cause acute gastroenteritis, although life threatening sequelae sometimes occur such as Guillain-Barré syndrome and hemolytic uremic syndrome (Scallan, Hoekstra, Mahon, Jones, & Griffin, 2015). Sockett et al. (2014) estimate there are 22,344 verotoxigenic *Escherichia coli* 0157 cases annually in Canada, and this pathogen has played a role in a number of high profile outbreaks. In a 4-year Canadian study (1 January 2001–31 December 2004), researchers counted 32,702 cases of *Campylobacter* spp., 5.1% of which required hospitalization; 3751 cases of enter hemorrhagic *Escherichia coli*, 3.9% of which required hospitalization; and 17,459 cases of *Salmonella* spp., 12.6% of which required hospitalization (Ruzante, Majowicz, Fazil, & Davidson, 2011). Although foodborne illness is most often limited to vomiting and diarrhea, cases often result in hospitalizations and occasionally deaths can occur.

In the United States, researchers have examined the human health burden of *Campylobacter* and non-typhoidal *Salmonella*. Scallan et al. (2015) estimated that 80%

of *Campylobacter* cases were foodborne, and that the resultant mean number of years lived with disability annually was 20,100 (8,800–36,100, 90% credible interval); the mean number of years of life lost annually due to mortality was 2,300 (200–6,800, 90% credible interval). In the same study, Scallan et al. estimated that 94% of non-typhoidal *Salmonella* was foodborne, and that the resultant mean number of years lived with disability annually was 24,300 (15,500–35,400, 90% credible interval), whereas the mean number of years of life lost annually due to mortality was 8,600 (430–25,700, 90% credible interval). However, when foods are handled safely, foodborne disease can often be prevented.

Four research groups that conducted studies in restaurants located in the United States uncovered widespread unsafe food handling practices. Bogard, Fuller, Radke, Selman, and Smith (2013) observed, in their study of 385 restaurants, that food handlers did not wash their hands between handling raw ground beef and cooked ground beef or other ready-to-eat foods 62% of the time. Green Brown et al. (2012) noted that 36.2% of 420 restaurant managers did not know their jurisdiction's cooling regulations, and 63.8% of restaurants had no written cooling procedures put in place to minimize pathogen proliferation. Furthermore, Green Brown, Khargonekar, Bushnell, and the Environmental Health Specialists Network Working Group (2013) found that only 43% of managers, from 448 restaurants, knew the temperature to which raw chicken needs to be cooked for it to be safe to eat (165°F or 74°C). Last, following interviews with 426 managers, Norton et al. (2015) reported that 46.2% of restaurants had no written policies regarding ill food workers (i.e., an individual infected with any communicable disease transmittable through food), despite the handling of food by an ill worker being a major cause of restaurant associated foodborne illness. The high number of known widespread unsafe food handling practices suggests that EHOs should prioritize restaurants for food safety communications and educational interventions.

The gap in knowledge that I have addressed with this study is whether temporary restaurant closures are associated with reductions in food handling violations postclosure. Research has shown that restaurant associated foodborne disease can be prevented by improving restaurant employees' food handling practices (Ghiselli, 2014). In looking at where food safety knowledge levels, working conditions, and restaurant food safety cultures are having a negative influence on food handling practices, I have considered whether additional strategies are needed following temporary restaurant closures to improve food handling behaviors. I will discuss potential strategies in Chapters 2 and 5.

Problem Statement

In this section, to frame the problem, I will review estimates of the numbers of individuals who experience foodborne illness annually and outline the known pathogens that cause the majority of foodborne illnesses. In North America, foodborne illnesses are a persistent public health problem, and confirmed cases likely represent only a small fraction of actual cases. In British Columbia, for every case of infectious gastrointestinal illness counted in the provincial statistics, it is estimated that 347 community cases occur (MacDougall et al., 2008). Using a modeling approach that accounts for underreporting and underdiagnosis, Thomas et al. (2013) estimated that, each year, a total of 4 million episodes of domestically acquired foodborne illness occur in Canada; approximately one in eight Canadians experiences an episode of foodborne illness annually. Thomas and Murray (2014) estimated that Norovirus, *Clostridium perfringens*, *Campylobacter*, and nontyphoidal *Salmonella* are responsible for approximately 90% of the illnesses caused by known pathogens in Canada.

Scallan, Griffin, Angulo, Tauxe, and Hoekstra (2011a) estimated that, each year, 47.8 million episodes of domestically acquired foodborne illnesses occur in the United States. Preliminary data for 2014 from the United States' Foodborne Diseases Active Surveillance Network, which monitors laboratory-confirmed infections caused by nine pathogens that are transmitted commonly through food to approximately 15% of the country's population, shows 19,542 infections, 4,445 hospitalizations, and 71 deaths (Crim et al., 2015). Also in the United States, Scallan et al. (2011b) reported Norovirus, nontypoidal *Salmonella* spp., *Clostridium perfringens*, and *Campylobacter* spp. cause 58% of illnesses caused by major pathogens.

The average Canadian household spends 27% of food expenditures on foods purchased from restaurants (Statistics Canada, 2015), whereas the restaurant industry's share of the food dollar in the United States is 47% (National Restaurant Association, 2015). Although eating in restaurants and ordering food to go is commonplace, foods prepared by restaurant employees may not be as safe to eat as those prepared in the home. In fact, when individuals eat more frequently in restaurants, they are at increased risk for foodborne illness (Jones & Angulo, 2006). In the United States, foods prepared by restaurant employees were associated with 68% of the foodborne disease outbreaks that reportedly occurred from 1998–2008 (Gould, Rosenblum, Nicholas, Phan, & Jones, 2013). Of 295 investigated restaurant-associated outbreaks that occurred in 2006 and 2007, Gould et al. found that an infected person handling foods (i.e., an individual infected with any communicable disease transmissible through food) was a contributing factor in 137 outbreaks, inadequate cold-holding temperature was a contributing factor in 47 outbreaks, slow cooling was a contributing factor in 34 outbreaks, and allowing foods to remain at room temperature was a contributing factor in 25 outbreaks. These findings illustrate that foodborne disease is often preventable.

Because restaurant employees often have inadequate food safety training, EHOs spend a great deal of time educating employees about safe food handling practices. However, food safety training does not always result in behavior change (Park, Kwak, & Chang, 2010), indicating that other factors may act as deterrents to performing safe food handling practices in work environments. Although researchers have studied the effects of food safety training on food handler behaviors, a gap in the research literature relates to both the effects of temporary restaurant closures on food handler behaviors and what strategies might be most effective in reducing food handling violations postclosure. In studying the literature, I identified lack of food handler knowledge, food handler perceptions of safe food handling as not being under their control, and restaurant cultures in which food safety is not a priority as three possible reasons why food handlers might not perform safe food handling practices despite temporary restaurant closures. As many factors may influence food handler behaviors, there was justification for looking into how effective temporary restaurant closures are in terms of motivating food handlers to perform safe food handling practices after restaurant reopenings.

Purpose of the Study

I have designed this quantitative study to examine whether temporary restaurant closures may be associated with reductions in food handling violations postclosure. As I will discuss, I used data from two health authorities to conduct the research. There were eight possible categories of food handling violations: contamination, handwashing, food safety management, sanitizing, refrigeration, training, cooling, and thawing. I examined whether there were differences in the average overall numbers of documented food handling violations per inspection in temporarily closed restaurants before and after closures (H_{O1}, H_{A1}), and for the individual violation categories handwashing, sanitizing, refrigeration, and contamination (H_{O2}, H_{A2}). Next, I determined whether there were differences in the average overall numbers of food handling violations between any of the following four groups: restaurants that had been temporarily closed and those categorized as high, moderate, or low risk (H_{O3}, H_{A3}). In addition, I examined whether type of cuisine served (H_{O4}, H_{A4}), chain or independent status (H_{O5}, H_{A5}), or number of menu items (H_{O6}, H_{A6}) could be used to predict being categorized in the temporarily closed or not closed high-risk categorized groups. Each alternative hypothesis was tested against the corresponding null hypothesis at the usual statistical significance level of $\alpha = 0.05$. I designed my methodology to examine the effect of temporary restaurant closures on food handling violations in two health authorities. Specifically, I designed the study to look at the prevalence of continued unsafe food handling practices postclosure, as a high rate of occurrence would provide evidence that additional interventions are needed in combination with temporary restaurant closures, such as food handler certification.

When EHOs rely solely on their personal experiences to determine the effectiveness of enforcement measures, they may over or under estimate effectiveness. It is, therefore, important to evaluate the effectiveness of policies and to determine whether enforcement measures result in significant improvements in food handling practices. With this study, I carried out the work of Walden University and contributed to positive social change by providing insight into some of the limitations of temporary restaurant closures. My findings indicate that additional interventions are advisable and should be put into practice following temporary restaurant closures, due to continued unsafe food handling practices postclosure. My results can be used by policy makers considering evidence that supports new and existing food safety intervention policies.

Research Questions and Statistical Hypotheses

In this study, I investigated six quantitative research questions (RQs). For ease of reference, I will refer to these questions as RQ1 through RQ6 throughout.

Routine inspection reports contain information on the following food handling violations: contamination, handwashing, food safety management, sanitizing, refrigeration, training, cooling, and thawing. RQ1 and RQ2 concern food handling violations identified during routine inspections conducted before and after temporary restaurant closures, for restaurants located within the Fraser Health Authority and the Vancouver Coastal Health Authority. RQ4, RQ5, and RQ6 enabled me to investigate whether type of cuisine, type of ownership, and/or the number of menu items are factors that can help to predict whether a restaurant located within the Fraser Health Authority will be temporarily closed or categorized as high risk.

After Fraser Health Authority EHOs conduct routine inspections, they post restaurant risk ratings and inspection reports online, whereas only inspection reports are posted on the Vancouver Coastal Health Authority website. Because risk ratings are not available for restaurants located in the Vancouver Coastal Health Authority, I focused on restaurants located in the Fraser Health Authority for RQ3 through RQ6.

My six quantitative RQs were as follows:

RQ1 – Is there a difference in the average overall number of food handling violations per inspection documented before and after temporary closures, for restaurants located in the Fraser Health Authority and the Vancouver Coastal Health Authority?

RQ2 – Is there a difference in the average number of specific food handling violations per inspection documented before and after temporary closures, for restaurants located in the Fraser Health Authority and the Vancouver Coastal Health Authority?

RQ3 – Are there any differences in the average overall numbers of food handling violations between the following groups of restaurants monitored by the Fraser Health Authority: restaurants that experienced a temporary closure (Group A), restaurants that were categorized as high risk (Group B), restaurants that were categorized as moderate risk (Group C), and restaurants that were categorized as low risk (Group D)?

RQ4 – Does the type of cuisine served in a restaurant predict it being categorized in the temporarily closed group (Group A) or the high-risk group (Group B), for restaurants located in the Fraser Health Authority?

RQ5 – Does a restaurant being independent rather than being a chain predict it being categorized in the temporarily closed group (Group A) or the high-risk group

(Group B), for restaurants located in the Fraser Health Authority?

RQ6 – Does the number of menu items offered by a restaurant predict it being categorized in the temporarily closed group (Group A) or the high-risk group (Group B), for restaurants located in the Fraser Health Authority?

Details about RQ1 through RQ6 follow. For RQ1, I considered the following data for each restaurant in my sample: (a) the number of overall food handing violations before temporary closure, (b) the number of routine inspections before temporary closure, (c) the number of overall food handling violations after temporary closure, and (d) the number of routine inspections after temporary closure. Specifically, I determined the overall number of food violations listed in items (a) and (c) by counting all of the following food handling violations observed across inspections: contamination, handwashing, food safety management, sanitizing, refrigeration, training, cooling, hot holding, and thawing.

For RQ2, I considered the following data for each restaurant in my sample: (a) the number of specific food handling violations before temporary closure, (b) the number of routine inspections before temporary closure, (c) the number of specific food handling violations after temporary closure, and (d) the number of routine inspections after temporary closure. For items (a) and (c), I considered in turn only selected specific food handling violations: handwashing, sanitizing, refrigeration, and contamination.

To address RQ3, I used the risk ratings (low, moderate, high) and restaurant closures information posted on the Fraser Health Authority website to assign restaurants to Group A, B, C, or D. For each restaurant in my sample, I considered the number of overall food violations documented. I determined the overall number of food violations by counting the same food handling violations listed in RQ1.

For RQ4, I considered popular types of cuisine (East Asian, Japanese, North American/other, and South Asian). Type of cuisine served has been a variable of interest in several studies (Brown et al., 2014; Manes, Liu, & Dworkin, 2013; Panchal, Bonhote, & Dworkin, 2013; Panchal, Carli, & Dworkin, 2014). As some types of cuisine have dishes that require more preparation, I included this variable in my study. Similarly, independent or chain status has been a variable of interest in a number of studies (Brown et al., 2014; Kassa et al., 2010; Manes et al., 2013; Panchal et al., 2013; Panchal et al. 2014; Roberts & Barrett, 2009). Chain restaurants are often required to follow company-wide standardized operating procedures, which may reduce numbers of food handling violations; therefore, including this variable was appropriate. Although the explanatory variable number of menu items has not been examined by other scholars, it provides valuable insight, as preparing too many menu items in restaurant kitchens with limited physical space and equipment is problematic with regard to safe food handling.

Each of the six quantitative questions generated two competing statistical hypotheses: a null hypothesis and an alternative hypothesis. Each alternative hypothesis was tested against the corresponding null hypothesis at the usual statistical significance level of $\alpha = 0.05$. Information about the statistical test used for each set of hypotheses will be given in Chapter 3. Table 1 lists all six RQs and the associated null and alternative hypotheses.

Table 1

Quantitative Research Questions of Interest and Corresponding Statistical Hypotheses

Research question ID	Research question description	Null hypothesis	Alternative hypothesis	Target restaurants
RQ1	Is there a difference in the average overall number of food handling violations per inspection documented before and after temporary closures?	H_{O1}- There is no difference in the average overall number of food handling violations per inspection documented before and after temporary closures.	H_{A1}- There is a difference in the average overall number of food handling violations per inspection documented before and after temporary closures.	Restaurants located in the Fraser Health Authority and Vancouver Coastal Health Authority.
RQ2	Is there a difference in the average number of individual food handling violations per inspection documented before and after temporary closures?	H_{O2}- There is no difference in the average number of individual food handling violations per inspection documented before and after temporary closures.	H_{A2}- There is a difference in the average number of individual food handling violations per inspection documented before and after temporary closures.	Restaurants located in the Fraser Health Authority and Vancouver Coastal Health Authority.
RQ3	Are there any differences in the average overall numbers of food handling violations between any of the following groups: Group A, B, C, D?	H_{O3}- There is no difference in the average overall number of food handling violations between the four restaurant groups: Group A, B, C, D.	H_{A3}-There is a difference in the average overall number of food handling violations between the four restaurant groups: Group A, B, C, D.	Restaurants located in the Fraser Health Authority.

(table continues)

Research question ID	Research question description	Null hypothesis	Alternative hypothesis	Target restaurants
RQ4	Does the type of cuisine served in a restaurant predict it being categorized in the temporarily closed group (Group A) or the high-risk group (Group B)?	H_{O4}- Type of cuisine served does not predict being categorized in the temporarily closed group (Group A) or the high-risk-group (Group B).	H_{A4}- Type of cuisine served does predict being categorized in the temporarily closed group (Group A) or the high-risk group (Group B).	Restaurants located in the Fraser Health Authority.
RQ5	Does a restaurant being independent rather than being a chain predict it being categorized in the temporarily closed group (Group A) or the high-risk group (Group B)?	H_{O5}- Being independent, rather than being a chain, does not predict being categorized in the temporarily closed group (Group A) or the high-risk- group (Group B).	H_{A5}- Being independent, rather than being a chain, does predict being categorized in the temporarily closed group (Group A) or the high-risk group (Group B).	Restaurants located in the Fraser Health Authority.
RQ6	Does the number of menu items offered by a restaurant predict it being categorized in the temporarily closed group (Group A) or the high-risk group (Group B)?	H_{O6}- Number of menu items offered by a restaurant does not predict being categorized in the temporarily closed group (Group A) or the high-risk group (Group B).	H_{A6}- Number of menu items offered by a restaurant does predict being categorized in the temporarily closed group (Group A) or the high-risk group (Group B).	Restaurants located in the Fraser Health Authority.

Theoretical Foundations for the Study

Food handler behaviors can be explained using the theory of planned behavior and the health action process approach. The theory of planned behavior originates from the theory of reasoned action, in which Ajzen and Fishbein (1980) proposed that a person's intention is a function of attitude toward the behavior and subjective norm. In this theory, Ajzen and Fishbein assumed that most actions are under volitional control. However, many behaviors depend on resources, skills, and the cooperation of others (Ajzen, 1991). In the theory of planned behavior, Ajzen (1991) added the construct perceived behavioral control to capture the role of behavioral control in achievement. For example, in terms of my study, restaurant employees' behaviors around using thermometers to check safe minimum cooking temperatures will be better predicted by the theory of planned behavior. Ajzen found the theory of planned behavior improved the prediction of both intentions and behaviors.

Schwarzer (1992) asserted that the health action process approach is similar to protection motivation theory and also combines some features of the theory of reasoned action. In protection motivation theory, Rogers (1975) explained that a person's intentions to adopt the recommended response are a function of appraised severity, expectancy of exposure, and belief in the efficacy of a coping response. In one application of protection motivation theory, Mullan, Allom, Sainsbury, and Monds (2016) found that self-efficacy, or a study participant's belief that they could perform safe food handling practices easily, was most significant in influencing the individual's motivations to perform safe food handling practices. Schwarzer (2008) clarified that the health action process approach makes a distinction between an initial motivation phase, in which a person develops an intention to act, and a postintentional phase, in which individuals must develop self-regulatory skills and strategies to maintain behaviors. This distinction makes the health action process approach more suitable for predicting behaviors requiring perseverant efforts (i.e., performing proper handwashing during peak hours). These theoretical foundations relate to my approach in this study, in that I investigated whether temporary restaurant closures were associated with improvements in food handling behaviors postclosure in the groups under study.

In making use of these theoretical foundations, I offer factors such as lack of food safety knowledge, food handlers' perceptions of their ability to perform safe food handling practices as being outside of their control, and lack of management commitment to food safety as potential explanations for ongoing unsafe food handling practices despite temporary restaurant closures. The reasons why restaurant employees might discontinue performing safe food handling practices after short periods of compliance can also be better understood though the health action process approach. In this chapter, I touch on why food handlers might not perform safe food handling practices despite temporary restaurant closures. I then explore this subject in detail in the literature review, in Chapter 2.

Nature of the Study

I decided on a quantitative design, and I used publicly available data involving restaurants located in the Fraser Health Authority and the Vancouver Coastal Health Authority in British Columbia. Maps showing the health authority boundaries are available in Appendix A. The explanatory variables were health authority and occasion (RQ1 and RQ2), group and year (RQ3), type of cuisine (RQ4), type of ownership (RQ5), and number of menu items (RQ6). The outcome variables were numbers of food handling violations (RQ1–RQ3) and group (RQ4–RQ6). A quantitative design was appropriate for examining the relationships between the explanatory variables and the outcome variables for RQ1 through RQ6. The research questions were developed from the problem statement. To answer RQ1 and RQ2, I used a mixed effects Poisson regression; to answer RQ3, I used a standard Poisson regression; and to answer RQ4 through RQ6, I used multinomial logistic regression. The research methodology is described further in Chapter 3.

Definition of Terms

Schwarzer's Health Action Process Approach

Action self-efficacy: Involves one's confidence in being able to perform a behavior.

Health action process approach: This framework distinguishes between pre-intentional motivation processes that lead to behavioral intentions and post-intentional volition processes that lead to actual behaviors. Action self-efficacy, outcome expectancies, and risk perception influence intentions to act, and maintenance self-efficacy and recovery self-efficacy lead to actual behaviors.

Maintenance self-efficacy: Represents beliefs about one's capability to deal with barriers that arise during the maintenance period.

Outcome expectancies: When a person balances the pros and cons of certain behavioral outcomes.

Recovery self-efficacy: Refers to the experience of failure and recovery from setbacks.

Risk perception: A contemplation process involving thoughts about consequences and competencies.

Ajzen's Theory of Planned Behavior

Attitude: How a person appraises the behavior in question.

Intentions: Indications of how much effort a person is planning to exert to perform a behavior.

Perceived behavioral control: Involves an individual's perceived difficulty in terms of performing a behavior.

Subjective norm: The perceived social pressure to perform a behavior.

Theory of planned behavior: In this theory, individuals' intentions to perform behaviors can be predicted from attitudes toward the behavior, subjective norms, and perceived behavioral control; these intentions account for considerable variance in actual behavior.

Other Definitions

Chain restaurant: A restaurant owned or operated by the same company or individual, with two locations or more.

Contamination: Foods may be contaminated by an infected food handler, by unclean work surfaces and utensils, by pests, or by other foods (Burton, 2014).

Danger zone: Refers to the temperature range in which bacteria multiply rapidly, between 4 and 60° Celsius (or between 40 and 140° Fahrenheit) (Burton, 2014).

East Asian cuisine: Includes the cuisine of China, Cambodia, Indonesia, Korea, Lao PDR, Malaysia, Mongolia, Myanmar, Pacific Islands, Papua New Guinea, Philippines, Singapore, Thailand, Timor-Leste, and Vietnam.

Food handling violation: Refers to a nonconformance with applicable food safety regulations in one of the following categories: contamination, cooling, food safety management, handwashing, refrigeration, sanitizing, thawing, or manager training.

Food safety culture: Refers to the shared attitudes and beliefs toward the food safety behaviors that are routinely demonstrated in food service establishments (Griffith, Livesey, & Clayton, 2010).

Food safety knowledge: Refers to a restaurant employee's level of awareness about safe food handling practices, as determined by scores on a survey.

Foodborne illness: An illness caused by foodborne contamination; contamination can be either biological, chemical, or physical (Burton, 2014).

Foodborne illness outbreak: An incident involving two or more persons experiencing a similar illness after ingesting a common food (U.S. Food and Drug Administration, 2013).

Habit: An impulse to act generated by a learned stimulus response association (Gardner, 2014).

Handwashing: A cleaning procedure requiring rinsing hands under running water, applying soap, rubbing hands together to make a lather for at least 20 seconds, rinsing, and drying with a paper towel (Burton, 2014; Centers for Disease Control and

Prevention, 2015).

High-risk category restaurant: In this category, the restaurant meets one or more of the following conditions: a history of non-compliance with food safety regulations, little or no emphasis on food safety, complex food preparation processes, inadequate standardized operating procedures, and/or inadequate food safety training of employees.

Japanese cuisine: The cuisine of Japan.

Manager: A restaurant employee with authority over the kitchen.

North American/other cuisine: The cuisine of North America, Africa, France, Jamaica, Mexico, Greece, and Italy.

Number of menu items: All dinner menu items including desserts, but excluding half orders, beverages, beer, and liquor.

South Asian cuisine: Includes the cuisine of Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka.

Temporary restaurant closure: A closure order issued when an EHO determines that conditions may lead, or have already lead, to a health hazard.

Trained food handler: An individual with a certificate indicating he/she has successfully completed a nationally or locally recognized food safety training program.

Type of cuisine served: Using menus, foods served were classified in this study as East Asian, Japanese, North American/other, or South Asian.

Assumptions

I made several assumptions, most notably that inspection reports can be used to capture restaurant employee behaviors related to food handling. Specifically, I assumed that EHOs documented all food handling violations from restaurants in the groups under study. This assumption was necessary because I did not design the study to involve any additional data collection from EHOs. Last, I assumed there were only minor differences in the consistency of observations between inspectors, and that food service establishments were accurately classified as low, moderate, or high risk according to observed breakdowns in safe food handling practices and managerial control.

Scope and Parameters

For RQ1 and RQ2, I delimited the study to temporarily closed restaurants located in the Fraser Health Authority and Vancouver Coastal Health Authority regions, whereas for RQ3 through RQ6, I delimited the study to restaurants located in the Fraser Health Authority. I did not include restaurants closed for lack of hot water or because of fires, floods, or sewage back-ups in RQ1 through RQ6, as managers cannot work to prevent closures for these reasons. Because I focused on unsafe food handling practices known to be associated with foodborne illness, I collected and analyzed data on specific food handling violations. Results may not be generalizable to other regions where different temporary restaurant closure policies and practices exist. Regarding this, even within the same country, enforcement measures may not be used uniformly by different local food control units (Kettunen et al., 2015). However, this research provides a foundation from which other scholars can design area-specific studies. Last, I did not examine barriers to the performance of safe food handling practices in work environments, or relationships between intentions and behaviors, or between knowledge and behaviors. Potential areas for future research are discussed in Chapter 5, such as undertaking qualitative studies that involve restaurant employees to examine barriers to the performance of safe food handling practices following temporary restaurant closures.

Limitations

Although secondary data analysis is widespread in public health research, there will always be limitations. For example, researchers may not find data for every variable they are interested in studying. Furthermore, there are rarely opportunities to address missing or inconclusive data. In this study, due to time constraints, I did not question EHOs to obtain clarifications about their restaurant inspections.

There are some issues related to analyzing restaurant inspection reports that should be noted. First, EHOs are only able to observe food handling practices that are occurring at the time of inspections, and they may never become aware of unsafe food handling practices happening at other times. Next, individual EHOs have their own biases, and as a result, there may be minor differences in terms of the violations they cite. Researchers have identified this limitation in several studies that have used inspection data (Cates et al., 2009; Cotterchio, Gunn, Coffill, Tormey, & Barry, 1998; Lee, Nelson, & Almanza, 2012; Murphy, DiPietro, Kock, & Lee, 2011). Researchers frequently use inspection scores or numbers of violations to study the effectiveness of food safety interventions, such as kitchen manager training; however, the ability of these studies to find improvements depends to some extent on the quality of inspections performed by inspectors.

In this study, selection was an important threat to internal validity. For example, data collected to answer RQ1 and RQ2 was gathered using a convenience sampling procedure, because a limited number of restaurants have been temporarily closed in the two health authorities in 2015 and 2016. I included all temporarily closed restaurants in the Fraser Health Authority and Vancouver Coastal Health Authority that had a restaurant menu available online, and for which the reasons for closure were improper food handling practices, pest infestations, and/or unsanitary conditions. Although random sampling procedures are preferable to convenience sampling procedures, I would argue that the sampled restaurants were representative of temporarily closed restaurants in British Columbia. When answering RQ1 through RQ6, I kept in mind that results might not be generalizable and made sure to develop conclusions carefully. Similarly, treatment variation was a threat to external validity. Although EHOs typically close a restaurant for no more than 1 to 3 days, occasionally restaurant closures are longer, and longer restaurant closures may have a greater influence on food handler behaviors.

Relevance

This study will assist EHOs in better understanding the effects of temporary restaurant closures on food handler behaviors. Limited data exists regarding the effects of temporary closures on food handlers' performance of safe food handling practices. By examining the effectiveness of this widely used enforcement measure, temporary restaurant closures, I have filled an important knowledge gap. Understanding behavioral outcomes will allow more effective policies to be developed. My findings also have the potential to increase EHOs' understandings of barriers to the performance of safe food handling practices. Unsafe food handling practices are of professional significance to EHOs as they are responsible for preventing foodborne illnesses.

In this study, I found that temporary restaurant closures terminated immediate health hazards but were generally ineffective in improving food handling behaviors. I have thus contributed to positive social change by challenging the traditional assumption that temporary restaurant closures automatically result in lasting improvements in food handling practices. My purpose with this study was to use scholarship to encourage EHOs to think differently about how to strengthen food handlers' intentions to perform safe food handling practices, specifically in situations where food safety knowledge levels, workplace conditions, and restaurant food safety cultures are negatively influencing food handling practices. I have several possible proposals for action to achieve these ends. One recommendation is for EHOs to deliver targeted food safety communications after closure orders are issued or at other teachable moments, such as after recurrent critical violations are observed. Next, there is a strong argument to be made for requiring all food handlers to complete a food safety training course after restaurants have been closed due to unsafe food handling practices or unsanitary conditions. One exception might be if food handlers cannot find a course in a suitable language. Last, I would suggest that if food handling practices do not improve following temporary restaurant closures, in addition to requiring employees to take a food safety training course, environmental health managers might require a reduction in problematic menu items.

My findings illustrate that EHOs need to engage in dialogue about new strategies that can be used in combination with temporary restaurant closures, as temporary restaurant closures overall were not found to be an adequate deterrent to future poor food handling practices. By evaluating behavioral outcomes and questioning the effectiveness of existing measures, as I did, EHOs can open doors to new strategies for protecting the public's health.

Summary

In this first chapter, I have described the topic of the study and its relevance. In the Theoretical Foundations section, I introduced the two theories that provided the frameworks for the study and discussed their relation to food handler behaviors. Next, I identified the research questions, study assumptions, scope, delimitations, and limitations. My research questions were formulated following a review of the literature discussed in the next chapter. In the literature review chapter, I will examine literature related to three major topics: food handler knowledge, theories that explain food handler behaviors, and studies examining food handler behaviors.

Chapter 2: Literature Review

Introduction

Despite temporary restaurant closures, employees may not improve food handling practices. In this literature review, I consider potential barriers to improving employees' food handling behaviors in restaurants where food safety knowledge levels, working conditions, and restaurant food safety cultures negatively influence food handling practices. I will focus on North American research; however, studies conducted in other countries are included because they offer a broader perspective of food handler knowledge levels and behaviors. Without identifying food handler knowledge gaps and other barriers to safe food handling practices, effective strategies for improving food handling behaviors following temporary restaurant closures cannot be developed.

Restaurant- and employee-related factors contributing to low levels of compliance with food safety regulations may not be adequately understood. For example, interviews with food handlers in the United States revealed that oftentimes preparing foods quickly takes precedence over following food safety procedures (Clayton et al., 2015). In Finland, Kettunen et al. (2015) noted that a preceding request to correct violations had been given in 52.1% of critical violations. In terms of specific violations, Waters et al. (2015) reported that the risk for holding temperature, contamination, and sanitizing violations increased after a follow-up by EHOs when compared to restaurants without a prior follow-up; the ORs were 1.91, 1.90, and 3.42, respectively. More research is needed to determine potential restaurant- and employee-related factors that contribute to low levels of compliance with food safety regulations and to create strategies EHOs can use to improve food handler behaviors, especially following temporary restaurant closures.

In this literature review, I concentrate on three topic areas: food handler knowledge, theoretical frameworks for the study, and food handler behaviors. Food safety knowledge is one factor that likely influences food handler intentions and behaviors. However, upon examining applicable studies, I found that food safety knowledge study results are not directly comparable because of differences in questionnaires. Food handler participants from the studies discussed in this review worked in fast food or full service restaurants, catering companies, food processing companies, hotels, hospitals, nursing homes, or schools. One limitation I discovered when reviewing studies on food handler knowledge is their dependency on participants willing to volunteer; participation bias may result in an overestimation of food handler knowledge, if those who volunteered to participate were more knowledgeable food handlers compared to others (Manes et al., 2013; Pichler, Ziegler, Aldrian, & Allerberger, 2014). I also discuss relationships between training, levels of education, language, experience, and age of food handlers, and overall food handler knowledge levels. Studies covered in this review highlight the possibility that inadequate food safety knowledge may be a barrier to improvements in food handling practices postclosure. In addition to reviewing study findings, I question the adequacy of provincial and territorial regulatory training requirements pertaining to restaurants that have been temporarily closed due to insanitary conditions and improper food handling practices.

In the second section, I report on how the theory of planned behavior and the health action process approach explain food handler behaviors. Studies covered in this section involved foodservice employee, university student, and consumer participants, and thus provide veritable insight into strategies likely to support behavior change among restaurant employees. In the third section of the literature review, which covers food handler behaviors, I discuss studies that primarily involved employees working in restaurants located in the United States or students attending universities in the United States. Studies conducted by researchers in Brazil, Canada, Dubai, Korea, and Portugal are also included. As well, I cover studies examining the importance of positive restaurant food safety cultures.

Literature Search Strategy

Research databases used to locate journal articles included the following: Academic Search Complete, CINAHL Complete, Emerald Management 200, ProQuest Central, PubMed Central, Science Direct, and Taylor and Francis Library. I also used the web resource Google Scholar. Relevant keywords used to search the literature were as follows: *behavior*, *food handler*, *food handling, food hygiene, food safety*, *food safety culture*, *food safety violations*, *habit*, *health action process approach*, *intentions*, *knowledge*, *motivation, past behavior*, *restaurant inspections*, *theory of planned behavior*, and *training*. During my literature search, I found approximately 140 behavioral science and food safety journal articles of interest.

In this literature review, I review journal articles published between 2008 and 2016 relating to food handler knowledge, the theoretical foundations for this study, food handler behaviors, and food safety culture. In addition, I discuss original articles written about behavioral change theories published before 2008. Last, I describe one qualitative study from 2005, in which researchers focused on barriers to performing safe food handling practices in restaurants.

Knowledge of Safe Food Handling Practices

Food safety instructors teach participants about foodborne illness causes and consequences, operating on the principle that once knowledge is enhanced individuals will perform safe food handling practices. In Canada, Manitoba, Newfoundland and Labrador, Ontario, and Yukon have no provincial or territorial requirements for food safety training (Manitoba, 1988; Newfoundland and Labrador, 1996; Ontario, 1990; Yukon, 1961), and in Alberta, British Columbia, New Brunswick, Northwest Territories, Nova Scotia, Prince Edward Island, Quebec, and Saskatchewan, food safety training is required for managers and for one employee in the absence of a manager (Alberta, 2006; B.C., 1999; New Brunswick, 2009; Northwest Territories, 2009; Nova Scotia, 2005; Prince Edward Island, 1988; Quebec, 2015; Saskatchewan, 2009). Managers of international multiunit restaurant businesses often provide standardized food safety training for employees, but such training takes place less frequently in independent restaurants and small chains. If employees were required to take food safety training programs after temporary restaurant closures for reasons such as unsanitary conditions and unsafe food handling practices, this would be beneficial in terms of helping individuals understand the importance of safe food handling behaviors. An exception might be if food handlers could not find a course in a suitable language. In the next section, I highlight research examining food handler knowledge levels about specific safe food handling practices.

Contamination

Restaurant food handlers may not have adequate knowledge about how to protect foods from contamination to prevent foodborne illness. Manes et al. (2013) observed that 39.5% of surveyed food handlers in the United States were not aware that raw meats should be stored separately in fridges. A study by Santos, Nogueira, Patarata, and Mayan (2008) surveyed food handlers in Portugal and found that 12.9% were not aware that raw meat fluids can contaminate foods and cause foodborne illness. Panchal et al. (2013) reported that 12% of food handler respondents in Switzerland did not realize that if raw chicken juice dripped onto salad greens they should be thrown away. Similarly, Panchal et al. (2014) observed that 44% of food handler participants in Italy did not know that raw chicken juice dripped onto salad greens contaminates them. These studies show that food handlers need more knowledge about how to protect against food contamination. EHOs traditionally communicate about food safety with restaurant employees both verbally and through inspection reports; however, new opportunities to use information technology to deliver targeted food safety communications exist.

Handwashing

Restaurant customers assume that food handlers are knowledgeable about how and when to wash their hands, but this is simply not true. DeBess, Pippert, Angulo, and Cieslak (2009) reported that 61% of food handler respondents in the United States did not know they needed to wash their hands for approximately 20 seconds after using the toilet. In other studies, Santos et al. (2008) highlighted that 34.7% of food handler participants working in schools in Portugal mistakenly thought hands should be dried with a multiuse kitchen towel, and Manes, Kuganantham, Jagadeesan, Laxmidevi, and Dworkin (2016) observed that 51% of food handlers working in restaurants in India did not know they should dry their hands with a clean paper towel. The findings of these studies give the impression that targeted food safety communications about protecting foods from contamination, handwashing, and glove use would be beneficial for employees in restaurants that have been cited for these types of critical violations.

Temperature Control

Restaurant food handlers may also not be aware of the safe minimum internal cooking temperatures required to prevent foodborne illness. Researchers in the United States found respectively that 80% and 82.8% of surveyed food handlers did not know the temperature to which hamburger should be cooked (71°C or 160°F) (DeBess et al., 2009; Manes et al., 2013). In Austria, 85% of restaurant food handlers incorrectly answered this same question about cooking hamburger (Pichler et al., 2014). Furthermore, studies conducted in Switzerland and Italy showed that none of the food handler respondents knew the internal temperature for properly (i.e., safely) cooked chicken pieces (74 °C or 165 °F) (Panchal et al., 2013; Panchal et al., 2014).

Besides this, restaurant food handlers may have knowledge gaps in relation to minimum hot holding temperatures for potentially hazardous foods. In the United States, 21% of assessed food handlers did not know the safe temperature for hot holding (60 °C or 140 °F) (DeBess et al., 2009). Researchers in Italy found that 82% of food handlers working in participating nursing homes and long-term care facilities were not aware of the safe temperatures for hot holding (Buccheri et al., 2010). Researchers in Italy and

Switzerland found respectively that 92% and 98% of food handlers working in participating restaurants were not aware of the maximum temperature at which pathogens grow well (Panchal et al., 2014; Panchal et al., 2013).

Moreover, researchers have shown that restaurant food handlers may not be aware of proper refrigeration temperatures to store foods to prevent foodborne illness. Manes et al. (2016) reported 97% of restaurant food handlers working in India who participated in the knowledge survey did not know the temperature at which potentially hazardous foods should be stored (5°C or 41°F, or colder). In Smigic et al.s (2016) study, conducted in Serbia, Greece, and Portugal, 59.5% of food handlers mistakenly believed that 13°C (55°F) was an adequate temperature for the cold storage of food. Similarly, 33.2% of food handlers working in the tourism industry in Brazil did not perceive it to be risky to store raw or cooked meats at room temperature (De Andrade, Sturion, & Mendoza, 2016). In addition to EHOs communicating with restaurant employees about food safety verbally and through inspection reports, health authorities could use communication technologies to deliver specific food safety messages that would address such crucial knowledge gaps.

Food Appearance

Foods may appear normal and yet be dangerous to eat. DeBess et al. (2009) demonstrated that 83% of food handlers assessed in the United States mistakenly assumed that one can tell if a food is dangerous to eat by its look, smell, and taste. Da Cunha, Stedefeldt, and de Rosso (2014b) found that 62.1% of surveyed food handlers in Brazil presumed food that is unfit for consumption always has a bad smell and tastes spoiled. Martins, Ferreira, Moreira, Hogg, and Gestal (2014) and Martins, Hogg, and Otero (2012) showed respectively that 48.9% of food handlers working in nursing homes and kindergartens and 64.4% of food handlers working in catering companies in Portugal thought sensorial checks could be used to identify bacterial contamination of foods.

There is little doubt that a food handler's misconceptions about how to tell if food is safe to eat may result in foodborne illness. Ultimately, food handlers with inadequate knowledge of safe food handling practices pose a threat to the health of the consumers eating at the restaurants where they work. There are two occasions at which targeted food safety messages might be sent to restaurant managers: after EHOs observe critical violations during inspections and immediately after temporary restaurant closures. In the following section, I expand this discussion to address employee-related factors associated with higher food safety knowledge survey scores.

Training and Food Safety Knowledge

There is evidence that food safety training programs improve food safety knowledge. Food safety training programs typically involve one day of classroom or online training. Researchers have found that food safety knowledge scores increase significantly with training (Brown et al., 2014; Buccheri et al., 2010; Da Cunha et al., 2014b; DeBess et al., 2009; Faour-Klingbeil, Kuri, & Todd, 2015; Husain, Muda, & Jamil, 2016; Liu, Zhang, Lu, Liang, & Huang, 2015; Manes et al., 2013; Martins et al., 2014; Osaili et al., 2013; Pichler et al., 2014; Santos et al., 2008). In British Columbia, Canada, FOODSAFE© trained food handlers scored an average of 68%, which was significantly higher than untrained food handlers, whose average score was 58%

(McIntyre, Vallaster, Wilcott, Henderson, & Kosatsky, 2013). Researchers evaluating FOODSAFE© retraining effectiveness in British Columbia, found significantly improved food safety knowledge scores for the intervention group, but not for the control group, with these groups scoring 83% and 74%, respectively (McIntyre, Peng, & Henderson, 2014). In the United States, certified food handlers on average scored 69%, whereas uncertified food handlers on average scored 63% (DeBess et al., 2009). On the other hand, researchers in Italy, Switzerland, and Trinidad and Tobago found food safety knowledge scores were not higher for trained food handlers (Panchal et al., 2013; Panchal et al., 2014; Webb & Morancie, 2015). However, these researchers did not assess when the training occurred, and it is tenable that any positive effects of training had diminished over time. In fact, Da Cunha et al. (2014b) and McIntyre et al. (2013) observed that knowledge scores do indeed decrease as the period of time from the last training increases.

