Neighborhood Effects on Restaurant Food Safety Performance

A Dissertation

Submitted on the Twenty-Second Day of August, 2016

To the Department of Global Health Management and Policy

In Partial Fulfillment of the Requirements

Of the School of Public Health and Tropical Medicine

Of Tulane University

For the Degree of

Doctor of Science

By

Adam J. Kramer

APPROVED: [Signature]
Joni Steinberg, PhD  Date

APPROVED: [Signature]
John Lefante, PhD  Date

APPROVED: [Signature]
Valerie Yeager, DrPH  Date

APPROVED: [Signature]
David Ludwig, MPH  Date
Gratitude

I would like to thank the faculty, staff, and other members of my cohort at Tulane. Through this experience I have met an exceptional group of individuals, who have not only taught me new skills, but have expanded the way in which I view potential research questions. I would like to especially thank the members of my committee: Dr. Joni Steinber; Dr. John Lefante; Dr. Valerie Yeager; and Mr. David Ludwig for their support and guiding me through this endeavor. Mr. Ludwig deserves special acknowledgement for providing my initial entry into Public Health and vision of what Environmental Health can be.

I also would like to thank my caring and supportive wife, Monique, who always provided support even when she had no idea what I was talking about. Without her support and prodding I know I would not be the person I am today. Lastly, I would like to thank Casi and Koko, whose indomitable spirit is a model for all of us.
Abstract

There are an estimated 48 million cases of foodborne illness per annum in the United States, with a majority of the illnesses associated with eating in a restaurant. Previous research into the causes of foodborne illness have primarily focused on factors that are internal to the restaurant. This research examines both internal components as well as external factors from the surrounding community that could influence how a food establishment operates.

Inspection data, providing the basis for this analysis, came from routine inspection reports from Maricopa County, Arizona and the State of Florida. Additional evaluations are from randomly sampled restaurants, containing information on the occurrence of specific risk factors for foodborne illness, captured from States A and B. External community demographic data from the U.S. Census Bureau’s American Community Survey was also used.

The routine inspection data was analyzed using a general estimating equations approach, and the risk factor study data was analyzed via a tobit regression. This approach allowed for the identification of the specific variables and their relative effect on the food safety performance of the establishment.

The only external factor to have an influence on restaurant food safety performance was the level of market competition, both near the restaurant and at a further distance from the restaurant. Other socio-demographic variables of the area were not found to have a significant effect. Internal factors, such as the level of food-handling and the food-safety related training held by employees were found to have an effect on the restaurants food safety performance.

This study has shown the utility in assessing the compliance status of each risk factor, and the limitations of only using a count of violations. Additionally, concordant with most facilities operating in a sanitary manner, large sample sizes are required to identify an effect from a covariate.
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Maricopa County Routine Inspections

Y1 - Inspection score

Y2 - Total Critical violations

Y3 - Total Non-Critical violations

Y4 - Total violations

Y5 - Risk Factor - Supervision

Y6 - Risk Factor - Employee Health

Y7 - Risk Factor - Good Hygienic Practices

Y8 - Risk Factor - Protection from contamination from hands

Y9 - Risk Factor - Approved Source

Y10 - Risk Factor - Protection from Contamination

Y11 - Risk Factor - Potentially Hazardous Food

Y12 - Risk Factor - Consumer Advisory

Y13 - Risk Factor - Highly Susceptible Populations

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Florida Routine Inspections

Y2 - Total Critical violations

Y3 - Total Non-critical violations
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Chapter 1. Background and Significance

The Centers for Disease Control and Prevention (CDC) estimates that there are 48 million cases of domestically acquired foodborne illness annually in the United States, resulting in 128,000 hospitalizations, and 3,000 deaths (Scallan, Griffin, Angulo, Tauxe, & Hoekstra, 2011; Scallan, Hoekstra, et al., 2011). A review of reported foodborne outbreaks found that 52% of the outbreaks were associated with dining in a restaurant (Jones & Angulo, 2006), and the National Restaurant Association (NRA) reports that a growing number of meals are being eaten in restaurants. The NRA reports that 49% of every food dollar is being spent in a restaurant, and over 130 million meals a day are being consumed (2010). The economic impacts of foodborne illness are difficult to calculate due to a wide number of variables, the operation of illness surveillance systems, and the amount of direct and indirect costs (Buzby & Roberts, 2009). However, Scharff has estimated the cost of acute foodborne illness for direct medical care and loss of quality of life in the United States at $152 billion annually (2010). This may be an underestimate as it fails to account for other societal costs including costs to industry for loss of reputation and food recalls.

Previous research into restaurant food safety performance has primarily focused on internal factors within the restaurant. Higgins incorporated these ideas into his conceptual model that focused on having trained staff, sufficient equipment, financial resources, and the level of food-handling as the primary factors affecting food safety performance (Higgins & Hartfield, 2004). Other research has focused on how regulatory actions, such as grading systems (Fielding, Aguirre, & Palaiologos, 2001) or evaluation frequency (Allwood, Lee, & Borden-Glass, 1999; Newbold, McKeary, Hart, & Hall, 2008) affect restaurant food safety performance. Furthermore, these intervention strategies have been studied individually and have not incorporated the effects of multiple intervention strategies at the same time.

A neighborhood effect, the influence of one’s neighborhood on individual outcomes, has been examined in many disciplines including environmental contamination, crime modeling, and health. The
premise holds that limited resources in economically disadvantaged areas may impact the ability of residents to achieve optimal success (Wilson, 1987). This effect has been studied minimally in the food service setting. Pothukuchi found that grocery stores in poorer areas had more violations (2008) and Darcey found that restaurants in more affluent areas had more critical violations (2011). Neither study delved beyond looking at gross counts of the numbers of violations into specific violation categories, which means that the specific violations noted may have had varying likelihoods to result in illness. They may have been related to a lack of handwashing or an unlabeled chemical container. While both of these are critical violations, one could argue that the potential for causing foodborne illness is greater with the former and this level of detail has not been examined in previous studies.

The current study integrates the intrinsic factors of the restaurants with neighborhood socio-demographics to examine which factors affect restaurant food safety performance. It further examines if there are differences in the types of violations that occur in different neighborhoods. By understanding the internal and external factors and their effect on restaurant food safety performance, findings from this study may inform the development of public health interventions to reduce the occurrence of foodborne illness risk factors and ultimately the rate of foodborne illness.
Chapter 2. Literature Review

Food Safety Assessments

Food safety assessments in the United States are primarily carried out by local or state health departments based on a version of the U.S. Food and Drug Administration’s (FDA) Model Food Code. The Food Code is a model put forth by the FDA with consensus guidance provided by the Conference for Food Protection (CFP). The CFP is a non-governmental organization comprised of members of academia, industry, and the regulatory community that provides guidance to FDA on recommended changes to the Food Code. Each State or jurisdiction may then choose to maintain their current food regulations, adopt the model code, or make amendments to the code to meet local needs. The model food code consists of eight chapters: Purpose and Definitions; Management and Personnel; Food; Equipment, Utensils, and Linens; Water, Plumbing, and Waste; Physical Facilities; Poisonous or Toxic Materials; and Compliance and Enforcement (U.S. Department of Health and Human Services, 2009). Within each chapter are the standards that are classified as critical or non-critical violations (with the adoption of the 2009 Food Code this terminology was changed to Priority, Priority Foundation, and Core violations). Critical/Priority violations are directly related with hazards that may result in an illness, while Priority Foundation violations are linked to the Priority items. Non-critical/Core violations are good practices to maintain the facility in a sanitary manner. The 2005 FDA Model Food Code introduced the concept of identifying the compliance status for each of the risk factors for foodborne illness as identified by the CDC and intervention strategies for the prevention of foodborne illness. This has allowed for an assessment to determine if the restaurant performs the action, and if so, if the inspector was able to verify that it was being conducted in accordance with minimum acceptable standards. Previously, only violations were debited on the inspection report. The violation is important, however it did not identify whether the facility was performing the practice properly, the inspector did not observe the practice, or that the facility does not perform the practice. Without this piece of information, the actual rate of occurrence for each of the risk factors is artificially lowered.
Restaurant Intrinsic Factors

Research on restaurant food safety performance has primarily focused on internal factors to the restaurant. Campbell and colleagues performed a systematic review of public health interventions in restaurants and found that the strategies primarily fit into three categories: Inspections (inspection score and frequency of inspections); Food Handler Training (retention of knowledge and change in inspection scores); and Community Based Education (including disclosure of inspection outcomes, and community outreach with safe food handling practices) (1998). Of these, the food handler training would be internal to the restaurant, while the other categories would apply to the regulatory environment. Other intrinsic factors that have been studied relate to the level and type of food-handling that is occurring, the ownership model for the restaurant, along with the type of restaurant (Burkink, Hughner, & Marquardt, 2005; R. Frash, Almanza, & Stahura, 2004; Higgins & Hartfield, 2004; Menachemi et al., 2012).