Level of Education and Food Safety Knowledge

Researchers have found that food safety knowledge scores increase significantly with higher levels of education, although levels of education are often categorized differently (Brown et al., 2014; Buccheri et al., 2010; DeBess et al., 2009; Jeon, Park, Jan, Choi, & Hong, 2015; Jianu & Chiş, 2012; Manes et al., 2016; Martins et al., 2012; Martins et al., 2014; Panchal et al., 2014; Pichler et al., 2014). In British Columbia, when researchers compared food handler knowledge scores with education level, workers with college and university education scored higher than those with some or completed high school education; their scores were 69%, 65%, and 62%, respectively (McIntyre et al., 2013). In the United States, food handlers with at least some college education scored 76% on average, whereas those with less education scored 66% on average (Manes et al., 2013). Also, in another study from the United States, food handlers who reported having some college education scored 73% on average, whereas food handlers who did not have any college education scored 64% on average (DeBess et al., 2009). However, researchers in Portugal, Switzerland, and Trinidad and Tobago have found that food safety knowledge scores do not increase significantly with higher levels of education (Panchal et al., 2013; Santos et al., 2008; Webb & Morancie, 2015). In the study conducted in Portugal, 89 participants had an elementary school education, and 31 participants had some education beyond elementary school, making the influence of level of education difficult to ascertain from this study population (Santos et al., 2008). In the study conducted in Switzerland, 86% of the study participants had obtained university, college, or technical degrees following high school, making the study participants highly similar in terms of education level (Panchal et al., 2013). In the study conducted in Trinidad and Tobago, information was not collected on whether participants had completed elementary school, high school, or college/university, making the influence of level of education difficult to ascertain from the collected data (Webb & Morancie, 2015).

Due to the various levels of education attained by restaurant food handlers, to be effective, food safety communications and educational interventions must be designed to meet the needs of learners with different educational backgrounds and capabilities. Meanwhile, Arendt et al. (2014) go even further, emphasizing that to improve food safety knowledge levels, educators must gear training toward learners of different ages and with different learning styles.

Language and Food Safety Knowledge

Language barriers can prevent restaurant employees from successfully completing food safety training programs and thwart communications between restaurant employees and EHOs. In British Columbia, food handlers who spoke English as their first language achieved significantly higher food safety knowledge scores than those for whom English was a second language, with their scores being 79.7 % and 74.5%, respectively (McIntyre et al., 2014). In the United States, food handlers who spoke English as their primary language scored 76% on average, and those with Spanish as their primary language scored 68% on average (Manes et al., 2013). Similarly, Brown et al. (2014) found that workers in the United States whose primary language was English had higher odds of passing a certification exam than did workers whose primary language was not English. In Austria, German-speaking food handlers on average scored 7.4% points higher than food handlers who spoke other first languages (Pichler et al., 2014).

Researchers in Italy and Switzerland found that the language spoken by food handlers did not affect their knowledge scores (Panchal et al., 2013; Panchal et al., 2014). In the study conducted in Italy, for 47% of the food handlers, their primary language was Italian, and for 41% of the food handlers, their primary language was German; however, the questionnaire was administered in both Italian and German, and therefore the finding of no association is unsurprising (Panchal et al., 2014). In Switzerland, researchers observed the primary language was French for 93% of the food handlers, whereas 7% of the food handlers spoke other languages (Panchal et al., 2013). Interestingly, food handlers who spoke other languages scored slightly higher than the French-speaking food handlers; however, the sample size of this group was small, with only seven individuals speaking other languages (Panchal et al., 2013). Although food safety training programs are offered in a variety of languages, such as French, Spanish, and Chinese, courses in other languages tend to be more difficult to access. Therefore, developers of food safety communications and educational interventions should keep individuals with limited language proficiencies in mind.

Experience and Food Safety Knowledge

Researchers examining experience and food safety knowledge have found variable results. Some researchers have found food safety knowledge scores increased significantly with years of experience (Buccheri et al., 2010; Da Cunha et al., 2014b; Faour-Klingbeil et al., 2015; Manes et al., 2013; Pichler et al., 2014). McIntyre et al. (2013), in a study conducted in British Columbia, revealed that more years of experience improved food safety knowledge scores in both FOODSAFE© trained and untrained groups. In a study conducted in the United States, Brown et al. (2014) agreed that workers with more food service experience had higher odds of passing a food safety certification exam. On the other hand, other researchers have found food safety knowledge scores do not increase significantly with years of experience (Jianu & Chiş, 2012; Martins et al., 2012; Martins et al., 2014; Osaili et al., 2013; Santos et al., 2008; Smigic et al., 2016; Webb & Morancie, 2015). Studies may show variable results because food handlers with more experience do not consistently have higher food safety knowledge levels. Furthermore, such findings of a lack of food safety knowledge in experienced food handlers provides evidence that food safety communications and educational interventions should be a priority for health authorities.

Age and Food Safety Knowledge

Researchers examining the relationship between age and food safety knowledge have found inconsistent results. In British Columbia, age improved food safety knowledge for untrained food handlers (McIntyre et al., 2013). In the United States, food handlers aged 15–19, 20–29, 30–39, and 40 or older had mean scores of 65%, 67%, 68%, and 71%, respectively (DeBess et al., 2009). In another study conducted in the United States, food handlers aged 18–29, 30–39, and 40 or older had mean scores of 70%, 74%, and 76%, respectively (Manes et al., 2013). Similarly, Brown et al. (2014) claimed older food handler participants in the United States had higher odds of passing a food safety certification exam. In addition, in Austria, researchers found food handlers aged 30 or older had greater mean knowledge scores compared to younger food handlers (Pichler et al., 2014). However, nearly equal numbers of researchers have found the opposite (Jeon et al., 2015; Jianu & Chiş, 2012; Manes et al. 2016; Martins et al., 2014; Panchal et al., 2013; Santos et al., 2008; Smigic et al., 2016). For example, in a study conducted in Portugal, food handlers aged less than 36, 36–45, 46–55, and greater than 55 had average scores of 12.5, 13.4, 12.7, and 14.4 respectively (Martins et al., 2012). In addition, food handlers aged 18–29, 30–39, 40–49, and 50 or older had mean scores of 65%, 68%, 63%, and 68%, in an Italian study (Panchal et al., 2014). Findings showing older food handlers, who potentially have more years of work experience, lacking knowledge of safe food handling practices provide further evidence of the need for food safety communications and educational interventions. It could be further argued that, regardless of their food knowledge levels and test scores, restaurant employees working in facilities that have been temporarily closed due to unsanitary conditions and improper food handling practices are most in need of food safety communications and training programs to assist them in improving their food handling behaviors.

Summary

In British Columbia, EHOs ascertain whether at least one employee present at the time of inspection has taken the FOODSAFE© course. In this study, I counted not having at least one employee present who has taken the FOODSAFE© course as a training violation. Other violation categories that contributed to the numbers of food handling violations included: contamination, handwashing, hot holding, refrigeration, thawing, sanitizing, and cooling.

Researchers' findings raise concerns about restaurant employees' food safety knowledge gaps. Similar study findings in terms of low knowledge levels over time and throughout many locations exemplify the need for food safety communications and educational interventions. Generally, food handlers appear to have greater food safety knowledge when they have taken a food safety training program, have higher levels of education, and speak the primary language where they are working. Regulatory requirements that mandate training for only one employee place less burden on restaurants, but these policies depend on that one employee taking responsibility for providing food safety training to other individuals. In restaurants where managers are not focused on food safety, the burden of providing food safety information defaults to EHOs. My findings suggest that food safety training programs should be mandatory for nearly all food handlers employed in restaurants that have been temporarily closed for reasons such as unsanitary conditions and improper food handling.

Scholars have deemed training for food handlers necessary to improve their food safety knowledge (Brown et al., 2014; Buccheri et al., 2010; DeBess et al., 2009; Faour-Klingbeil et al., 2015; McIntyre et al., 2013; Osaili et al., 2013; Pichler et al., 2014; Sani & Siow, 2014; Santos et al., 2008; Webb & Morancie, 2015). In addition, many experts have concluded that food handlers require periodic retraining and recertification (Buccheri et al., 2010; Da Cunha et al., 2014b; DeBess et al., 2009; Faour-Klingbeil et al., 2015; Jianu & Chiş, 2012; McIntyre et al., 2014; Osaili et al., 2013; Sani & Siow, 2014; Webb & Morancie, 2015). This is because, as Da Cunha et al. (2014b) and McIntyre et al. (2013) observed, trained food handler knowledge scores decrease over time. In looking at the numbers of food safety violations, one could argue that regulatory food safety training requirements in Canada are failing to protect the public's health. Because the answer to why particular restaurant food handlers have such low levels of compliance with food safety regulations remains unknown, a pragmatic approach would be to use a combination of strategies to improve compliance. As a first step, EHOs should work to increase restaurant employees' food safety knowledge using food safety communications and educational interventions.

Theoretical Foundations

In this second section, I discuss how the theory of planned behavior and the health action process approach help to explain food handler intentions and behaviors. I do so by providing a review of relevant studies. The theory of planned behavior has been used more frequently than the health action process approach to examine food handling intentions and behaviors. In such studies, researchers determine the relative importance of the theoretical constructs with respect to food safety practices.

The reviewed studies have several limitations that decrease the reliability of the researchers' findings. For example, participants' food handling practices were self-reported, making findings vulnerable to recall and social desirability bias. In addition, questions are often asked about general intentions to perform safe food handling practices, rather than intentions to perform specific behaviors such as handwashing. The limitation with researchers asking about general intentions to perform safe food handling practices is that these intentions are less likely to correspond closely with participants' actual behaviors. Moreover, researchers operated on the assumption that respondents were aware of the times when they had prepared food safely versus unsafely, which is not a valid assumption; in many cases, individuals lack food safety knowledge. Despite these limitations, I included these studies in this review because they provide insight into behavioral interventions most likely to be effective in changing unsafe food handling practices.

Using regression analyses, researchers have drawn conclusions about the extent to which the theory of planned behavior can explain food handling intentions and behaviors. Food handlers' intentions to perform safe food handling practices are influenced by subjective norm or perceived social pressure from important others (Bai, Tang, Yang, &

Gong, 2014; Fulham & Mullan, 2011; Mullan, Allom, Sainsbury, & Monds, 2015; Mullan & Wong, 2009; Mullan & Wong, 2010; Mullan, Wong, & Kothe, 2013; Pilling, Brannon, Shanklin, Howells, & Roberts, 2008; Shapiro, Porticella, Jiang, & Gravani, 2011). In Seaman and Eves's 2008 study, food handlers who worked in child and residential care settings were asked how likely it was that most people important to them felt they should carry out safe food handling practices; participants responded that subjective norm had the greatest influence on their intentions to perform safe food handling practices ($\beta = 0.55$, $p \leq 0.001$). In Seaman and Eves's 2010 study, food handlers who worked in hospitality settings were asked the same question; respondents again stated that subjective norm had the greatest influence on their intentions to perform safe food handling practices ($\beta = 0.62$, $p \leq 0.001$). Clayton and Griffith (2008) assessed caterers' perceptions about how likely it was that their managers, EHOs, customers, and co-workers felt they should perform proper handwashing; subjective norm had the greatest influence on food handlers' intentions ($\beta = 0.28$, $p < 0.01$) when researchers considered the variables attitude, subjective norm, and perceived behavioral control. Looking at such results, we can conclude that following temporary restaurant closures, if food handlers do not perceive any social pressure to perform safe food handling practices, especially from their managers, it is unlikely they will change their food handling behaviors. Moreover, if restaurant employees were required to take a food safety training course following temporary restaurant closures for reasons such as insanitary conditions or improper food handling practices, this might lead to the formation of new beliefs that would positively affect their performance of expected protocols.

Similarly, food handlers' intentions to perform safe food handling practices are influenced by perceived behavioral control (Bai et al., 2014; Fulham & Mullan, 2011; Mari, Tiozzo, Capozzo, & Ravarotto, 2012; Milton & Mullan, 2012; Mullan et al., 2015; Mullan & Wong, 2009; Mullan & Wong, 2010; Mullan et al., 2013; Shapiro et al., 2011). In Seaman and Eves's 2008 study, food handlers who worked in child and residential care settings were asked if it was true that, if they wanted to, they could carry out safe food handling practices on every occasion; respondents' answers illustrated that perceived behavioral control had the second greatest influence on their intentions to carry out safe food handling practices ($\beta = 0.24$, $p \leq 0.001$). In other words, these participants felt that their perceptions about their abilities to perform safe food handling practices influenced their behaviors. Seaman and Eves (2010) asked the same question of food handlers working in hospitality settings, and respondents again indicated that perceived behavioral control had the second greatest influence on their intentions to carry out safe food handling practices ($\beta = 0.21$, $p \leq 0.001$). In another study, Pilling et al. (2008) found that perceived behavioral control had the second greatest influence on food service employees' handwashing intentions ($\beta = 0.37$, $p < 0.01$), when they asked participants how frequently not having enough time affected their handwashing. When researchers Clayton and Griffith (2008) considered the variables attitude, subjective norm, and perceived behavioral control, caterers' responses showed that perceived behavioral control had the second greatest influence on their handwashing intentions ($\beta = 0.27$, $p < 0.01$). In addition to these findings, Rimal (2000) found the overall relation between knowledge and behavior to be strongest among those with high levels of perceived behavioral control and lowest among those with low levels of perceived behavioral control. These findings illustrate the possibility that, even if their restaurant is temporarily closed, if food handlers have low levels of perceived behavioral control, they might not develop intentions to change their food handling behaviors of their own accord. One way to ensure that restaurant employees feel capable of performing safe food handling practices is for restaurant managers to formulate standardized operating procedures detailing how and when behaviors are to be performed.

In the next section, I provide brief overviews of the theory of planned behavior and the health action process approach before a further discussion of their applications to food handling.

The Theory of Planned Behavior

In this theory, Icek Ajzen (2011) focuses on explaining intentions and behaviors. Ajzen (1991) proposes that intentions to perform behaviors can be predicted from attitudes toward the behavior, subjective norm, and perceived behavioral control. A person's intentions to perform a behavior should be stronger the more favorable the attitude and subjective norm, and the greater the perceived control (Ajzen, 2002). Enforcement measures, such as temporary restaurant closures, may not be sufficient to change food handler intentions because they are not directed at attitudes towards food safety, subjective norm, and perceived behavioral control.

The Health Action Process Approach

In the health action process approach, Ralf Schwarzer (2008) focuses on a distinction between the processes that lead to behavioral intention and the processes that lead to actual behaviors. Action self-efficacy, outcome expectancies, and risk perception lead to behavioral intentions, and postintentional factors influence behaviors such as maintenance and recovery self-efficacy (Schwarzer, 2008). Schwarzer emphasizes that, if no preparatory steps are taken such as managers developing standardized operating procedures, intentions may not be translated into action or behaviors might not be maintained. As restaurant employees often stop performing safe food handling practices after complying for a short period, this theory is particularly relevant.

Next, to set the theoretical foundations for the current study, I review studies examining food handling intentions and behaviors using the theory of planned behavior or the health action process approach.

Applying the Theory of Planned Behavior

Researchers have examined handwashing intentions using the theory of planned behavior. In one study, using a theory of planned behavior questionnaire, Pilling et al. (2008) found that restaurant food handler handwashing intentions are significantly predicted by attitudes ($\beta = 0.50$, $p < 0.001$) and then perceived behavioral control ($\beta = 0.37$, $p < 0.01$). Moreover, Shapiro et al. (2011) used a similar questionnaire to find that consumer handwashing intentions are significantly predicted by perceived behavioral control ($\beta = 0.43$, $p < 0.001$), attitudes ($\beta = 0.27$, $p < 0.001$), and then subjective norm ($\beta = 0.11$, $p < 0.05$). Pilling et al. (2008) and Shapiro et al. (2011) identified perceived behavioral control and attitudes as predictors of handwashing intentions, although these factors' importance varied. When restaurant food handlers were asked about barriers to handwashing, they frequently mentioned not having enough time and resources not being conveniently located (York, Brannon, Roberts, Shanklin, & Howells, 2009). Ultimately, it is possible that restaurant food handlers may perceive handwashing to be only partially under their control. This could explain why some food handlers might not perform proper handwashing, even following temporary restaurant closures. I now examine intentions to use thermometers.

Using a survey, Pilling et al. (2008) found restaurant food handler intentions in terms of using thermometers were significantly predicted by attitudes ($\beta = 0.53$, $p < 0.001$), subjective norms ($\beta = 0.34$, $p < 0.001$), and then perceived behavioral control ($\beta = 0.26$, $p < 0.01$). In a study conducted in the United States, consumer participants indicated that perceived behavioral control ($\beta = 0.37$, $p < 0.001$) most strongly predicted thermometer use, followed by subjective norms ($\beta = 0.27$, $p < 0.001$), and then attitudes ($\beta = 0.12$, $p < 0.05$); perceived behavioral control was measured by asking participants if using a thermometer the next time they cooked chicken would be very easy (Shapiro et al., 2011). Pilling et al. (2008) and Shapiro et al. (2011) found the theory of planned behavior constructs predicted intentions to use thermometers, but their relative importance varied. When restaurant food handlers were asked about barriers to thermometer use, not having enough time and not having thermometers available were the most frequent responses (York et al., 2009). These findings show that many food handlers may perceive their ability to use thermometers as only partially under their control.

In this study, I examined overall food handling violations and specific categories of food handling violations before and after temporary restaurant closures. Because intentions to perform safe food handling practices are likely situation dependent, examining overall food handling violations and specific categories of food handling violations was a constructive approach.

Applying the Health Action Process Approach

The theory of planned behavior and the health action process approach offer insights into why restaurant food handlers may fail to perform safe food handling behaviors despite temporary restaurant closures. Mullan, Wong, and O'Moore (2010) noticed first-year university students' intentions to perform hygienic food handling behaviors were significantly predicted by action self-efficacy ($\beta = 0.37, p < 0.01$), risk awareness ($\beta = 0.26, p < 0.05$), and outcome expectancies ($\beta = 0.24, p < 0.01$), with action self-efficacy being the strongest predictor. In a second study, first-year university students' answers showed that severity ($\beta = 0.13, p < 0.05$), risk awareness ($\beta = 0.16, p < 0.01$), outcome expectancies ($\beta = 0.36, p < 0.001$), and motivational self-efficacy ($\beta = 0.25, p < 0.001$) significantly predicted their intentions to avoid contamination; however, outcome expectancies were the strongest predictor (Bearth, Cousin, & Siegrist, 2014). In a third study, Chow and Mullan (2010) found university students' intentions in terms of performing safe food handling practices were significantly predicted by past behavior ($\beta = 0.38, p < 0.001$), direct and indirect subjective norms ($\beta = 0.19, p = 0.001$) ($\beta = 0.17, p = 0.006$), and outcome expectancies ($\beta = 0.14, p = 0.006$); past behavior and direct subjective norm had the greatest influence on intentions. Outcome expectancies and action self-efficacy appear to be important in the motivation phase, which is where an individual chooses what to do. Motivation to continue with unsafe food handling practices will be high following temporary restaurant closures, as employees' action self-efficacy or confidence about being able to perform safe food handling practices may decrease. Furthermore, restaurant employees may not work to correct unsafe food handling practices if they decide that it is unlikely that an EHO will issue another closure order.

Applying Extended Models of the Theory of Planned Behavior

There are limits to the predictive powers of the theory of planned behavior. Ajzen (2011) observed the intention-behavior correlation can vary considerably. Because of this, many researchers have added one or more additional variables in an attempt to increase the predictive power (Bai et al., 2014; Clayton & Griffith, 2008; Fulham & Mullan, 2011; Mari et al., 2012; Mullan et al., 2016; Mullan & Wong, 2009; Mullan & Wong, 2010). Although empirical evidence is necessary to support any extension of the theory of planned behavior, Conner and Armitage (1998) highlighted that theoretically describing the processes through which the variable influences intentions and behaviors is equally critical. In this section, I focus on several variables that have been used to extend the theory of planned behavior, such as habit.

To increase the predictive power, researchers have added the variable habit; however, it is nearly impossible to reliably determine whether behaviors are habituated. Ajzen (2002) emphasized that even if a behavior has been performed many times that does not guarantee it has been habituated; repeated performance may instead be related to weak intentions. Although past behavior provides information about actual behavioral control, Ajzen (1991) concluded that researchers should not assume past behavior frequency is a valid measure of habit, as many other factors can influence past behavior. Ouellette and Wood (1998) and Verplanken and Orbell (2003) concurred that past behavior frequency does not necessarily indicate whether a behavior has become habituated. Incidentally, Verplanken and Aarts (1999) believed that retrospective, self-reported behavioral frequency is frequently invalidated if participants are asked to retrieve from memory instances when they performed behaviors. They also observed that questions asking participants to report on having unconsciously conducted an act in the past are also problematic as respondents may have difficulty thinking along these lines. To alleviate this problem, Verplanken and Orbell recommended using a 12-question self-report habit index to evaluate habit strength, instead of using self-report measures to examine past behavioral frequency. Although it may not be possible to reliably determine whether unsafe food handling practices are habituated, it is certainly a possibility that unsafe food handling practices may continue postclosure because these behaviors are habituated.

Past behavior is frequently used to extend the theory of planned behavior; however, exactly what past behavior represents has not yet been adequately conceptualized (Rhodes & Courneya, 2003). Conner and Armitage (1998) agreed that researchers adding past behavior have not clarified the process by which this variable affects theory of planned behavior constructs. Other researchers have presumed that past behavior adds to predictive value because theory of planned behavior constructs are temporally unstable (Rhodes and Cournya, 2003). Moreover, Doll and Ajzen (1992) observed that the ability to predict behaviors improves as the temporal stabilities of attitudes, perceived behavioral control, and intentions increase. Researchers Ouellette and Wood (1998) went further to advise that past behavior may affect future responses through multiple mechanisms. To explain, when behaviors are performed once or twice a year and occur in unstable contexts, intentions more strongly predict future behavior than past behavior; however, when behaviors are performed daily or weekly in stable contexts, past behaviors more strongly predict future behavior than intentions (Ouellette & Wood, 1998). Last, another line of thinking is that intention stability moderates the effect of intentions on behavior; when intention stability is high, past behavior is unrelated to current behavior, but when intention stability is low, past behavior strongly predicts current behavior (Conner, Sheeran, Norman, & Armitage, 2000). What all of these studies point to is that, to change food handler intentions about performing safe food handling practices, multiple strategies may be needed, as past behavior is expected to be a strong predictor of future food handling behaviors. From here onward, I review studies examining food handler intentions and behaviors using extended models of the theory of planned behavior.

Researchers who have added past behavior to improve explained variance in intentions to perform safe food handling practices appear to have overlooked the challenges involved in accurately measuring past behaviors. Individuals may not remember their own frequently performed behaviors, and will thus often attempt to make inferences regarding past behavioral frequency (Verplanken & Aarts, 1999). Given the above discussion about past behavior, it should be kept in mind that respondents may not be knowledgeable about safe food handling practices, and they may not be able to recall whether they performed these behaviors.

When they conducted a study in China with consumer participants to examine intentions to perform safe food handling practices, Bai et al. (2014) found that adding past behavior, perceived ease, and habit to the theory of planned behavior increased explained variance from 41.8% to 44.5%. Participants reported the number of times they had prepared food safely, and this number was divided by the number of times food was prepared to calculate past behavior proportions (Bai et al., 2014). Participants also answered questions about whether they prepared food safely without having to consciously remind themselves, and were asked if they would feel weird if they did not prepare food safely; this information was used to measure habit (Bai et al., 2014). Participants' intentions were significantly predicted by attitude ($\beta = 0.24$, $p < 0.001$), perceived ease ($\beta = 0.23$, $p < 0.001$), subjective norm ($\beta = 0.21$, $p < 0.001$), habit ($\beta = 0.15$, $p < 0.001$), past behavior ($\beta = 0.08$, $p < 0.01$), and perceived behavioral control ($\beta = 0.06$, $p < 0.05$); attitude made the largest contribution to predictions of intentions (Bai et al., 2014). This study's findings illustrate that specific restaurant- and employee-related factors may result in one or more construct or variable being more influential, and these differences may affect food handling behaviors.

In a study with Australian university student participants, Mullan and Wong (2009) noticed that adding past behavior as a factor increased the variance predicted from 66.4% to 69.3% for intentions to prepare food safely. Participants completed two online questionnaires one month apart; past behavior was measured by asking participants how many times per week in the previous four weeks they had prepared food safely. The researchers found that participants' intentions to prepare food hygienically were significantly predicted by perceived behavioral control ($ß = 0.511$, $p < 0.01$), subjective norm ($ß = 0.220$, $p < 0.05$), and past behavior ($ß = 0.198$, $p < 0.01$); perceived behavioral control was the most significant predictor of intentions. In the same study, participants' behaviors were significantly predicted by past behavior ($ß = 0.525$, $p <0.01$). Mullan and Wong (2009) reached the same conclusion as Milton and Mullan (2012) that, to change intentions, interventions should focus on increasing food handlers' perceptions of control.

Fulham and Mullan (2011) demonstrated how adding behavioral prepotency to the theory of planned behavior constructs increased the variance predicted from 37.6% to 43.7%, for Australian university students' intentions to prepare food safely. To measure behavioral prepotency or past behavior frequency, participants answered questions about the percentage of meals they had prepared hygienically in the week preceding the study. Participants' intentions to prepare food safely were predicted by perceived behavioral control ($ß = 0.371$, $p < 0.001$), subjective norm ($ß = 0.236$, $p < 0.001$), and behavioral prepotency ($ß = 0.271$, $p < 0.001$), and again, perceived behavioral control was the strongest predictor of intentions (Fulham & Mullan, 2011). As was the case in Mullan and Wong's 2009 study, past behavior or behavioral prepotency was a significant predictor of actual behaviors ($ß = 0.587$, $p < 0.001$) (Fulham & Mullan, 2011).

In their 2010 study on Australian university students' intentions to perform safe food handling practices, when Mullan and Wong added past behavior to the theory of planned behavior constructs, explained variance increased from 32.8% to 38.4%. Participants' intentions were significantly predicted by attitudes ($ß = 0.216$, $p < 0.01$), subjective norm ($\beta = 0.173$, $p < 0.01$), perceived behavioral control ($\beta = 0.286$, $p < 0.01$), and past behavior ($\beta = 0.255$, $p < 0.01$); perceived behavioral control had the greatest influence on intentions (Mullan & Wong, 2010). To calculate the past behavior proportion, the Mullan and Wong asked respondents how many meals they had prepared safely in the week preceding the study, and then divided this number by the number of meals cooked. Interestingly, intentions ($\beta = 0.233$, $p < 0.01$) and past behavior ($\beta = 0.209$, $p < 0.01$) both significantly predicted behavior; however, intentions, not past behavior, was the most significant predictor (Mullan & Wong, 2010).

As a final point, Mullan and Wong (2009, 2010) and Fulham and Mullan (2011) have shown that adding the factor of past behavior improves the prediction of food handling behaviors above and beyond the theory of planned behavior constructs. Although the above researchers have provided empirical evidence for adding past behavior, investigators have not focused on the processes through which past behavior might be influencing food handling behaviors. Nor have they discussed the reliability and validity of self-reported past behavior measures. These are important factors to consider because the question about past behavior regarding the number of times foods were prepared hygienically is open to multiple interpretations, such as whether it refers to handwashing between handling raw and cooked foods, or whether it refers to using a thermometer to check minimum internal cooking temperatures.

In another study, researchers Ramalho, de Moura, and Cunha (2015) extended the theory of planned behavior constructs with the variable personal norm and examined butchers' intentions to implement food safety systems in both high and low compliance establishments. Ramalho et al. defined personal norm as feelings of strong obligation that people experience within themselves that then prompt them to engage in certain social behaviors. Notably, Conner and Armitage (1998) observed that, for behaviors where moral norms are not relevant, the variable personal norm may prove useful because of its focus on personal rather than societal values. Ramalho et al. found that in butcher shops with high levels of compliance with regulations, attitude ($\beta = 0.38$, $p < 0.001$) and personal norm ($\beta = 0.37$, $p = 0.002$) were the only significant predictors of intentions to fully implement food safety systems. For butcher shops with low levels of compliance with regulations, participants' responses showed that personal norm ($\beta = 0.84$, $p = 0.000$) was the only significant predictor of intentions to fully implement food safety systems (Ramalho et al., 2015). Pertinent to the current study, food handlers' cognitions around food safety may be very different, in particular between those working in food premises with low rather than high levels of compliance with regulations.

In another study, Mullan et al. (2015) observed that adding moral norm as a factor improved prediction of intentions from 46.5% to 50.9% for handwashing. To measure moral norm, Mullan et al. asked participants to rate whether it was within their principles to clean their hands every time they prepared foods over the next week. In this case, participants' responses showed that perceived behavioral control ($\beta = 0.36$, $p < 0.001$) and moral norm ($\beta = 0.304$, $p < 0.001$) both significantly predicted their handwashing intentions (Mullan et al., 2015). The researchers did not establish that university student participants viewed handwashing as a moral issue. However, Mullan et al. commented that for behaviors that affect other people, compared to more individually focused behaviors, intention is more likely to be influenced by moral norm than subjective norm. Mullan et al. also noted that only habit could significantly predict handwashing behavior; this was measured as the extent to which respondents rated whether they performed the behavior automatically. These researchers' findings are in agreement with those of Ouellette and Wood (1998), who found that when behaviors are performed daily, past behavior more strongly predicts behavior than intentions.

In another study, adding moral norms and descriptive norms improved explained variance in caterers' hand hygiene intentions from 43% to 49% (Clayton & Griffith, 2008). These researchers examined normative beliefs instead of subjective norm, with the understanding that normative beliefs and motivation underlie subjective norm. Clayton and Griffith (2008) distinguished descriptive norms as describing one's perceptions of what others do, whereas subjective norms concern one's perceptions of others' opinions. To measure descriptive norms, respondents were asked whether their managers and work colleagues carried out appropriate food safety actions at all appropriate times. To measure moral norm, Clayton and Griffith asked participants whether they felt they had a moral obligation to carry out hand hygiene at all appropriate times. Findings showed that caterers' handwashing intentions were significantly predicted by normative beliefs ($\beta = 0.20$, $p < 0.05$), perceived behavioral control ($\beta = 0.20$, $p < 0.05$), and descriptive norms ($\beta = 0.23$ $p < 0.05$) (Clayton & Griffith, 2008). Thus, contrary to Mullan et al.'s 2015 study, the researchers found that moral norms did not significantly predict hand hygiene intentions. Given the different results from these two studies, whether food handlers perceive safe food handling practices such as handwashing in moral terms remains unclear. One might speculate that, in restaurants with low food safety regulation compliance levels, food handlers are not viewing food safety as a moral issue. If this is the case, temporary restaurant closures might not increase food handlers' internal feelings of obligation to perform safe food handling practices.

Summary

Using theory of planned behavior questionnaires, researchers have found that subjective norm and perceived behavioral control explain food handler intentions. However, in temporarily closed and high-risk categorized restaurants, food handlers' normative and control beliefs are likely weaker than those of food handlers from other restaurants. To achieve behavioral change following temporary restaurant closures, additional strategies may be required. Restaurant- and employee- related factors may contribute to the non-uniform motivational effects of temporary restaurant closures. This literature review section covered researchers who examined individual food handling intentions and behaviors using questionnaires based on the theory of planned behavior or health action process approach. In the next literature review section, I focus on food handler behaviors, and later, in Chapter 5, I interpret the study findings using the theoretical foundations as context.

Food Handler Behaviors

In the first section of the literature review, I examined studies about food handler food safety knowledge. In the second section of the literature review, I focused on theoretical frameworks that explain food handling intentions and behaviors. In this third and final section of the literature review, I discuss food handler behaviors and restaurant food safety culture. In my review of the literature, I focus on two factors that may prevent the performance of safe food handling practices following temporary restaurant closures (i.e., inadequate food safety knowledge and negative food safety cultures).

Applying Inspection Results

Although researchers have used a variety of indicators to evaluate the effectiveness of various food safety interventions, the number of violations cited in inspection reports is used frequently as the data is readily available. One study conducted in the United States by Burke, Manes, Liu, and Dworkin (2014) found that a violation related to handwashing was more likely to occur in restaurants where at least one manager had missed at least one question related to handwashing (RR 1.96, 95% CI 1.38 – 2.78, p 0.047). However, with this one exception, restaurant inspection results did not correlate well with manager food safety knowledge (Burke et al., 2014). For example, a violation related to improper regulation of temperature (RR 1.01, 95% CI 0.78 – 1.32, p 0.911) and a violation related to contamination (RR 0.70, 95% CI 0.36 – 1.37, p 0.249) were not statistically more likely to be related to manager knowledge gaps regarding these practices (Burke et al., 2014). A limitation of this study was that researchers did not verify that the manager working at the time of inspection was the same manager who had taken the knowledge survey (Burke et al., 2014). Nevertheless, these findings suggest manager food safety knowledge may have only a limited influence on food handler behaviors. A future research priority is to investigate restaurant- and employee-related factors associated with lower levels of compliance with food safety regulations.

Examining numbers of cited violations in inspection reports is also a way in which researchers can examine whether particular restaurant characteristics are associated with lower levels of compliance with food safety regulations. In a study conducted in the United States, using the Wilcoxon test, Harris, Murphy, DiPietro, and Rivera (2015) found significant differences in numbers of violations related to inadequate cooking and improper holding temperatures between ethnic-operated and nonethnic-operated restaurants. Researchers determined that, in a city with 789 ethnic-operated restaurants and 2079 nonethnic-operated restaurants, a significantly higher number of violations were related to inadequate cooking/improper holding temperatures among ethnic-operated restaurants; the mean for ethnic-operated restaurants was 0.946 and the mean for nonethnic-operated restaurants was 0.680 ($W = 1,225,258.50$, $Z = 5.44$, $p < 0.001$) (Harris et al., 2015). In a different city with 349 ethnic-operated restaurants and 2168 nonethnic-operated restaurants, a significantly higher number of violations were also related to inadequate cooking/improper holding temperatures among ethnic-operated restaurants; the mean for ethnic-operated restaurants was 2.206 and the mean for nonethnic-operated restaurants was 1.409 ($W = 467,793.00$, $Z = 7.48$, $p < 0.001$) (Harris et al., 2015). Harris et al. created the variable “ethnic-operated restaurant” and included only restaurants easily identified as serving Mexican, Asian, or Italian foods in this category. One limitation of this study was that the explanatory variable under study was not pragmatically defined; for example, it would have been more specific to define the explanatory variable as restaurants serving Mexican, Asian, or Italian foods. Another limitation of this study was that researchers did not examine any other variables that might have been related to the findings, for example, ownership, such as whether a restaurant was part of a chain or independent. It is possible that other variables are better predictors of problems with food safety violations than whether restaurants are ethnic-operated or not. Inspection findings and restaurant characteristics should be used to prioritize restaurants for food safety communications. For example, if restaurants serving a particular type of cuisine have a higher risk of being closed or high-risk categorized, then once EHOs have determined the type of cuisine served in restaurants, they can provide appropriate restaurants with targeted e-learning food safety resources.

Researchers have also used inspection reports to study enforcement measure outcomes. One study conducted in Finland by Kettunen et al. (2015) evaluated types of enforcement measures used by authorities to determine whether compliance was achieved or not, and whether enforcement measures had to be used recurrently due to repeated violations. Kettunen et al. reported that orders were used in 76.5% of cases. In Finland, official hearings are conducted before orders are issued, and orders differ from written directives in inspection reports in that they can be further reinforced by penalty payments or suspension of operations (Kettunen et al., 2015). Violations were not completely corrected in 31.8% of cases and enforcement measures were used recurrently in 15.7% of cases (Kettunen et al., 2015). One limitation of this study was that researchers did not investigate factors that might be related to noncompliance in situations where enforcement measures had to be used repeatedly (i.e., restaurant- and employee-related factors). Researchers found that, in many cases, violations were only partially corrected and that regular, repeated enforcement measures were needed. These findings are pivotal to the present study because they provide evidence that temporary restaurant closures might have limited effectiveness. This means that other interventions should be used in conjunction with enforcement measures; for example, employees can be required to attend food safety training programs and environmental health managers can require restaurants to stop serving problematic menu items.

Researchers have investigated the effect of type of ownership, specifically independent versus chain, using inspection reports. Murphy et al. (2011) examined whether there were any differences in violation frequencies among chain restaurants on the 2008 Restaurants and Institutions Top 400 Restaurant Chains List, other chain restaurants, and independent restaurants located in Florida. Murphy et al. hypothesized no significant differences between chain and independent restaurants would be found because the state of Florida requires that all food service employees be trained in safe food handling practices every three years in approved training programs, and that managers successfully complete training within 30 days of employment. However, Murphy et al. found there was a difference in critical violations between restaurant types ($F [2,904] = 6.325$, $p < 0.05$). Using the Scheffe procedure, Murphy et al. determined there was a significant difference in critical violations between chain restaurants on the 2008 Restaurants and Institutions Top 400 Restaurant Chains List and independent restaurants. Fewer violations may be found in multiunit chains compared to independent restaurants due to several factors, including: standardized, mandatory operating procedures; superior kitchen designs; and specialized equipment. If independent restaurants are found more likely to be in the temporarily closed or high-risk categorized group, this may indicate that EHOs need to prioritize independent restaurants for food safety communications, such as information graphics that can be posted in restaurants.

Researchers have calculated the likelihood of having at least one critical violation of food temperature and time control inspection items for restaurants with and without certified kitchen managers. When Cates et al. (2009) conducted a study in the United States, they examined the effect of the presence of a certified manager and service type (fast food/full service) on the odds of food temperature and time control violations. The researchers used logistic regression analyses and the explanatory variables were certified manager presence and service type. Cates et al. observed that restaurants with a certified kitchen manager present were less likely to have a critical violation for hot holding (Odds Ratio 0.75, $p < 0.05$); however, the presence of a certified kitchen manager did not have a significant effect on cooling (0.98), cold holding (1.08), cooking (1.26), or reheating violations (0.86). Full service establishments were more likely than fast food establishments to have a critical violation for food temperature and time control (1.83) (Cates et al., 2009). One limitation of this study was that limited data about restaurant characteristics and other factors was available (Cates et al., 2009), which is also a limitation of the present study. In the present study, I examined number of menu items as an explanatory variable because health authorities do not collect information about service type, i.e., fast food or full service. In full service restaurants and restaurants with larger numbers of menu items, more food preparation has to occur simultaneously, and kitchens may not be adequately designed to support the preparation of large quantities of different types of foods safely. One potential policy intervention is for Environmental Health managers to require a reduction in problematic menu items in restaurants where food handling practices do not improve postclosure.

In the United States, Kassa, Silverman, and Baroudi (2010) evaluated a manager food safety training program using inspection reports. Researchers compared restaurants with and without certified managers and calculated means and standard deviations for numbers of critical and non-critical violations (Kassa et al., 2010). Researchers have used numbers of violations cited by EHOs in inspection reports as an indicator in quite a few food safety studies (Burke et al., 2014; Cates et al., 2009; Harris et al., 2015; Kassa et al., 2010; Murphy et al., 2011). Kassa et al. determined the mean number of critical violations per inspection for restaurants with certified personnel was 1.88 ± 2.078; for premises without certified personnel, the mean number of critical violations per inspection was 2.19 ± 2.368 (p 0.065). Manager food safety training did not appear to reduce numbers of critical violations significantly. In addition, researchers found that as numbers of outlets increased in multiunit chains, numbers of critical violations decreased (Kassa et al., 2010). One limitation of this study, however, was that the researchers did not explore other restaurant characteristics associated with fewer violations. In this particular study, critical and non-critical violations were analyzed separately, with critical violations being defined in these categories: time and temperature, poor hygiene practices by food handlers, cross contamination, and food from unapproved sources. As Kassa et al. found that restaurants belonging to a chain with many outlets have fewer critical violations, food safety communications should likely be focused on independent restaurants and those with fewer locations that do not have well-implemented standard operating procedures. In the present study, instead of analyzing critical and non-critical violations separately, I focused on food handling violations associated with foodborne illness outbreaks.

Examining Food Handler Behaviors

In this section, I review studies involving observations of food handlers' behaviors; data was not collected from inspection reports. Park et al. (2010) conducted a study in Korea that evaluated the effectiveness of a one-hour food safety training program. Park et al. assessed food handler knowledge using a 20-item questionnaire and observed food handling practices. Park et al. calculated mean scores and standard deviations for food safety knowledge and food handler behaviors and they performed t-tests. The intervention group's food safety knowledge score before training was 49.3 ± 19.5, while after training it was 66.6 ± 16.5, making the difference significant ($p < 0.05$) (Park et al., 2010). Food handler behavior scores increased from 57.2 ± 7.8 before training to 63.7 ± 7.6 after training; however, the difference was not significant (Park et al., 2010). One limitation of this study was that there were differences between the intervention and control groups in terms of participants' education levels and work experience. Such differences among participants can produce variability in results, specifically around how well participants perform on food safety knowledge tests. As one example, if a participant did not graduate from high school, it is possible his or her food safety knowledge score will greatly differ from another participant who has a college level education. Park et al.'s study shows that food handlers have difficulty translating food safety knowledge into practice in the workplace. As individuals are more easily motivated to meet clearly defined goals, EHO food safety communications should be specific about the actions restaurant managers must take, to have closure orders rescinded and after restaurant reopenings. Food safety communications from EHOs might provide reminders to restaurant managers to verify employees are performing specific food safety behaviors consistently.

Researchers have also assessed knowledge and observed food handling behaviors. In a study conducted in Dubai, Abushelaibi et al. (2015) examined the effect of a kitchen manager training program on food handlers' practices. Researchers assessed kitchen manager knowledge with 12 food safety questions and observed food service establishment employees to record their performance of 20 food safety practices (Abushelaibi et al., 2015). Abushelaibi et al. found that managers' food safety knowledge had improved significantly after training; the mean values before training were 71.3%, whereas after training mean values were 76.1% ($p < 0.05$). However, in terms of observed food handler food safety practices, they found no significant difference after manager food safety training, as the mean values before the intervention were 70.4% and after training values were 69.8% (Abushelaibi et al., 2015). These results show that managers either did not attempt to change food handler behaviors, or, alternatively, they did try and were unsuccessful in changing food handler practices. These findings are similar to Burke et al.'s (2014) findings, which showed that inspection results did not correlate well with manager knowledge. Therefore, having one manager on duty who has taken a food safety training course may have little influence on a restaurant's food safety culture. To change food handler intentions, managers need to work actively to reduce unsafe food handling practices on a daily basis and implement standard operating procedures. Further, Abushelaibi et al. did not investigate barriers that may have prevented the translation of food safety knowledge into practices. According to the theory of planned behavior and the health action process approach, constructs important in the translation of food safety knowledge into practice are perceived behavioral control, action self-efficacy, and subjective norms. Investigating related barriers can provide important information on what can be done to encourage food handlers to practice proper food handling protocols.

Researchers conducted the next study in the hot/cold self-serve bars of grocery stores, where food is available for immediate consumption. Rowell, Binkley, Alvarado, Thompson, and Burris (2013) evaluated SafeMark© by providing training to the managers of eight grocery stores, whereas the managers of seven other stores received no additional training. Rowell et al. completed pretraining observations, and four to six weeks following the training sessions they coordinated posttraining observation sessions. For the facility category, the change in mean for the control stores was 0.85 ± 1.27 and the change in mean for the intervention stores was -0.14 ± 1.74 ($p < 0.05$) (Rowell et al., 2013). Three violations in the facility category were handwashing sinks not supplied, handwashing sinks obstructed, and sanitation issues. For the equipment category, the change in mean for the control stores was 0.84 ± 0.90 and the change in mean for the intervention stores was 0.10 ± 1.04 ($p < 0.05$) (Rowell et al., 2013). Two violations in the equipment category were equipment and food containers not being properly cleaned. Rowell et al. concluded that, in this case, training managers had little influence on food handler behaviors. It is possible that being observed or other external factors may have prompted improvements for the control group. These results are similar to those found by Abushelaibi et al. (2015), in that managers who were trained may not have trained their employees, or if they did provide training it appeared to have had little influence. Overall, I would conclude from such findings that B.C. Food Premises Regulations that require only one person at a restaurant to have taken a food safety training program pose a barrier to food handlers' performance of safe food handling practices, because many food handlers are not knowledgeable about how to handle foods safely. Therefore, in the absence of more stringent training regulations, there is a need for e-learning resources (both verbal and non-verbal) that EHOs can use to quickly show restaurant managers and food handlers how to correct violations. EHOs need to coach restaurant employees in not only how to perform safe food handling practices, but in what equipment they require, so that no further violations occur due to lack of knowledge.

Strohbehn, Paez, Sneed, and Meyer (2011) evaluated a food safety training intervention focused on reducing contamination in restaurants located in the United States. Researchers provided managers with food safety training materials over a one-year time frame. Using a food practices assessment form, Strohbehn et al. observed food handlers at each establishment for 15 hours before the intervention and for three hours after the intervention. Researchers calculated mean scores and standard deviations and used ANOVA comparisons to check for significant differences between pre-test and post-test scores (Strohbehn et al., 2011). Food handler scores improved significantly: mean pre-test scores were 63.7 ± 5.7 and mean post-test scores were 70.7 ± 7.7 ($p \leq 0.001$) (Strohbehn et al., 2011). The intervention, which involved providing restaurant managers with modifiable standard operating procedures, posters, soap dispensers with timers, and educational materials with lesson plans, appeared to be useful in helping food handlers improve their food safety behaviors. Two barriers to the performance of food safety behaviors are lack of good habits and employees not knowing that they need to follow safe food handling practices (Strohbehn et al., 2014). Therefore, it follows that, in restaurants where managers do not have clear food safety expectations and/or do not train staff in how to perform tasks correctly, there will be fewer improvements in food handling practices postclosure.

Investigating Food Handler Risk Perceptions

Risk perceptions are believed to be important in influencing food handlers' intentions to perform safe food handling practices. Da Cunha, Stedefeldt, and De Rosso (2014a) asked study participants in Brazil: "What is the consumers' likelihood of presenting abdominal pain and/or vomiting (foodborne disease) after eating a meal or food prepared by you?" (p. 96). Food handlers working in street food kiosks, beach kiosks, restaurants, hospitals, and school meal services perceived themselves as less likely than other food handlers to spread foodborne disease to consumers (Mean Difference = 2.75, $p < 0.01$) (Da Cunha et al., 2014a). The concern here is that food handlers with these misperceptions might not be easily convinced that performing safe food handling practices is necessary. This relates to the fact that optimistic bias (Weinstein & Klein, 1995), or unrealistic optimism, may also result in food handlers not performing safe food handling practices and/or not changing their behaviors following temporary restaurant closures. Optimistic bias poses a much more subtle barrier to the performance of safe food handling practices than inadequate resources; however, it is an equally important factor to consider. One of the strongest arguments for providing food safety training to as many food handlers as possible revolves around increasing their knowledge about how to manage risks associated with food preparation to prevent foodborne disease. Although food safety training courses may not always be successful in terms of changing food handler behaviors, they do appear to increase knowledge about how to prepare foods safely. They may also address food handler misperceptions around the need to perform safe food handling practices.

Examining Food Safety Culture

In this section, I review four studies examining food safety culture. Restaurant employees are believed to be more likely to develop intentions to perform safe food handling practices when they have attended a food safety training course and work in restaurants with positive food safety cultures. Brannon, York, Roberts, Shanklin, and Howells (2009) asked study participants to list the people who cared about them washing their hands, using thermometers, and protecting foods from contamination (i.e., customers, managers, and coworkers). Study participants were recruited from a university in the United States. Participants were classified into three groups: as having no experience with preparing foods in restaurants; as having basic experience, but not having completed a food safety training course; or, as having well informed experience if they had both prepared foods in restaurants and taken a food safety training course (Brannon et al., 2009). Not unexpectedly, respondents with no experience reported a perception that fewer important others cared about them performing handwashing, using thermometers, and protecting foods from contamination (2.63 ± 1.48) than those with basic experience (3.05 ± 1.47), or those with well-informed experience (3.83 ± 1.50); these differences were significant (Brannon et al., 2009). Although training may not always change restaurant employee behaviors, it does appear to strengthen food handlers' perceptions that people important to them at their workplace think they should perform safe food handling practices. Ajzen's theory of planned behavior suggests that, generally, there is a relationship between favorable subjective norms and the strength of food handlers' intentions (Ajzen, 1991). One limitation of my study design is that I was not able to investigate postclosure barriers to the performance of safe food handling practices, such as normative beliefs and other background factors, for example, knowledge and the availability of resources.

By sending employees to food safety training courses, restaurant managers may improve food handlers' knowledge and intentions. Lee, Almanza, Jang, Nelson, and Ghiselli (2013) examined whether organizational climate and food safety certification can affect food handlers' intentions to perform safe food handling practices. Participants were asked seven questions about organizational climate, e.g., "Employees receive enough training and are strongly encouraged to develop their skills" (Lee et al., 2013, p. 286). Lee et al. found employees' perceptions of organizational climate significantly influence their attitudes and intentions to follow safe food handling practices. Restaurant food handlers with food safety certification showed significantly better behavioral intentions with respect to following food safety practices in food service establishments (6.34 ± 0.75) than food handlers without certification (6.08 ± 0.97, $t = 5.02$, p 0.013) (Lee et al., 2013). Managers are uniquely positioned to motivate food handlers to perform safe food handling practices. As studies like Lee et al.'s show, employees' commitment to food safety is likely to be greater when management consistently focuses on safe food handling. As Lee et al. found that restaurant employees with food safety certification had better intentions to follow food safety practices, requiring as many food handlers as possible to take a food safety training course following a temporary restaurant closure may be crucial in strengthening safe food handling intentions.

In the next study, researchers examined certified and noncertified restaurant managers' behavioral intentions and beliefs around sending employees to food safety training courses. Using a telephone survey, Roberts and Barrett (2009) noticed foodservice managers in the United States who were certified had significantly higher intentions to train their employees (6.16 ± 1.34) than their noncertified counterparts (5.22 ± 1.92, $p = 0.000$). Roberts and Barrett also observed differences in behavioral beliefs about whether training would increase employees' awareness of food safety among certified managers (18.39 ± 5.31) and noncertified managers (16.00 ± 6.95, $p = 0.011$). Certified managers appeared to have different behavioral beliefs than noncertified managers about food safety training; such differing beliefs may influence managers' intentions to send or not send employees to a food safety training course. These researchers looked at managers' behavioral beliefs and intentions in their study and found that such intentions also connect to food safety culture. Restaurants with certified employees and a positive food safety culture likely have employees who are more attentive to potential threats to food safety. Lack of mindfulness about food safety is another subtle barrier to the performance of safe food handling practices.

Using a food safety climate survey, Neal, Binkley, and Henroid (2012) assessed participants' beliefs about factors that contribute to food safety culture in food service establishments. Participants were majoring in hotel and restaurant management and attended a university located in the United States. Based on their findings, Neal et al. concluded that a work environment that encourages safe food handling practices is essential in creating a positive food safety culture. Their study participants identified the role of management as a critical factor in food safety culture; for example, it is important that management stresses food safety even when the restaurant is busy (Neal et al., 2012). Green and Selman (2005) similarly determined that manager and coworker emphasis plays a significant role in the extent to which employees engage in safe food handling practices. These studies support my contention that without cooperation from restaurant managers, food handlers are unlikely to improve their food handling practices despite temporary restaurant closures.

Qualitative Studies

In the studies reviewed previously, researchers did not focus on barriers to the performance of safe food handling practices in work environments, and therefore, in this section, I examine studies about this topic. EHOs can use such information to develop strategies for improving food handling practices at specific restaurants. Green and Selman (2005) conducted a study in the United States with food service workers and managers that explored factors that participants believed influenced food handlers' handwashing, protection of foods from contamination, and temperature control of potentially hazardous foods. Focus group respondents emphasized that time pressure, high volume of business, and staffing, as well as the structural environment, equipment, and resources influenced food preparation practices (Green & Selman, 2005). In addition, food handler respondents observed that management and coworker emphasis affected their handwashing, protection of foods from contamination, and temperature control of potentially hazardous foods (Green & Selman, 2005). Although the results of this study are not generalizable, various combinations of these factors are likely relevant in other situations. Temporary restaurant closures might not be associated with reductions in numbers of food handling violations because these measures do not adequately address the full range of factors that influence restaurant employee behaviors, for example, time pressure and high volumes of business.

In the United States, Clayton et al. (2015) conducted 25 interviews with restaurant employees to discover what factors might be influencing their performance of safe food handling practices. In their discussion of their findings, Clayton et al. claimed more comprehensive approaches are needed to address the range of factors that affect employees' food handling practices. Two particular factors discussed were employee perceptions about management supervision and whether food safety knowledge was related to food hygiene practices. Across all respondents, manager supervision was believed to be key in keeping food handlers focused on food safety (Clayton et al., 2015). Notably, although a number of participants stated that food safety knowledge was unrelated to their food hygiene practices, a couple of participants suggested that knowledge was related to food hygiene practices (Clayton et al., 2015). Clayton et al.'s findings highlight that without addressing individual factors (e.g., knowledge and attitudes) and institutional factors (e.g., issues with resources and inadequate standardized operating procedures), enforcement measures may not have the anticipated effect on food safety behaviors. Furthermore, although some factors such as time pressure and workload have been well documented as affecting employee performance in this regard, others have not, such as rate of pay and benefits.

Roberts, Arendt, Strohbehn, Ellis, and Paez (2012) conducted focus groups in the United States with current and future food service managers around challenges managers face in training and motivating employees to follow safe food handling practices. Most participants agreed that shorter, focused, activity-based training sessions were preferable to full-day, classroom-based food safety courses (Roberts et al., 2012). However, it is important to note that because the study participants were current restaurant managers or university students studying to become food service managers, the perspectives of food service employees were missing from these results. Roberts et al. suggested workplace training provided by managers might be more effective in motivating food handlers to apply their food safety knowledge than full-day, classroom-based food safety courses. This study supports my recommendation that EHOs provide targeted e-learning resources to restaurant managers.

Arendt, Roberts, Strohbehn, Paez, and Ellis (2014) conducted a study with food handlers in the United States, with the goal of developing recommendations for managers around how to increase food handlers’ performance of safe food handling practices. Participants said that having standard operating procedures related to food safety was important; equally critical was having managers follow up on procedures to assure food handler compliance (Arendt et al., 2014). Findings were similar to the study conducted by Roberts et al. (2012), in which researchers found that communication with food handlers within restaurants was a key issue. In particular, Arendt et al. illustrated that managers can motivate food handlers to perform safe food handling practices by having proper procedures in place. With regard to training preferences, 88% of the 32 participants in Arendt et al.'s study reported that they preferred workplace food safety training to classroom-style courses. One particularly thought-provoking point made by the researchers was that food handlers are likely to be motivated to follow safe food handling practices for different reasons (Arendt et al., 2014). Applying this to the current study, this implies that EHOs will need to use multiple strategies to assist restaurant employees in changing unsafe food handling behaviors and that the success of strategies may ultimately depend on cooperation from managers.

EHOs need to better understand the possible reasons for lack of compliance with safe food handling practices, particularly in restaurants with low levels of compliance with food safety regulations. Arendt, Paez, and Strohbehn (2013) conducted focus groups in the United States with current food service managers and university students enrolled in hospitality programs. These researchers explored the question: "What role do managers play in making certain that employees follow safe food handling practices?" (Arendt et al., 2013, p. 125). One theme that emerged from the focus group discussions was employee resistance to following food safety regulations; current and future managers attributed this to a variety of factors such as employees' lack of motivation and lack of time (Arendt et al., 2013). Another theme from the focus group discussions was the need for managers to continuously communicate about food safety using various training tools (Arendt et al., 2013). One limitation of Arendt et al.'s study was that all the responses were coming from a managerial perspective due to the makeup of the group under study. To help EHOs better understand the possible reasons for lack of compliance with safe food handling practices, future research needs to be conducted with food handlers, especially those working in restaurants with low levels of compliance with food safety regulations. Certainly the reasons for employees' lack of compliance do not justify noncompliance; however, uncovering such reasons will provide an important perspective on the types of interventions that are most needed in restaurants with low levels of compliance with food safety regulations.

Summary

In this literature review, I have discussed research examining food service establishment employees' food safety knowledge levels. Following an account of the theoretical foundations for this study, I reviewed studies relating to food handler behaviors. In reviewing food safety research, I noted several themes. Individuals who take food safety training courses appear to benefit in terms of their food safety knowledge. Although food handler food safety knowledge is important, other factors influence the translation of this knowledge into behaviors, for example, manager commitment to food safety. Abushelaibi et al. (2015) and Rowell et al.'s findings (2013) provide evidence that policies requiring the training of managers alone are not sufficient to change food handler behaviors; one possible reason for this is that many managers may lack the skills and training tools necessary to communicate food safety information to employees. Manager commitment and positive food safety cultures appear to play a key role in motivating food handlers to perform safe food handling practices consistently.

To conclude, I will summarize what is known in relation to food handling violations. Brown et al. (2014), Manes et al. (2013), and McIntyre et al. (2013, 2014) have established that food handler training programs improve food safety knowledge. However, the proportions of food handling violations observed by EHOs attributable to inadequate food handler knowledge are not clear. Seaman and Eves (2008, 2010) and Mullan and Wong (2009, 2010) corroborated that food handler intentions to perform safe food handling practices are explained by subjective norm and perceived behavioral control. Nevertheless, further research is needed to clarify how EHOs can utilize these study findings to change food handler behaviors. Abushelaibi et al. (2015), Park et al. (2010), Roberts et al. (2008), Rowell et al. (2013), and York et al. (2009) confirmed food safety training courses are not effective in changing food handler behaviors. Still, researchers have not yet fully examined the skills and training tools that restaurant managers might need to reduce food handling violations.

Research shows that restaurant employees' food handling practices may not improve through any single intervention. Multiple interventions are most likely required because food handlers generally lack a strong foundation of food safety knowledge, and many do not have well developed intentions to perform safe food handling practices. In the current study, I filled a notable gap in the literature regarding the effectiveness of temporary restaurant closures in reducing food handling violations. This study was unique because of my focus on food handling violations and on how EHOs might support food handlers in performing safe food handling practices using enforcement and nonenforcement-related approaches.

In Chapter 3, I describe the research design and rational, data collection procedures, and data analysis strategy.

Chapter 3: Research Method

Introduction

EHOs often claim that compliance with food safety regulations improves following temporary restaurant closures. In this study, I investigated whether this presumption is correct by examining differences in the average overall numbers of food handling violations per inspection in temporarily closed restaurants, both before and after closures. My hypothesis was that EHOs who maintain that temporary restaurant closures improve restaurant food handler behaviors may be overlooking the broad range of factors that influence practices, including attitude, perceived behavioral control, subjective norm, and action self-efficacy. For instance, Clayton et al. (2015) found that employees are unlikely to perform safe food handling practices consistently in restaurants where managers are not focused on food safety. Furthermore, Kettunen et al. (2015) reported that enforcement measures do not always result in food safety violations being corrected, as enforcement actions had to be used recurrently for 15.7% of the cases examined in their study. In the absence of a positive food safety culture, a subset of food handlers may not be compelled to improve their food handling behaviors despite enforcement actions. One purpose of this study was to determine whether temporary restaurant closures are associated with reductions in food handling violations postclosure in the groups under study.

In this chapter, I discuss the research design and rationale, the methodology, and threats to the validity of the study. With regard to the research design and rationale, in the next section I focus on the approach I took to answer the research questions. The methodology section describes the sampling, data collection, and data analysis procedures. Last, the threats to validity section reviews threats to both internal and external validity, as well as the ethical procedures.

Research Design and Rationale

For RQ1 and RQ2, the explanatory variables were occasion and health authority and the outcome variable was a count variable, (i.e., numbers of food handling violations) measured repeatedly for each restaurant. The occasion variable kept track of whether the violations were recorded before or after closure. Next, for RQ3, the explanatory variables were group and year and the outcome variable was a count variable (i.e., numbers of food handling violations), measured once per restaurant. Finally, for RQ4 through RQ6, the explanatory variables were type of cuisine, type of ownership, and number of menu items, respectively, and the outcome variable was group (i.e., temporarily closed, high, moderate, or low risk). After investigating the availability of restaurant data, I chose to perform a secondary data analysis. Restaurant inspection reports are publicly available on health authority websites. Moreover, my decision to use restaurant data made a quantitative study design the logical choice. This research plan also resulted in my study having a retrospective, rather than a prospective, design.

Not only did my decision to analyze secondary data have important implications for the study design, it also had consequences for other aspects of the study. I was limited to analyzing publicly available data posted by the health authorities on their inspection report and restaurant closures webpages. Data were not available about several variables I would have liked to investigate, such as inspection time of day and inspector. More importantly, I had no control over the frequency of inspections because the study involved conducting a secondary analysis of restaurant data. Another consequence of my choice to analyze secondary data for this study was that there were a greater number of threats to validity, as will be discussed shortly.

After reviewing food safety research and finding a gap in the research, I developed my research questions. The study design was influenced by my research questions and time constraints. To answer RQ1, I counted numbers of food handling violations per inspection and studied the relationship between temporary restaurant closures and the occurrence of food handling violations; therefore, a quantitative design was necessary. Time constraints made on-site observations of food handlers impractical. Furthermore, as other researchers have found, few restaurant managers are willing to allow their employees to participate in food safety research (Roberts et al., 2008; York et al., 2009). Restaurant managers' unwillingness to allow their employees to participate in food safety research involving on-site observations of food handlers has meant that considerable research has focused on examining food handler knowledge levels (DeBess et al., 2009; Manes et al., 2013; McIntyre et al., 2013; McIntyre et al., 2014; Panchal et al., 2014). Theoretical constructs most influential in explaining restaurant employees' performance of safe food handling behaviors have also been widely studied (Bearth et al., 2014; Fulham & Mullan, 2011; Pilling et al., 2008; Seaman & Eves, 2008, 2010). However, minimal research has been conducted on the influence of temporary restaurant closures on numbers of food handling violations.

I determined that it was necessary to study overall and specific food handling practices to better inform EHOs and decision makers of the efficacy of restaurant closures as an enforcement measure. I decided this was important as Mullan et al. (2015), Pilling et al. (2008), and Shapiro et al. (2011) found that examining different safe food handling practices separately resulted in meaningful distinctions between predictors of behaviors. This might be a result of food handlers feeling that they have less control over performing some food handling practices and more control over performing others. This might also be due to the fact that food handlers perceive social pressure to perform some food handling behaviors and not others. My first approach of examining overall food handling practices provides a more general perspective. In contrast, my second approach considered the effect of temporary restaurant closures on individual food handling practices to provide more detailed information.

Last, it is through the analysis of restaurant data that EHOs can advance knowledge and develop strategies to better protect the public's health. Evaluations like my study are widely accepted as important in tracking outcomes, assessing the effectiveness of policies, and providing opportunities for making policy adjustments. In the next section, I describe my research procedures.

Methodology

Sampling and Sampling Procedures

The availability of restaurant inspection reports and data about temporarily closed restaurants influenced my sampling procedures. For example, the director of the Vancouver Coastal Health Authority posts recent restaurant inspection reports on the health authority's website. However, the Fraser Health Authority director posts recent restaurant closure information on the health authority's website. As has been mentioned, in British Columbia only the directors of Fraser Health Authority and Vancouver Coastal Health Authority post restaurant closures information on their websites. I used a convenience sampling technique because there were not an adequate number of temporarily closed restaurants (i.e., 96 restaurants) to allow for the use of a probability sampling technique. In addition, data on the total number of restaurants located within the areas serviced by Fraser Health Authority and Vancouver Coastal Health Authority were not available.

Operationalization

I established a scoring system after reviewing prewritten food safety violation comments available to EHOs working within the Fraser Health Authority and Vancouver Coastal Health Authority (see Appendix B). This scoring system specified how violations would be categorized and counted. I did not use a weighting system; in other words, each food handling violation was counted as one. For some categories of violations, the maximum possible score was one, whereas for others more than one violation was achievable. There were five possible violations that fell under the category of contamination violations: foods not covered, foods stored on the floor, foods double stacked without covers, foods stored in open tin cans, and raw meats stored above cooked and ready to eat foods. There were three possible handwashing category violations: kitchen handwashing sinks not adequately supplied, kitchen handwashing sinks not accessible, and handwashing not performed. The violations of no written safe food handling procedures, no written records of refrigeration equipment temperatures, and no thermometers were counted as food safety management category violations. Three violations were counted as sanitizing category violations: no sanitizing solutions, wiping cloths not in sanitizing solutions, and inadequate manual or mechanical dishwashing. Potentially hazardous foods being stored at room temperature and refrigerator temperatures being in excess of 4°C (40°F) were counted as refrigeration category violations. A training violation consisted of no restaurant employees on-site having taken a food safety training course. A cooling violation referred to procedures not being followed to ensure foods were cooled to 4°C (40°F) or colder within 6 hours. Potentially hazardous foods being hot held at temperatures below 60°C (140°F) was a hot holding violation. Finally, potentially hazardous foods being thawed at room temperature or without flowing cool water was a thawing violation (see Appendix B). Identical violations were not counted twice in the same inspection report; however, two handwashing violations could be cited if the EHO had observed no liquid soap and the handwashing sink not being accessible.

The outlined scoring system made it possible to consistently analyze inspection reports. One point was assigned for each food handling violation and zero points were assigned for the use of correct procedures. Less serious violations not known to be associated with foodborne illness were excluded, i.e., items stored on-site that were not required for daily operations. Although inspection reports can be used to facilitate the comprehension of the status quo in restaurants, no guidelines exist concerning how to use scores in research (Da Cunha, De Rosso, & Stedefeldt, 2016). When scores include low-risk violations, the results may be confusing (Da Cunha et al., 2016). As there are no guidelines on how to score violations, I developed a system for categorizing and counting food handling violations that focused on the violations more likely to result in foodborne illness.

For RQ4 through RQ6, I assessed the explanatory variables as follows. Type of cuisine was ascertained by referring to restaurant websites and menus. Independent or chain status was determined by referring to restaurant and health authority websites. Number of menu items was determined by referring to restaurant menus online.

Data Collection Procedures and Delimitations

I obtained lists of temporarily closed restaurants from the restaurant closures webpages of the Fraser Health Authority and Vancouver Coastal Health Authority websites. One study delimitation with regard to RQ1 and RQ2 was that restaurants closed because of lack of hot water, fire, flood, or sewage back-ups were excluded, because managers do not have control over these types of events. Another delimitation for RQ1 and RQ2 was that at least one routine inspection report had to be available from before and after the closure for the restaurant to be included in the study. Last, for RQ1 through RQ6, restaurants were excluded if restaurant menus were not available online.

Sample Size Justification

To establish how many restaurants to include in my analysis, I performed a sample size calculation using a Monte Carlo simulation study. Monte Carlo simulation can be used for sample size calculations when planning a research study, provided analytic formulas for the sample size are not available for the setup considered in that study. This setup refers to the study design, research questions, data, and statistical model(s) pertaining to the study. Details about the steps involved in conducting such a simulation are provided in Landau and Stahl's (2013) article. This calculation was driven by RQ3. I determined the smallest number of restaurants, n, required for detecting statistically significant differences in the average overall number of food handling violations between temporarily closed and high-risk categorized restaurants at the $\alpha =$ 0.05 significance level with 80% power. Recall that the four restaurant groups were: Group A (temporarily closed), Group B (high-risk categorized), Group C (moderate-risk categorized), and Group D (low-risk categorized). For the simulation study, each restaurant group contained the same number of restaurants, k, such that the sample size was given by $n = 4 \times k$. Then, for a given k, I followed these steps:

Step 1: I generated 2,000 simulated data sets from a Poisson regression model, with each data set containing data on the variable's number of food handling violations, number of routine inspections, and restaurant group.

Step 2: For each simulated data set, I used the deviance test to test the null and alternative hypotheses H_{O3} and H_{A3} corresponding to RQ3.

Step 3: After performing the deviance test for all 2,000 simulated data sets, I computed their associated *p* values with reference to the chi-square distribution.

Step 4: I estimated the power of the deviance test as the proportion of times the null hypothesis was rejected in favor of the alternative hypothesis across the 2,000 simulated data sets; the null hypothesis was rejected for a simulated data set if the *p* value associated with the deviance test was smaller than $\alpha = 0.05$. I repeated the above steps for each value of *k*, where $k = 1, 2, 3, \ldots, k$.

The Poisson regression model with log link used in Step 1 was formulated as follows:

log(average overall number of food handling violations)=

$ß_0 + ß_1D_2 + ß_2D_3 + ß_3D_4$ + log(number of inspections)

Where D_2, D_3, and D_4 are dummy variables equal to 1 for restaurants in groups C, B, and A, respectively, and 0 otherwise.

The values of the Poisson regression parameters $ß_0$, $ß_1$, $ß_2$, and $ß_3$ I used in my simulation study were chosen to satisfy the equations: $\exp(ß_0) = 0.5$, $\exp(ß_0 + ß_1) = 1.5$, $\exp(ß_0 + ß_2) = 2.5$, $\exp(ß_0 + ß_3) = 3.5$. The quantities $\exp(ß_0)$, $\exp(ß_0 + ß_1)$, $\exp(ß_0 + ß_2)$, and $\exp(ß_0 + ß_3)$ in these equations denote the theoretical average of overall number of food handling violations per inspection for restaurants in Groups D, C, B, and A, respectively.

Subtractions revealed that the differences in the theoretical average overall number of food handling violations per inspection corresponding to the above stated regression parameter values were 1.5 – 0.5 = 1 (Group C – Group D), 2.5 – 0.5 = 2.0 (Group B – Group D), 3.5 – 0.5 = 3.0 (Group A – Group D), 2.5 – 1.5 = 1.0 (Group B – Group C), 3.5 – 1.5 = 2.0 (Group A – Group C), and 3.5 – 2.5 = 1.0 (Group A – Group B). The values of the offset variable corresponding to the restaurants in each group were simulated for each simulation iteration from a Poisson distribution with a mean of 3, thereby allowing for an average of 3 inspections during the study period under study.

The simulation study was performed with the open source software R version 3.2.4, using R code with modifications (Murakami, 2010), and produced the estimated power curve displayed in Figure 1. The estimated power curve corresponds to the null hypothesis of no difference between just Group A (temporarily closed restaurants) and Group B (high-risk categorized restaurants), with respect to the average overall number of food handling violations per inspection versus the alternative hypothesis of a difference between these groups. The curve displays the estimated power of the deviance test as a function of the number of restaurants in each group, *k*, for *k* = 1, 2, 3, . . . 40. From this curve, I could see that the smallest value of *k* for which I would be able to achieve a target power level of 80% was *k* = 24. Thus, the smallest value of *n* = 4 × *k* for which I could achieve this power was *n* = 96.

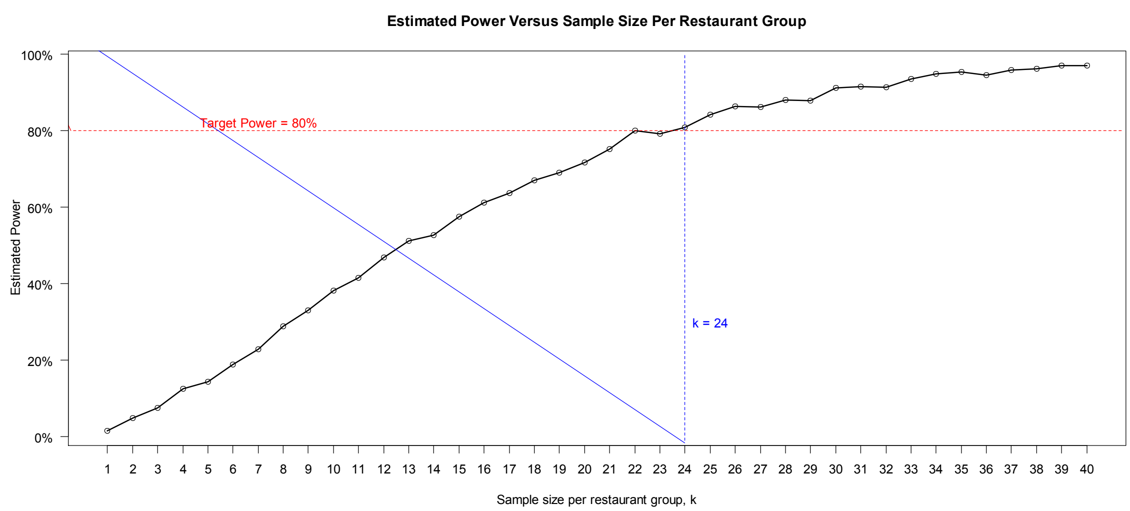

Figure 1. Estimated power associated with the test for detecting significant differences between temporarily closed and high-risk categorized restaurants.

Data Analysis Plan

I used R software version 3.2.4 to perform the data analyses. To start with, I addressed RQ1 and RQ2 using mixed effects Poisson regression modeling (Hedeker & Gibbons, 2006). This type of modeling accounts for the fact that each restaurant will contribute repeated measures data on two occasions: before and after the temporary closure. Specifically, for RQ1, I used a mixed effects Poisson regression model, which included the outcome variable overall number of food handling violations (treated as a count variable) and the explanatory variables occasion (treated as a categorical variable, with the categories before the temporary closure and after the temporary closure) and health authority (treated as a categorical variable with the categories Fraser Health Authority and Vancouver Coastal Health Authority). The model used a log link and included number of inspections as an offset variable. To account for the possibility that the overall number of food handling violations recorded before and after the temporary closure might be correlated for each restaurant, the model also included a random restaurant intercept assumed to follow a Normal distribution.

Since the model included occasion and health authority as explanatory variables with fixed effects, I tested first for the significance of the interaction between these two variables after controlling for heterogeneity among restaurants via the random restaurant effect. I decided that if the interaction between occasion and health authority was found to be statistically significant, I would interpret this as evidence that the effect of occasion is different for each health authority, conditional on the restaurant (e.g., for the average restaurant). To understand how this effect differed across health authorities, I would further test the significance of the effect of occasion separately for each health authority. These separate tests are described as tests of simple effects of occasion for each health authority. If the interaction between occasion and health authority was found not statistically significant, I would omit the interaction term involving these variables from the model, but kept the main effects of occasion and health authority in the model. With this modification in place, I would assume the effect of occasion to be the same for each health authority and I would test the significance by performing a test of the main effect of occasion, conditional on the restaurant (e.g., for the average restaurant).

Subsequently, for RQ2, I used a separate mixed effects Poisson regression model with log link for each specific food violation, which included the number of specific food handling violations as the outcome variable, occasion and health authority as the explanatory variables (defined exactly as for RQ1), number of inspections as the offset variable, and a random restaurant intercept assumed to follow a Normal distribution. For each mixed effects Poisson regression model, I investigated whether the explanatory variables occasion and health authority interacted in their effect on the outcome variable. I decided if occasion and health authority interacted with each other to affect the outcome variable, I would report the simple effect of the explanatory variable occasion for each health authority, with the two simple effects being different across authorities. In the model corresponding to RQ1, the simple effects of occasion quantified the differences in the average overall number of food handling violations per inspection documented before and after temporary closure for restaurants in the two health authorities. In the models corresponding to RQ2, the simple effects quantified the differences in the average number of specific food handling violations per inspection documented before and after temporary closure for restaurants in the two health authorities. I made the decision if occasion and health authority did not interact with each other, I would omit the interaction term involving these variables from the model and report the main effect of occasion. I fit all mixed effects Poisson regression models to the data using the glmer function in the lme4 (Bates, Maechler, & Bolder, 2012) package of R.

I answered RQ3 by fitting a Poisson regression model to restaurant-specific data collected on the outcome variable overall number of food handling violations and the explanatory variable restaurant group (Group A, Group B, Group C, and Group D). After fitting the Poisson regression model to the data available for answering RQ3, I conducted a deviance test based on the Chi square distribution to assess the overall effect of the explanatory variable restaurant group. If the *p* value associated with the deviance test was statistically significant, this suggested differences in the average overall number of food handling violations between at least two of the four restaurant groups. To uncover the pairs of restaurant groups between which the differences occurred, I used Tukey's post-hoc multiple comparisons to follow up on the deviance test. On the other hand, if the *p* value associated with the deviance test was not statistically significant, this indicated the data did not provide sufficient evidence of a difference between the restaurant groups with respect to average overall numbers of food handling violations.

Prior to reporting the final results produced by the Poisson regression model for RQ3, I checked the major assumptions underlying Poisson regression modeling. As there was no evidence of over dispersion or zero inflation in the data, I did not need to use a more appropriate model for the data, such as negative binomial regression or zero inflated Poisson regression. I used the allEffects function in the effects package to visualize the final results.

I addressed the final three research questions, RQ4 through RQ6, by fitting multinomial regression models to the data corresponding to these questions, with one model per question. Multinomial logistic regression models help relate a nominal outcome variable to one or more explanatory variables. I implemented the multinomial regression models by employing the multinom function in the nnet package (Venables & Ripley, 2002) of the open-source statistical software R (R Foundation, 2016), using version 3.2.0 on a Windows platform.

All three multinomial regression models used restaurant group (Group A, Group B, Group C, and Group D) as the nominal outcome variable. Each model included a single explanatory variable, which was different across models. Specifically, the model for RQ4 used type of cuisine served as the explanatory variable. The model for question RQ5 used restaurant type (chain or independent) as the explanatory variable. Finally, the model for question RQ6 used number of menu items as the explanatory variable. For all three models, the reference group was Group D, which corresponded to low-risk categorized restaurants.

For each multinomial regression model, I reported the following information: (a) *p* values, (b) odds ratios, and (c) probabilities. The *p* values helped in detecting the effects of the explanatory variable on the outcome variable, restaurant group, in the multinomial regression models. The odds ratios and probabilities quantified the effects of the explanatory variables on the outcome variable on different scales. I reported the probabilities as percentages. In addition, I used side-by-side bar charts to represent the effect of the explanatory variable included in the model on the predicted probability of a restaurant being categorized in a particular group. For example, the side-by-side bar chart corresponding to RQ5 displays the predicted probabilities of an independent restaurant being categorized into each of the four groups alongside the predicted probabilities of a chain restaurant being categorized in those same groups, enabling the direct comparison of predicted probabilities across types of restaurant for every group.

Threats to Validity

Inconsistencies in the documentation of food handling violations between EHOs are one threat to validity. Because this study involved conducting a secondary analysis of data, I was not able to calculate the degree of agreement among inspectors or interrater agreement. One way in which I addressed this issue was by selecting restaurants from different cities and municipalities. In doing so, I included data reported by a diverse group of inspectors. In addition, certified EHOs typically have a university undergraduate degree and two years of educational training in public health inspection and have also completed a certification exam. However, educational prerequisites for EHOs have changed over time. These changing requirements have resulted in EHOs having differing educational backgrounds.

Performing a retrospective secondary analysis of inspection reports also increased threats to validity. When researchers observe food handling practices and analyze data themselves, it is easier to make interpretations. Confounding factors are another threat to validity; for example, management changes and not temporary restaurant closures might have caused improvements in food handling practices postclosure. Treatment diffusion was also a threat to construct validity. For example, a previous temporary restaurant closure may have occurred before the period under study began. Previous temporary restaurant closures, or the use of other enforcement measures such as violation tickets, might also have influenced numbers of food handling violations.

Internal validity is also essential when researchers try to draw conclusions from study findings. There were two threats to internal validity in this study in terms of history and selection. Because random assignment did not occur, temporarily closed restaurants may have differed on a number of confounding factors, for example, restaurant- and employee-related characteristics. Specifically, restaurant employee turnover may have resulted in improvements in food handling behaviors.