Food Safety Training

Food Safety training can be categorized into two different regimens. The first is for a Certified Kitchen Manager (CKM) that is obtained by passing an American National Standards Institute approved exam and which also typically entails classroom training. The other method is for a Certified Food Handler (CFH), which is obtained by passing a health department-administered exam or course.

The CKM has been found to have a generally positive impact on the performance of the restaurant. In Boston, managers who had voluntarily completed a training program had their overall inspection score improve, however it does not appear that there was a change in the rate of violations for the risk factors for foodborne illness when compared to control restaurants that did not undergo training (Cotterchio, Gunn, Coffill, Tormey, & Barry, 1998). In Ohio, researchers found that having a CKM was associated with fewer critical violations, but more non-critical violations, and that the effect was limited to a small subset of facilities (Kassa, Silverman, & Baroudi, 2010). Frash conducted a nationwide cross-sectional survey and failed to find a correlation between inspection scores and having a CKM (2006). This may be due to the wide variety of training requirements in the various states. In an EHS-Net (CDC
sponsored group investigating the antecedents of foodborne illness outbreaks in association with the FOODNET\textsuperscript{1} program) study, it was found that having a CKM provided a protective effect for foodborne outbreaks (Hedberg et al., 2006). Building on this, Cates found that having a CKM was associated with some lower critical violation frequencies, but not with all of the risk factors for foodborne illness, most notably a majority of the temperature control items (2009). This lack of improvement in temperature-related items may be related to the age and condition of the equipment that is used. While having an increased awareness of the issues can allow for earlier identification and repair of the equipment or implementing alternative strategies, if the equipment is incapable of operating correctly, temperature-related violations will continue to occur.

The efficacy of training at the food handler level has shown some short term improvements. A report by Kassa, indicated that training for food service workers improved the inspection score (2001), though the confidence intervals that were reported indicated that the results would not be statistically significant. An evaluation of the efficacy of a training program in Florida compared chain restaurant facilities to independent facilities. The researchers hypothesized that any difference in violations between independent and chain restaurants, which have internal training mechanisms, would be eliminated if the State provided training to all facilities. They found that the independent facilities still had a statistically significant higher rate of critical violations than chain facilities (Murphy, DiPietro, Kock, & Lee, 2011). Perhaps this discrepancy is due to some other factors that were not being measured in the above studies. A number of studies have examined various aspects of this dilemma. These include: 1 - Does the food service worker comprehend the information; 2 - Does the food service worker retain the information; 3 - Is the food service workers actions linked to their level of knowledge; and 4 - What motivates a food service worker to perform safe food handling? A study in Oregon examined the first question in regards to communication and found that the food service workers utilized an oral culture for learning and would base practices on their experiences, while regulators and restaurant management typically came from a

\textsuperscript{1} FOODNET is the CDC sponsored Foodborne Disease Active Surveillance Network that is a collaboration of ten State Health Departments, FDA, and the U.S. Department of Agriculture and actively seeks cases of foodborne illness through surveys of laboratories, physicians, and the general public.
book culture in which material could be learned from reading (Beegle, 2004). In addition, it was found that the materials used and examples given must be appropriate for the audience (DeBess, Pippert, Angulo, & Cieslak, 2009; Fraser & Alani, 2009; Niode, Bruhn, & Simonne, 2011). This would include materials in the individual’s primary language and to use examples that are applicable to their situations. To answer the second question, various studies have looked at knowledge retention of food service workers and found that employees who have been trained were able to correctly answer more questions on a post-test administered during an inspection (Egan et al., 2007; Hislop & Shaw, 2009; Raval-Nelson & Smith, 1999) indicating that the workers were retaining the knowledge. The third question poses the crux of the matter, and unfortunately research suggests that knowledge alone does not change food handling behaviors (Green et al., 2005; Seaman & Anita, 2010). Instead, other factors such as a lack of resources, lack of staff, a lack of time (Clayton, Griffith, Price, & Peters, 2002), and a need for ongoing reinforcement for implementation of safe food handling practices are barriers to improved food-handling (Jenkins-McLean, Skilton, & Sellers, 2004; York et al., 2009). The final question dealt with identifying other factors that motivate an employee. Ellis and colleagues found that the largest motivating factor was an intrinsic motivation and that it did not differ amongst different demographic groups, while other extrinsic factors (e.g. communication or reward-punishment systems) had varying levels of motivation based on demographic criterion (2010). A study by Pilling et al. found that employee attitudes was a significant predictor for three safe food handling practices (2008). Frash and MacLaurin found that the employee’s perceptions of the training that they received was related to health inspection scores, where employees that enjoyed the training and saw it as applicable to their situation scored better on health inspections (2010). Due to this myriad of influences, Mitchell and colleagues has advocated for the use of an ecological model in addressing this situation (2007), and Seaman has devised a new model, the Food Hygiene Training Model (2010). Both of these models are broader and encompass other models to help explain the complexity of why certain behaviors occur in a food establishment.
Design of the Facility

The design of the facility can lead to an efficient food flow through the facility from receiving to service. While conversely, a poor design can lead to raw foods cross-contaminating cooked foods with pathogens or providing disincentives for employees to wash their hands by making the hand sink inaccessible. From the consumer perspective, having an open kitchen (where the employees can be viewed by the public) allows for the re-assurance of the overall cleanliness of the establishment (Alonso & O'Neill, 2010).

Ownership and Type of Food-handling

Chain operated restaurants have been found to have improved food handling practices compared to independently owned restaurants (Bogard, Fuller, Radke, Selman, & Smith, 2013; Burkink et al., 2005). The authors assert that this is due to increased resources and standardized processes at the chain facilities. These increased resources and the ability to tailor training to the specific operations may have been the driving force in Murphy’s (2011) observations on the difference in violation frequencies between independent and chain restaurants in Florida that occurred while examining the impact of a State required training regimen for food service workers.

Burkink found that full-service restaurants had significantly more violations than limited-service restaurants (2005). This difference could be explained by the increased amount of food-handling that occurs in a full-service restaurant or, as Bogard suggested that full-service restaurants were more willing to engage in higher-risk food-handling activities than limited-service restaurants (2013).

An additional factor that may relate to food safety is that the restaurant industry has a higher than average employee turnover rate. In 2013, the turnover rate was approximately 20% higher than other private industry businesses and has in the past reached up to 80% in a year (National Restaurant Association, 2014). This high level of turnover has affected overall store performance as training needs to continually be provided to newer staff and social networks need to be re-established. Though in
restaurants that have routinely high turnover, the disruption is less apparent (Shaw, Duffy, Johnson, & Lockhart, 2005).

**Extrinsic Factors to the Restaurant**

*Effect of Community*

A neighborhood effect, the influence of one’s neighborhood on individual outcomes, has been examined in many disciplines including environmental contamination, crime modeling, and health. Sampson found that “social problems tend to come bundled together at the neighborhood level, including, but not limited to, crime, adolescent delinquency, social and physical disorder, low birth weight, infant mortality, school dropout, and child maltreatment (Sampson, Morenoff, & Gannon-Rowley, 2002).” The premise holds that limited resources in economically disadvantaged areas may impact the ability of residents to achieve optimal success (Wilson, 1987). While this research has primarily focused on the effects on an individual, community collective action can also have an effect on businesses (Besser, 1998), and a business will need to further adapt to the market to remain viable (Zacharakis, Meyer, & DeCastro, 1999).