There were two threats to external validity in the present study: population and treatment variation validity. Differences might exist in restaurant and restaurant employee characteristics that prevent study findings from being generalizable. For instance, independent restaurants may be predominately high-risk categorized in one district and low-risk categorized in another. Another factor was that temporary restaurant closures might vary in length of time, from 1 day to many months, depending on the time required to address the issues causing the health hazard. Longer closures might have a greater effect on restaurant employees' safe food handling intentions.

Because I did not conduct interviews with EHOs, background information about restaurants was not available. Nearly all of the restaurants identified on the Fraser Health

Authority and Vancouver Coastal Health Authority restaurant closure lists were included in this study, making random assignment for the temporarily closed restaurants impractical. For the high, moderate, and low-risk categorized restaurants, I selected restaurants from different cities and municipalities to ensure inspections were not performed by a small number of EHOS. In addition, as I did not examine any details about food service employees and only a few details about restaurant characteristics, confounding variables such as restaurant employee food safety knowledge levels were a concern.

Ethical Procedures

I performed a secondary data analysis of publicly available data. As information was not collected from restaurant employees, consent forms were not needed for this study. I assigned numbers to each food service establishment to protect the identity of restaurants in the data set. To prevent a data breach, data was secured on a password protected computer. After five years, I will delete the study data from my computer and security-protected storage device. The Walden University approval number for this study is 09-19-16-0085853.

Summary

When EHOs issue closure orders, restaurant employees typically work swiftly to address all violations so that they may reopen as soon as possible to minimize the economic effect. In this study, I used data from two British Columbia health authorities to examine whether restaurant employees continued to focus on food safety once closure orders were rescinded in the groups of restaurants under study. In this chapter, I have described the research design and rationale, the methodology, and the threats to the validity of the study. In the next chapter, I will discuss the study findings.

Chapter 4: Results

Introduction

The focus of this chapter is to present the findings of the statistical analyses conducted to address RQ1 through RQ6. The outline of this chapter is as follows: overview of research questions, descriptive statistics, results related to each research question, and a summary of the results.

The purpose of RQ1 was to determine whether temporary restaurant closures motivated restaurant employees to improve their food handling practices, with an improvement translating into fewer food handling violations in postclosure restaurant inspections. Next, with RQ2, I examined (one violation at a time) whether temporary closures were associated with a decrease in the average number of handwashing, sanitizing, refrigeration, and contamination violations per inspection for the typical restaurant in each health authority—Vancouver Coastal Health Authority or Fraser Health Authority—and whether that decrease was the same or different across the two authorities. I designed RQ3 to verify whether the average number of food handling violations differed significantly among high, moderate, and low-risk categorized restaurants. With RQ4 through RQ6, the purpose was to determine whether the explanatory variables predicted two outcomes: temporary restaurant closure and restaurant categorization as high risk. RQ4 centers on how well the type of cuisine predicted the categorization of restaurants into the temporarily closed and high-risk categorized groups. With RQ5, attention was placed on how well the type of ownership (chain or independent) predicted restaurants being categorized into the temporarily closed and high-risk groups. And last, RQ6 concentrated on whether the number of menu items was useful in predicting whether a restaurant would be temporarily closed and categorized as high risk.

Descriptive Statistics

Descriptive statistics corresponding to RQ1 and RQ2 are shown in Table 2. These statistics were computed from data in routine inspection reports from 61 temporarily closed restaurants located in the Fraser Health Authority and from 35 temporarily closed restaurants located in the Vancouver Coastal Health Authority. The inspection dates for these reports ranged from March 20, 2014, to October 6, 2016, for restaurants in the Fraser Health Authority and from January 16, 2014, to September 22, 2016, for restaurants in the Vancouver Coastal Health Authority. The majority of temporarily closed restaurants in the Fraser Health Authority served East Asian cuisine (34%), were independent (66%), and had between 50 and 100 menu items (28%). In contrast, the majority of temporarily closed restaurants located in the Vancouver Coastal Health Authority served North American/other cuisine (40%), were independent (74%), and had <50 or 50 to 100 menu items (57%). As can be seen in Table 2, temporarily closed restaurants in the Fraser Health Authority and Vancouver Coastal Health Authority have different characteristics, and this is of interest because it provides evidence that health service regions may need to be taken into consideration during such analyses.

Descriptive statistics relating to RQ3 through RQ6 are given in Table 3, and were computed from data in routine inspection reports from 376 temporarily closed, high, moderate, and low-risk categorized restaurants located in the Fraser Health Authority.

The inspection dates listed in the routine inspection reports ranged from January 8, 2015, to September 19, 2016. Forty-one percent of the high-risk categorized restaurants served North American/other cuisine, 71% of the high-risk categorized restaurants were independent, and 38% of the high-risk categorized restaurants had between 50 and 100 menu items. Alternatively, 83% of the low-risk categorized restaurants served North American/other cuisine, 51% of the low-risk categorized restaurants were chain restaurants, and 47% of the low-risk categorized restaurants had less than 50 menu items. Differences were observed in restaurant characteristics between temporarily closed, high, moderate, and low-risk categorized restaurants. My findings from this study showed diversity in restaurant characteristics between food service establishments of different risk categories, which supports further investigations into how type of cuisine, type of ownership, and number of menu items may be influencing inspection outcomes.

Table 2

Temporarily Closed Restaurants in Vancouver Coastal Health Authority and Fraser Health Authority

Restaurant characteristic	VCHA *n* (%)	FHA *n* (%)
Type of cuisine		
North American/other	14 (40%)	20 (33%)
East Asian	12 (34%)	21 (34%)
Japanese	6 (17%)	11 (18%)
South Asian	3 (9%)	9 (15%)
Ownership		
Chain	9 (26%)	21 (34%)
Independent	26 (74%)	40 (66%)
Number of menu items		
<50	10 (28.5%)	16 (26%)
50-100	10 (28.5%)	17 (28%)
101-150	8 (23%)	14 (23%)
151-200	6 (17%)	13 (21%)
>201	1 (3%)	1 (2%)

Note. VCHA, Vancouver Coastal Health Authority; FHA, Fraser Health Authority.

Table 3

Temporarily Closed, High, Moderate, and Low-Risk Categorized Restaurants in Fraser Health Authority

Restaurant characteristic	All groups	Closed	High	Moderate	Low
			FHA *n*		
Type of cuisine					
North American/other	201	34	39	50	78
East Asian	88	31	26	24	7
Japanese	44	16	13	12	3
South Asian	43	13	16	8	6
Type of ownership					
Chain	139	34	27	30	48
Independent	237	60	67	64	46
Number of menu items					
<50	129	28	32	25	44
50-100	135	24	36	39	36
101-150	61	18	17	16	10
151-200	38	19	6	9	4
>201	13	5	3	5	0

Note. FHA, Fraser Health Authority.

Research Question 1

When EHOs issue a closure order to an operator, it is a last resort measure to protect the public from a situation where foodborne illness is likely to occur. EHOs sometimes assume temporary restaurant closures will motivate restaurant employees to improve their food handling practices, with an improvement translating into fewer food handling violations in postclosure restaurant inspections. In this section, I focus on whether this assumption is correct for a typical restaurant in the Vancouver Coastal Health Authority and for a typical restaurant in the Fraser Health Authority. The section starts with an exploratory analysis of the data used to address RQ1, which was designed to test the correctness of this assumption. I then provide a discussion of the statistical modeling employed to formally address RQ1 and the findings produced by this modeling. The section concludes with a verification of modeling assumptions based on diagnostic plots.

Data from 96 temporarily closed restaurants were included in the statistical analyses; 35 of these restaurants were located in the Vancouver Coastal Health Authority and 61 in the Fraser Health Authority. These were the only health authorities considered, since other British Columbia health authorities do not post their restaurant closure information on a public website. Restaurants considered in the analyses experienced a single closure over the period of the study (2015–2016) and were inspected at least once before closure and at least once postclosure.

The average numbers of food handling violations per inspection observed before and after temporary restaurant closure for the restaurants in the Vancouver Coastal Health

Authority and the Fraser Health Authority are displayed in Figure C1 and Figure C2, respectively. For restaurants in the Vancouver Coastal Health Authority, 12 out of 35 restaurants had fewer numbers of overall food handling violations per inspection postclosure compared to before closure. Meanwhile, for restaurants in the Fraser Health Authority, 20 out of the 61 restaurants had fewer overall numbers of food handling violations per inspection postclosure.

For restaurants in the Vancouver Coastal Health Authority, the average number of overall food handling violations per inspection ranged from 0 to 9 before closure and from 0 to 8 postclosure. In contrast, for restaurants in the Fraser Health Authority, the average number of overall food handling violations per inspection ranged from 0 to 5 before closure and from 0 to 6.5 postclosure. Before closure, the typical restaurant had an average number of overall food handling violations per inspection that was 2.73 in the Vancouver Coastal Health Authority and 2.07 in the Fraser Health Authority. After closure, the typical restaurant had an average number of food handling violations that was 3.03 in the Vancouver Coastal Health Authority and 2.50 in the Fraser Health Authority. Interestingly, in both authorities, there was an increase in the average number of overall food handling violations per inspection postclosure compared to before closure for the restaurants included in this study.

I used mixed-effects Poisson regression modeling to determine if temporary restaurant closures were associated with a decrease in the average overall number of food handling violations per inspection postclosure, after controlling for restaurant and whether the effect of temporary restaurant closure differed across the two health authorities. The response variable used in this modeling was a count variable that consisted of the number of overall food handling violations incurred by a restaurant. This variable was measured on two occasions for each restaurant in the study: before temporary closure and after temporary closure. The explanatory variables used in this modeling were Occasion and Authority; an offset term took into account the number of routine inspections conducted before and after closure. The variable Occasion had two levels—before closure and after closure—with the former being treated as the reference level. The modeling allowed for a random intercept effect for restaurant, intended to control for heterogeneity among restaurants due to restaurant characteristics that were not captured in the modeling.

I considered three competing models as part of the mixed effects Poisson regression modeling used to address RQ1. The first model (glmer.1) included only Occasion as an explanatory variable. The second model (glmer.2) included both Occasion and Authority as explanatory variables, assuming the effect of Occasion to be the same across both health authorities. The third model (glmer.3) contained not just Occasion and Authority as explanatory variables, but also their interaction, thereby assuming that the effect of Occasion on the outcome variable was different in each health authority. I compared the three models against each other on the basis of the Akaike information criterion (AIC) to determine which model was best for the overall food handling violations data. A model was deemed best for the data if it produced the smallest AIC value. The notation glmer stands for generalized linear mixed effects models, of which the mixed effects Poisson regression models used here are a special case.

The glmer.2 model fitted to the overall food handling violations data had the lowest AIC value of 835.544, compared to 837.246 for glmer.1, and 836.425 for glmer.3, so it was preferable for the overall food handling violations data. The best-fitting model, glmer.2, investigated the effect of temporary restaurant closure on the (log) average number of overall food handling violations per inspection, after controlling for the Authority and random restaurant effect. In light of this, the effect of temporary restaurant closure captured—for a typical restaurant—the difference in the (log) average number of overall food handling violations per inspection between the two occasions considered, controlling for the Authority the restaurant came from.

Models such as glmer.2, which includes a count response variable, can suffer from overdispersion. Therefore, I checked for overdispersion in the glmer.2 model using the R package *glmeco*. The scale parameter for the glmer.2 model was 1.079, which is very close to 1. In the absence of any evidence of overdispersion for the glmer.2 model, I used this model for final reporting. The summary output associated with the glmer.2 model is reported in Table C1 (on the log scale). For reference, I also included the summary outputs for the competing models glmer.1 and glmer.3 in the same table.

The marginal and conditional R squared values associated with the glmer.2 model revealed the following. For the glmer.2 model, the proportion of variance in the average number of overall violations per inspection explained by the fixed factors alone was 0.039, whereas the proportion of variance explained by both the fixed and random factors was 0.424. The former proportion represents the marginal R squared and the latter represents the conditional R squared. Recall that the glmer.2 treated Occasion and

Authority as fixed factors and the random restaurant effect as the random factor. Therefore, it appears that the restaurant-to-restaurant variation in the number of overall food handling violations captured by the random restaurant effect was the dominant source of variation in the model. This variation could have been induced by either unobserved restaurant-level factors or observed restaurant-level factors that were not included in the model, but that might have affected the number of overall food handling violations per inspection recorded on each occasion. Such factors are assumed to have had a stable influence over time on each restaurant at each occasion—at least throughout the study duration.

There was no evidence in the data that, for the typical restaurant in either health authority, the log average number of overall food handling violations after closure was significantly lower than the log average number of overall food handling violations before closure (one sided p 0.9708). In fact, the typical restaurant in either health authority had an estimated 16% increase in the average number of overall food handling violations per inspection after temporary closure compared to before closure; this is opposed to the (expected) decrease that would be observed were restaurant closure an effective intervention in reducing food handling violations.

Figure 2 helps in visualizing the findings produced by the glmer.2 model using two different scales—the log scale used by the model and the natural scale obtained by the exponentiation of results reported on the log scale. For each health authority, these findings apply to all restaurants, which are represented by the restaurants included in this study. In particular, Figure 2 shows that both the log average number of overall food handling violations per inspection (left panel) and the average number of overall food handling violations per inspection (right panel) increased—rather than decreased—from before to after temporary restaurant closures for the typical restaurant in both health authorities. On the log scale, the log average number of overall food handling violations increased from 0.89 to 1.03 for the typical restaurant in the Vancouver Coastal Health Authority. Meanwhile, the log average number of overall food handling violations increased from 0.65 to 0.79 for the typical restaurant in the Fraser Health Authority. On the natural scale, the average number of overall food handling violations increased from 2.43 to 2.81 for restaurants in the Vancouver Coastal Health Authority and from 1.91 to 2.21 for restaurants in the Fraser Health Authority. For the natural scale, notice how 2.81 represents a 16% increase over 2.43, whereas 2.21 represents a 16% increase over 1.91. The reported increases seem fairly small from a practical perspective; however, they go in the opposite direction relative to what would be expected if temporary closure were an effective measure for reduction of food handling violations.

The results reported here for the best-fitting glmer.2 model hold, provided the assumptions underlying the model are not violated by the data. Residual diagnostic plots for the glmer.2 model are shown in Figure C3. These diagnostics were produced using the DHARMa package in R and are discussed below (Dunn & Smyth, 1996; Gelman & Hill, 2006). The DHARMa package uses simulation to produce readily interpretable residuals for generalized linear mixed effects models (such as the glmer.2 model) that are standardized to values between 0 and 1. By virtue of how they were simulated, these residuals would be expected to have a uniform (flat) distribution.

The top left panel in Figure C3 displays a qq-uniform plot to detect deviations from the overall uniformity of the standardized residuals. For a correctly specified model, one would expect a uniform (flat) distribution of the overall standardized residuals, evidenced by a straight line in the qq-plot.

The top right panel in Figure C3 displays the plot of standardized residuals versus predicted (or fitted) values. For a correctly specified model, one would expect uniformity of the standardized residuals in the y-direction in this plot. To provide a visual aid for detecting deviations from uniformity in y-direction in the plot, 0.25, 0.5, and 0.75 quantile regression lines are displayed across the plot. These lines should be straight, horizontal, and at y-values of 0.25, 0.5, and 0.75. However, some deviations from this are to be expected by chance, even for a perfect model, especially if the sample size is small.

The bottom left and right panels in Figure C3 display the standardized residuals versus the explanatory variables included in the model using side-by-side boxplots: Occasion (bottom left) and Authority (bottom right). For a correctly specified model, one would expect uniformity in the y direction if the residuals were plotted against any predictor. In other words, there should be no systematic dependency of the standardized residuals on the explanatory variables. By examining the top left, top right, bottom left, and bottom right panels of Figure C3 for the glmer.2 model, I concluded that the model is correctly specified for the data.

Last, Figure C4 shows a final diagnostic plot for the glmer.2 model, which consists of a caterpillar plot of the predicted random effects of restaurant. This plot shows that most restaurants have uncertainty intervals around the predicted random effects that cross the zero line, suggesting that they are close to the typical restaurant in their respective health authority. Although I did not exclude any restaurants from my analysis, several restaurants located at the top right of this diagnostic plot appeared significantly different compared to the typical restaurants across the health authorities. Either temporary restaurant closures do not motivate food handlers to perform safe food handling practices, or, alternatively, barriers to safe food handling practices could not be overcome. In RQ2, I will examine whether temporary restaurant closures were associated with decreases in four specific food handling violations, beginning with handwashing violations.

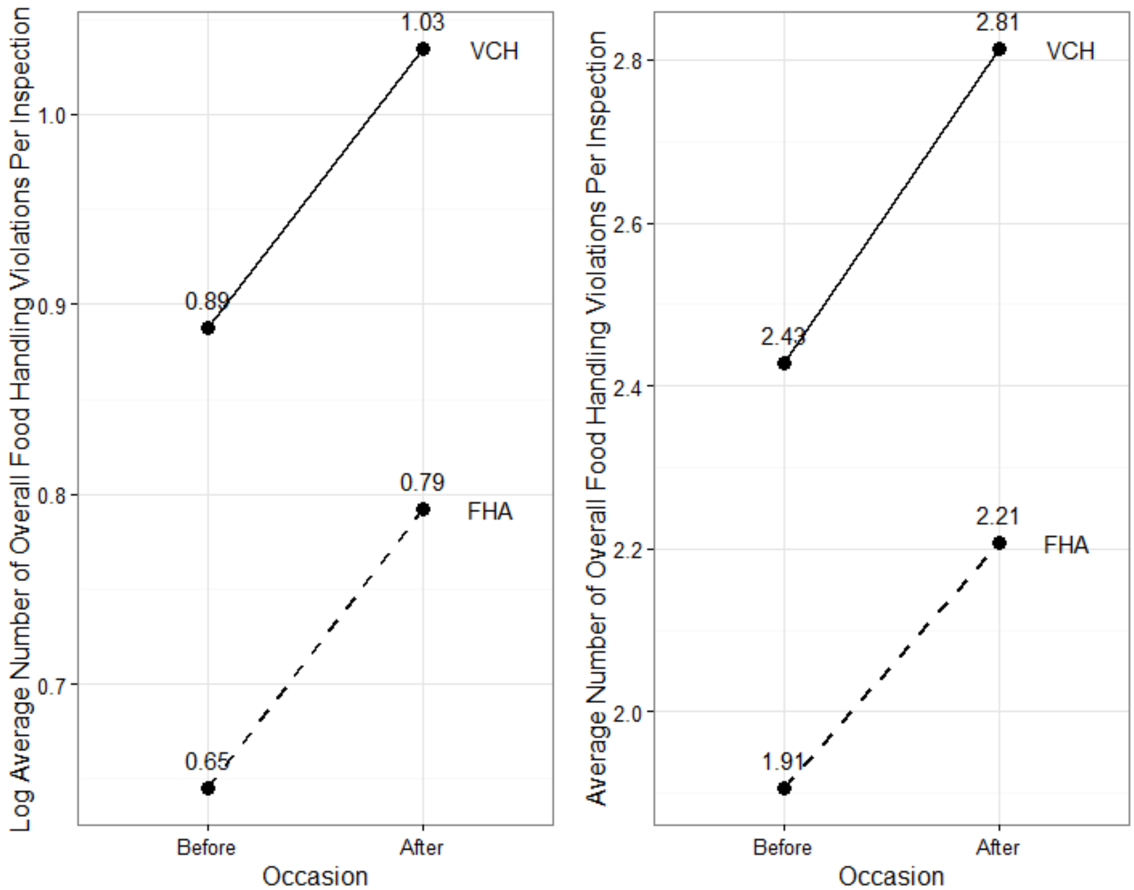

Figure 2. Log average and average number of overall food handling violations per inspection before and after temporary restaurant closure.

Research Question 2

In the previous section, I focused on presenting the results of the mixed-effects Poisson regression modeling for overall food handling violations. In the current section, I present similar results regarding specific food violations: handwashing, sanitizing, contamination, and refrigeration violations. These results correspond to my second research question, RQ2, with which I investigated whether, during the time period of the study, temporary restaurant closures were associated with a decrease in the average number of specific violations per inspection for a typical restaurant in either one or both of the two health authorities considered.

Handwashing Violations

In this subsection, I describe how I used mixed-effects Poisson regression modeling to uncover whether temporary closures were associated with a decrease in the average number of handwashing violations per inspection for the typical restaurant in each health authority—Vancouver Coastal Health Authority or Fraser Health Authority—and whether that decrease was the same or different across the two authorities.

Prior to conducting the mixed-effects Poisson regression modeling for the handwashing violations data, I performed an exploratory examination of the data, the related insights of which are discussed below.

The average number of handwashing violations per inspection before and after temporary restaurant closures for each restaurant included in the study are presented in Figure D1 and Figure D2. Among the 35 restaurants studied in the Vancouver Coastal Health Authority, only 8 restaurants had fewer numbers of handwashing violations per inspection after closure compared to before closure. Meanwhile, among the 61 restaurants in the Fraser Health Authority, only 11 restaurants had fewer handwashing violations per inspection after closure compared to before closure.

For restaurants in the Vancouver Coastal Health Authority, the average number of handwashing violations per inspection ranged from 0 to 2 before closure and from 0 to 3 postclosure. Meanwhile, for restaurants in the Fraser Health Authority, the average number of handwashing violations per inspection ranged from 0 to 2 both before and after closure. The average number of handwashing violations for a typical restaurant before closure was 0.37 in the Vancouver Coastal Health Authority and also 0.37 in the Fraser Health Authority, whereas after closure, it was 0.40 in the Vancouver Coastal Health Authority and 0.52 in the Fraser Health Authority.

As was the case for RQ1, I considered three competing mixed-effects Poisson regression models for my analysis of the handwashing violations data, which were of increasing complexity. These models, referred to as glmer.1, glmer.2, and glmer.3, were similar to the ones corresponding to overall food violations, except they used a different outcome variable. Whilst the outcome variable for the glmer models concerning overall food violations was the number of overall food violations, measured before and after temporary restaurant closure, the outcome variable for the glmer models concerning handwashing violations was the number of handwashing violations, also measured before and after temporary restaurant closure. All three models included an offset term that kept track of the number of inspections conducted before and after closure for each restaurant.

I evaluated the glmer.1, glmer.2, and glmer.3 models for the handwashing violations data to determine which of these models had the best fit. The glmer.1 model had the lowest Akaike information criterion value of 384.772, compared to 386.614 for glmer.2, and 386.777 for glmer.3. Thus, the glmer.1 model was preferable.

Using the R package *blmeco*, I found no evidence of overdispersion for the glmer.1 model, since the estimated scale parameter returned by this package for the glmer.1 model was 0.954, which was close to 1. In the absence of any evidence of overdispersion for the glmer.1 model, I used this model for final reporting. I detail the summary output for glmer.1 model on the log scale in Table D1. For reference, I also report the summary outputs associated with the competing models glmer.2 and glmer.3.

Using the glmer.1 model, I investigated the effect of temporary restaurant closure on the (log) average number of handwashing violations per inspection after controlling for the random restaurant effect. As discussed in my section on RQ1, the glmer.1 model does not control for health authority, so the model combines restaurants from the two health authorities, rather than treating them separately. The effect of temporary restaurant closure in the glmer.1 model is quantified via the fixed effect of the Occasion variable, where Occasion keeps track of when handwashing violations were measured for each restaurant. To this end, the Occasion variable was treated in the glmer.1 model as a fixed factor with two levels: 1) before temporary restaurant closure (reference level), and 2) after temporary restaurant closure. The fixed effect of Occasion in the glmer.1 model (or, equivalently, the effect of temporary restaurant closure) —for the typical restaurant across the two health authorities—was the difference in the (log) average number of handwashing violations per inspection between the two occasions considered. Recall that the random restaurant effect was included in the glmer.1 model to capture the potential correlation among the number of handwashing violations contributed by the same restaurant before and after temporary closure.

In investigating the effect of temporary restaurant closure using the glmer.1 model, I found no evidence in the data that the log average number of handwashing violations per inspection after closure was significantly lower than the log average number of handwashing violations per inspection before closure (one-sided *p* value 0.900). In fact, the data showed that the average number of handwashing violations after closure was 29% higher than before closure for a typical restaurant across the two health authorities.

A visualization of the results produced by the glmer.1 model for all restaurants, represented by the 96 restaurants from the Vancouver Coastal Health Authority and Fraser Health Authority included in this study, is provided in Figure 3, and uses both the log scale and the natural scale. The figure shows that the log average number of handwashing violations per inspection increased from -1.26 before to -1.01 after temporary restaurant closure, whereas the average number of handwashing violations increased from 0.28 before to 0.36 after temporary restaurant closure, with 0.36 representing a 29% increase over 0.28.

For the glmer.1 model, the proportion of restaurant-to-restaurant variation in the number of handwashing violations per inspection explained by the Occasion factor alone was 0.010, whereas the proportion of variance explained by both Occasion and the random restaurant effect was 0.270. Therefore, the restaurant-to-restaurant variation in the number of handwashing violations captured by the random restaurant effect was the dominant source of variation in the model. This variation was induced by either unobserved restaurant-level factors or observed restaurant-level factors that were not included in the model, but that might have affected the number of handwashing violations per inspection recorded on each occasion. Such factors can be assumed to have a stable influence over time on each restaurant at each occasion—at least throughout the study duration. For handwashing violations, adding the random restaurant effect to the model was useful; however, for sanitizing violations, which I discuss later, this was not the case.

The results I reported for the glmer.1 model depend on the assumptions underlying the model not being violated by the data. Model diagnostics used to test whether assumptions hold for the glmer.1 model are shown in Figure D3.

The diagnostic plots in Figure D3 were constructed with the help of the DHARMa package in R. As explained previously, this package uses simulation to produce readily interpretable residuals for generalized linear mixed models (such as the glmer.1 model) that are standardized to values between 0 and 1. For a correctly specified model, these residuals would be expected to have a uniform (flat) distribution by virtue of how they were simulated. For guidelines on the interpretation of these diagnostics, please refer back to the section on overall food violations. In examining these diagnostics, I found no evidence that the glmer.1 model was incorrectly specified.

The diagnostic plot in Figure D4 consists of a caterpillar plot of the predicted random effects of restaurant in the glmer.1 model. Restaurants have uncertainty intervals around the predicted random effects that cross the zero line, suggesting that they are close to the typical restaurant across the two health authorities. No restaurants appeared to be significantly different compared to the typical restaurant.

In the restaurants studied, despite temporary restaurant closures there were no overall improvements in keeping kitchen handwashing sinks properly supplied with liquid soap and paper towels, in ensuring kitchen handwashing sinks were accessible, and in performing handwashing properly and at appropriate times. Therefore, targeted food safety communications delivered by EHOs to managers following temporary restaurant closures should place some focus on handwashing.

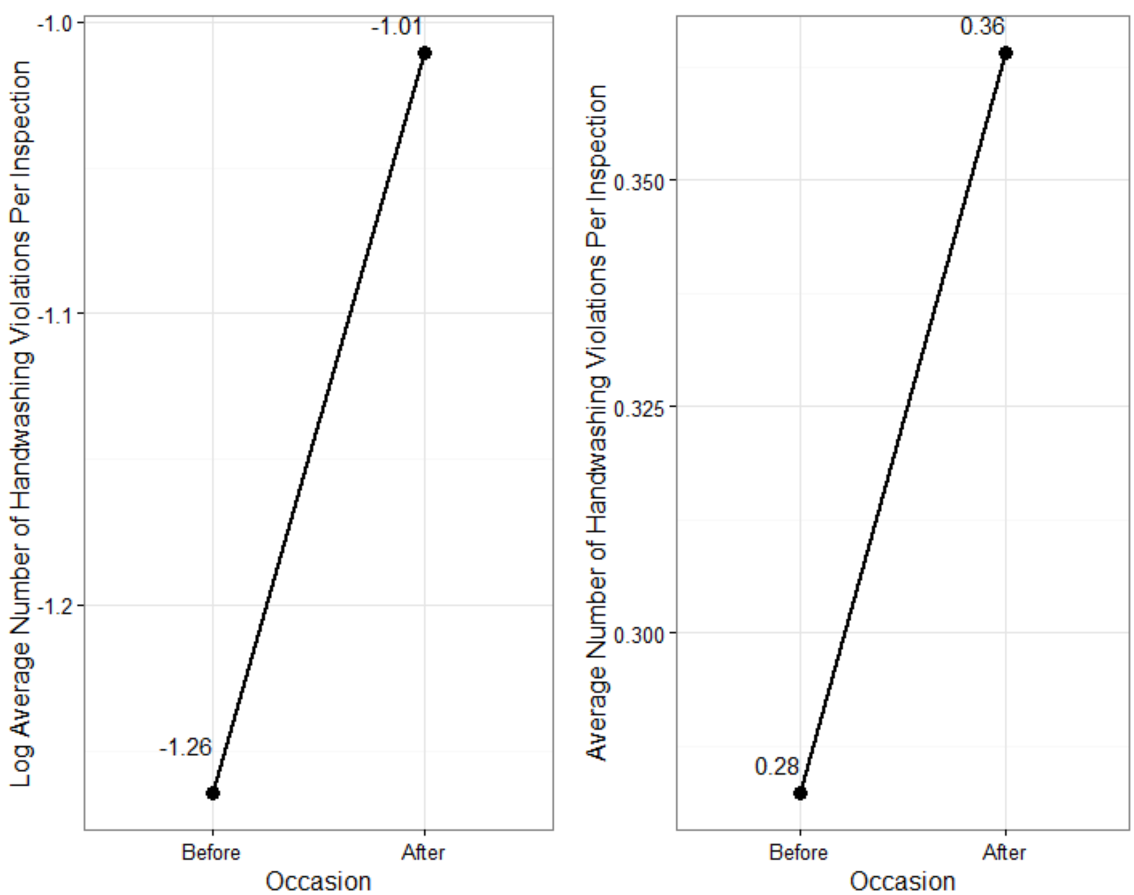

Figure 3. Log average and average number of handwashing violations per inspection before and after closure.

Sanitizing Violations

This subsection covers my findings related to sanitizing violations and whether temporary restaurant closures are associated with a decrease in the average number of sanitizing violations per inspection postclosure. I discuss the sanitizing violations data first and then present the results produced by the statistical modeling applied to these data.

The average number of sanitizing violations per inspection observed before and after closure for the 35 restaurants in Vancouver Coastal Health Authority and the 61 restaurants in Fraser Health Authority are displayed in Figure E1 and Figure E2, respectively, and are discussed below. For restaurants in the Vancouver Coastal Health Authority, 10 restaurants had fewer numbers of sanitizing violations per inspection postclosure. With regard to restaurants in the Fraser Health Authority, 25 restaurants had fewer numbers of sanitizing violations per inspection postclosure.

For the 35 restaurants studied in the Vancouver Coastal Health Authority, the average number of sanitizing violations per inspection ranged between 0 and 2 both before and after temporary closure. For the 61 restaurants in the Fraser Health Authority, the average number of sanitizing violations per inspection ranged between 0 and 2 before temporary closure and between 0 and 3 after closure. The average number of sanitizing violations for a typical restaurant before closure was 0.59 in the Vancouver Coastal Health Authority and 0.57 in the Fraser Health Authority. The average number of sanitizing violations for a typical restaurant after closure was 0.67 in the Vancouver Coastal Health Authority and 0.64 in the Fraser Health Authority. This preliminary exploration of the data reveals there was not much differentiation between health authorities when considering the difference in the average number of sanitizing violations across the two occasions. Also, there was an increase in the typical number of sanitizing violations across occasions in each health authority.

To formally analyze the sanitizing violations data, I considered three mixed-effects Poisson regression models of increasing complexity. For economy, the notation used for these sanitizing violation models is identical to that used for the overall food handling violations models: glmer.1, glmer.2, and glmer.3. All three models shared the same outcome variable—number of sanitizing violations—and used the log number of inspections as an offset term. The glmer.1 model included occasion of measurement (Occasion) as an explanatory variable. The glmer.2 model included Occasion and Health Authority as explanatory variables. The glmer.3 model included not just Occasion and Health Authority, but also their interaction. The summary output associated with the glmer.1, glmer.2, and glmer.3 models is reported in Table E1, and is used here only as a basis for performing the comparison of the three models.

Based on the Akaike information criterion (AIC), glmer.1 was the best of the three mixed effects Poisson regression models considered for the sanitizing violations data. This model had the lowest AIC value of 459.079, compared to 460.760 for glmer.2, and 462.736 for glmer.3.

Further examination of the results produced by the glmer.1 model revealed that the estimated variance for the random restaurant effect included in the model was equal to zero, suggesting that the random restaurant effect is not needed in the model. Indeed, the variation among restaurants with respect to the number of sanitizing violations was explained by the occasion of measurement (i.e., before or after temporary closure), but not by restaurant-level factors with a stable influence on the number of sanitizing violations across occasions. As discussed previously, such restaurant-level factors refer to either unobserved factors or factors that were observed but not included in the glmer.1 model.

Since the glmer.1 model did not warrant including a restaurant-level random effect, I simplified this model to a standard Poisson regression model, by omitting the random restaurant effect while keeping the fixed effect of occasion of measurement. The simplified model, glm.1, is used for final reporting in what follows. The summary output associated with the glm.1 model is reported in Table E2.

Prior to interpreting the results produced by the glm.1 model, I checked the model for signs of overdispersion using the function *dispersiontest* in the R package *modEva*. The (estimated) scale parameter for the glm.1 model was 0.898, which was not significantly different from 1 (p value = 0.9072). Thus, there was no evidence of overdispersion for the glm.1 model, so the model can be interpreted safely, provided the underlying model assumptions are not violated by the data. The verification of model assumptions is deferred to the end of this section, whereas the interpretation of model results is provided next.

The effect of temporary closure was captured by the fixed effect of Occasion in the glm.1 model. On the log scale, this effect is expressed as the difference in the log average number of sanitizing violations per inspection after closure and the log average number of sanitizing violations per inspection before closure across restaurants in both authorities combined. Note that the model does not distinguish between restaurants in the two health authorities, with respect to the log average number of sanitizing violations per inspection before and after closure, since the data provided no evidence that health authority should be included as an explanatory variable in the model.

The data provided no evidence that the log average number of sanitizing violations after closure was significantly lower than the log average number of sanitizing violations before closure (one-sided p 0.820). In actuality, the average number of sanitizing violations per inspection after temporary closure was estimated to be 15% higher than before temporary closure. This increase in the average number of sanitizing violations runs counter to what one might expect to see if temporary closure were an effective intervention for reducing sanitizing violations.

Figure 4 presents the log average (left panel) and the average (right panel) number of sanitizing violations before and after closure across restaurants in the two health authorities combined. Irrespective of which authority the restaurant came from, the restaurants studied experienced an average number of 0.56 sanitizing violations per inspection before closure. After closure, they experienced an average number of 0.64 sanitizing violations per inspection. As reported earlier in this section, this represents a 15% increase in the average number of sanitizing violations per inspection between the two occasions.

As is the case with other models considered thus far, the results reported for the glm.1 model hold provided the assumptions underlying the model are not violated by the data. The model diagnostics used to test whether assumptions hold for the glm.1 model are reported in Figure E3. These diagnostics were produced using the DHARMa package in R and are discussed below. The package uses simulation to produce readily interpretable residuals not only for generalized linear mixed models (such as the glmer.1 model discounted in favor of the glm.1 model), but also for generalized linear models (such as the glm.1 model employed here for final reporting). The residuals are standardized to values between 0 and 1. By virtue of how they were simulated, the residuals would be expected to have a uniform (flat) distribution if the glm.1 model was correctly specified for the sanitizing violations data.

The top left panel in Figure E3 displays a qq-uniform plot to detect deviations from the overall uniformity of the standardized residuals. The straight line followed by the observations in that plot is consistent with the glm.1 model being correctly specified. The top right panel in Figure E3 displays the plot of standardized residuals versus the predicted (or fitted) values produced by the glm.1 model, with superimposed 0.25, 0.5 and 0.75 quantile regression lines. These lines provide a visual aid for detecting deviations from the expected uniformity of the standardized residuals in the y-direction. The y-direction refers to the vertical direction. Since the quantile regression lines are straight, nearly horizontal, and approximately located at the y-values of 0.25, 0.5, and 0.75, this provides further evidence that the glm.1 model is correctly specified for the data.

The bottom panel in Figure E3 displays the standardized residuals versus the explanatory variable Occasion included in the glm.1 model using a side-by-side boxplot.

Since the side-by-side boxplots reveal no systematic dependency of the standardized residuals on the explanatory variables Occasion, this further reinforces the fact that the glm.1 model is correctly specified. In conclusion, in assessing the residual diagnostic plots provided in Figure E3, I found no evidence that the glm.1 model was incorrectly specified.

To conclude, temporary restaurant closures may not motivate food handlers to prepare sanitizing solutions, keep wiping cloths in sanitizing solutions, and ensure dishes are properly washed (manually or mechanically). Lack of progress in reducing sanitizing violations despite temporary restaurant closures indicates targeted food safety communications may need to cover food contact surface maintenance and proper dishwashing.

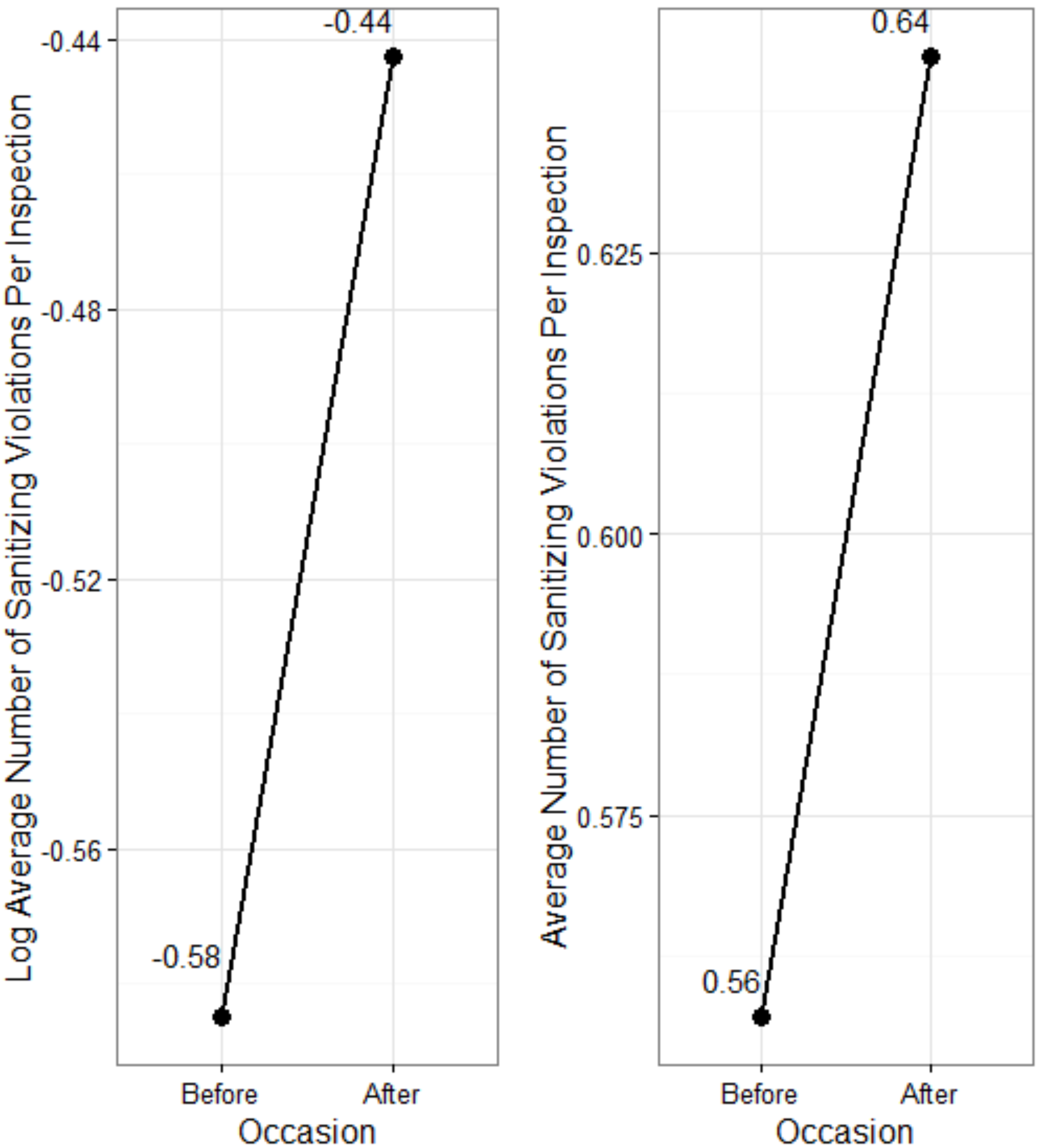

Figure 4. Model results visualization for glm.1 (log scale on the left, natural scale on the right).