Research into the safety of food products in small corner grocery stores that are located in low socio-economic status or minority areas has found increased contamination on the products (Quinlan, 2013; Signs, Darcey, Carney, Evans, & Quinlan, 2011; Silbergeld et al., 2013). In a review of ethnic foods, Lee found that there are a large number of foodborne outbreaks associated with ethnic foods (2014), and Rudder found that language barriers and a lack of understanding of food safety principles had led to poor food-handling in ethnic restaurants (2006).

*Market Characteristics*

Research on restaurant market characteristics has been published in the business literature and has focused primarily on market segmentation of the customers and the criterion for siting a new restaurant. Studies have focused on identifying the demographics of the customer base for successful restaurants and
understanding the marketing channels they use (Bojanic, 2007; Bojanic & Shea, 1997; Chou, Hsu, & Chen, 2008; University of Wisconsin-Extension For Your Information Network, 2011). The other primary focus has been on identifying new locations for a restaurant. Tzeng et al. identified five criteria² for determining sites for new restaurants. Of these, the level of market competition ranked fourth, accounting for 16% of the decision (2002).

Regulatory Characteristics

During an inspection, an inspector is able to use professional judgment in determining whether to mark a violation. This decision can be complex and affected by biases (Medeiros & Wilcock, 2006). Johnson and colleagues found that in general a violation would be marked, but that there are other factors that may influence this, such as the facility’s responsiveness to make the correction and their previous inspection history (2014). This corresponds with and expands on prior research into what factors influence an inspection (Isaacs, Abernathy, Hart, & Wilson, 1999). During an evaluation of Detroit area food facilities, the gender of the inspector was also found to be significantly associated with the number of violations cited, with females marking more violations (Pothukuchi et al., 2008).

Public Policy

Posting of Inspection Results

There is information asymmetry for the public regarding food sanitation when they dine in a restaurant. Consumers will try to gain information by doing an assessment of the facility’s cleanliness in public places and the volume of business that is occurring (Henson et al., 2006). To assuage this, many jurisdictions have publicly posted results, such as through online web portals, posting of grade cards or other similar rating systems in the establishment, or through other media channels (Filion & Powell, 2009). In Los Angeles, after implementing a posted grade card system, the overall inspection scores

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² Tzeng et al. identified criteria for selection of a restaurant site. These included: Access to transportation corridors and parking capacity (26%); the commercial area and extent of public facilities (25%); rent cost and other economic factors (23%); amount and intensity of market competition (16%), and the utility infrastructure (9%).
improved (Fielding et al., 2001). While this does provide additional information to the consumer, it may not be used or understood as intended. Jones surveyed residents of Tennessee to understand their beliefs of restaurant food safety performance and found that their expectations surpassed the reality of what was currently occurring (Jones & Grimm, 2008). Surveys of consumers and inspectors alike found difficulty in interpreting a single score or grade (Dundes & Rajapaksa, 2001). With this difficulty, Ho evaluated food safety reports in New York and San Diego and found that the implementation of a posted grade was having negative consequences with score inflation and a shifting of resources to handle grade disputes (Ho, 2012).

**Inspection Outcomes**

*Inspections as Predictors for Foodborne Illness*

There has been mixed research correlating restaurant inspection results with foodborne illness. Infectious disease transmission can be modeled by the agent – host – environment triad. In this model, if any one of the three elements is removed, then illness will not occur. Food safety assessments target the environment piece focusing on the practices that would allow a pathogen to survive and propagate. If the agent is missing from the equation, then poor sanitary practices would still not result in a foodborne illness. This would support the proposition that food safety assessments reflect the occurrence of the practices that could result in a foodborne illness if the causative agent is present. Adding to this is the passive nature of foodborne illness reporting. If someone does become ill from food, they may report the illness to the local health department. A focus group with consumers found barriers to reporting included: not knowing whom to contact; being too ill; unsure of the cause; and a belief that reporting would not be beneficial (Arendt et al., 2013). If the illness is severe enough, a victim may see a health care provider, who may take a sample to submit to a lab, that may detect the pathogen in the sample and report the confirmed case to the health department (Centers for Disease Control and Prevention, 2012). This multi-tiered approach results in many cases of foodborne illness not being reported and investigated.
The passive nature in how illness is reported and the different approaches that have been taken to correlate inspection outcomes have led to contradictory results. Irwin and colleagues found restaurants with a foodborne outbreak had a lower overall inspection score (on the inspection preceding the outbreak) than non-outbreak restaurants (1989), while others have not found an association (Cruz, Katz, & Suarez, 2001; Jones, Pavlin, LaFleur, Ingram, & Schaffner, 2004). The discrepancy may be due to how the studies approached the problem. Irwin compared restaurants with an outbreak to those without, while the other authors examined all restaurants and looked for outbreaks. The latter authors make the assumption that the pathogen is present at a sufficient enough level to cause illness, if the pathogen was not present, then even the most egregious cases of poor sanitary practices would not result in an illness. Additionally, these latter studies are based on the assumption that all foodborne outbreaks are reported.

*Inspection documentation*

While inspections are carried out at the local/county health department levels, inspection forms lack uniformity and a consistent violation categorization methodology between states and in some instances between counties. Previous versions of the Food Code had provided a model form that was widely adopted (U.S. Food and Drug Administration, 1976), although this was dropped in subsequent issuances of the food code. In the 2005 version of the Food Code, a model form was re-introduced which had the advantage of recording whether a process was occurring and whether the inspector was able to verify if the process met minimum standards (U.S. Food and Drug Administration, 2005). The recording of the compliance state for specific risk factors for foodborne illness is slowly being incorporated into local inspection forms and has not been adopted in a widespread manner.
Chapter 3. Theoretical Perspective and Research Questions

The “social-ecological model” has been used for examining multilevel effects and interconnectivity within a larger system (Brooks-Gunn, Duncan, Klebanov, & Sealand, 1993). This model initially was applied to human development and has been heralded by Bronfenbrenner. Since then, it has been employed in health services research to examine multilevel complex systems. The framework considers development within five contexts: the micro-system; meso-system, exo-system; macro-system; and chrono-system (Bronfenbrenner, 1997).

The micro-system is composed of the experiences of the developing person. The meso-system relates to linkages between two different settings of the individual. The exo-system examines the relationship between two or more settings, one of which does not include the developing person, yet still has an effect on the person. The macro-system is related to the prevalent culture that the other systems are within. The chrono-system accounts for changes that occur over time as the developing person adapts. The basics of this framework were adopted by Pothukuchi into a conceptual model to examine the relationships between Community, Market, Supply Chain, Retailer, and Regulatory characteristics with Inspection outcomes (Pothukuchi et al., 2008).

Conceptual Model

Building on the work of Pothukuchi, this study employs an expanded conceptual model that has been adapted for use with restaurants. Figure 1 displays this expanded model. This conceptual structure provides an opportunity to view this problem from the policy, neighborhood and individual levels.
At the policy level are the laws and regulations that relate to safe food handling, inspection frequency, and posting of inspection results (such as grade cards). These factors are the prevailing statutes that would apply to all food facilities within the study population and may vary by jurisdiction. The posting of inspection results has been found to have an effect on consumer choice (Choi, Nelson, & Almanza, 2011; Henson et al., 2006) and also an improvement on inspection results (Jin & Leslie, 2003).

The public policy components will directly affect the regulatory inspection program by providing the framework for the inspection activities, the standards to be enforced, and any potential punitive actions for facilities that fail to comply with the requirements. Policy is directly influenced by the

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**Figure 1. Conceptual model of the internal and external factors on restaurant food safety performance**

**Policy Level**

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The community is able to bring local concerns to their elected officials that in turn may result in additional requirements or limitations on the regulatory agency and the regulated entities.