Contamination Violations

This subsection focuses on the results of the mixed-effects Poisson regression modeling concerning contamination violations. This modeling addresses whether temporary closures were associated with a decrease in the average number of contamination violations per inspection for the typical restaurant in each health authority and whether this decrease was different across the two health authorities.

The average numbers of contamination violations per inspection observed before and after closure for the 35 restaurants in the Vancouver Coastal Health Authority and the 61 restaurants in the Fraser Health Authority are displayed in Figure F1 and Figure F2. For restaurants in the Vancouver Coastal Health Authority, only seven restaurants had fewer numbers of contamination violations per inspection postclosure. Meanwhile, for restaurants in the Fraser Health Authority, only 19 restaurants had fewer contamination violations per inspection postclosure.

The average number of contamination violations per inspection in the Vancouver Coastal Health Authority ranged between 0 and 5 before temporary restaurant closure and between 0 and 3 after temporary restaurant closure. In the Fraser Health Authority, this average number ranged between 0 and 1.5 before temporary restaurant closure and between 0 and 3 after temporary restaurant closure. Before closure, for the typical restaurant, the average number of contamination violations per inspection was 0.57 in the Vancouver Coastal Health Authority and 0.53 in the Fraser Health Authority. After closure, the typical restaurant had an average number of contamination violations per inspection was 0.71 in the Vancouver Coastal Health Authority and 0.55 in the Fraser

Health Authority.

Since I considered three competing mixed effects Poisson regression models for the contamination violations data (referred to as glmer.1, glmer.2, and glmer.3), I first determined which of these models provided the best fit to my data in the sense of producing the smallest Akaike information criterion (AIC) value. These models were similar in nature to those considered for the overall food violations data, except they used the number of contamination violations as the response variable, rather than the number of overall food violations. The glmer.1 model fitted to the contamination violations data had the lowest AIC value of 457.495, compared to 459.306 for glmer.2 and 461.150 for glmer.3, so it was preferred.

As the best-fitting model was glmer.1, I used this model as a basis for investigating the effect of temporary restaurant closure on the (log) average number of contamination violations per inspection after controlling for the random restaurant effect. Recall that the glmer.1 model does not control for health authority. The effect of temporary closure in the model is quantified via the fixed effect of the Occasion variable. The Occasion variable detailed when the (total) number of contamination violations was recorded for each restaurant and was treated as a factor with two levels: 1) before temporary restaurant closure (reference level), and 2) after temporary restaurant closure. In light of this, the effect of temporary restaurant closure captures—for a typical restaurant across the two health authorities combined—the difference in the (log) average number of contamination violations per inspection between the two occasions considered.

I checked for overdispersion in the glmer.1 model using the R package *glmeco*.

The scale parameter for the glmer.1 model was 0.969, which is very close to 1. In the absence of any evidence of overdispersion for the glmer.1 model, I used this model for final reporting. The summary output associated with the glmer.1 model is reported in Table F1. For completeness, I also report summary outputs associated with the competing models glmer.2 and glmer.3. The findings that emerged from this table in connection with the glmer.1 model are discussed in more detail below.

For the glmer.1 model, the proportion of restaurant-to-restaurant variation in the average number of contamination violations per inspection explained by the Occasion factor alone was 0.002, whereas the proportion of variance explained by both Occasion and the random restaurant effect was 0.281. Therefore, the restaurant-to-restaurant variation captured by the random restaurant effect was the dominant source of variation in the model. This variation would have been induced by either unobserved restaurant-level factors or observed restaurant-level factors that were not included in the model, but that might affect the number of contamination violations per inspection recorded on each occasion. Such factors were assumed to have a stable influence over time on each restaurant across occasions—at least throughout the study duration.

The one-sided *p* value for the Wald z-test used to test the significance of the fixed-effect of Occasion was 0.7264. Since this *p* value was not statistically significant at the 5% significance level, there was no evidence in the data that, for the typical restaurant in both authorities combined, the log average number of contamination violations after closure was significantly lower than the log average number of contamination violations before closure. In fact, the typical restaurant across these two authorities had an estimated

10% increase in the average number of contamination violations per inspection after temporary closure compared to before closure, rather than the decrease expected, if restaurant closure were to be an effective intervention.

Figure 5 helps in visualizing the findings produced by the glmer.1 model using two different scales—the log-scale used by the model and the natural scale obtained by exponentiation of results reported on the log-scale. In particular, this figure shows that both the log average number of contamination violations per inspection (left panel) and the average number of contamination violations per inspection (right panel) increased—rather than decreased—from before to after temporary restaurant closure for the typical restaurant in the two health authorities. Specifically, the log average number of contamination violations per inspection increased from -0.77 to -0.68, whereas the average number of contamination violations per inspection increased from 0.46 to 0.51 (i.e., the 10% increase reported earlier). The reported increases seem fairly small from a practical perspective; however, they go in the opposite direction relative to what would be expected if temporary closure were an effective measure for reducing contamination violations.

The results reported here for the glmer.1 model hold provided the assumptions underlying the model are not violated by the contamination data. I report on three of the model diagnostic plots used to test whether assumptions hold for the glmer.1 model in Figure F3. These diagnostics were produced using the DHARMa package in R and revealed no evidence of violations of the model assumptions, suggesting that the model is correctly specified for the data. Recall that a more detailed discussion of how these diagnostics should be interpreted was provided in the results section concerning overall food violations.

Figure F4 shows the fourth and final diagnostic plot for the glmer.1 model, which consists of a caterpillar plot of the predicted random effects of restaurant. This plot shows that most restaurants have uncertainty intervals around the predicted random effects that cross the zero line, suggesting that they are close to the typical restaurant in their respective health authority. Only three restaurants seem to be significantly different compared to the typical restaurant. These restaurants are located at the top right of the plot. It is possible that the glmer.1 model fit would improve if these three restaurants were excluded from the model, however I did not take this action.

Following temporary restaurant closures, targeted food safety communications about how to protect foods from contamination are advisable. However, it is unlikely these types of violations will be reduced by education alone in the absence of measures that could be taken in restaurant kitchens, including the provision of adequate shelving and suitable containers with tight fitting lids.

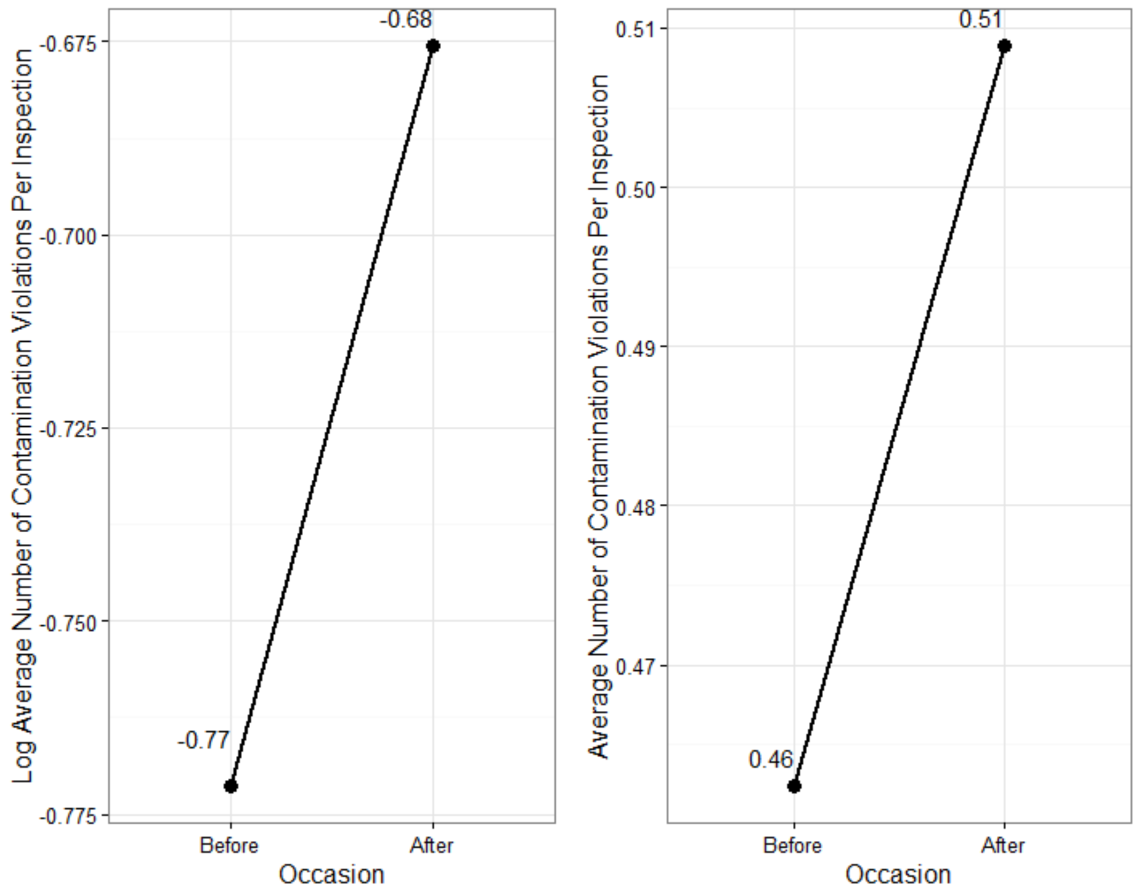

Figure 5. Log average and average number of contamination violations per inspection before and after temporary restaurant closure.

Refrigeration Violations

In this subsection, I focus on refrigeration violations. After describing features of the refrigeration data, I will present the results produced by the mixed-effects Poisson regression modeling I applied to these data. In this modeling, I addressed whether temporary restaurant closures were associated with a decrease in the average number of refrigeration violations per inspection for the typical restaurant in either one or both of the two health authorities considered.

The average number of refrigeration violations per inspection before and after temporary restaurant closures are shown in Figure G1 for the 35 restaurants in the Vancouver Coastal Health Authority and in Figure G2 for the 61 restaurants in the Fraser Health Authority. For restaurants in the Vancouver Coastal Health Authority, 15 restaurants had fewer average numbers of refrigeration violations per inspection postclosure. For restaurants in the Fraser Health Authority, 17 restaurants had fewer average numbers of refrigeration violations per inspection postclosure.

For restaurants in the Vancouver Coastal Health Authority, the average number of refrigeration violations before closure ranged from 0 to 1.5 and from 0 to 1 postclosure. Meanwhile, for restaurants in the Fraser Health Authority, the average number of refrigeration violations ranged from 0 to 1 both before and after closure. Before closure, for the typical restaurant, the average number of refrigeration violations per inspection was 0.47 in the Vancouver Coastal Health Authority and 0.30 in the Fraser Health Authority. After closure, the typical restaurant had an average number of refrigeration violations per inspection that was 0.36 for the Vancouver Coastal Health Authority and

0.26 for the Fraser Health Authority.

The three mixed-effects Poisson regression models I considered for the refrigeration violations data, glmer.1, glmer.2, and glmer.3, were similar in nature to those used previously. Specifically, the models used the same explanatory variables and offset term as outlined for the overall food handling violations data, but employed a different outcome variable (i.e., number of refrigeration violations). This outcome variable was measured on two different occasions for each restaurant—before temporary closure and after temporary closure—thereby justifying the inclusion of a random restaurant effect in the model. The random restaurant effect captures the within-restaurant correlation among the values of the outcome variable. For completeness, I report the summary outputs for all three models in Table G1.

Based on the Akaike information criterion (AIC), glmer.2 was the best of the three mixed-effects Poisson regression models considered for the refrigeration violations data. The glmer.2 model had the lowest Akaike information criterion value of 331.412, compared to 334.260 for glmer.1 and 332.488 for glmer.3. In addition to an offset term for the number of inspections, the glmer.2 model included a fixed effect for occasion of measurement and a fixed effect for health authority, along with a random restaurant effect.

Closer examination of the results produced by the glmer.2 model revealed the estimated variance of the random restaurant effect was very small. However, I decided to keep the random restaurant effect in the glmer.2 model since the estimated variance of the random restaurant effect was not exactly zero and it was still possible to calculate marginal and conditional R-squared values for the model.

As the best fitting model for the refrigeration violations data was glmer.2, I used this model as a basis for investigating the effect of temporary restaurant closure on the log average number of refrigeration violations per inspection, after controlling for health authority and for random restaurant effect. Recall that the effect of temporary closure is captured in the glmer.2 model by the effect of the Occasion variable. In the model, Occasion was treated as a fixed factor with two levels: before temporary restaurant closure (reference level) and after temporary restaurant closure (nonreference level). Furthermore, Authority was treated as a fixed factor with two levels: Vancouver Coastal Health Authority (reference level) and Fraser Health Authority (nonreference level). For each factor, the nonreference level was compared against the reference level.

Prior to conducting the one-sided test of significance of the effect of temporary restaurant closure in the glmer.2 model, I checked the model for evidence of overdispersion, using the function *dispersion_glmer* from the R package *blmeco*. The scale parameter for the glmer.2 model was 0.927, which is very close to 1, suggesting that overdispersion was not an issue for the glmer.2 model.

The *p* value associated with the one-sided test of significance of the effect of temporary restaurant closure in the glmer.2 model was 0.153, indicating that there was no evidence in the data in favor of a statistically significant decrease postclosure in the average number of refrigeration violations per inspection for the typical restaurant in either health authority. Although the typical restaurant in either health authority had an average number of refrigeration violations per inspection after temporary closure that was

19% lower than before temporary closure, this decrease was not statistically significant. The decrease is further explored via Figure 6, which displays the log average number of refrigeration violations per inspection predicted by the glmer.2 model (left panel), and the average number of refrigeration violations per inspection predicted by the glmer.2 model (right panel), for the typical restaurant in each health authority before and after temporary restaurant closure. As can be seen from the right panel, the average number of refrigeration violations per inspection before closure for the Vancouver Coastal Health Authority was 0.48, while the number postclosure was 0.39. The latter number (0.39) represents a 19% decrease in the former (0.48). Meanwhile, for the Fraser Health Authority, the average number of refrigeration violations per inspection before closure was 0.3, while the number postclosure was 0.24. Here as well, the latter number (0.24) represents a 19% decrease in the former (0.3). Although the 19% decrease seems large, because it is applied to fairly small numbers (i.e., 0.48 for the Vancouver Coastal Health Authority and 0.3 for the Fraser Health Authority), it results in numbers that are also small (i.e., 0.39 for the Vancouver Coastal Health Authority and 0.24 for the Fraser Health Authority). The lack of statistical significance of this decrease suggests that there are no grounds for believing, based on this study, that the decrease noted in the sample of restaurants can be generalized to the underlying population of restaurants represented by the sample.

The marginal R^2 value, which represents the variance explained by the fixed factors of Occasion and Authority, was 0.053. Meanwhile, the conditional R^2 value, which represents the variance explained by both fixed and random factors, was 0.053.

Therefore, the fixed factors, not the random factors, explained the observed variance.

Residual diagnostic plots for the glmer.2 model are shown in Figure G3. These diagnostics were produced via the DHARMa package in R. The top left panel in Figure G3 displays a qq-uniform plot to detect deviations from the overall uniformity of the standardized residuals. The straight line in the qq-plot provides evidence that the model is correctly specified.

The top right panel in Figure G3 displays the plot of standardized residuals versus predicted (or fitted) values. For a correctly specified model, one would expect uniformity of the standardized residuals in the y-direction in this plot. The nearly straight, horizontal lines, at the y-values 0.25 and 0.75, provide further evidence that the model is correctly specified. Some deviations from this are to be expected by chance, even for a perfect model, especially if the sample size is small.

The bottom left and right panels in Figure G3 display the standardized residuals versus the explanatory variables included in the model using side-by-side boxplots: Occasion (bottom left) and Authority (bottom right). For a correctly specified model, one would expect uniformity in the y direction if the residuals were plotted against any predictor. In other words, there should be no systematic dependency of the standardized residuals on the explanatory variables. In assessing the residual diagnostic plots provided in Figure G3, I found no evidence that the glmer.2 model was incorrectly specified.

The caterpillar plot of random effects shown in Figure G4 shows little variation among the predicted random effects, which is to be expected considering that the estimated variance of the random restaurant effect was very close to 0.

This study provides evidence that there is a need for food safety communications about handwashing, sanitizing, and preventing contamination following temporary restaurant closures. Targeted food safety communications about ensuring that refrigerators are maintaining foods at 4 degrees Celsius (40 degrees Fahrenheit) or colder and not storing potentially hazardous foods at room temperature should be reserved for restaurants in which these types of violations have been recurrently observed.

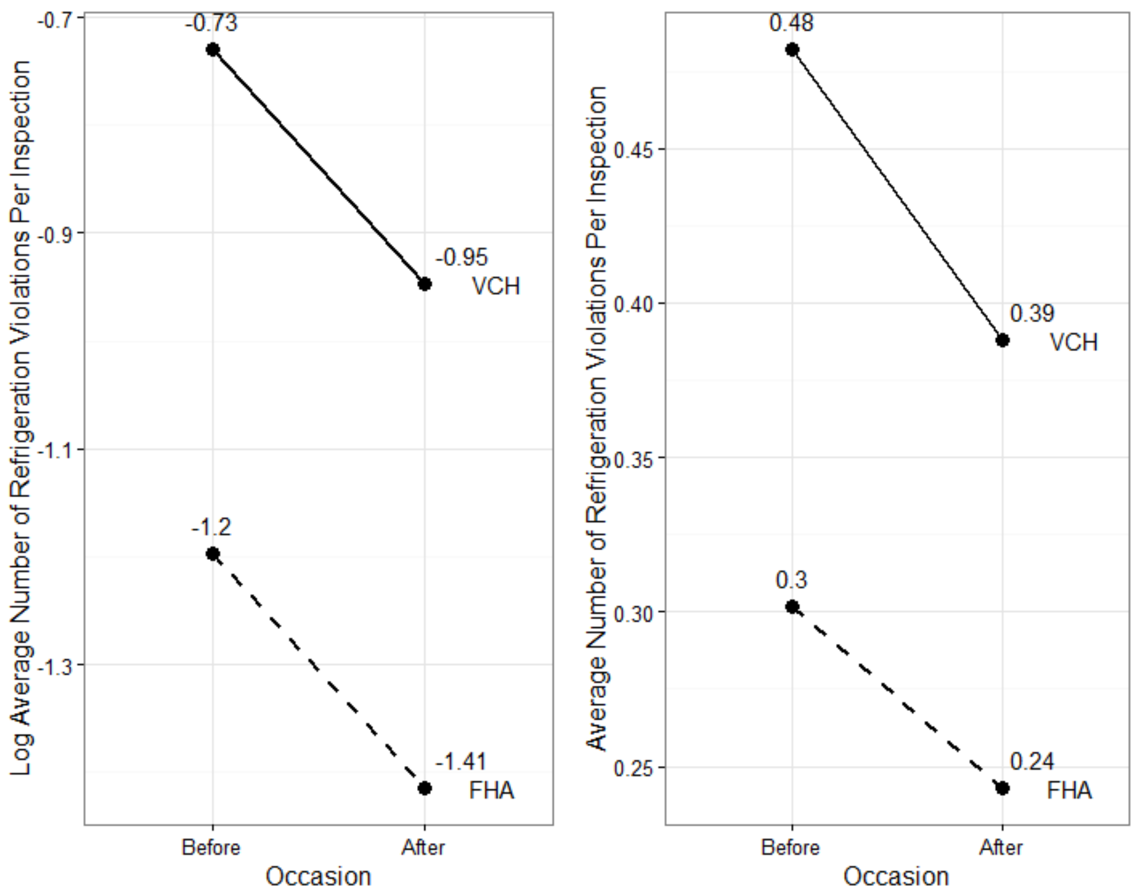

Figure 6. Model results visualization for glmer.2 (log scale on the left, natural scale on the right).

Research Question 3

With RQ3, I set out to answer the following question: is there any evidence that the average number of food handling violations differs significantly among closed, high, moderate, and low-risk categorized restaurants for the groups studied? In the event of differences in the average number of food handling violations between groups, I determined whether this effect differed across years. In this section, I describe and explore the data available in relation to RQ3, introduce the statistical models used to analyze these data, and present and interpret the model findings. I conclude the section by considering whether the data satisfied the underlying modeling assumptions.

The restaurants of interest for RQ3 were all located in the Fraser Health Authority, were inspected in either one or both of the years 2015 and 2016, and were categorized as closed, high, moderate, or low risk. Each of the four risk groups contained 38 restaurants in 2015 and 56 restaurants in 2016. The overall numbers of restaurants across the four risk groups were 152 in 2015 and 224 in 2016, for a total of 376 across the two years. Predominately different restaurants were sampled from one year to the next, with only 24 restaurants being sampled in both years.

Frequency distributions showing the number of overall food handling violations documented in routine inspections for the restaurants in the closed, high, moderate, and low-risk groups that were included in this study are presented in Figure H1 and are discussed below. For restaurants in the closed group, the typical number of food handling violations was 3 in both years, where typical refers to the most prevalent number of food handling violations that occurred across all restaurants in the group included in this study.

For restaurants in the high-risk group, the typical number of food handling violations was 3 in 2015 and 4 in 2016. In the moderate risk group, the typical number of food handling violations was 2 in 2015, but 1 in 2016. In the low risk group, the typical number of food handling violations was 0 in both years.

The closed and high-risk groups exhibited a wider range of numbers of food handling violations compared to the low and moderate-risk groups. Indeed, for restaurants in the closed group, the number of food handling violations ranged from 0 to 10 in 2015 and from 0 to 12 in 2016. For restaurants in the high-risk group, it ranged from 0 to 7 in 2015 and from 1 to 7 in 2016. The moderate-risk group restaurants experienced between 0 and 4 violations in 2015 and between 0 and 5 violations in 2016. In contrast, the low-risk group restaurants experienced between 0 and 2 violations in each of the 2 years.

To address RQ3, I considered three competing standard Poisson regression models. The three models shared the same outcome variable, number of overall food handling violations documented in routine inspections, however the models included different explanatory variables. The first model (glm.1) included restaurant group as an explanatory variable. This model ignored the year effect when investigating whether there were differences between restaurant groups with respect to the average number of overall food handling violations. The second model (glm.2) included both restaurant group and year as explanatory variables. Thus, the glm.2 model controlled for the year effect and assumed that differences between groups with respect to the average number of overall food handling violations were the same across years. The third model (glm.3) included restaurant group, year, and their interaction as explanatory variables, thereby allowing for the possibility that differences between restaurant groups with respect to the average number of overall food handing violations might be different across years.

I compared the fits of the three models to the data on the basis of the Akaike information criterion (AIC), to identify which model provided the best fit to the data. The glm.2 model was preferred because it had the lowest AIC value of 1209.997, compared to AIC values of 1217.220 for glm.1 and 1211.879 for glm.3.

To corroborate these findings, I also conducted two analyses of deviance. The first analysis of deviance compared glm.2 against glm.1, and the second one compared glm.3 against glm.2. The comparison of glm.2 versus glm.1 favored glm.2 ($\chi^2 = 311.55$, $df = 371$, p 0.0024). Therefore, I concluded it was appropriate to add the explanatory variable year to the model. The comparison of glm.3 versus glm.2 also favored glm.2 ($\chi^2 = 307.43$, $df = 368$, p 0.249). The non-significant change in deviance indicated that I should not add the group by year interaction to the model, as it did not improve the model fit. Modeling results reported in the remainder of this section are therefore based on the output for the best-fitting model glm.2, which included the statistically significant main effect of group and the statistically significant main effect of year. Summary outputs for glm.2, as well as glm.1 and glm.3 are shown in Table H1.

According to the findings produced by the glm.2 model, the closed group had an average number of overall food handling violations that was 9.95 times higher than that corresponding to the low-risk group after controlling for the year effect (CI 7.29–13.99). The high-risk group had an average number of overall food handling violations that was

8.18 times higher than that corresponding to the low-risk group after controlling for the year effect (CI 5.97–11.52). Last, the moderate-risk group had an average number of overall food handling violations that was 4.93 times higher than that corresponding to the low-risk group after controlling for the year effect (CI 3.55–7.01).

In Figure 7, I show the estimated average number of food handling violations per inspection for each restaurant group separately, for the years 2015 and 2016, along with corresponding 95% confidence intervals. The corresponding average reported in this figure refers to all the restaurants in that group that are represented by the restaurants included in the present study for the year in question. For 2015, the figure reveals that the estimated average numbers of food handling violations per inspection in the four groups were as follows: 3.73 (Closed), 3.07 (High), 1.85 (Moderate), and 0.38 (Low). For 2016, higher average numbers of violations per inspection were estimated in all four groups: 4.57 (Closed), 3.76 (High), 2.26 (Moderate), and 0.46 (Low).

After controlling for the year effect, Tukey's multiple comparisons revealed statistically significant differences between all possible pairs of restaurant groups with respect to the (true) log average number of food handling violations, as seen in Figure 8.

Figure H2 shows rootograms for the three models. Rootograms compare observed and expected numbers/counts of overall food handling violations on a square root scale, with the expected numbers being produced by the glm.2 model (a standard Poisson regression model). In a rootogram, bars are used to denote observed counts and a dashed curve is used to indicate expected values. If a particular Rootogram bar fails to reach the zero line, then the model overpredicts the underlying observed count; if the bar exceeds the zero line, then the model underpredicts that count. In examining the rootograms for the three models, I saw that there was generally good agreement between expected and observed counts for each model, and especially for the glm.2 model. Each model appeared to under predict between one and four, and over predict above five cumulative overall food handling violations. Figure H3 shows the results of the model diagnostics associated with RQ3, I found no evidence that the model was incorrectly specified.

The significant differences in the log average number of food handling violations after controlling for the year effect were smallest between temporarily closed restaurants and high-risk categorized restaurants. Accordingly, EHOs should prioritize restaurants that have been temporarily closed and establishments that are high-risk categorized, to focus on achieving long term compliance with safe food handling practices rather than only corrections during inspections.

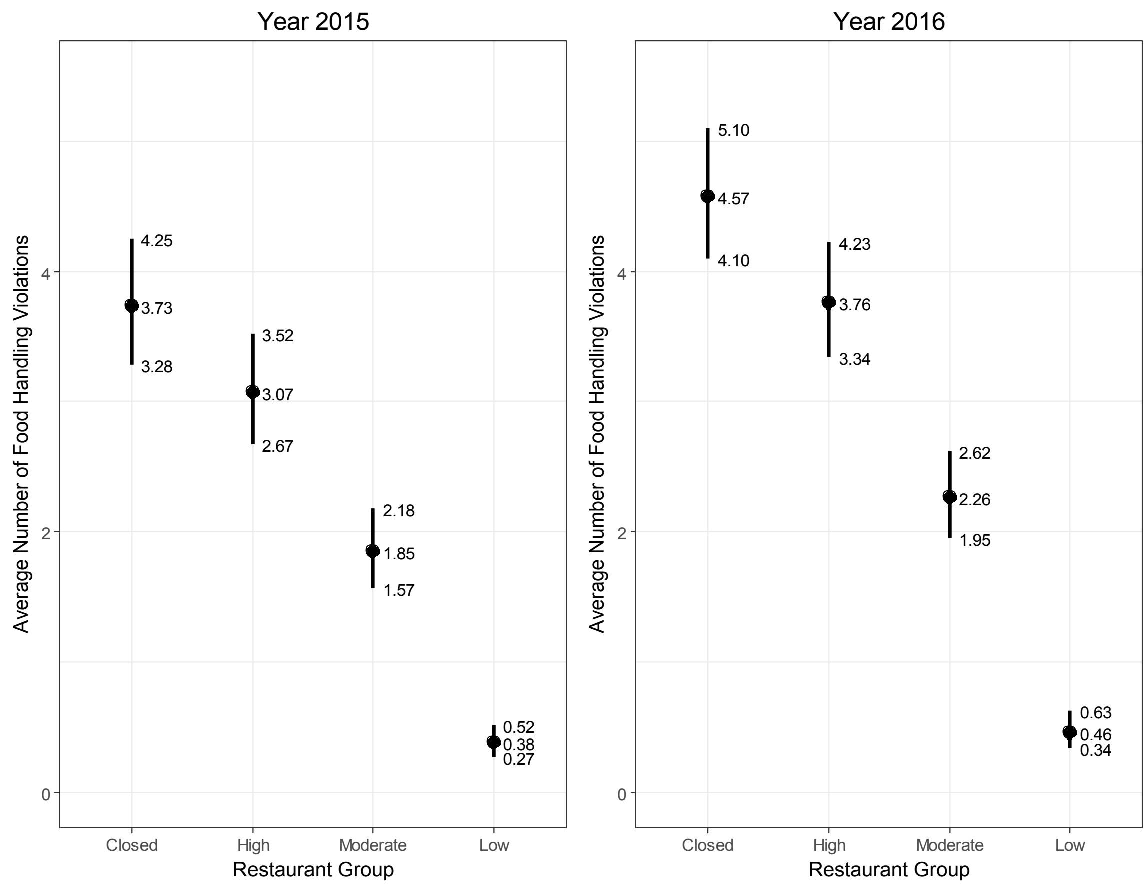

Figure 7. Average numbers of food handling violations in the four restaurant groups, as estimated by the glm.2 model.

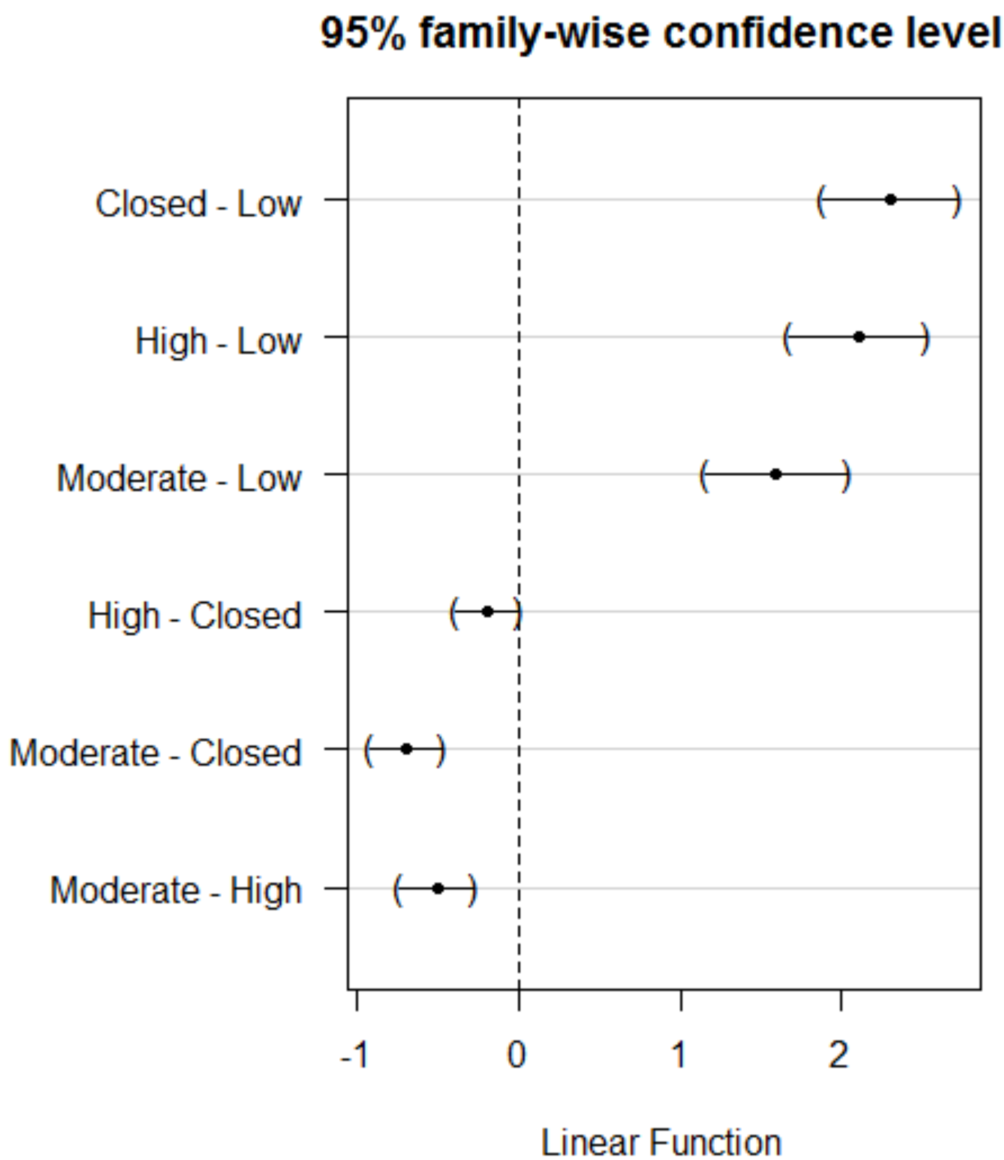

Figure 8. Differences in the log average numbers of food handling violations among all possible pairs of groups.

Research Question 4

With this question, I examined whether restaurants serving particular types of cuisines were associated with higher probabilities of being temporarily closed or high-risk categorized. For restaurants located in the Fraser Health Authority, multinomial logistic regression indicated that type of cuisine (i.e., North American/other, East Asian, Japanese, or South Asian) was a statistically significant predictor of restaurant group categorization ($p < 0.001$). In particular, this suggests that there may be significant differences between cuisines served by restaurants that relate to the odds of a restaurant being categorized as temporarily closed or high-risk rather than being categorized as low risk. However, type of cuisine was a relatively weak predictor of restaurant group categorization $R^2 = 5.412\%$.

Restaurants in the Fraser Health Authority serving East Asian, Japanese, or South Asian foods as opposed to North American/other foods had greater odds of being categorized as temporarily closed or high risk rather than low risk. These results can be seen in Table I and are detailed below. Compared to restaurants serving North American/other cuisine, restaurants serving East Asian cuisine were significantly more likely to be in the temporarily closed ($p < 0.001$) or in the high-risk categorized group ($p < 0.001$) rather than in the low-risk categorized group. In particular, for restaurants serving East Asian rather than North American/other cuisine, the odds of being temporarily closed were approximately 10 times higher than the odds of being categorized as low risk, whereas the odds of being categorized as high risk were almost 7.5 times higher than the odds of being categorized as low risk.

Restaurants serving Japanese rather than North American/other cuisine had greater odds of being temporarily closed as opposed to being categorized as low risk (*p* 0.0001), and also had greater odds of being categorized as high risk rather than low risk (*p* 0.0013). Specifically, for restaurants serving Japanese rather than North American/other cuisines, the odds of being temporarily closed were approximately 12 times higher than the odds of being categorized as low risk, whereas the odds of being categorized as high risk were nearly 9 times higher than the odds of being categorized as low risk.

Restaurants serving South Asian cuisine were significantly more likely than those serving North American/other cuisine to be in the temporarily closed (*p* 0.0027) or the high-risk categorized groups (*p* 0.0012) as opposed to the low-risk categorized group. Indeed, for restaurants serving South Asian foods compared to North American/other foods, the odds of being temporarily closed were almost 5 times higher than the odds of being categorized as low risk, whereas the odds of being high-risk categorized were slightly more than 5 times higher than the odds of being categorized as low risk.

As seen in Figure 9, type of cuisine influenced the magnitude of the predicted probability of a restaurant in the Fraser Health Authority being either temporarily closed or categorized as high risk. Note that Figure 9 also displays predicted probabilities of a restaurant in the Fraser Health Authority being categorized as moderate or low risk, but these probabilities are not of direct interest in answering RQ4. In interpreting these predicted probabilities, the overall focus was on determining which type of cuisine was associated with the highest/lowest predicted probability of a restaurant being temporarily closed or high-risk categorized.

In the Fraser Health Authority, restaurants serving Japanese cuisine were associated with the highest predicted probability of being temporarily closed (36.4%), followed by restaurants serving East Asian cuisines (35.2%), and South Asian cuisine (30.2%). Restaurants serving North American/other cuisine had the lowest predicted probability of being closed, at 16.9%. These findings indicate that restaurants in the Fraser Health Authority that serve ethnic cuisines seem to be more prone to temporary restaurant closure than restaurants serving North American/other cuisine.

Type of cuisine was also associated with higher predicted probabilities of a restaurant in the Fraser Health Authority being high-risk categorized. Restaurants serving South Asian cuisine had the greatest predicted probability of being high-risk categorized (37.2%), followed by restaurants serving Japanese foods (29.5%), and restaurants serving East Asian foods (29.5%). Restaurants serving North American/other cuisines had the lowest probability of being high-risk categorized (19.4%). To sum up, the restaurants in the Fraser Health Authority serving Japanese cuisine had the greatest predicted probability of being closed, whereas the restaurants serving South Asian cuisine had the greatest predicted probability of being high-risk categorized.

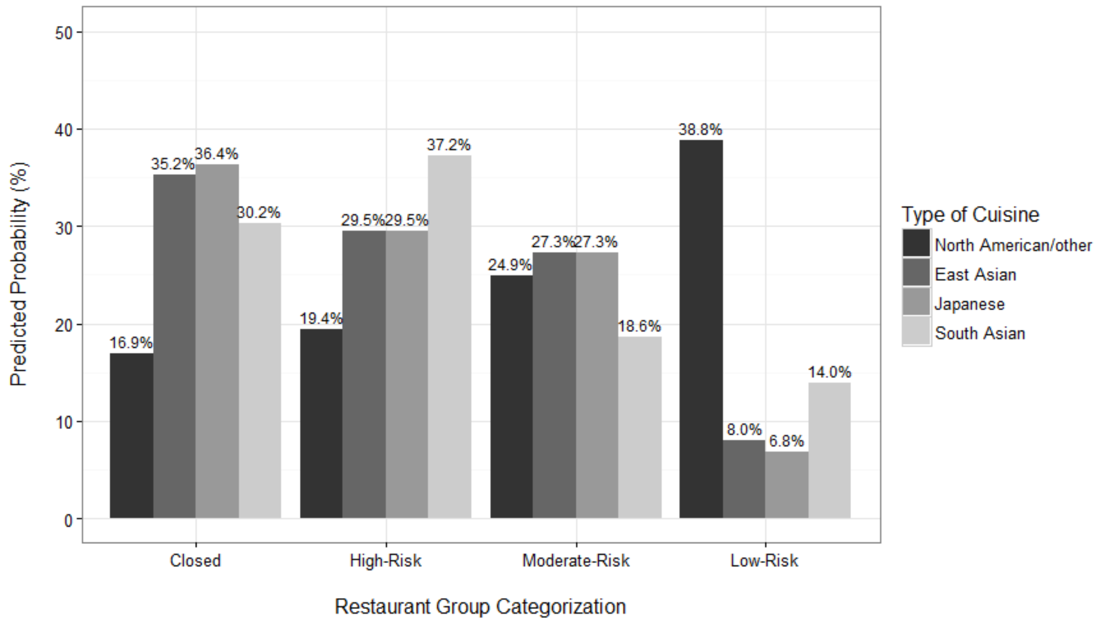

Figure 9. Probability of a restaurant being categorized in the closed, high, moderate, or low-risk groups according to type of cuisine served.

Research Question 5

With this question, I explored whether chain restaurants out-performed independent restaurants in terms of the probability of being temporarily closed or categorized as high risk, and whether type of ownership is an important explanatory variable. Multinomial logistic regression modeling established that type of ownership (i.e., chain versus independent) was a statistically significant, though weak, predictor of restaurant group membership for restaurants in the Fraser Health Authority (p 0.009; R^2 = 1.117%). The results of this modeling are presented in Table J and are discussed below.

Compared to chain restaurants, independent restaurants in the Fraser Health Authority were more likely to be temporarily closed rather than low-risk categorized (p 0.040). In addition, independent restaurants in the Fraser Health Authority were more likely than chain restaurants to be high-risk categorized rather than low-risk categorized (*p* 0.002). Based on the magnitude of the reported *p* values, type of ownership was considerably more useful in predicting membership in the high-risk categorized group than in the temporarily closed group (relative to the low-risk group), since the corresponding *p* value was much smaller.