**Neighborhood Level**

The Neighborhood level has three major components: The regulatory/inspection office characteristics; the community characteristics; and the market characteristics. The regulatory/inspection office characteristics combine the potential effects from the culture of the office and the individual inspector. If the office culture tends towards a greater focus on initiating enforcement actions there will be increased attention paid to identifying violations. Similarly, the individual characteristics of the inspector will affect how they are received and interact with the restaurant (J.-E. Lee, Nelson, & Almanza, 2012). These may include such factors as the gender of the inspector. For example, depending upon the culture of the restaurant operator, having a female in a position of authority may not be acceptable and would inhibit the flow of information between both parties (this is inter-related with the restaurant characteristics and their response to regulation).

The community has an indirect effect on how a restaurant performs. The socio-economic factors of the community may limit the geographic mobility of the community members (e.g., if they do not own cars they would be limited to restaurants in walking distance or by using other means of transportation). Additionally, the patronage of the restaurant will be affected by the pricing of menu items and the amount of income that individuals have to spend on food. If a customer has limited financial resources they will be looking to optimize their purchasing power. Finally, the surrounding community may provide the labor pool for the restaurant.

The level of competition within the community between restaurants will provide an impetus for a restaurant to perform at a higher level. If community members have multiple options that are priced similarly and offer a similar menu then they will most likely look for other factors to make their choices including food safety information (Henson et al., 2006).
Individual Level

At the restaurant level are the intrinsic factors that can lead to food safety. This will include the level of food-handling. Restaurants fall into three categories based on their level of food-handling: no cook (e.g. deli); cook and serve (e.g. fast food restaurant); and restaurants that cook and then cool and reheat the food for later service (e.g. full-service restaurants). Each level of food-handling maintains the risks from the previous level and adds additional hazards. Within the no cook level, the food is the safest upon arrival and it is up to the restaurant to not contaminate the food or allow any pathogens that are present to grow to unsafe levels. In the cook and serve restaurants, raw potentially hazardous food items are introduced and the food must be cooked to lower the level of bacteria below the infective dose for illness. In the third category, food is made in advance and cooked and cooled down to be reheated later. This advanced preparation leaves food within a temperature zone that is conducive to bacterial growth for the longest period of time. All of the restaurants would have a similar risk of contaminating food with pathogens; however, those that cook the food have a processing step present to reduce the amount of pathogens below the infective dose for illness.

Training of employees should have an effect on restaurant food safety performance. If an employee is trained on the policies and procedures for their tasks then they should be implementing them in the correct manner and increasing the level of food safety.

The design of a facility can lead to safer food handling. If the facility is designed for food to be received and then flow through the facility without the opportunity for re-contaminating cooked food with raw food then the potential for cross-contamination will be decreased. Additionally, if there is sufficient equipment (e.g., including hand sinks for employees to wash their hands, refrigeration equipment for holding of cold food, and cooking equipment) that is in good working order then the foundational pieces for safe food handling will be present.

Similar to the inspector characteristics and how they interact with restaurant operators, is how the restaurant operator responds to regulation. If the operator responds positively, then any needed corrective
actions can be implemented and the level of food safety will be increased. If the facility is part of a chain, then it is likely that there will be streamlined processes and the business will be maintained at a higher level of food safety to protect the brand identity. Lastly is employee turnover, the restaurant industry is known for having a high employee turnover rate that can result in a decreased level of food safety as employees become familiar with the restaurants procedures.

**Summary of Research Questions**

Research into restaurant food safety has primarily focused on the existing intervention strategies, such as employee education and on regulatory interventions. There has been evidence of increased foodborne illness rates for specific pathogens in lower socio-economic status areas; however, it is unknown if this is due to poor food handling practices at home or in restaurants. Due to limited access to healthcare in these settings, these estimates may be underreported. This study examines the internal and external variables in a multivariable manner to understand how they relate to a restaurant’s food safety performance. This study will examine the following specific research questions:

RQ1: Do external factors to a restaurant influence the overall food safety in a restaurant?

RQ2: What is the level of influence exhibited by both the internal and external factors on a restaurant’s food safety performance?

RQ3: Are these factors consistent in alternate settings?

RQ4: Does having a centralized support structure affect these factors?

From this study we will not be able to assess the public policy component, as all of the facilities within a studied jurisdiction will be using the same set of regulations and posting of results. While there is a difference in the version of the Food Code that is being implemented by the jurisdictions under study, the basic tenets are the same in all versions. The external community characteristics are of particular interest to understand if there is a difference in food-handling violations by different community characteristics. The level of market competition has not been examined in regards to food safety practices. The role of the inspector introduces a unique question. Is there truly a significant difference
between inspectors when viewed in a larger context? The inspector could also be an endogenous variable when examining the spatial effects. Are the differences in restaurant food safety performance due to the inspector or is the inspector reporting on actual food safety practice differences? This research will also examine the available internal factors of the restaurants to observe their effect in a multivariable manner. Finally, a variety of outcome variables (as discussed in the research methods section) is used to understand if specific risk factors for foodborne illness are a better predictor than a gross count of violations.
Chapter 4. Research Methods

This study uses a cross-sectional study design to assess the overall level of food safety performance and how it is affected by various internal and external variables. Community characteristic data comes from the U.S. Census Bureau American Community Survey datasets for the associated locations. Food inspection result data comes from routine inspection reports from Maricopa County, AZ and the State of Florida. Additional food inspection result data comes from randomly sampled restaurants in two States that were collected to determine the overall control of the risk factors for foodborne illness in different segments of the food industry within their respective states.

Data Sources

Data Sources – Maricopa County

Maricopa County, Arizona encompasses 9,200 square miles surrounding the greater Phoenix area with a 2010 population of over 3.8 million (Quickfacts.census.gov, 2014b). Routine restaurant inspection reports were obtained from the Maricopa County Environmental Health Division for inspections that occurred between January 2002 and December 2004. The facilities were limited to restaurants that had a minimum of two inspections during that timeframe to allow for a repeated measures analysis. This provided 12,492 restaurants with a range of 2 to 16 evaluations per facility during that timeframe. These facilities can be further broken down by the level of food-handling that occurs based on the County’s priority rating system. This system ranks facilities from 1 to 5, with 1-2 being a low level of food-handling, 3 being a moderate level, and 4-5 being advanced levels of food-handling most often associated with full service restaurants. The inspections were conducted using the 1999 version of the FDA Model Food Code. The dataset contains specific restaurant names and addresses, whether the facility has a CKM, the inspector and their office, the number and type of violations, and the compliance status of the risk factors for foodborne illness. The name of the facility is used to identify chain restaurants, and the address is used to geocode the restaurant, allowing identification of other nearby restaurants and
combination with other socio-demographic indicators. While this dataset is the most robust used in this study, it is the oldest and covers the smallest geographic area.

>Data Sources – State of Florida

The State of Florida had over 18 million residents in 2010 and encompasses over 53,000 square miles (Quickfacts.census.gov, 2014a). Routine restaurant inspection reports were obtained from the Florida Division of Hotels and Restaurants for inspections conducted between July 2010 and December 2012. The inspections were conducted using the 2009 version of the FDA Model Food Code. The dataset contains inspections for 56,205 restaurants with 2 or more inspections. This dataset does not allow for the differentiation of facilities by their level of food-handling. The dataset does contain the name and address for the restaurants (allowing for the identification of chain restaurants, and identification of other nearby restaurants), if the facility has a CKM, and the purpose of the inspection. The dataset does not identify an individual inspector; however it does contain offices so it is possible to identify it there are differences between offices. The dataset is further limited to reporting on the classifications of violations, as the compliance status of the risk factors is recorded on a paper inspection form and is not available electronically for analysis.

>Data Sources – State A and State B Risk Factor Studies

The FDA has implemented voluntary national retail food program standards for local and state health departments to evaluate themselves (U.S. Food and Drug Administration, 2011). As part of this program, jurisdictions evaluate a random sample of facilities in different segments of the food industry. In these evaluations, the compliance status of the individual risk factors is assessed. Both jurisdictions collected information on full service and fast food restaurants following the FDA’s sampling and evaluation methodology.
Data Sources – U.S. Census Bureau American Community Survey (ACS)

The American Community Survey provides demographic information to the census block level (the lowest geographic level) that can be used to create socio-demographic index indicator variables. The level of social deprivation and socio-economic status has been previously used to classify neighborhoods. Kim found that diners over age 60 do not have as many choices in dining and tend to be more loyal to a specific restaurant (Kim & Jang, 2014). Other studies have identified minority groups to be at an increased risk for foodborne illness (Valerie L. Darcey, 2010). It can also be assumed that if a population has a lower rate of auto ownership they would be limited to the restaurants in their neighborhood. Lastly, residents that are employed in food-handling occupations would have a greater knowledge of acceptable practices and would hold restaurants that they visited to those standards.