The odds of an independent restaurant being temporarily closed rather than low-risk categorized in the Fraser Health Authority were 1.8 times higher than those of a chain restaurant. On the other hand, the odds of an independent restaurant being high-risk categorized rather than low-risk categorized in the Fraser Health Authority were 2.6 times higher than those of a chain restaurant.

Figure 10 shows the probabilities of independent or chain restaurants in the Fraser Health Authority being assigned to each of the four restaurant categorization groups, where the probabilities were predicted from the multinomial regression model and expressed in percentage form. Independent restaurants were only slightly more likely to be categorized in the temporarily closed group than chain restaurants. An independent restaurant had a 25.3% probability of being categorized in the temporarily closed group, whereas a chain restaurant had a 24.5% probability of being in the temporarily closed group. Independent restaurants were much more likely to be categorized in the high-risk group than chain restaurants: the chance of an independent restaurant being categorized as high risk was 28.3%, compared to only 19.4% for a chain restaurant.

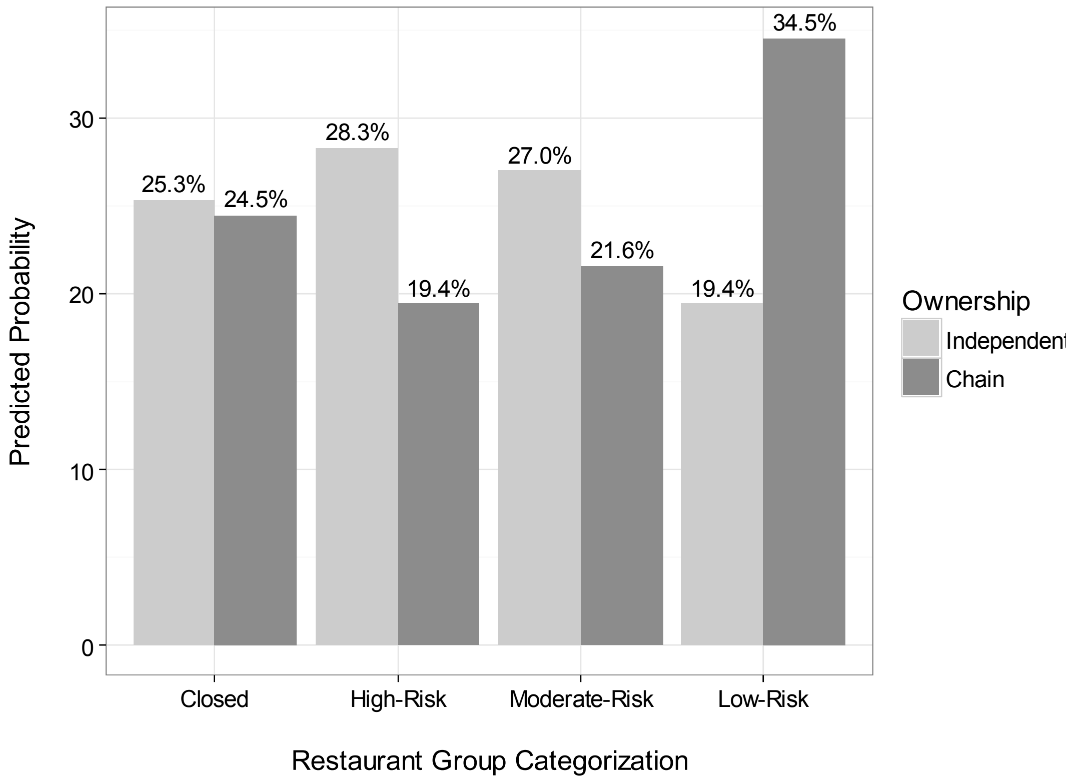

Figure 10. Probabilities of an independent or chain restaurant being categorized in the closed, high, moderate, or low-risk groups.

Research Question 6

Serving greater numbers of menu items may amplify the potential for food handling violations, whereas serving smaller numbers of items may diminish that potential. With this question, I set out to investigate the connection, if any, between the number of menu items and the probability that a restaurant would be temporarily closed or categorized as high risk. The number of menu items was a statistically significant yet relatively weak predictor of membership in these two categories for restaurants in the Fraser Health Authority ($p < 0.001$; $R^2 = 2.473\%$). Full results produced by the multinomial logistic regression are reported in Table K. Only those results relevant for addressing RQ6 are discussed here.

The number of menu items had a significant positive effect on the log-odds of a restaurant in the Fraser Health Authority being temporarily closed versus being categorized as low risk ($p < 0.001$). Thus, greater numbers of menu items increase the likelihood that a restaurant in this authority will be temporarily closed as opposed to categorized as low risk. For each additional menu item, the odds of a restaurant in the Fraser Health Authority being in the temporarily closed group, rather than the low-risk categorized group, increased by 1.5%.

The number of menu items also had a significant positive effect on the log-odds of a restaurant in the Fraser Health Authority being high-risk categorized versus low-risk categorized ($p <0.01$), but this effect was weaker than that reported for temporarily closed restaurants. The odds of a restaurant in the Fraser Health Authority being in the high-risk rather than the low-risk group increased by 0.9% for each additional menu item.

The 376 Fraser Health Authority restaurants included in the multinomial logistic regression model formed two groups: one group for which the typical number of menu items was smaller (i.e., 50), and another group for which the typical number of menu items was larger (i.e., 175). These results are shown in the top panel of Figure 11. Based on the multinomial logistic regression model, the probability of a Fraser Health Authority restaurant with 50 menu items being closed was predicted to be 20.6%, whereas the probability of a Fraser Health Authority restaurant with 175 items being closed was predicted to be nearly twice as high, namely 38.7%. In contrast, the probability of a Fraser Health Authority restaurant with 50 menu items being high-risk categorized was predicted to be 25.7%, and the probability of a Fraser Health Authority restaurant with 175 menu items being high-risk categorized was predicted to be slightly lower, namely 23.1%. These predicted probabilities are displayed in visual form in the bottom panel of Figure 11, and convey the fact that increasing the number of menu items from 50 to 175 was associated with a substantial increase in the probability of a restaurant in the Fraser Health Authority being in the closed group, but associated with a minor decrease in the probability of a restaurant in that same authority being in the high-risk categorized group.

The findings reported above illustrate that the account provided by the estimated odds is different from the description provided by the predicted probabilities. The odds ratios reflect a comparison of odds rather than probabilities. In that capacity, the odds ratio can indicate a positive effect of the number of menu items on the odds of a restaurant being in the high-risk categorized group (versus the low-risk categorized group), even in the presence of decreasing probabilities of a restaurant being in the high-risk categorized group in correspondence with an increased number of menu items. This illustrates a unique situation that can occur with multinomial logistic regression, in that despite increasing odds, probabilities can decrease.

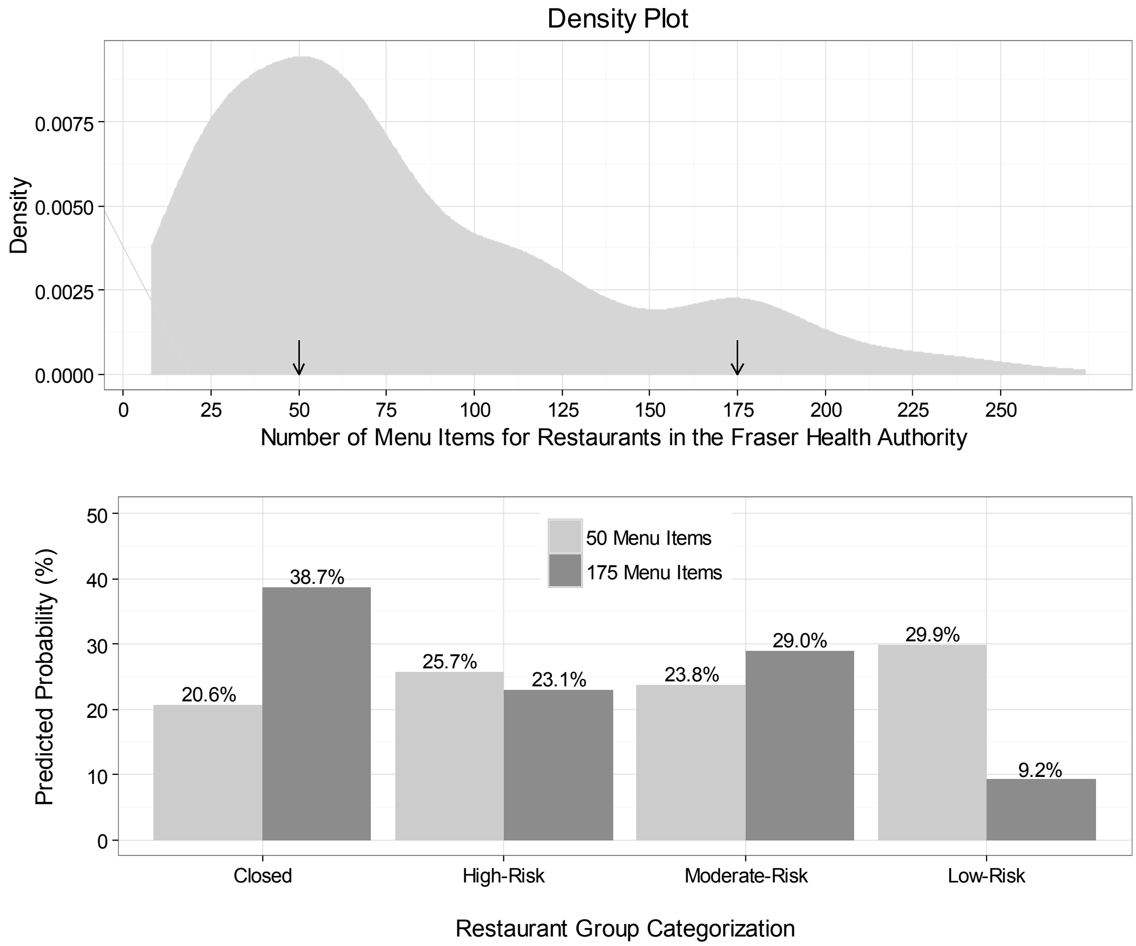

Figure 11. Density plot of the number of menu items (top panel), along with predicted probabilities of restaurants being categorized into each of the four outcome groups.

Summary

There was no evidence in the data that, for the typical restaurant in either health authority, the log average number of overall food handling violations after closure was significantly lower than the log average number of overall food handling violations before closure. Furthermore, after considering one violation at a time, I found no evidence in the data that the log average number of handwashing, sanitizing, refrigeration, and contamination violations per inspection after closure was significantly lower than the log average number of violations per inspection before closure. Tukey's multiple comparisons revealed statistically significant differences between all possible pairs of restaurant groups with respect to the (true) log average number of food handling violations, after controlling for the year effect. My findings showed that type of cuisine served predicted restaurants being closed or categorized as high risk better than type of ownership and number of menu items. Restaurants serving East Asian and Japanese foods were more than twice as likely to be closed, whereas restaurants serving South Asian foods were nearly twice as likely to be high-risk categorized compared to restaurants serving North American/other foods. The probabilities of independent restaurants and chain restaurants being high-risk categorized varied considerably; however, independent restaurants were only slightly more likely to be closed than chain restaurants. Last, greater numbers of menu items modestly increased the likelihood of temporary closure, and, to an even lesser extent, the likelihood of high-risk categorization.

The overall findings related to RQ1 and RQ2 highlight that EHOs should not assume there will be any improvements in food handling practices following temporary restaurant closures in a typical restaurant. Additional interventions are needed at this time in restaurants closed to due to insanitary conditions and improper food handling practices, to change food handler behaviors. RQ3 findings affirm the average number of food handling violations differs in an expected manner between restaurants categorized as high, moderate, and low risk; this also supports the logic behind risk-based inspection programs. The findings related to RQ4 through RQ6 illustrate that restaurant characteristics and inspection findings should be used to prioritize restaurants for targeted food safety communications. In Chapter 5, I discuss my findings in relation to the theoretical frameworks and the findings of other researchers.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

When EHOs issue closure orders, restaurant employees typically work swiftly to address all violations so that they may reopen as soon as possible to minimize the economic effect. In this study, I used data from two British Columbia health authorities to examine whether restaurant employees continued to focus on food safety once closure orders were rescinded. Specifically, one purpose of this study was to determine whether temporary restaurant closures were associated with reductions in food handling violations postclosure in the groups under study. I found no reduction in the average overall number of food handling violations per inspection following temporary restaurant closures. In fact, after closure, a typical restaurant had an 16% increase in the average overall number of food handling violations compared with the number of violations before closure. This finding was true for a typical restaurant irrespective of where that restaurant was located (in the Fraser Health Authority or Vancouver Coastal Health Authority). Specifically, the average numbers of handwashing, sanitizing, and contamination violations after closure were 29%, 15%, and 10% higher, respectively, than before closure for the typical restaurant across the two health authorities. However, the typical restaurant in both health authorities had an average number of refrigeration violations per inspection after temporary closure that was 19% lower than before temporary closure. My overall findings show that temporary restaurant closures, for reasons such as improper food handling practices and insanitary conditions, do not appear to increase food handlers' intentions to perform safe food handling practices, and therefore additional interventions are needed to protect the public's health. As the B.C. Food Premises Regulation only requires one person working in a restaurant to have taken a food safety training course, it is commonplace for food handlers to have limited knowledge of safe food handling practices. One possible intervention would be for EHOs to deliver targeted e-learning food safety resources to restaurant mangers following temporary restaurant closures. In addition to this, EHOs might have all employees who can find a food safety training course in a suitable language take a course.

The second purpose of this study was to determine whether three restaurant characteristics—type of cuisine served, type of ownership, and number of menu items—were a factor in restaurants being temporarily closed or high-risk categorized, for restaurants in the Fraser Health Authority. My findings showed that type of cuisine served (i.e., North American/other, East Asian, Japanese, or South Asian) was a statistically significant predictor of restaurant group categorization ($p < 0.001$) for the group studied. Through multinomial logistic regression modeling, I established that type of ownership (i.e., independent versus chain) was a statistically significant predictor of restaurant group membership (p 0.009). Finally, the number of menu items was a statistically significant predictor of restaurant group membership ($p < 0.001$). Based on my results, I would argue that inspection findings and restaurant characteristics should be used to prioritize restaurants for targeted food safety communications. Specifically, EHOs could provide restaurant employees with e-learning food safety resources at teachable moments, such as after a closure order has been issued or in the event of recurrent food handling violations. Improving restaurant employees' knowledge of safe food handling practices and teaching them how to implement these procedures in their workplaces may challenge complacency and increase employees' perceived behavioral control. It is important to address factors such as perceived behavioral control and subjective norms, as researchers have shown that these are factors that drive food handlers' intentions and actions.

Interpretation of the Findings

Multiple factors and not just food safety knowledge affect whether food handlers perform safe food handling practices. Therefore, there is a need for food safety interventions that do more than provide knowledge. Other factors such as inadequate equipment need to be addressed. I discuss my study findings in this section and link these findings to other research studies to draw conclusions. Studies discussed examined the same types of factors and were conducted in Canada and the United States.

Although temporary restaurant closures may create, in some employees, feelings that they should improve their food handling practices, barriers in the work environment may prove insurmountable. Green and Selman (2005) found that time pressures and problems in the structural environment influenced safe food preparation practices, and Clayton et al. (2015) observed that manager indifference toward proper food safety practices affected behaviors. Moreover, when food handlers do not have their food safety certification (Lee et al., 2013) and do not receive food safety training in their workplaces (Neal et al., 2012), they are less likely to develop intentions to perform food safety practices. Barriers to the performance of safe food handling procedures, such as inadequate food handler knowledge and equipment, are likely responsible for the continuation of unsafe food handling practices following temporary restaurant closures. Any intentions to improve food handling practices created as a result of temporary restaurant closures may be quickly eroded in the face of poorly designed kitchen facilities, inadequate equipment, and insufficient standard operating procedures. Further, manager and coworker indifference to food safety may negatively influence any intentions food handlers have to incorporate food safety practices into their work.

Restaurant characteristics may influence the food safety culture in food service establishments. In the Fraser Health Authority, my findings showed that restaurants serving Japanese cuisine were associated with the highest predicted probability of being closed (36.4%), followed by restaurants serving East Asian cuisines (35.2%), and South Asian cuisine (30.2%). Restaurants serving North American/other cuisine had the lowest predicted probability of being closed, at 16.9%. My study's results confirm other findings that the type of cuisine served in restaurants does influence inspection outcomes (Harris et al., 2015; Kwon, Roberts, Shanklin, Liu, & Yen, 2010; Liu & Lee, 2016; Menachemi et al., 2012; Nadler, 2016). For example, New York City restaurants serving Chinese (Adjusted OR 0.52) and Latin foods (Adjusted OR 0.52) were least likely to receive an A Grade (Nadler, 2016). In Louisiana, researchers studying 769 restaurants determined that ethnic restaurants were 1.74 times more likely than nonethnic restaurants to have critical violations (Liu & Lee, 2016). Liu and Lee (2016) found the mean number of total time/temperature violations for surveyed ethnic restaurants was 0.43 ± 0.84, whereas for nonethnic restaurants the mean number of total time/temperature violations was 0.20 ± 0.66 ($p < 0.001$). In addition, Liu and Lee found the mean number of total cross contamination violations for ethnic restaurants was 0.34 ± 0.82, whereas for nonethnic restaurants the mean number of total cross contamination violations was 0.12 ± 0.50 ($p < 0.001$). Similarly, in Kansas, ethnic restaurants had more critical violations, 4.52 ± 2.97, than nonethnic restaurants, which had 2.90 ± 2.83 ($p < 0.001$). Restaurant inspection scores, whether they are expressed as categories or number or letter grades, reflect numbers of violations and their seriousness. My study's findings may reflect that some types of cuisine involve foods that are more challenging to prepare safely, or that restaurant inspections are having less of an effect on restaurants that serve certain cuisines.

For this study, I obtained data about the type of cuisine served in restaurants from restaurant menus and websites, as British Columbian health authorities do not collect this information. If EHOs did collect data about the type of cuisine served in the restaurants they inspect, a number of reports could be generated; for example, such data would show the numbers of restaurants serving particular types of cuisine and the most common violations in restaurants serving specific types of cuisine (e.g., Japanese). Restaurants might then be prioritized by type of cuisine served and inspection findings for targeted food safety communications.

My findings also showed that, compared to chain restaurants, independent restaurants in the Fraser Health Authority were more likely to be temporarily closed (p 0.040) and high-risk categorized (p 0.002), rather than low-risk categorized. Chain restaurants tend to have fewer critical violations than independent restaurants. Previously, researchers in Florida found significant differences in critical violations between chain restaurants (from the Restaurants and Institutions [R&I] magazine's 2008 Top 400 Restaurants Chains list) (Mean 11.00) and independent restaurants (Mean 12.82, $p < 0.05$), with independent restaurants faring worse than chain restaurants (Murphy et al., 2011). In Louisiana, Liu and Lee (2016) recently found that independent restaurants were 1.64 times more likely than chain restaurants to have critical violations. The mean number of time/temperature violations for independent restaurants was 0.36 ± 0.83, whereas the mean number of time temperature violations for chain restaurants was 0.11 ± 0.44 ($p < 0.001$) (Liu & Lee, 2016). Furthermore, the mean number of cross contamination violations was 0.24 ± 0.68 for independent restaurants, but for chain restaurants it was 0.09 ± 0.46, $p < 0.001$ (Liu & Lee, 2016). The present study confirmed the findings of Murphy et al. (2011) and Liu and Lee (2016). For example, I found the predicted probability of independent restaurants being high-risk categorized to be 28.3%, but the predicted probability of chain restaurants being high-risk categorized was only 19.4%. One implication of having multiple units in chains of restaurants is that food handlers are often expected to follow standardized operating procedures. In addition, chain restaurants tend to have superior kitchen designs and specialized equipment. These factors may particularly contribute to fewer critical violations being found in restaurant chains.

I found that adding the category of number of menu items to my model clearly showed significant effects when this factor was taken into account. For each additional menu item, the odds of a restaurant in the Fraser Health Authority being in the temporarily closed group, rather than the low-risk categorized group, increased by 1.5%.

The odds of a restaurant in the Fraser Health Authority being in the high-risk rather than the low-risk group increased by 0.9% for each additional menu item. In a related study conducted in Iowa, Cates et al. (2009) found that full service restaurants were more likely to have cooling (OR 3.39), cold holding (OR 1.85), hot holding (OR 1.42), and reheating (OR 1.83) critical violations than fast food restaurants. This may be because full service restaurants generally have more menu items than fast food restaurants. In this study, I found that restaurants with more menu items were more likely to be temporarily closed and high-risk categorized rather than low-risk categorized, meaning that those food service establishments had more violations. In restaurants with greater numbers of menu items, more food preparation has to occur simultaneously, and kitchens are rarely adequately designed in ways that support the safe preparation of large quantities of different types of foods. These types of factors outside of food handlers' control must also be addressed to ensure that restaurants can limit their numbers of violations. This will positively affect public safety.

Interpretation of the Findings in the Context of the Theoretical Frameworks

It is perhaps not unexpected that my findings showed temporary restaurant closures were not associated with improvements in food handling behaviors, as this enforcement measure is not likely to increase food handlers' perceived behavioral control or action self-efficacy. Increasing action self-efficacy and perceived behavioral control is believed to be important in translating knowledge into behaviors (Rimal, 2000). According to the theory of planned behavior, increasing food handlers' perceived behavioral control leads to improvements in their intentions to perform safe food handling practices. Similarly, the health action process approach proposes that action self-efficacy, or individuals' beliefs about their capabilities to initiate and maintain behaviors, shapes food handlers' intentions. By consulting behavioral change theories, decision makers can gain insight into possible interventions that could be used in combination with temporary restaurant closures, so that the public's health can be better protected.

Food handler intentions to perform safe food handling practices are influenced by a restaurant's food safety culture and climate. Lee et al. (2013) observed that employees' perceptions of their restaurant's food safety climate (the climate referring to how people feel about food safety) significantly influenced their intentions to follow food safety practices in their workplace. In restaurants where kitchen facilities are not well designed, this may decrease food handlers' behavioral control and self-efficacy beliefs around their abilities to perform safe food handling practices; for example, if there is not an adequate number of sinks, food handlers may believe it is not always possible to thaw foods under cool running water. Similarly, in independent restaurants without well-established standardized operating procedures, food handlers' feelings of perceived social pressure (subjective norm) to perform safe food handling practices, i.e., pressure from managers as well as other employees, may be decreased, leading to a decreased focus on food safety. As I have shown, food handlers' intentions are influenced by restaurant food safety culture and climate and can be understood through the theoretical constructs perceived behavioral control, action self-efficacy, and subjective norm.

Limitations of the Study

The use of secondary data in this study, and particularly, the use of inspection reports, brings potential limitations. I did not interview EHOs to determine approximately how much time they had spent conducting each inspection. It is logical to assume that EHOs who spend less time conducting their inspections will find fewer violations. In addition, the inspection process itself is not without shortcomings. Inspection reports only provide a snapshot of conditions at the time of inspection, which may or may not provide a true representation of broader conditions. Finally, less observable aspects of restaurant operations are rarely mentioned in inspection reports, for example, employees' attitudes about food safety or employees' mindfulness of food safety issues.

The findings of this study depended on the population of restaurants sampled. Data from two British Columbian health authorities were used to answer RQ1 and RQ2. Subsequently, data from one British Columbian health authority were analyzed in RQ3 through RQ6. Due to my focus on temporary restaurant closures for RQ1 and RQ2, I was limited to studying British Columbian health authorities that make their restaurant closures data publicly available. Because data were not included from the First Nations Health Authority, Interior Health Authority, Northern Health Authority, and Vancouver Island Health Authority, it is not possible to generalize the results to all restaurants in British Columbia or beyond. Further studies are needed in other British Columbian health authorities and throughout all Canadian provinces to provide a better understanding of the reliability of these findings. For example, without analyzing data from other regions, it remains to be established whether temporary restaurant closures for reasons such as unsanitary conditions and improper food handling practices are associated with reductions in numbers of other types of food handling violations elsewhere.

Last, data were primarily collected from one or two inspection reports before and after the related temporary restaurant closures. EHO observations made during one or two inspections before and after temporary restaurant closures may present a potentially incomplete picture of the effect of temporary restaurant closures on restaurant employees' food handling practices. These limitations notwithstanding, my study provides evidence that temporary restaurant closures do not automatically lead to improvements in food handling practices postclosure in a typical restaurant, and this necessitates new strategies to protect the public's health.

Future Research

Only a few studies have been conducted in Canada that examine food handling in restaurants. To better understand why temporary restaurant closures were not associated with improvements in food handling practices in the groups studied in this research, qualitative studies are needed to identify underlying barriers in individual restaurants. For example, a survey of restaurant managers might highlight which barriers lead to the continuation of unsafe food handling practices postclosure. In addition, interviews with EHOs working in British Columbia could hone in on whether health authority guidance documents are or are not sufficient to ensure coherent practices. In Finland, Läikkö-Roto, Lundén, Heikkilä, and Nevas (2016) identified that 32.7% of inspectors felt guidance documents were insufficient to ensure coherent practices in health authority units. These same interviews could also assess whether enforcement measures (e.g., administrative penalties, orders) are being used progressively and consistently within and between health authorities.

Although EHOs are quite familiar with the restaurants in their districts with the lowest levels of compliance with food safety regulations, research has not been conducted on underlying commonalities between such restaurants at the health authority or provincial level. Expanding the collection of data about restaurant characteristics, in particular, is of great importance for assessing needs and supporting future research. Researchers also need to look into how inspection results and restaurant characteristics can be used to identify restaurants most in need of food safety interventions, and into how targeted e-learning resources can be delivered to restaurant employees. For example, information about how to cool foods safely and tools available for cooling foods rapidly could be provided, if recurrent cooling violations were observed.

Future researchers should also focus on studying the influence of restaurant characteristics on inspection results and use classification terms more consistently. Canziani et al. (2016) noted that restaurant characteristic classification terms are weakly defined, making studies difficult to compare. For example, the National Restaurant Association categorizes restaurants into five major categories: quick service restaurants, fast casual, midscale, moderate, and fine dining (Canziani et al., 2016). The United States Census Bureau has four categories: full-service restaurants, limited service eating places, special food services, and drinking places (Canziani et al., 2016). Analysts have also introduced new category definitions such as specialty eateries (Canziani et al., 2016). The absence of a standardized scheme for defining restaurants' categories and characteristics has resulted in new definitions being frequently developed and these definitions being used inconsistently in food safety and restaurant management research. With so many definitions in use, the meaning of terms has become unclear, which is detrimental to research about restaurants. To enable comparisons of findings from research conducted in restaurants in Canada and the United States, we need to ensure that we have the same typologies with which to classify restaurants. This is a research priority.

Implications

This study has implications for both EHOs and policy makers. I have created positive social change with this study in addressing EHOs' misconceptions about temporary restaurant closures. The standard perception about temporary restaurant closures is that this enforcement measure will automatically lead to substantial changes in employee behaviors. Ultimately, this fallacy may be hampering the development of strategies that could more effectively influence restaurant employees' food handling practices over the span of their careers. My findings suggest the numbers of restaurant- and employee-related factors contributing to low levels of compliance with food safety regulations are not fully appreciated. Finally, this study highlights that there are opportunities for using e-learning programs to better educate food handlers about food safety. One recommendation I have is for EHOs to deliver targeted e-learning food safety resources after closure orders are issued and at the time of recurrent critical violations.

There is a strong argument to be made for requiring all food handlers to complete a food safety training course after restaurants have been closed due to improper food handling practices and/or unsanitary conditions. One exception might be if food handlers cannot find the course in a suitable language. Food safety training improves knowledge of safe food handling procedures (DeBess et al., 2009; McIntyre et al., 2013), which in turn can result in better practices. In fact, Roberts and Barrett (2009) found that restaurant managers themselves believe that training increases the probability of employees serving safe food. In the absence of regulations that require more than one individual per restaurant to take a food safety training course, it is important for EHOs to provide restaurant employees with targeted e-learning food safety resources. Although such materials would not replace a food safety course, they would certainly improve the chances of employees making better decisions around food handling and food safety. In situations where only one restaurant employee has taken a food safety course, it is challenging for EHOs to impress upon staff the need for reform of unsafe food handling practices. Neither a temporary restaurant closure nor the fear of another restaurant closure appear to motivate food handlers to perform safe food handling practices.

Although health authorities do not typically track numbers of menu items, my findings do indicate that tracking this information would be useful in terms of policy development. One suggestion would be that if food handling practices do not improve in restaurants following temporary restaurant closures, in addition to requiring that employees take a food safety training course, environmental health managers might require a reduction in problematic menu items.

In many instances, EHOs may not know whether restaurants are independent or part of a small chain, as health authorities do not track this information. Although many independent restaurants are well run, others are not. According to my research findings, high-risk categorized independent restaurants located in the Fraser Health Authority would benefit from targeted food safety communications. One goal in implementing targeted food safety communications would be to increase restaurant managers' familiarity with food safety regulations. If critical violations were found to be more frequent in restaurants serving particular types of cuisine, broader educational initiatives could be taken at the health authority level, such as providing targeted e-learning food safety resources. Such educational food safety interventions would be aimed at reducing food handling violations associated with the preparation of specific food products.

Conclusion

In this research, I found no reduction in the average overall number of food handling violations per inspection following temporary restaurant closures. In fact, there was a 16% increase in the average overall numbers of food handling violations per inspection after temporary restaurant closure compared to before temporary restaurant closure. The implications for policy makers are that temporary restaurant closures may not influence food handler behaviors even over the short term. For restaurants closed due to unsanitary conditions and/or improper food handling practices, combinations of interventions are likely needed to change restaurant employee behaviors. Two interventions at the policy level might include having all food handlers who can find a food safety training course in a suitable language take a course, and environmental health managers requiring restaurants to stop preparing the foods that they have repeatedly been found to not prepare safely. Although these are two policies that might decrease the risks of potential foodborne hazards, other interventions are also needed to increase food handlers' intentions to perform safe food handling practices.

I found that restaurants serving East Asian, Japanese, and South Asian foods had a greater predicted probability of being closed or high-risk categorized than restaurants serving North American/other foods. Meanwhile, the predicted probability of independent restaurants being high-risk categorized was 28.3% compared to 19.4% for chain restaurants. Last, the predicted probability of restaurants with 175 menu items being closed was 38.7%, while the predicted probability of a restaurant with 50 menu items being closed was 20.6%. My findings show that both restaurant characteristics and inspection findings should be used to prioritize restaurants for food safety communications. Above all, new teaching resources are needed that EHOs can use during inspections, particularly for food handlers whose first language is not English.

Thus, in terms of future policy-making, EHOs need to become more involved in advancing the field of environmental public health through evaluating food safety intervention policies. EHOs should not assume temporary restaurant closures will affect food handler behaviors once closure orders are rescinded. Instead, EHOs should provide e-learning food safety resources and support restaurant action planning so that it will be easier for food handlers to carry out their intentions. An approach that focuses on proactive strategies to prevent foodborne illness is needed, rather than an approach that concentrates on determining the causes of outbreaks retroactively.

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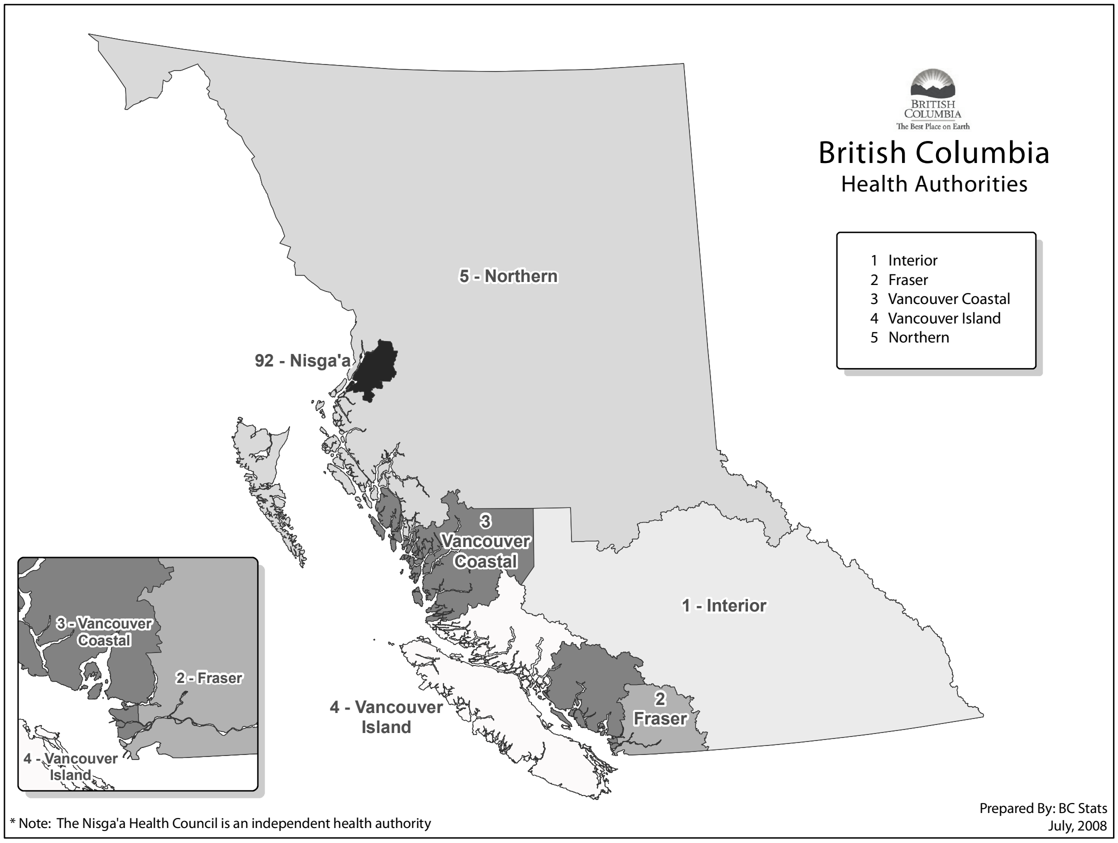
Appendix A: Map of Health Authority Boundaries, British Columbia



Source: Government of British Columbia, BC Stats, retrieved from http://www.bcstats.gov.bc.ca/StatisticsBySubject/Geography/ReferenceMaps/Health.aspx.

Appendix B: Prewritten Food Safety Violation Comments

Violation Categories	Frequently Used Environmental Health Officer Comments
Contamination	Food stored directly on floor Food not protected from contamination Food not stored off of floor Food stored in a manner that promotes cross contamination Food not properly covered and protected from contamination Food in contact with non-corrosion resistant or toxic materials
Handwashing	Adequate handwashing stations not available for employees Employee does not wash hands properly or at adequate frequency Handwashing stations not properly supplied and maintained Handwashing station obstructed or being used for other purposes Employees are not washing hands as often as necessary to prevent contamination of foods
Food Safety Management	Refrigeration units and hot holding equipment lack adequate thermometers A food safety plan is not developed Temperature records are not being used to monitor critical limits An accurate thermometer is not provided for temperature monitoring
Sanitizing	Equipment/utensils/food contact surfaces not properly washed and sanitized Equipment/utensils/food contact surfaces not maintained in sanitary condition Sanitizing solution is not present or is at insufficient concentration Mechanical dishwasher does not provide sufficient washing and/or sanitizing action to remove contamination Wiping cloths are not clean, restricted in use, and/or stored in a approved sanitizing solution

(table continues)

Violation Categories	Frequently Used Environmental Health Officer Comments
Refrigeration	Cold potentially hazardous food stored/displayed above 4°C (40°F) Potentially hazardous food not stored, displayed, or transported at a temperature of 4°C (40°F) or colder
Training	In operator's absence no staff on duty has FOODSAFE© level 1 or equivalent No employee present holds a valid FOODSAFE© or equivalent certificate when the operator is absent
Cooling	Food not cooled in an acceptable manner Potentially hazardous food not cooled using appropriate equipment and or approved methods Potentially hazardous food not cooled from 60°C (140°F) to 21°C (70°F) within 2 hours and then from 21°C (70°F) to 4°C (40°F) within 4 hours
Hot Holding	Hot potentially hazardous food stored displayed below 60°C (140°F) Potentially hazardous food not stored or displayed at 60°C (140°F) or above
Thawing	Food not thawed in an acceptable manner Potentially hazardous food not thawed using appropriate equipment and/or approved methods

Appendix C: Overall Food Handling Violations

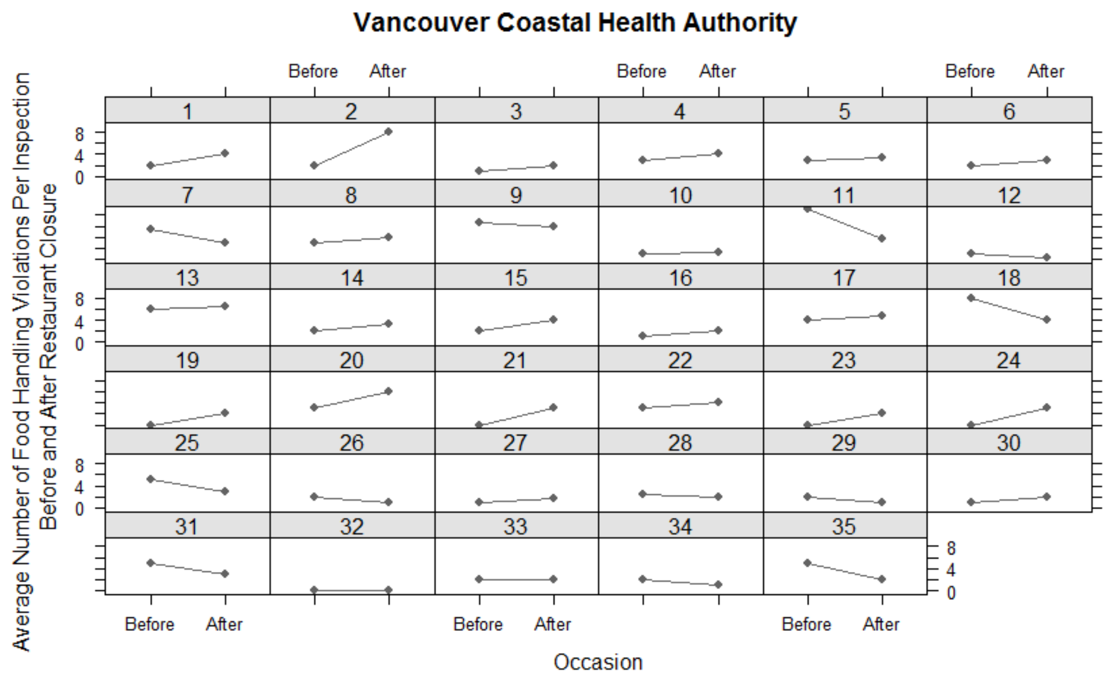


Figure C1. Average number of overall food handling violations per inspection before and after temporary restaurant closures, Vancouver Coastal Health Authority.

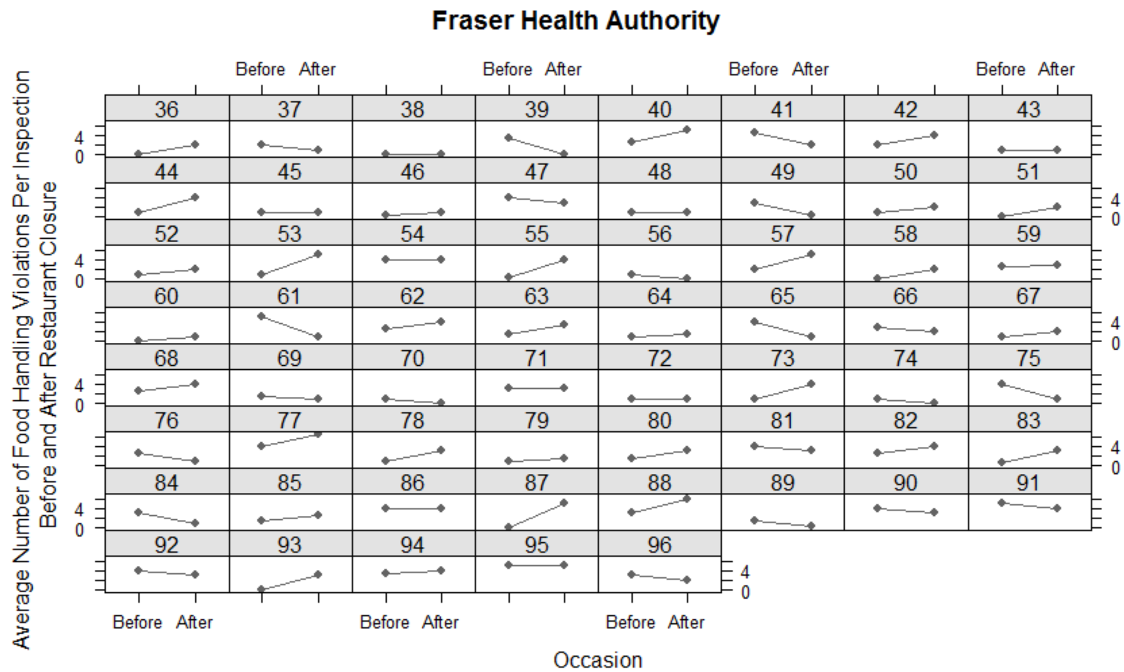


Figure C2. Average number of overall food handling violations per inspection before and after temporary restaurant closures, Fraser Health Authority.

Table C1

Summary Outputs for the Overall Food Handling Violations Data

	Model											
Item	glmer.1				glmer.2				glmer.3			
Fixed Effects	*Estimate*	*Std. Error*	*z-value*	*P-value*	*Estimate*	*Std. Error*	*z-value*	*P-value*	*Estimate*	*Std. Error*	*z-value*	*P-value*
Intercept	0.727	0.075	9.659	<0.001	0.887	0.108	8.224	<0.001	0.944	0.119	7.935	<0.001
Occasion	0.158	0.077	2.042	<0.05	0.147	0.078	1.893	0.0583	0.051	0.118	0.434	0.6646
Health Authority	-	-	-	-	-0.242	0.123	-1.966	<0.05	-0.334	0.149	-2.234	<0.05
Occasion × Health Authority	-	-	-	-	-	-	-	-	0.167	0.156	1.070	0.2844
Random Effect	*Variance*		*Standard Deviation*		*Variance*		*Standard Deviation*		*Variance*		*Standard Deviation*	
Restaurant	0.206		0.453		0.188		0.433		0.186		0.432	
Model Fit Information												
Number of Observations	192				192				192			
Number of Restaurants	96				96				96			
AIC	837.246				835.544				836.425			
Marginal R-Squared	0.013				0.039				0.046			
Conditional R-Squared	0.430				0.424				0.427			

Notes. 1. Occasion was treated as a factor with two levels: before temporary closure (treated as a reference level) and after temporary closure.
2. Health Authority was treated as a factor with two levels: Vancouver Coastal Health (treated as a reference level) and Fraser Health Authority.
3. Occasion × Health Authority denotes the interaction between Occasion and Health Authority.
4. Estimated fixed effects of Occasion, Health Authority, and their interaction are expressed on the log scale, but become more easily interpretable after exponentiation.

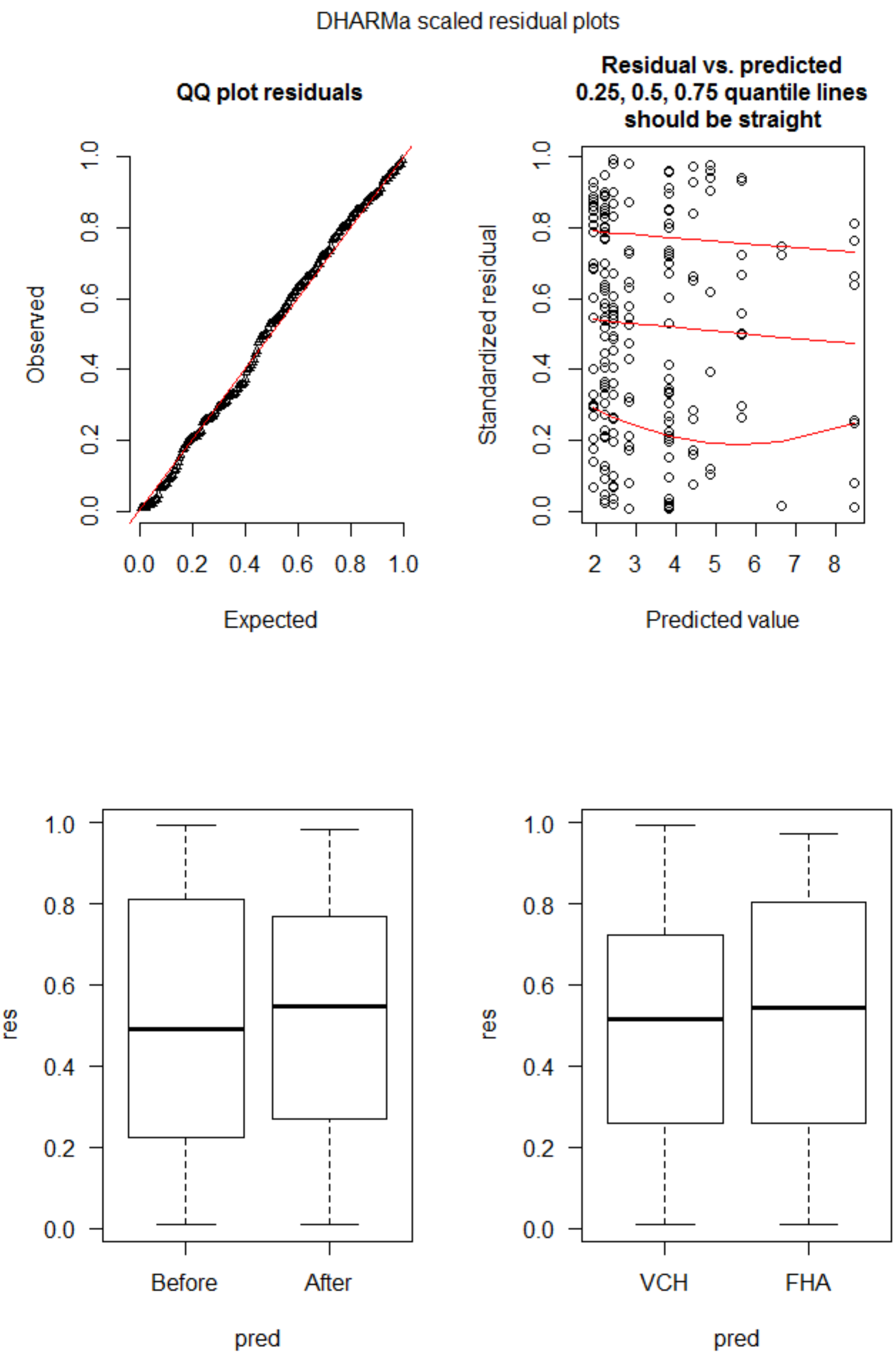


Figure C3. Glmer.2 model diagnostics for overall food handling violations.

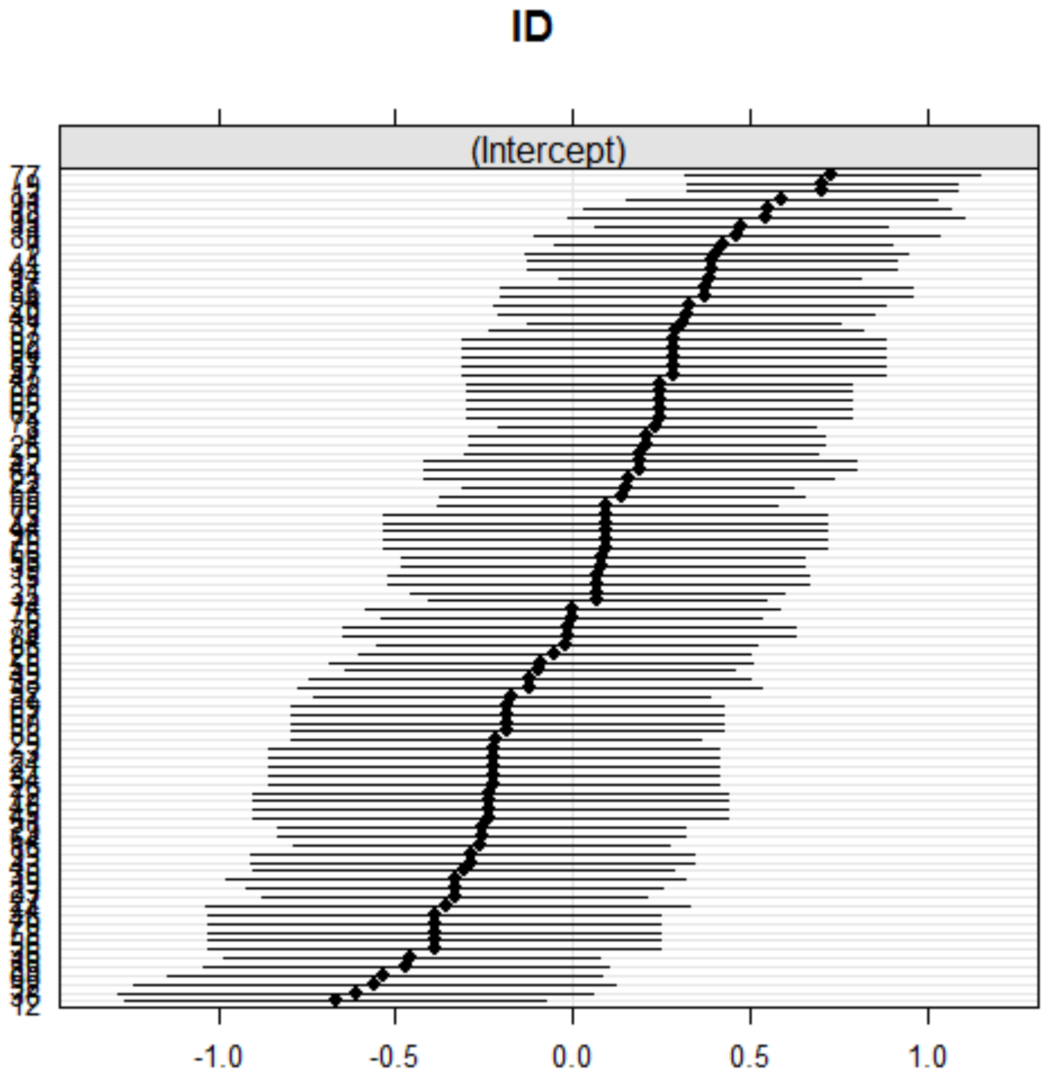


Figure C4. Glmer.2 Caterpillar plot for overall food handling violations.

Appendix D: Handwashing Violations

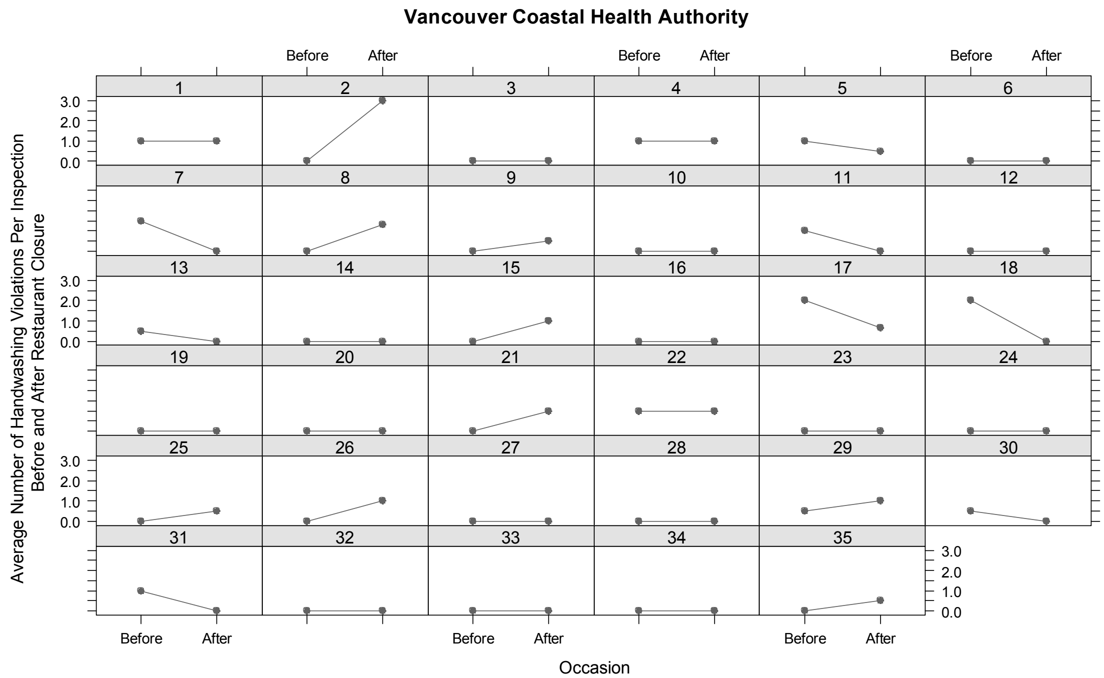


Figure D1. Average number of handwashing violations per inspection before and after temporary restaurant closures, Vancouver Coastal Health Authority.

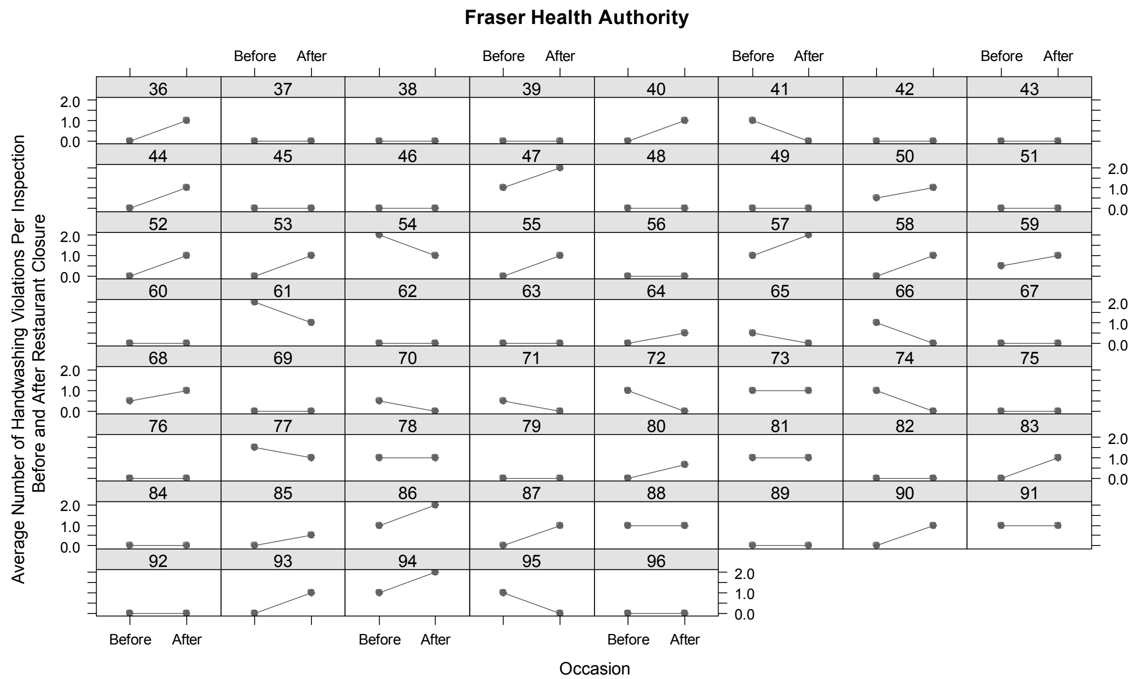


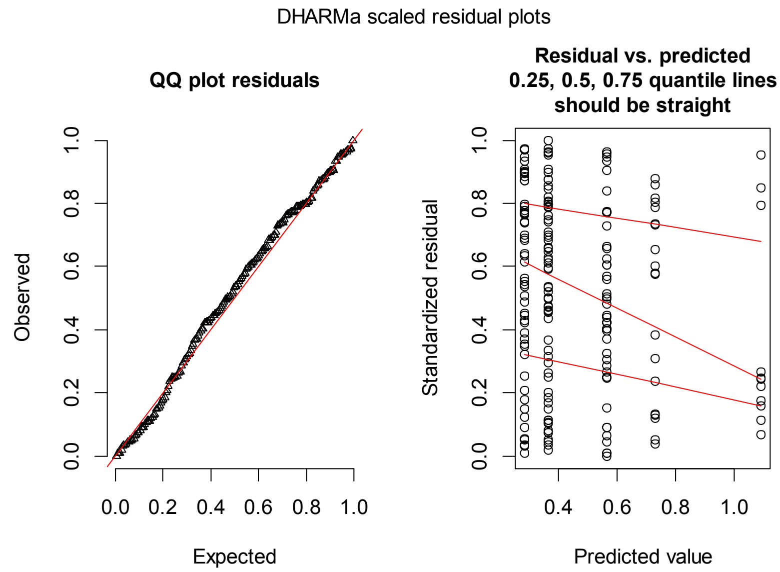
Figure D2. Average number of handwashing violations per inspection before and after temporary restaurant closures, Fraser Health Authority.

Table D1

Summary Outputs for the Handwashing Violations Data

	Model for Handwashing Violations											
Item	glmer.1				glmer.2				glmer.3			
Fixed Effects	*Estimate*	*Std. Error*	*z-value*	*P-value*	*Estimate*	*Std. Error*	*z-value*	*P-value*	*Estimate*	*Std. Error*	*z-value*	*P-value*
Intercept	-1.265	0.181	-6.981	<0.001	-1.331	0.250	-5.329	<0.001	-1.111	0.283	-3.933	<0.001
Occasion	0.254	0.198	1.282	0.2	0.261	0.199	1.315	0.188	-0.106	0.331	-0.319	0.750
Health Authority	-	-	-	-	0.100	0.252	0.396	0.692	-0.220	0.337	-0.654	0.513
Occasion × Health Authority	-	-	-	-	-	-	-	-	0.562	0.413	1.362	0.173
Random Effect	*Variance*		*Standard Deviation*		*Variance*		*Standard Deviation*		*Variance*		*Standard Deviation*	
Restaurant	0.405		0.636		0.402		0.634		0.393		0.627	
Model Fit Information												
Number of Observations	192				192				192			
Number of Restaurants	96				96				96			
AIC	384.772				386.614				386.777			
Marginal R-Squared	0.010				0.012				N/A			
Conditional R-Squared	0.270				0.270				N/A			

Notes. 1. Occasion was treated as a factor with two levels: before temporary closure (treated as a reference level) and after temporary closure.
2. Health Authority was treated as a factor with two levels: Vancouver Coastal Health (treated as a reference level) and Fraser Health Authority.
3. Occasion × Health Authority denotes the interaction between Occasion and Health Authority.
4. Estimated fixed effects of Occasion, Health Authority, and their interaction are expressed on the log scale, but become more easily interpretable after exponentiation.



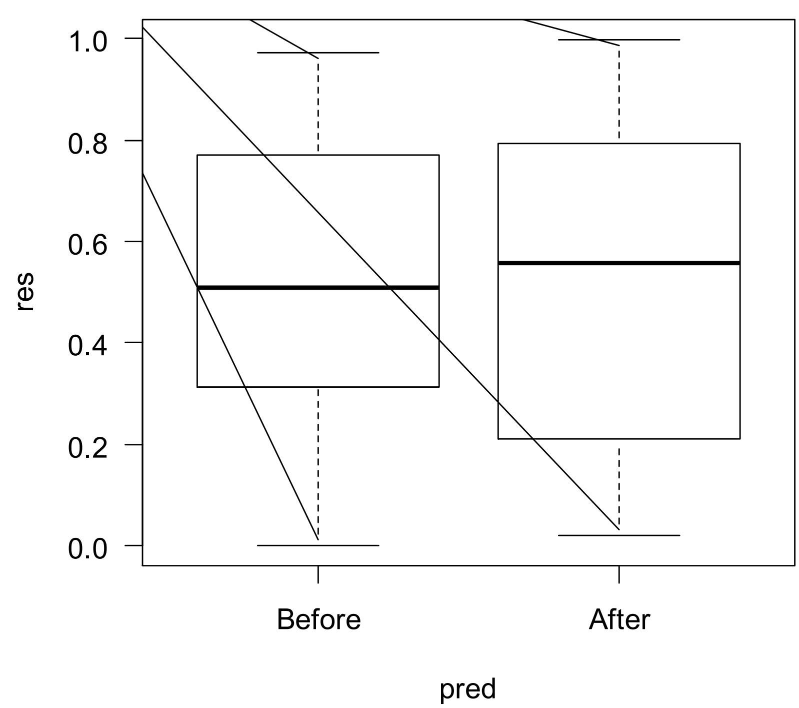


Figure D3. Glmer.1 model diagnostics for handwashing violations.

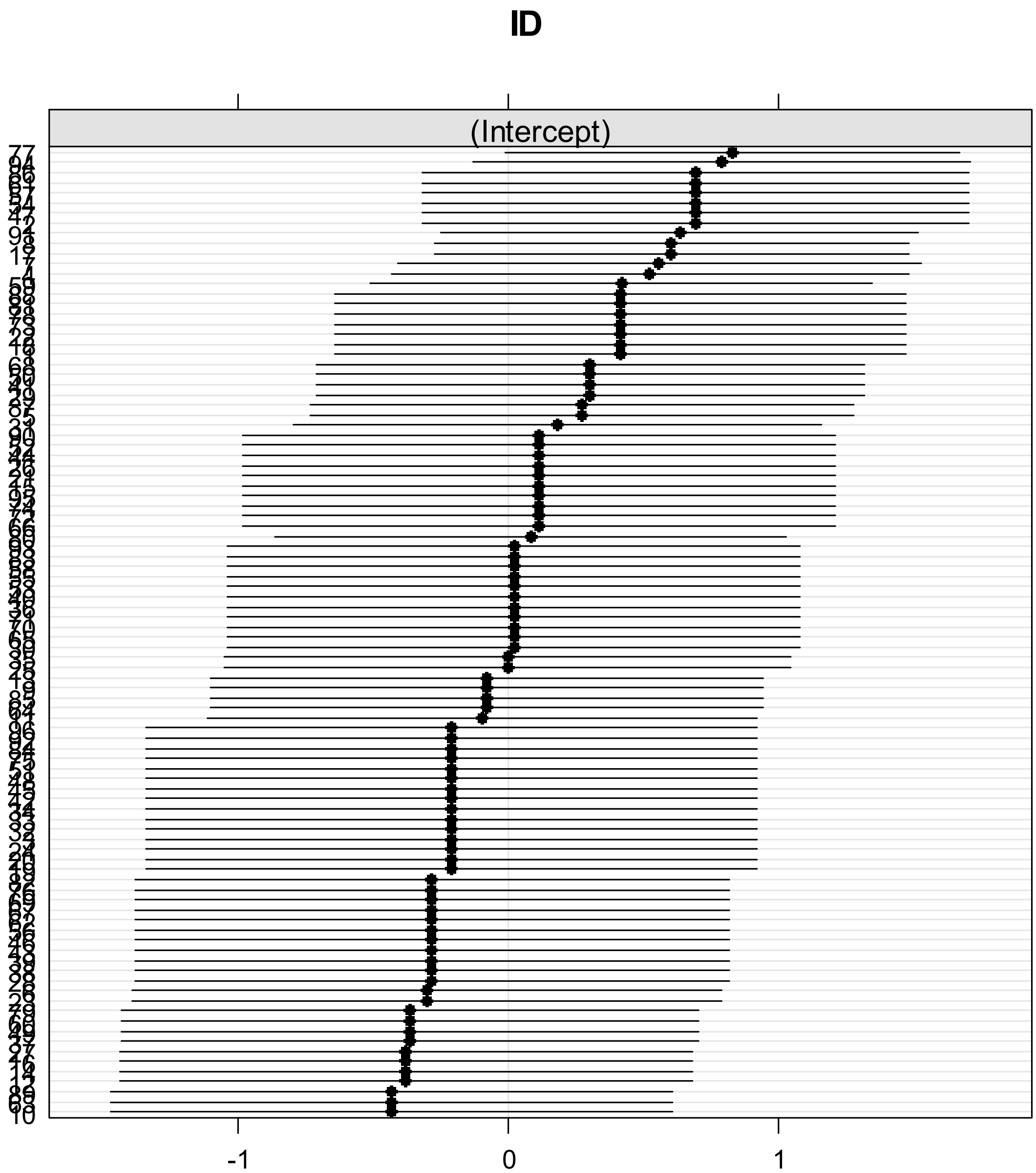


Figure D4. Glmer.1 Caterpillar plot for handwashing violations.

Appendix E: Sanitizing Violations

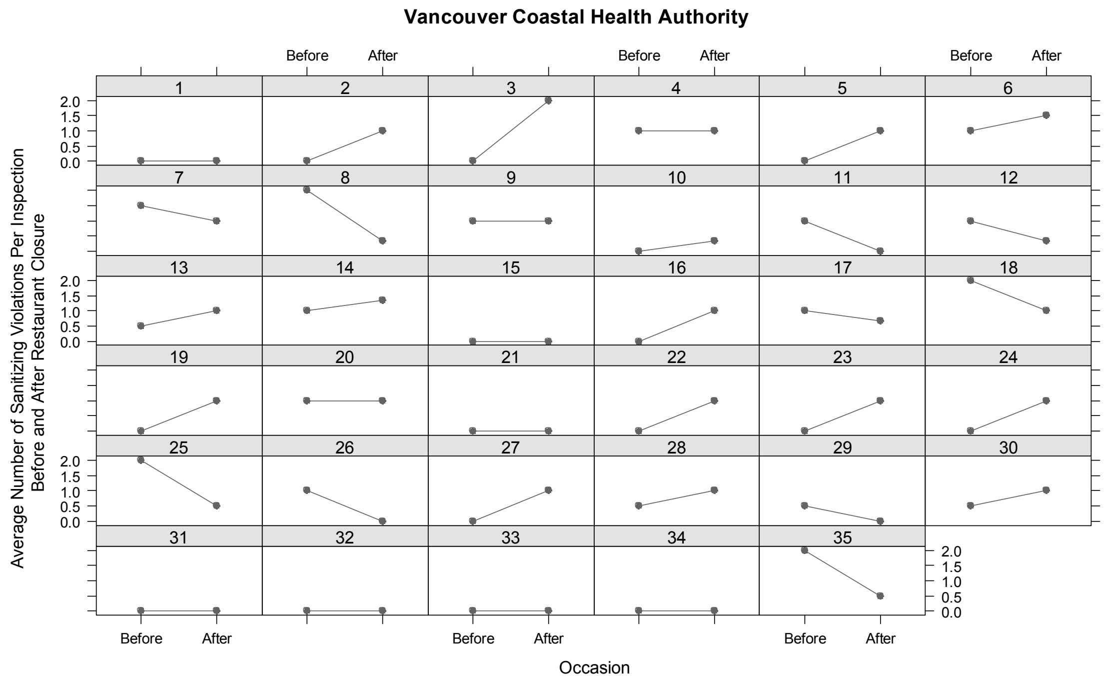


Figure E1. Average number of sanitizing violations per inspection before and after temporary restaurant closures, Vancouver Coastal Health Authority.

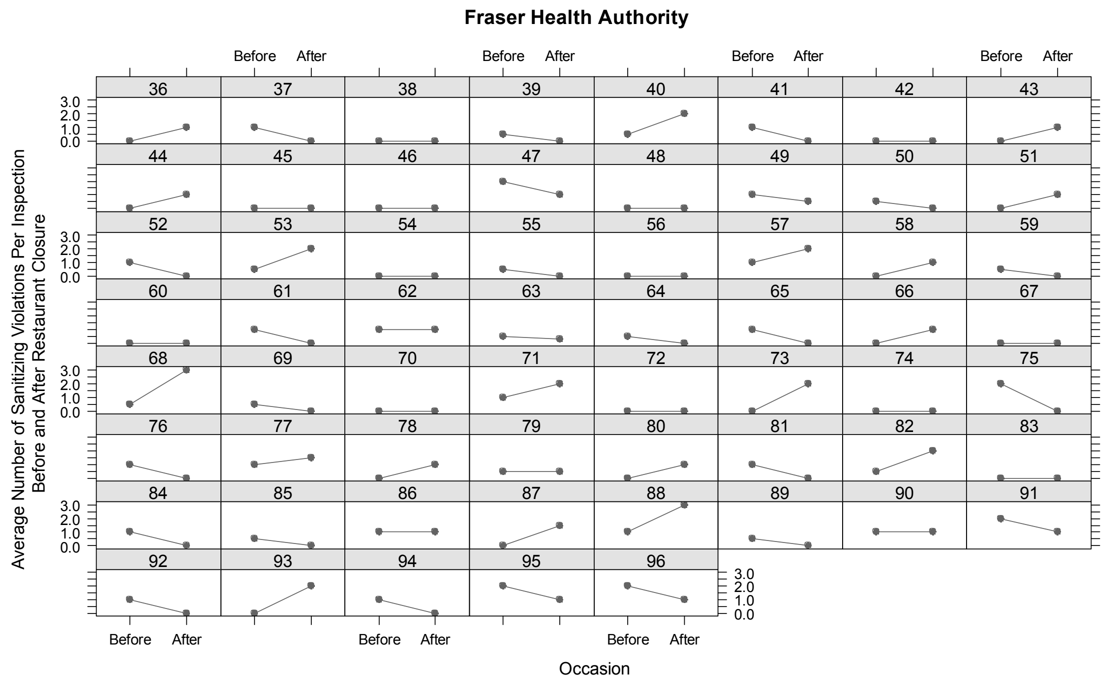


Figure E2. Average number of sanitizing violations per inspection before and after temporary restaurant closures, Fraser Health Authority.

Table E1

Summary Outputs for the Sanitizing Violations Data

Item	Model for Sanitizing Violations											
	glmer.1				glmer.2				glmer.3			
Fixed Effects	*Estimate*	*Std. Error*	*z-value*	*P-value*	*Estimate*	*Std. Error*	*z-value*	*P-value*	*Estimate*	*Std. Error*	*z-value*	*P-value*
Intercept	-0.585	0.113	-5.166	<0.001	-0.523	0.156	-3.346	<0.001	-0.542	0.200	-2.712	<0.01
Occasion	0.142	0.156	0.915	0.36	0.130	0.157	0.830	0.406	0.162	0.254	0.637	0.524
Health Authority	-	-	-	-	-0.091	0.160	-0.566	0.571	-0.062	0.243	-0.256	0.798
Occasion × Health Authority	-	-	-	-	-	-	-	-	-0.051	0.323	-0.157	0.875
Random Effect	*Variance*		*Standard Deviation*		*Variance*		*Standard Deviation*		*Variance*		*Standard Deviation*	
Restaurant	0		0		0		0		0		0	
Model Fit Information												
Number of Observations	192				192				192			
Number of Restaurants	96				96				96			
AIC	459.079				460.760				462.736			
Marginal R-Squared	N/A											
Conditional R-Squared	N/A											

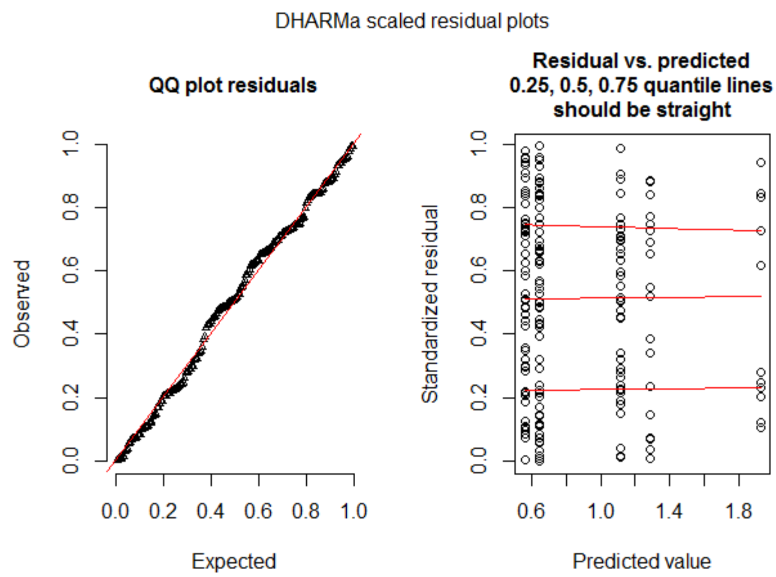
Notes. 1. Occasion was treated as a factor with two levels: before temporary closure (treated as a reference level) and after temporary closure.
2. Health Authority was treated as a factor with two levels: Vancouver Coastal Health (treated as a reference level) and Fraser Health Authority.
3. Occasion × Health Authority denotes the interaction between Occasion and Health Authority.
4. The marginal and conditional R-squared values could not be computed in light of the fact that the estimated variances of the random restaurant effects were equal to 0 in all three models.

Table E2

Results for the glm.1 Model

	Model for Sanitizing Violations			
Item	glm.1			
Fixed Effects	*Estimate*	*Std. Error*	*z-value*	*P-value*
Intercept	-0.585	0.113	-5.166	<0.0001
Occasion	0.142	0.156	0.915	0.36
Model Fit Information				
Number of Observations	192			
AIC	457.08			
R-Squared (McFadden)	0.038			

Notes. 1. Occasion was treated as a factor with two levels: before temporary closure (treated as a reference level) and after temporary closure.
2. The estimated effect of Occasion is expressed on the log scale, but can be re-expressed via exponentiation on the natural scale: exp(0.142) = 1.15.
3. The effect of Occasion on the natural scale can be converted to a percent increase in the average number of sanitizing violations after temporary closure compared to before closure using the following calculation: (1.15-1) x100% = 15% increase.



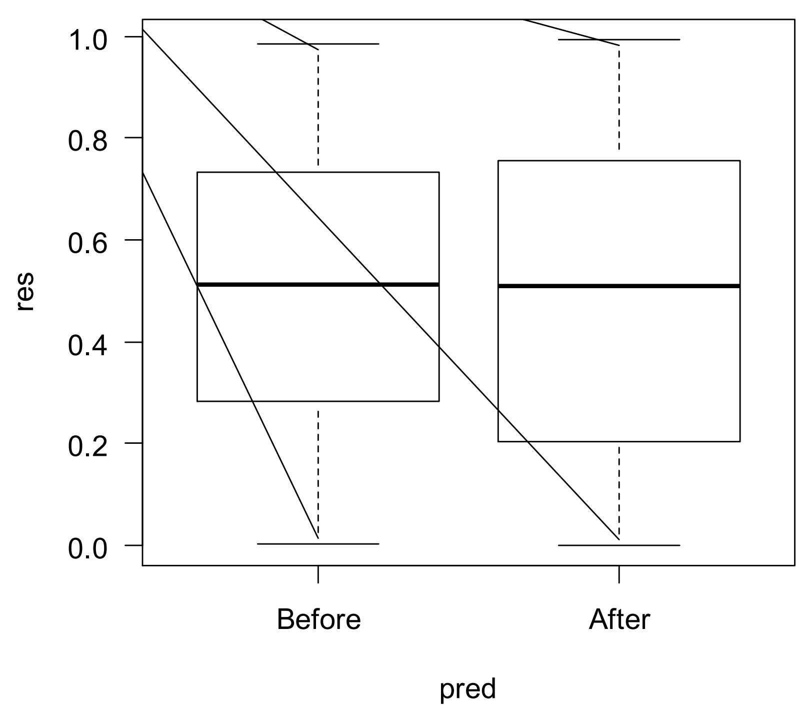


Figure E3. Glm.1 model diagnostics for sanitizing violations.

Appendix F: Contamination Violations

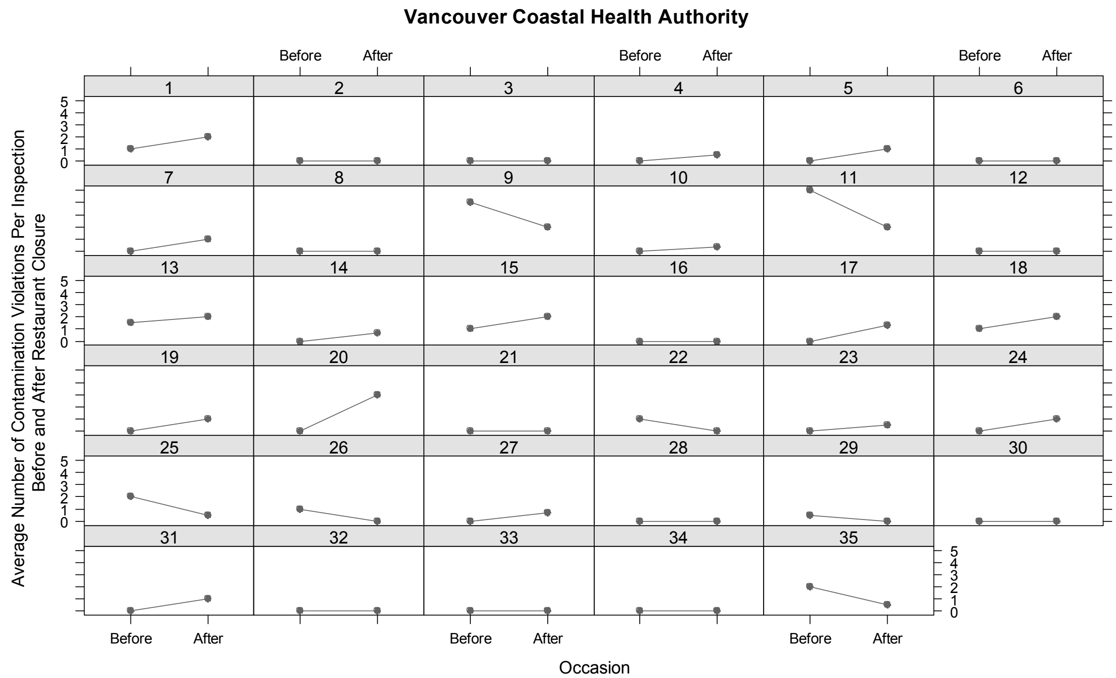


Figure F1. Average number of contamination violations per inspection before and after temporary restaurant closures, Vancouver Coastal Health Authority.