Data Summary

Table 1 provides a summary of the various datasets and the types of data that they contain. In order to examine any spatial effects, it was imperative that the address of the restaurant be provided. This allowed for the socio-demographic variables from the American Community Survey to be linked to the restaurant. The table further illustrates the variations in how data is collected by the varying jurisdictions. In some instances, such as with Florida, there is a count of violations observed, while with Maricopa County, there is a measure of the in and out of compliance rates for specific practices.

Table 1. Summary of data sources

<table>
<thead>
<tr>
<th>Variable</th>
<th>Maricopa County Routine Inspection</th>
<th>State of Florida Routine Inspection</th>
<th>State A Risk Factor Study</th>
<th>State B Risk Factor Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Facility</td>
<td>By level of food-handling</td>
<td></td>
<td>Full Service</td>
<td>Full Service</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fast Food</td>
<td>Fast Food</td>
</tr>
<tr>
<td>Number of facilities</td>
<td>12,492</td>
<td>56,205</td>
<td>200 (100 full service)</td>
<td>172 (89 full service)</td>
</tr>
<tr>
<td>Number of inspections</td>
<td>81,474 (range from 2 – 16 per facility)</td>
<td>314,285 (range from 2 – 24 per facility)</td>
<td>200 (1 per facility)</td>
<td>172 (1 per facility)</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------------------------</td>
<td>-----------------------------------------</td>
<td>---------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Chain</td>
<td>By name of chain</td>
<td>By name of chain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spatial Location</td>
<td>Address</td>
<td>Address</td>
<td>Address</td>
<td>Address</td>
</tr>
<tr>
<td>Certified Kitchen Manager</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Inspection Purpose</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inspector</td>
<td>By Inspector and Office</td>
<td>Only District and Office</td>
<td>By Inspector</td>
<td></td>
</tr>
<tr>
<td>Outcome Variable – Risk Factor In Compliance</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Outcome Variable – Number of Violations</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Statistical Analysis**

*Dependent Variables*

The dependent variables by source are provided in Table 2. Due to the different methods that are used to record the data, while the headings may use similar names and capture some of the same information they are not interchangeable. The risk factor variables may be marked as: IN compliance where the process was observed and found to meet the standards; OUT of compliance, where it was observed and found to not meet the standard; Not Observed (NO), where the process occurs in the facility but the inspector was unable to verify if it met standards; and Not Applicable (NA) if it is a process that the facility does not perform. The risk factor variable is a proportion of the number of times that the
factor was observed in compliance (IN/IN+OUT). The non-risk factor variables are counts of the frequency that a violation was debited per inspection.

**Table 2. List of dependent variables by dataset.**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Maricopa County Routine Inspection</th>
<th>State of Florida Routine Inspection</th>
<th>State A and B Risk Factor Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y₁ - Inspection score</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y₂ - Total Critical violations</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Y₃ - Total Non-critical violations</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Y₄ - Total violations marked</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Y₅ - Risk Factor – Supervision¹</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y₆ - Risk Factor – Employee Health¹</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y₇ - Risk Factor – Good Hygienic Practices¹</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y₈ - Risk Factor – Protection from contamination from hands¹</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y₉ - Risk Factor – Approved Source¹</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y₁₀ - Risk Factor – Protection from Contamination¹</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y₁₁ - Risk Factor – Potentially Hazardous Food¹</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y₁₂ - Risk Factor – Consumer Advisory¹</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y₁₃ - Risk Factor – Highly Susceptible Populations¹</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y₁₄ - Risk Factor – Chemicals¹</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y₁₅ - Risk Factor – Conformance with Approved Procedures¹</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y₁₆ - Food Source</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y₁₇ - Temperature Control</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Y_{18} ) - Food Protection</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Y_{19} ) - Personnel</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Y_{20} ) – Food Equipment and Utensils</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Y_{21} ) - Single-service and Single-use Articles</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Y_{22} ) – Water and Sewerage/Plumbing</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Y_{23} ) - Toilet and Hand washing facilities</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Y_{24} ) - Garbage and Refuse Disposal</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Y_{25} ) - Insect, Rodent, and Animal control</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Y_{26} ) - Floors, Walls, and Ceilings</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Y_{27} ) - Lighting and Ventilation</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Y_{28} ) - Other Areas</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Y_{29} ) - Risk Factor – Food Source (^1)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Y_{30} ) - Risk Factor – Pathogen Destruction (^1)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Y_{31} ) - Risk Factor – Limitation of Growth of Organisms of Public Health Concern (^1)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Y_{32} ) - Risk Factor – Personal Hygiene (^1)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Y_{33} ) - Risk Factor – Protection from Contamination (^1)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Y_{34} ) - Risk Factor – Other (^1)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) Risk Factor variables are reported in a proportion of IN compliance, while other values are a count of the occurrence.

*Independent Variables – Community Characteristics*

\( C_1 = \) Socioeconomic Status – This is an index measure using the Medicare SES formula (Agency for Healthcare Research and Quality, 2012); data will come from the ACS.

\( C_2 = \) Social Deprivation – This is an index measure for the level of social deprivation (Messer et al., 2006); data will come from the ACS.
$C_3 =$ Predominant Race – This is a categorical variable for the race that comprises the largest portion of the population in the census block surrounding the restaurant; data will come from the ACS.

$C_4 =$ Percentage of population over 60 – This is the percentage of the population that is over 60 in the census block surrounding the restaurant; data will come from the ACS.

$C_5 =$ Percentage of population in Food Handling Occupations – This is the percentage of the population that is engaged in food handling occupations in the census block surrounding the restaurant; data will come from the ACS.

$C_6 =$ Percentage of population without a vehicle – This is the percentage of the population that does not own a vehicle in the census block surrounding the restaurant; data will come from the ACS.

**Independent Variables – Market Characteristics**

$M_{1A} =$ Number of competing restaurants within a ½ mile diameter of the restaurant – An index measure\(^3\) similar to the Herfindahl-Hirschman Index will be calculated for all other restaurants within a ½ mile of the establishment; data will come from the jurisdiction inspection records and the measure assumes equal market share and that the facility was operating for the entire length of the study period.

$M_{1B} =$ Number of competing restaurants within a 1 mile diameter of the restaurant – An index measure similar to the Herfindahl-Hirschman Index will be calculated for all other restaurants within a 1 mile of the establishment; data will come from the jurisdiction inspection records and assumes equal market share and that the facility was operating for the entire length of the study period.

$M_{1C} =$ Number of competing restaurants within a 3 mile diameter of the restaurant – An index measure similar to the Herfindahl-Hirschman Index will be calculated for all other restaurants within a 3 mile of the establishment; data will come from the jurisdiction inspection records and assumes equal market share and that the facility was operating for the entire length of the study period.