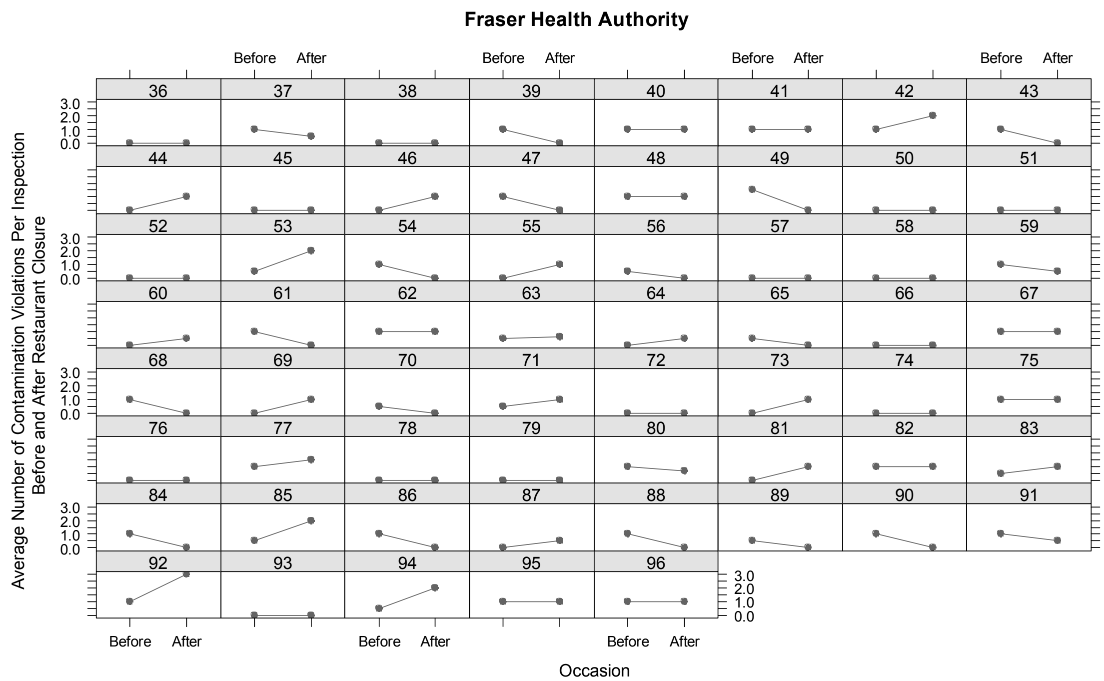


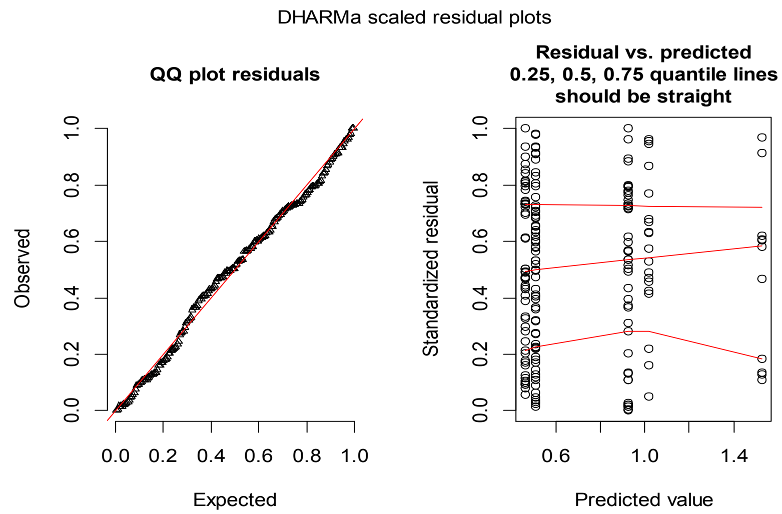
Figure F2. Average number of contamination violations per inspection before and after temporary restaurant closures, Fraser Health Authority.

Table F1

Summary Outputs for the Contamination Violations Data

	Model for Contamination Violations											
Item	glmer.1				glmer.2				glmer.3			
Fixed Effects	*Estimate*	*Std. Error*	*z-value*	*P-value*	*Estimate*	*Std. Error*	*z-value*	*P-value*	*Estimate*	*Std. Error*	*z-value*	*P-value*
Intercept	-0.771	0.143	-5.398	<0.001	-0.706	0.205	-3.441	<0.001	-0.752	0.239	-3.150	0.002
Occasion	0.096	0.159	0.602	0.547	0.089	0.160	0.557	0.578	0.166	0.252	0.656	0.512
Health Authority	-	-	-	-	-0.094	0.215	-0.438	0.662	0.024	0.280	-0.085	0.932
Occasion × Health Authority	-	-	-	-	-	-	-	-	-0.129	0.327	-0.394	0.694
Random Effect	*Variance*		*Standard Deviation*		*Variance*		*Standard Deviation*		*Variance*		*Standard Deviation*	
Restaurant	0.358		0.599		0.349		0.591		0.349		0.591	
Model Fit Information												
Number of Observations	192				192				192			
Number of Restaurants	96				96				96			
AIC	457.495				459.306				461.150			
Marginal R-Squared	0.002				0.003				0.004			
Conditional R-Squared	0.281				0.276				0.277			

Notes. 1. Occasion was treated as a factor with two levels: before temporary closure (treated as a reference level) and after temporary closure.
2. Health Authority was treated as a factor with two levels: Vancouver Coastal Health (treated as a reference level) and Fraser Health Authority.
3. Occasion × Health Authority denotes the interaction between Occasion and Health Authority.
4. Estimated fixed effects of Occasion, Health Authority and their interaction are expressed on the log scale, but become more easily interpretable after exponentiation.
5. The estimated effect of occasion after controlling for the random restaurant effect is expressed on the log scale but can be re-expressed on the natural scale via exponentiation exp(0.096)=1.10. The effect can be further converted to a 10 percent increase in the average number of violations after temporary restaurant closure compared to before closure via the following calculation (1.10-1)x100=10%.



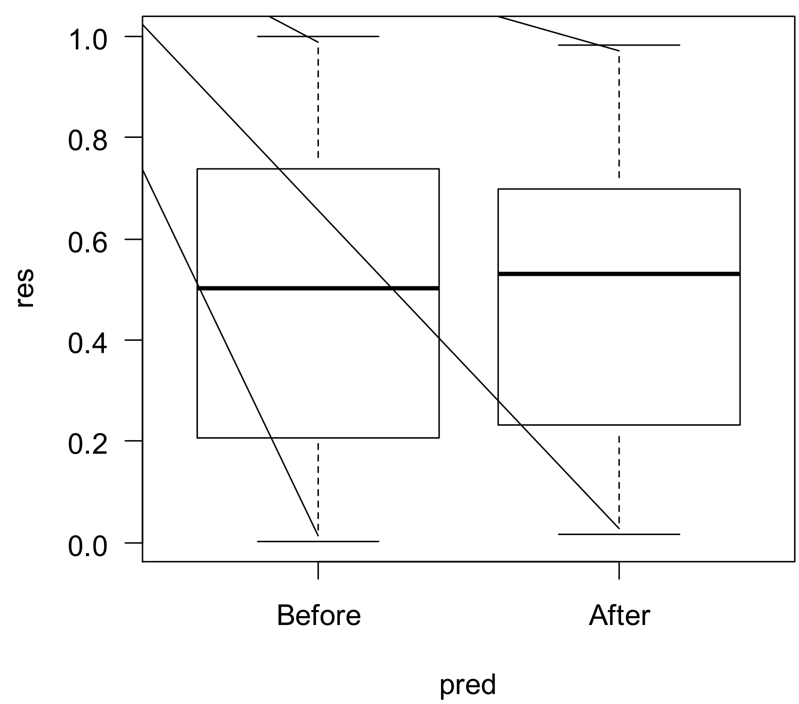


Figure F3. Glmer.1 model diagnostics for contamination violations.

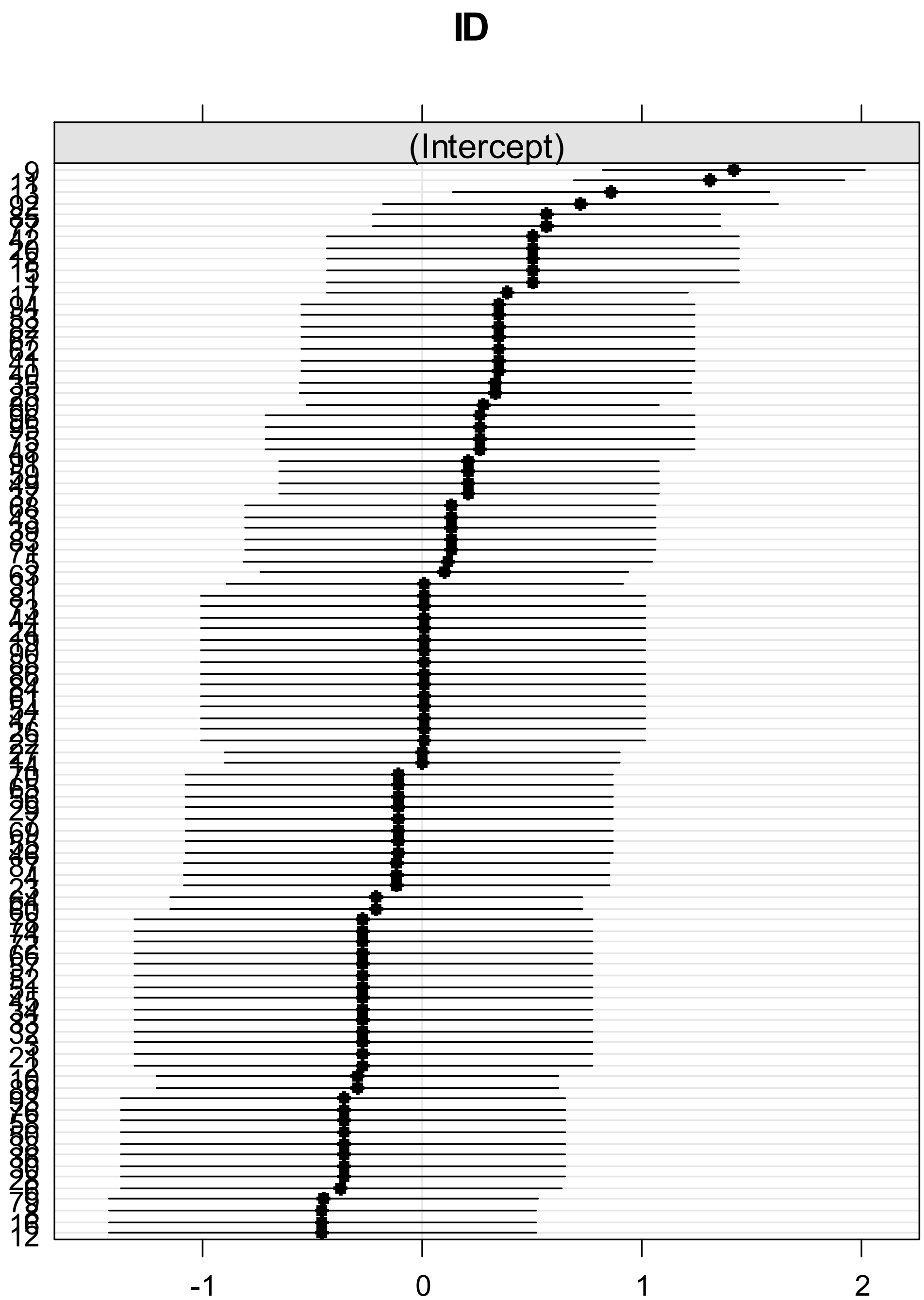


Figure F4. Glmer.1 Caterpillar plot for contamination violations.

Appendix G: Refrigeration Violations

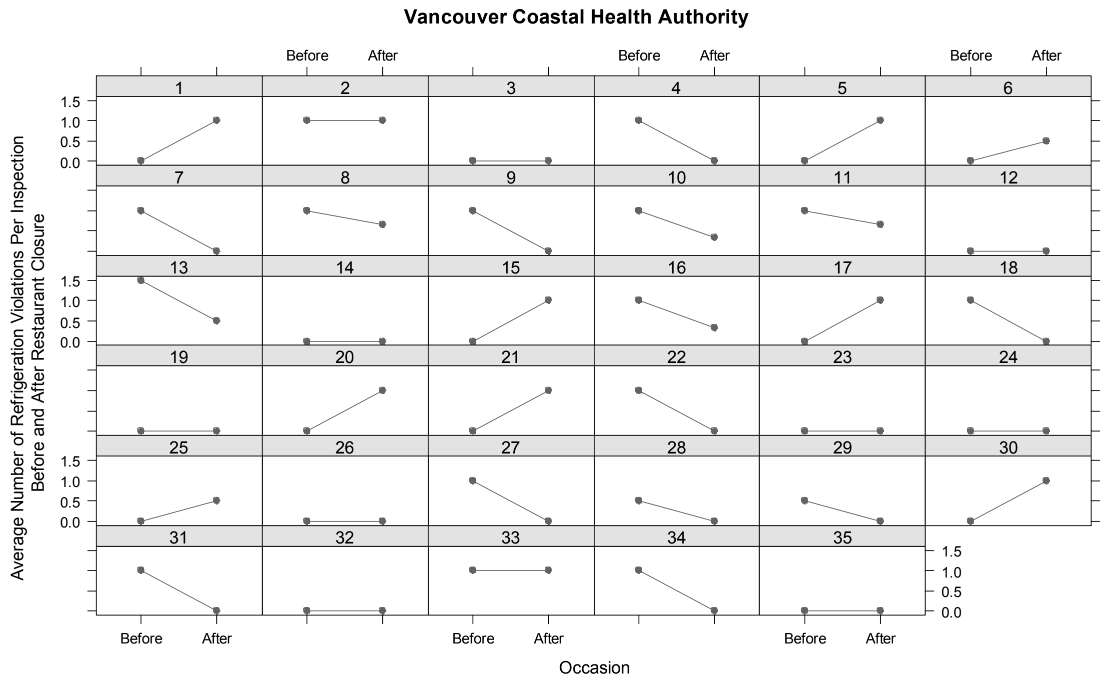


Figure G1. Average number of refrigeration violations per inspection before and after temporary restaurant closures, Vancouver Coastal Health Authority.

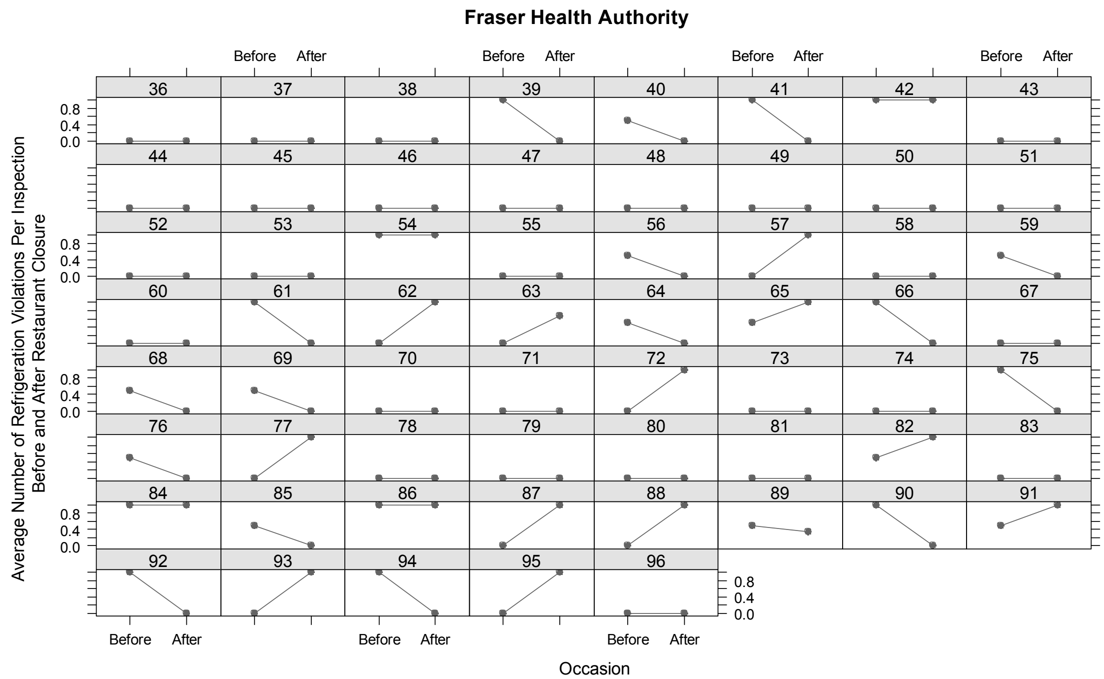


Figure G2. Average number of refrigeration violations per inspection before and after temporary restaurant closures, Fraser Health Authority.

Table G1

Summary Outputs for the Refrigeration Violations Data

	Model for Refrigeration Violations											
Item	glmer.1				glmer.2				glmer.3			
Fixed Effects	*Estimate*	*Std. Error*	*z-value*	*P-value*	*Estimate*	*Std. Error*	*z-value*	*P-value*	*Estimate*	*Std. Error*	*z-value*	*P-value*
Intercept	-1.030	0.141	-7.281	<0.001	-0.730	0.188	-3.890	<0.001	-0.626	0.209	-3.00	<0.01
Occasion	-0.153	0.209	-0.730	0.466	-0.216	0.211	-1.024	0.306	-0.424	0.302	-1.405	0.160
Health Authority	-	-	-	-	-0.468	0.211	-2.218	0.027	-0.653	0.284	-2.302	0.021
Occasion × Health Authority	-	-	-	-	-	-	-	-	0.404	0.419	0.963	0.336
Random Effect	*Variance*		*Standard Deviation*		*Variance*		*Standard Deviation*		*Variance*		*Standard Deviation*	
Restaurant	1.238e-15		3.519e-08		6.841e-15		8.271e-08		0		0	
Model Fit Information												
Number of Observations	192				192				192			
Number of Restaurants	96				96				96			
AIC	334.260				331.412				332.488			
Marginal R-Squared	0.005				0.053				N/A			
Conditional R-Squared	0.005				0.053				N/A			

Notes. 1. Occasion was treated as a factor with two levels: before temporary closure (treated as a reference level) and after temporary closure.

2. Health Authority was treated as a factor with two levels: Vancouver Coastal Health (treated as a reference level) and Fraser Health Authority.

3. Occasion × Health Authority denotes the interaction between Occasion and Health Authority.

4. Estimated fixed effects of Occasion, Health Authority and their interaction are expressed on the log scale but become more easily interpretable after exponentiation.

5. The estimated effect of Occasion controlling for health authority and random restaurant effect is expressed on the log-scale but can be re-expressed on the natural scale via exponentiation: exp(-0.216) = 0.81. The effect can be further converted to a 19% percent decrease in the average number of violations after temporary closure compared to before closure via the following calculation: (0.81-1)x100% = -19%.

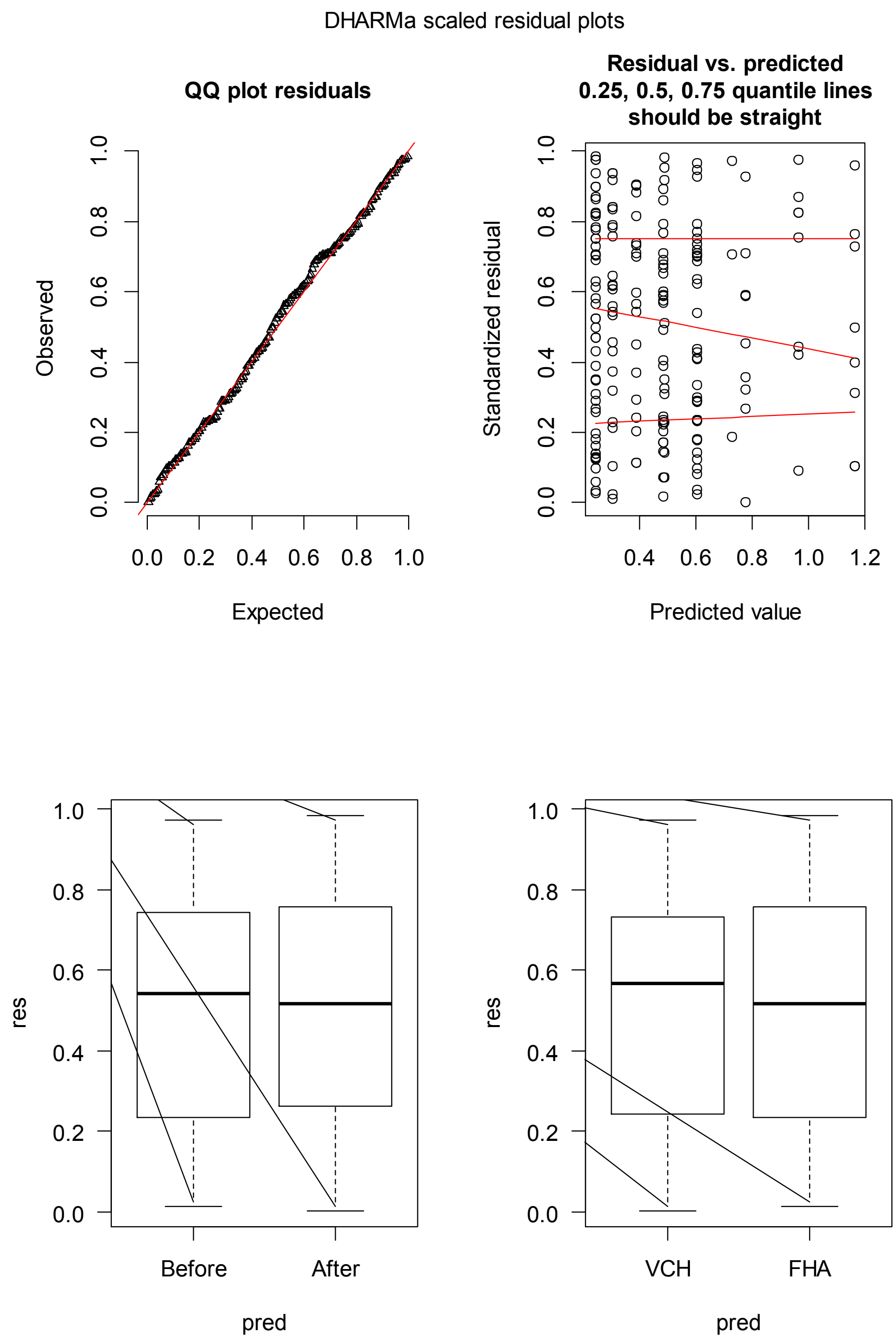


Figure G3. Glmer.2 model diagnostics for refrigeration violations.

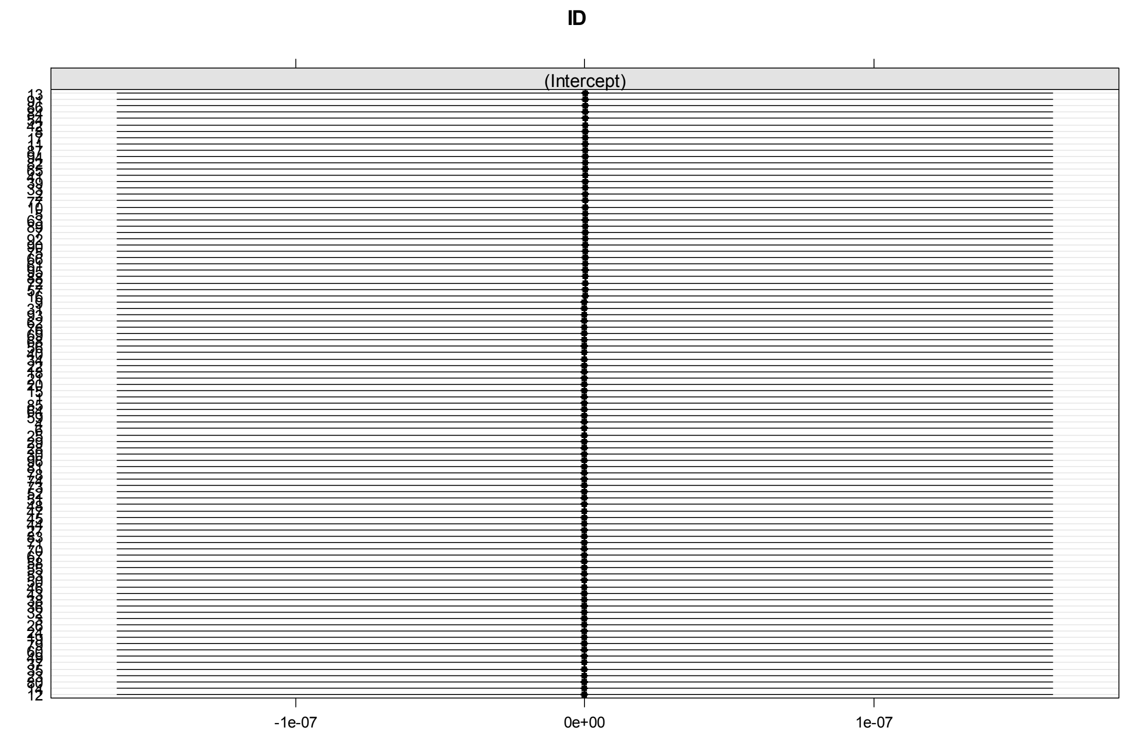


Figure G4. Glmer.2 Caterpillar plot for refrigeration violations.

Appendix H: Differences in Average Food Handling Violations for Restaurant Groups

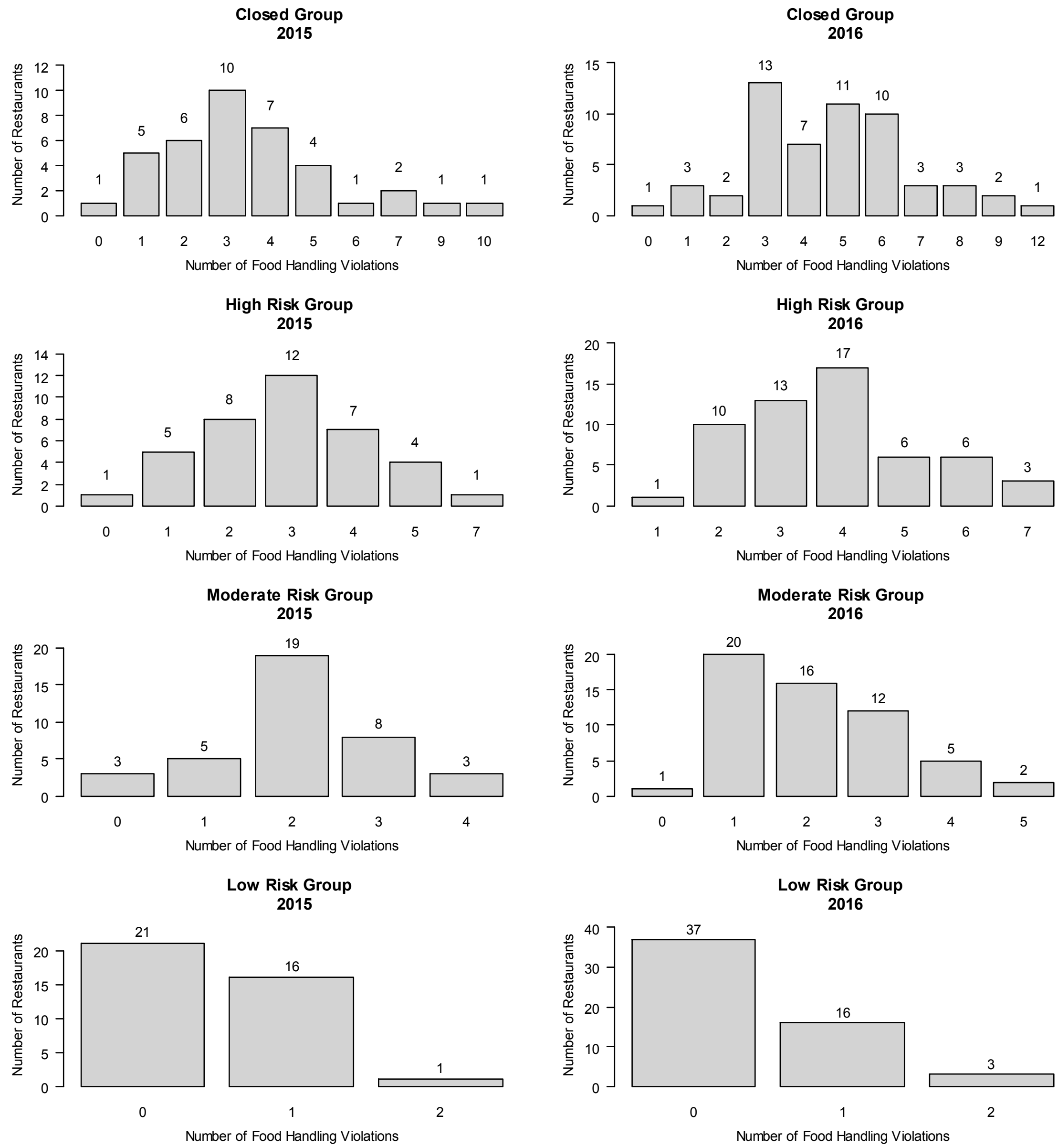


Figure H1. Frequency distributions depicting the number of food handling violations documented in the closed, high, moderate, and low-risk groups.

Table H1

Summary Outputs for RQ3 Expressed on the Natural Scale

Model Term	GLM1		GLM2		GLM3	
	Exp(B)	95% CI	Exp(B)	95% CI	Exp(B)	95% CI
Intercept	0.426	0.307-0.571	0.375	0.268 - 0.510	0.474	0.287 - 0.727
Risk Group						
Closed	9.950	7.287-13.985	9.950	7.287 - 13.985	7.444	4.681 - 12.597
High	8.175	5.965-11.523	8.175	5.965 - 11.523	6.222	3.886 - 10.579
Moderate	4.925	3.548-7.014	4.925	3.548 - 7.014	4.389	2.696 - 7.552
Low	Ref	Ref	Ref	Ref	Ref	Ref
Year						
2016	-	-	1.225	1.07 - 1.40	0.829	0.445 - 1.564
2015	Ref	Ref	Ref	Ref	Ref	Ref
Risk Group x Year						
Closed *x* Year 2016	-	-	-	-	1.612	0.828 - 3.104
High *x* Year 2016	-	-	-	-	1.571	0.801 - 3.046
Moderate *x* Year 2016	-	-	-	-	1.222	0.611 - 2.422
Model Fit Information						
Residual Deviance	320.77		311.55		307.43	
Residual Degrees of Freedom	372		371		368	
AIC	1217.220		1209.997		1211.879	
Pseudo R-Squared (McFadden)	0.2390		0.2448		0.2474	

Notes. 1. *B* is used to denote estimated model coefficients for the Poisson regression models on the log scale.

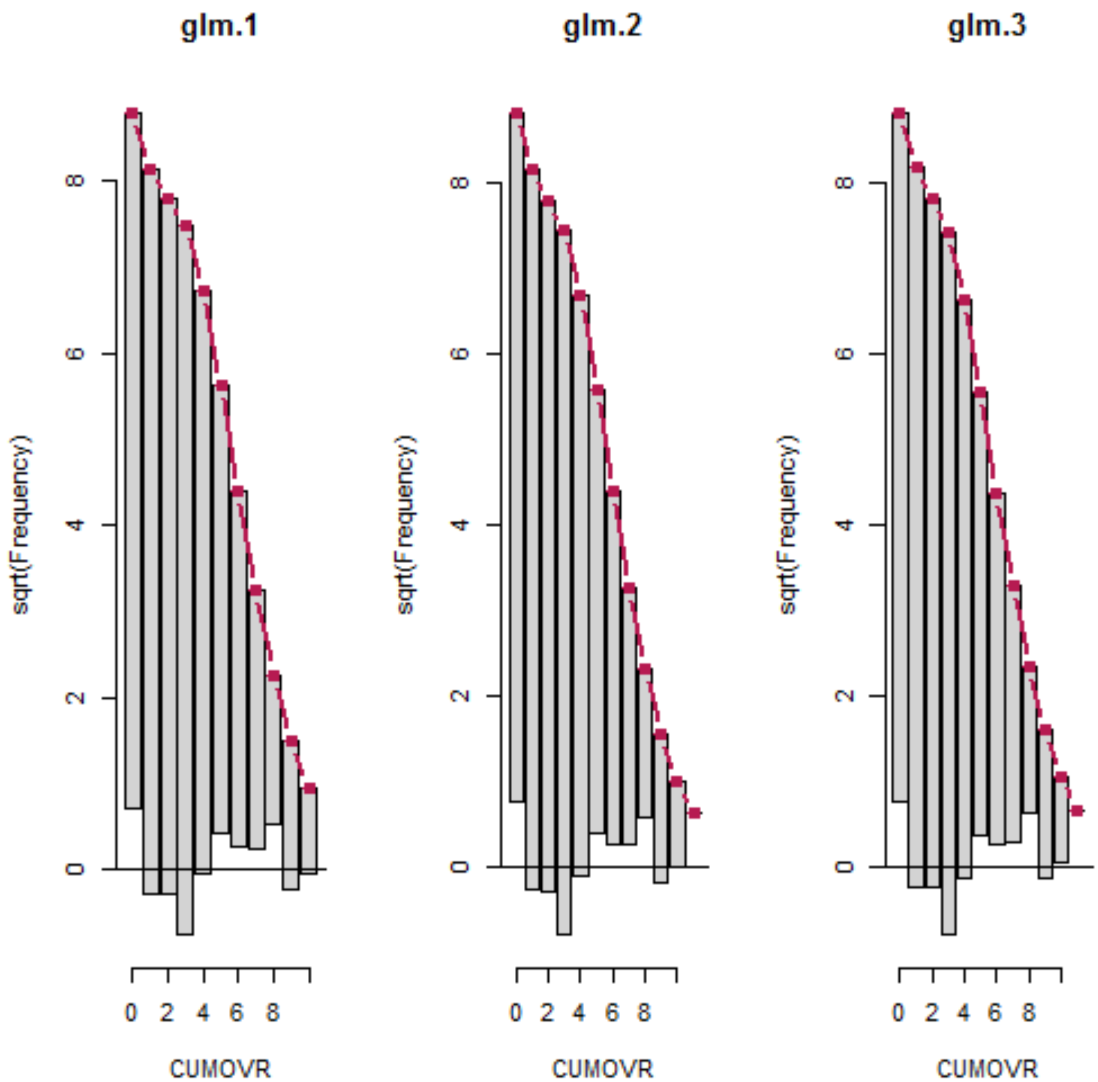


Figure H2. Rootograms for GLM1, GLM2 and GLM3.

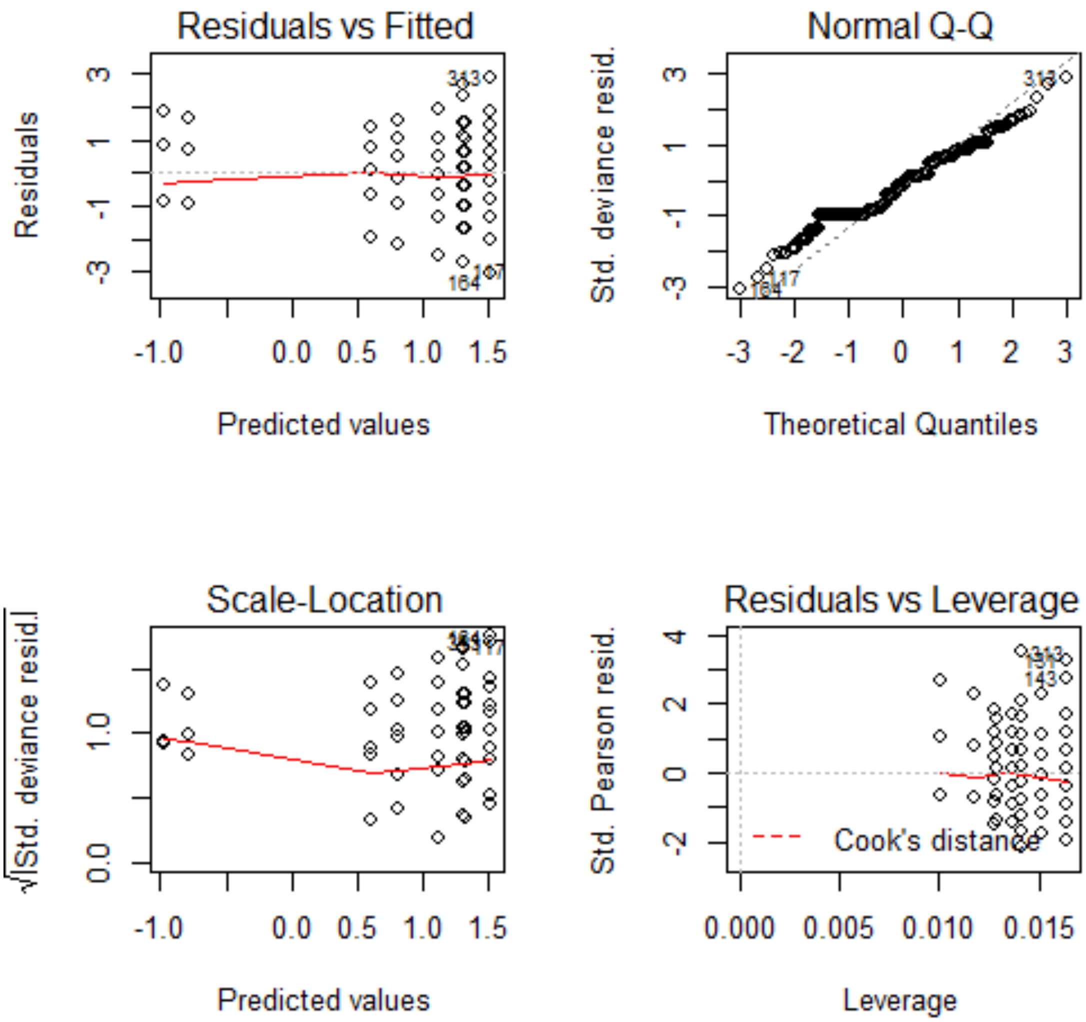


Figure H3. Model diagnostics for glm.2.

Appendix I: Results of the Multinomial Regression Analysis Relating Restaurant Group to Cuisine Type

	Closed vs. Low Risk				High vs. Low Risk				Moderate vs. Low-Risk			
	Log-Odds Scale		*Odds Ratio Scale*		*Log-Odds Scale*		*Odds Ratio Scale*		*Log-Odds Scale*		*Odds Ratio Scale*	
Variable	B	SE	OR	95% CI	B	SE	OR	95% CI	B	SE	OR	95% CI
Intercept	-0.830***	0.205	0.44	0.29-0.65	-0.693***	0.196	0.50	0.34-0.73	-0.445*	0.181	0.64	0.45-0.91
Cuisine Type												
North American/ other	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
East Asian	2.318***	0.466	10.16	4.07-25.34	2.005***	0.469	7.43	2.96-18.62	1.677***	0.466	5.35	2.14-13.34
Japanese	2.504***	0.662	12.24	3.34-44.77	2.159**	0.670	8.67	2.33-32.21	1.831**	0.670	6.24	1.68-23.22
South Asian	1.603**	0.535	4.97	1.74-14.17	1.674**	0.517	5.33	1.93-14.70	0.732	0.570	2.08	0.68-6.35

Notes. 1. B = coefficient, SE = standard error, OR = odds ratio, CI = confidence interval

2. The dependent variable, restaurant group has 4 categories: Low-Risk, Moderate-Risk, High-Risk, and Closed. The Low-Risk category was treated as the reference category.

*p< .05, **p< .01, *** .001

Appendix J: Results of the Multinomial Regression Analysis Relating Restaurant Group to Type of Ownership

	Closed vs. Low-Risk				High vs. Low Risk				Moderate vs. Low-Risk			
	Log-Odds Scale		*Odds Ratio Scale*		*Log-Odds Scale*		*Odds Ratio Scale*		*Log-Odds Scale*		*Odds Ratio Scale*	
Variable	B	SE	OR	95% CI	B	SE	OR	95% CI	B	SE	OR	95% CI
Intercept	-0.345	0.224	0.71	0.46-1.10	-0.575*	0.240	0.56	0.35-0.90	-0.470*	0.233	0.62	0.40-0.99
Ownership												
Chain	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Independent	0.610*	0.298	1.8	1.03-3.30	0.951**	0.307	2.59	1.42-4.73	0.800**	0.302	2.23	1.23-4.03

Notes. 1. B= coefficient, SE= standard error, OR= odds ratio, CI= confidence interval
2. The outcome variable, restaurant group has 4 categories: Low-Risk, Moderate-Risk, High-Risk, and Closed. The Low-Risk was treated as the reference category.
*p< .05, **p< .01, *** .001

Appendix K: Results of the Multinomial Regression Analysis Relating Restaurant Group to Number of Menu Items

	Closed vs. Low-Risk				High vs. Low-Risk				Moderate vs. Low-Risk			
	Log-Odds Scale		*Odds Ratio Scale*		*Log-Odds Scale*		*Odds Ratio Scale*		*Log-Odd Scale*		*Odds Ratio Scale*	
Variable	B	SE	OR	95% CI	B	SE	OR	95% CI	B	SE	OR	95 % CI
Intercept	-1.097***	0.274	0.33	0.19-0.57	-0.580*	0.261	0.56	0.33-0.93	-0.780**	0.265	0.46	0.27-0.77
No. of Menu Items	0.014***	0.003	1.01	1.01-1.02	0.008**	0.003	1.01	1.00-1.01	0.011***	0.003	1.01	1.00-1.02

Notes. 1. B= coefficient, SE= standard error, OR= odds ratio, CI= confidence interval

2. The outcome variable, restaurant group has 4 categories: Low-Risk, Moderate-Risk, High-Risk, and Closed. The Low-Risk was treated as the reference category.

*p< .05, **p< .01, *** .001

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