---

\(^3\) The measure will be constructed as $\sum_{i=1}^{N} s_i^2$, where $N$ is the number of establishments and it will assume that $s_i$ (market share) is equal for all establishments. For example if there were four restaurants within the area HHI=0.25^2+0.25^2+0.25^2+0.25^2=0.25, a higher value equates with less competition.
M_{1D} = \text{Number of competing restaurants within a 5 mile diameter of the restaurant} – \text{An index measure similar to the Herfindahl-Hirschman Index will be calculated for all other restaurants within a 5 mile diameter of the establishment; data will come from the jurisdiction inspection records and assumes equal market share and that the facility was operating for the entire length of the study period.}

M_{2A} = \text{Number of similar competing restaurants within a \(\frac{1}{2}\) mile diameter of the restaurant} – \text{An index measure similar to the Herfindahl-Hirschman Index will be calculated for all other restaurants with a similar level of food-handling within a \(\frac{1}{2}\) mile of the establishment; data will come from the Maricopa County inspection records and assumes equal market share and that the facility was operating for the entire length of the study period.}

M_{2B} = \text{Number of similar competing restaurants within a 1 mile diameter of the restaurant} – \text{An index measure similar to the Herfindahl-Hirschman Index will be calculated for all other restaurants with a similar level of food-handling within a 1 mile of the establishment; data will come from the Maricopa County inspection records and assumes equal market share and that the facility was operating for the entire length of the study period.}

M_{2C} = \text{Number of similar competing restaurants within a 3 mile diameter of the restaurant} – \text{An index measure similar to the Herfindahl-Hirschman Index will be calculated for all other restaurants with a similar level of food-handling within a 3 mile of the establishment; data will come from the Maricopa County inspection records and assumes equal market share and that the facility was operating for the entire length of the study period.}

M_{2D} = \text{Number of similar competing restaurants within a 5 mile diameter of the restaurant} – \text{An index measure similar to the Herfindahl-Hirschman Index will be calculated for all other restaurants with a similar level of food-handling within a 5 mile of the establishment; data will come from the Maricopa County inspection records and assumes equal market share and that the facility was operating for the entire length of the study period.}
Independent Variables – Regulatory Characteristics

\( \text{RO}_1 = \) The inspection office that covers the establishment – This is a categorical variable for the office that oversees the establishment; data will come from the jurisdictional inspection records.

\( \text{RO}_2 = \) The individual inspector – This is a categorical variable for the inspector that performed the evaluation; data will come from the jurisdictional inspection records.

\( \text{RO}_3 = \) The inspectors gender – This is a categorical variable for the gender of the inspector that performed the evaluation; data will come from the jurisdictional inspection records on the inspector and the gender will be assessed by either personal knowledge or assessing the name through search methodologies.

Independent Variables – Restaurant Characteristics

\( \text{R}_1 = \) The level of food-handling – This is a categorical variable denoting the level of food-handling with an increasing number being consistent with an increased level of menu complexity/food-handling; data will come from the Maricopa County inspection records.

\( \text{R}_2 = \) Certified Kitchen Manager – This is a categorical variable indicating if the establishment has a Certified Kitchen Manager; data will come from the jurisdictional inspection records.

\( \text{R}_3 = \) Percentage of employees that are Certified Food Handlers – This is a continuous variable denoting the percentage of employees that have obtained a Certified Food Handler card; data will come from the Maricopa County inspection records.

\( \text{R}_4 = \) Facility Type – This is a categorical variable that indicates if the facility is a full service restaurant or fast food restaurant; data will come from the State A and B risk factor study results.

The other specific restaurant characteristics will be minimized due to the repeated nature of the data, since they will be assumed to not change significantly between inspections.
Table 3 provides a summary of the above noted independent variables and whether each of the dataset may be assessed for the item. Some items, such as Inspector (RO2), were not available in all of the datasets.

**Table 3. List of independent variables and associated datasets.**

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Maricopa County Routine Inspection</th>
<th>State of Florida Routine Inspection</th>
<th>State A and B Risk Factor Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>C₁ - Socioeconomic Status</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>C₂ - Social Deprivation</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>C₃ - Predominant Race</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>C₄ - Percentage of population over 60</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>C₅ - Percentage of population in Food Handling Occupations</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>C₆ - Percentage of population without a vehicle</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>M₁ₐ - Number of competing restaurants within a ½ mile diameter of the restaurant</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>M₁₉ - Number of competing restaurants within a 1 mile diameter of the restaurant</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>M₁₇ - Number of competing restaurants within a 3 mile diameter of the restaurant</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>M₁₉ - Number of competing restaurants within a 5 mile diameter of the restaurant</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>M₂₉ - Number of similar competing restaurants within a ½ mile diameter of the restaurant</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>M₃₉ - Number of similar competing restaurants within a 1 mile diameter of the restaurant</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>M₃₉ - Number of similar competing restaurants within a 3 mile diameter of the restaurant</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
Data Preparation

The Maricopa County and Florida data sets were initially reduced to restaurants that had two or more inspections. The addresses for the establishments in all datasets were initially geocoded using the ESRI-supplied US Locator for ArcGIS Desktop 10.2.2 with an 80% spelling sensitivity, 85% minimum match score, and 75% minimum candidate score (ESRI, 2014). Restaurants that were unable to be initially matched, were searched using the Yahoo local search application programming interface for the name of the establishment along with the city and state, and the updated address was recorded. These updated addresses were compared to the original address utilizing the Levenshtein distance algorithm (Gilleland). Any addresses with a >0.5 distance variation were hand-geocoded along with any restaurants that were unable to be automatically geocoded. Restaurants were then examined on a map and hand-geocoded if they did not fall within the boundaries of the associated jurisdiction.

The Maricopa County and Florida datasets had each restaurant plotted in ArcGIS with a buffer at 0.5-, 1-, 3-, and 5-mile increments with a spatial join performed between the buffer layer and the point layer. A modified competition index was calculated based on the other points in the associated buffer to
provide a modified HHI\(^4\) assuming that each restaurant had the same market share. This was performed for the total number of restaurants in both the Maricopa County and Florida datasets and for restaurants with similar level of food-handling in the Maricopa County dataset.

The 2012 5-year American Community Survey data per block group was used to create the socio-demographic indicators. The levels of SES (Agency for Healthcare Research and Quality, 2012) and social deprivation (Messer et al., 2006) were calculated for each block group along with identifying the predominant race, the percentage of the population over 60, the percent of the population in food-handling occupations, and the percentage of the population without a vehicle.

**Statistical Approach**

The initial statistical models presented below are representative of the dependent and independent variables presented. Depending upon the distribution of the dependent variable an appropriate model was selected for use. All statistical analysis was completed using SAS 9.4 software (SAS Institute, 2008).

**Initial Statistical Model – Maricopa County**

\[
Y_{1-15} = \beta_0 + \beta_1 C_1 + \\
\beta_2 C_2 + \beta_3 C_3 + \beta_4 C_4 + \beta_5 C_5 + \beta_6 C_6 + \beta_7 M_{1A} + \beta_8 M_{1B} + \beta_9 M_{1C} + \beta_{10} M_{1D} + \beta_{11} M_{2A} + \beta_{12} M_{2B} + \beta_{13} M_{2C} + \beta_{14} M_{2D} + \beta_{15} \text{RO}_1 \\
+ \beta_{16} \text{RO}_2 + \beta_{17} \text{RO}_3 + \beta_{18} R_1 + \beta_{19} R_2 + \beta_{20} R_3 + \beta_{21} (R_2 \times R_3) + \varepsilon
\]

**Initial Statistical Model – State of Florida**

\[
Y_{2-4,16-28} = \beta_0 + \beta_1 C_1 + \beta_2 C_2 + \beta_3 C_3 + \beta_4 C_4 + \beta_5 C_5 + \beta_6 C_6 + \beta_{11} \text{RO}_1 + \beta_{14} R_2 + \varepsilon
\]

**Initial Statistical Model – State A and State B Risk Factor Study**

\[
Y_{29-34} = \beta_0 + \beta_1 C_1 + \beta_2 C_2 + \beta_3 C_3 + \beta_4 C_4 + \beta_5 C_5 + \beta_6 C_6 + \beta_7 M_{1A} + \beta_8 M_{1B} + \beta_9 M_{1C} + \beta_{10} M_{1D} + \beta_{11} R_2 + \beta_{12} R_4 + \varepsilon
\]

The initial steps for each regression analysis include looking at the interaction between the dependent variable and each of the potential independent variables. A regression analysis using a

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\(^4\) See footnote 3 on page 24 for the modified HHI formula.
generalized estimating equation was performed in which the inspector adjusted for the priority level of the restaurant was regressed against the dependent variable for Maricopa County facilities to determine if the inspector variable should remain in the model.

The relevant variables were tested using a generalized estimating equation, to account for the repeated and unbalanced nature of the data. For the Maricopa County risk factors good hygienic practices and approved source an ordinal multinomial model was used due to the limited range of outcome measures. The dependent variables that were count-based were fitted with both a poisson and a negative binomial model and the model with the best fit was selected. A backward selection technique was utilized to identify the statistically significant variables. After identifying the statistically significant variables, the resulting variables were assessed to see if they still had practical significance (whether they make a significant impact), by assessing if they would alter a result by more than 2%. The model was then checked for multi-collinearity amongst any of the remaining variables. For the Maricopa County dataset, if the percentage of food-handler cards and having a Certified Kitchen Manager were significant, the interaction between these items was tested. Following this, various covariance structures were tested to identify the best fit. Finally, the model was tested again along with regression diagnostics.

For the State A and B risk factor study, the distributions of the dependent variable were tested against one another to see if the datasets may be combined or if they need to be analyzed individually. Furthermore, the dependent variable is reported as a percentage so a tobit regression was conducted to account for truncating of results.

Two major chain restaurants (one primarily a cook and serve restaurant, and one primarily a no cook restaurant) from Maricopa County were tested to see if the socio-demographics of the surrounding area would affect the restaurant performance.

**IRB Approval**

This study is exempt from IRB approval as it uses secondary organizational-level data that has already been collected and is publicly available. All findings will be reported as aggregate measures. No individual inspector or restaurant identifiers will be presented.
Chapter 5. Results

Geocoding

The majority of the records were geocoded using the ESRI-supplied US locator (Maricopa County – 96%, Florida – 82%, State A – 84%, and State B – 72%). The Yahoo application programming interface was used to geocode the majority of the remaining records with only 1,128 records required hand-geocoding.

Table 4 provides a summary of the results for Maricopa County. The arrow direction indicates whether the outcome variable is improved by the independent variable. Since some variables have a lower value as better, while for others a higher value is better, a uniform implementation for reporting of the effect was adopted. The specific models are discussed individually following the table.
Maricopa County Routine Inspections

Table 4. Maricopa County summary of relevant independent variables.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>HHI(^a) within ½-mile</th>
<th>HHI(^a) within 1-mile</th>
<th>HHI(^a) within 5-mile</th>
<th>Certified Kitchen Manager (CKM) (1=Yes, 0=No)</th>
<th>Inspector Gender (1=Male, 0=Female)</th>
<th>Priority Level (as compared to Level 5 restaurant)</th>
<th>Percentage of Employees with Food Handler Cards (FHC)</th>
<th>Interaction of CKM*FHC</th>
<th>HHI(^a) of Similar Restaurants within ½-mile</th>
<th>HHI(^a) of Similar Restaurants within 3-mile</th>
<th>HHI(^a) of Similar Restaurants within 5-mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y(_1) – Inspection score</td>
<td>↑</td>
<td>↓</td>
<td>↑</td>
<td></td>
<td></td>
<td>1 = ↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Y(_2) - Total Critical violations</td>
<td>↑</td>
<td>↓</td>
<td>↑</td>
<td></td>
<td></td>
<td>1 = ↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Y(_3) - Total Non-critical violations</td>
<td>↑</td>
<td>↓</td>
<td>↑</td>
<td></td>
<td></td>
<td>1 = ↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Y(_4) - Total violations marked</td>
<td>↑</td>
<td>↓</td>
<td>↑</td>
<td></td>
<td></td>
<td>1 = ↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Y(_5) - Risk Factor – Supervision</td>
<td>No significant independent variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y(_6) - Risk Factor – Employee Health</td>
<td>No significant independent variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y(_7) - Risk Factor – Good Hygienic Practices</td>
<td></td>
<td>↑</td>
<td>↑</td>
<td></td>
<td></td>
<td>1 = ↑</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Y(_8) - Risk Factor – Protection</td>
<td></td>
<td>↑</td>
<td>↑</td>
<td></td>
<td></td>
<td>1 = ↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
</tr>
</tbody>
</table>
A ↑ indicates that the independent variable improves the outcome variable, a ↓ indicates that it worsens the outcome variable. A blank result indicates that the independent variable was either not statistically significant or lacked practical significance.

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Statistically significant independent variables were identified however the effect was negligible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y2 - Risk Factor - Approved Source b</td>
<td>Statistically significant independent variables were identified however the effect was negligible</td>
</tr>
<tr>
<td>Y10 - Risk Factor - Protection from Contamination</td>
<td>1 = ↑ 2 = ↑ 3 = ↑ 4 = ↓</td>
</tr>
<tr>
<td>Y11 - Risk Factor - Potentially Hazardous Food</td>
<td>1 = ↑ 2 = ↑ 3 = ↑ 4 = ↓</td>
</tr>
<tr>
<td>Y12 - Risk Factor - Consumer Advisory</td>
<td>No significant independent variables</td>
</tr>
<tr>
<td>Y13 - Risk Factor - Highly Susceptible Populations</td>
<td>No significant independent variables</td>
</tr>
<tr>
<td>Y14 - Risk Factor - Chemicals</td>
<td>1 = ↑ 2 = ↑ 3 = ↓ 4 = ↓</td>
</tr>
<tr>
<td>Y15 - Risk Factor - Conformance with Approved Procedures</td>
<td>No significant independent variables</td>
</tr>
</tbody>
</table>

Refer to Page 24 footnote 3 for the calculation of the modified HHI. A larger value reflects less competition.

While the model may have statistical significance, the effect from the individual predictors lacks sufficient effect to be of practical significance.
The following independent variables lacked either statistical or practical significance and were excluded in all models: The overall level of competition from any restaurant in a 3-mile radius; The overall level of competition from restaurants with a similar level of food-handling in a 1-mile radius; The percentage of the population that is over 60 years of age; The percentage of the population in food-handling occupations; The percentage of the population without a vehicle; The socio-economic status of the block group; The level of social deprivation of the block group and; The regional office for the inspector. The predominant race was excluded as a small minority of block groups was driving the statistical difference. The effect of the inspector, once adjusted for the level of food-handling was found to not be statistically significant, except for those involved in specialized programs (e.g. inspectors performing plan review inspections would be expected to be different from inspectors performing routine evaluations).

\( Y_1 \) - Inspection score

N=80828 inspections

Distribution = Normal

*A lower score indicates better compliance with the food code requirements

\[
y = 29.4226 + 7.0229(X_1) - 4.0488(X_2) - 6.0275(X_3) - 8.1004(X_4) - 14.2886(X_5) - 10.0934(X_6) \]
\[
- 4.2926(X_7) + 2.3143(X_8) - 1.0504(X_9) + \varepsilon
\]

\( X_1 \)=Measure of competition within 5 miles - This is an index of market competition that indicates that as the level of competition within 5 miles decreases that the score increases (gets worse). In general, as the level of competition decreases within a 5 mile radius the score may increase up to 7 points higher.

\( X_2 \)=Measure of competition with 1/2 miles - This is an index of market competition that indicates that as the level of competition decreases in the local area that the score decreases (gets better). In general, as the level of competition within the local ½ mile area decreases, the score may drop up to 4 points.
$X_3 =$ Percentage of employees with food handler’s cards - as the percentage of employees with food handler’s cards increases the score decreases (improves). For each 10% increase in the percentage of employees with food handler cards, the score drops 0.6 points.

$X_4 =$ Certified Food Service Manager - Having a Certified Food Service Manager decreases the score on average 8.1 points (improves).

$X_5 =$ Priority 1 restaurants - Priority 1 (lowest level of food-handling) restaurants have on average a score that is 14.3 points lower than a priority 5 restaurant.

$X_6 =$ Priority 2 restaurants - Priority 2 restaurants have on average a score that is 10.1 points lower than a priority 5 restaurant.

$X_7 =$ Priority 3 restaurants - Priority 3 restaurants (typical cook and serve or fast food restaurants) have on average a score that is 4.3 points lower than a priority 5 restaurant.

$X_8 =$ Priority 4 restaurants - Priority 4 restaurants have on average a score that is 2.3 points higher than a priority 5 restaurant.

$X_9 =$ Certified Food Service Manager*Percentage of employees with food handler cards - There is a synergistic effect that having both a Certified Food Service Manager and employees decreases the score by up to an additional 1.05 points (assuming both a Certified Food Service Manager and 100% of employees with food handler cards.)

$Y_2 =$ Total Critical violations

N=81553 inspections

Distribution = Negative Binomial

*A higher result indicates more critical violations

$$\ln (y) = 1.4651 + 0.476(X_3) - 0.5127(X_2) - 0.3589(X_3) - 0.4019(X_4) - 0.2124(X_5) - 1.2382(X_6)$$

$$- 0.7668(X_7) - 0.2817(X_8) + 0.1235(X_9) - 0.3309(X_{10}) + \varepsilon$$
$X_1$=Measure of competition within 1 mile - This is an index of market competition that indicates that as the level of competition within 1 mile decreases that the number of critical violations increases (Worsens). For each 10% decrease in the level of competition, the number of critical violations increases by 0.21.

$X_2$=Measure of competition with 1/2 miles - This is an index of market competition that indicates that as the level of competition decreases in the local area that the number of critical violations decreases (Improves). As the level of competition decreases by 10%, the number of critical violations increases by 0.21 violations.

$X_3$=Percentage of employees with food handler’s cards - as the percentage of employees with food handler’s cards increases the number of critical violations decreases (improves). For each 10% increase in the percentage of employees with food handler’s cards, the number of critical violations decreases by 0.15 violations.

$X_4$=Certified Food Service Manager - Having a Certified Food Service Manager decreases the number of critical violations on average by 1.4 (improves).

$X_5$=Inspector Gender - Male health inspectors on average notate 0.8 fewer critical violations than female health inspectors.

$X_6$= Priority 1 restaurants - Priority 1 (lowest level of food-handling) restaurants have on average 3.07 fewer critical violations than a priority 5 restaurant.

$X_7$= Priority 2 restaurants - Priority 2 restaurants have on average 2.32 fewer critical violations than a priority 5 restaurant.

$X_8$= Priority 3 restaurants - Priority 3 restaurants (typical cook and serve or fast food restaurants) have on average 1.06 fewer critical violations than a priority 5 restaurant.

$X_9$= Priority 4 restaurants - Priority 4 restaurants have on average 0.57 more critical violations than a priority 5 restaurant.
\(X_{10}= \text{Certified Food Service Manager} \times \text{Percentage of employees with food handler cards} - \text{There is a synergistic effect that having both a Certified Food Service Manager and employees decreases the number of critical violations by up to 1.22 violations.}

\(Y_3 - \text{Total Non-Critical violations}\)

N=81553 inspections
Distribution = Poisson

*A higher result indicates more non-critical violations

\[ \ln (y) = 1.2898 + 0.5425(X_1) - 0.5232(X_2) - 0.5886(X_3) - 0.0438(X_4) - 0.0869(X_5) - 0.7766(X_6) \]
\[ - 0.5555(X_7) - 0.2724(X_8) - 0.0921(X_9) - 0.01306(X_{10}) + \varepsilon \]

\(X_1=\text{Measure of competition within 1 mile} - \text{This is an index of market competition that indicates that as the level of competition within 1 mile decreases that the number of non-critical violations increases (Worsens). For each 10\% increase in market competition, the number of non-critical violations increases by 0.2.}\)

\(X_2=\text{Measure of competition within a \(\frac{1}{2}\) mile} - \text{This is an index of market competition that indicates that as the level of competition decreases in the local area that the number of non-critical violations decrease (Improves). For each 10\% decrease in competition within the local market, the number of non-critical violations decreases by 0.19.}\)

\(X_3=\text{Percentage of employees with food handler’s cards} - \text{as the percentage of employees with food handler’s cards increases the number of non-critical violations decreases (improves). For each 10\% increase in the number of employees with food handler’s cards, the number of non-critical violations decreases by 0.21 violations.}\)

\(X_4=\text{Certified Food Service Manager} - \text{Having a Certified Food Service Manager decreases the number of non-critical violations on average by 0.16 violations (improves).}\)
$X_5 =$ Inspector Gender - Male health inspectors on average notate 0.3 fewer non-critical violations than female health inspectors.

$X_6 =$ Priority 1 restaurants - Priority 1 (lowest level of food-handling) restaurants have on average 1.96 fewer non-critical violations than a priority 5 restaurant.

$X_7 =$ Priority 2 restaurants - Priority 2 restaurants have on average 1.54 fewer non-critical violations than a priority 5 restaurant.

$X_8 =$ Priority 3 restaurants - Priority 3 restaurants (typical cook and serve or fast food restaurants) have on average 0.87 fewer non-critical violations than a priority 5 restaurant.

$X_9 =$ Priority 4 restaurants - Priority 4 restaurants have on average 0.32 fewer non-critical violations than a priority 5 restaurant.

$X_{10} =$ Certified Food Service Manager*Percentage of employees with food handler cards - There is a synergistic effect that having both a Certified Food Service Manager and employees decreases the number of non-critical violations by up to 0.047 violations.

$Y_4 =$ Total violations

N=81582 inspections

Distribution = Negative Binomial

* A higher result indicates more violations

$$
\ln (y) = 2.0059 + 0.513(X_1) - 0.5223(X_2) - 0.4213(X_3) - 0.2585(X_4) - 0.1442(X_5) - 0.9829(X_6) \\
- 0.6329(X_7) - 0.2467(X_8) + 0.0336(X_9) - 0.1712(X_{10}) + \varepsilon
$$

$X_1 =$ Measure of competition within 1 mile - This is an index of market competition that indicates that as the level of competition within 1 mile decreases that the number of violation increases (gets worse). For each 10% increase in the amount of market competition there is on average an additional 0.39 violations noted.
$X_2=$Measure of competition with 1/2 miles - This is an index of market competition that indicates that as the level of competition decreases in the local area that the number of violation decreases (gets better). For each 10% decrease in the amount of market competition the number of violations decreases by 0.38 violations.

$X_3=$Percentage of employees with food handler’s cards - as the percentage of employees with food handler’s cards increases the number of violations decrease (improves). With each 10% increase in the number of employees that have obtained food handler cards the number of violations drops by 0.31 violation.

$X_4=$Certified Food Service Manager - Having a Certified Food Service Manager decreases the number of violations on average by 1.69 violations (improves)

$X_5=$Inspector Gender - Male health inspectors on average notate 1 fewer violation than female health inspectors

$X_6=$Priority 1 restaurants - Priority 1 (lowest level of food-handling) restaurants have on average 4.65 fewer violations than a priority 5 restaurant.

$X_7=$Priority 2 restaurants - Priority 2 restaurants have on average 3.49 fewer violations than a priority 5 restaurant.

$X_8=$Priority 3 restaurants - Priority 3 restaurants (typical cook and serve or fast food restaurants) have on average 1.63 fewer violations than a priority 5 restaurant.

$X_9=$Priority 4 restaurants - Priority 4 restaurants have on average 0.25 more violations than a priority 5 restaurant.

$X_{10}=$Certified Food Service Manager*Percentage of employees with food handler cards - There is a synergistic effect that having both a Certified Food Service Manager and employees decreases the number of violations by up to 1.17 violations.

$Y_5 – Risk Factor – Supervision$
The risk factor for Supervision was only associated with having a Certified Food Service Manager Card. This is not unexpected as this is one of the major requirements for this risk factor. The regression equation is not reported as it does not provide any additional insights.

\[ Y_6 - Risk Factor \text{ – Employee Health} \]

No variables were statistically associated with this outcome measure.

\[ Y_7 - Risk Factor \text{ – Good Hygienic Practices} \]

N=77926 inspections

Distribution = Ordinal Multinomial

*A higher score indicates better compliance with the food code requirements

\[
\ln(y_{0.0}) = -4.4262 - 0.9361(X_1) - 0.1497(X_2) - 0.1555(X_3) - 1.2949(X_4) - 0.08280(X_5) - 0.0566(X_6) \\
+ 0.0786(X_7) + \varepsilon
\]

\[
\ln(y_{0.33}) = -4.4021 - 0.9361(X_1) - 0.1497(X_2) - 0.1555(X_3) - 1.2949(X_4) - 0.08280(X_5) - 0.0566(X_6) \\
+ 0.0786(X_7) + \varepsilon
\]

\[
\ln(y_{0.5}) = -1.6263 - 0.9361(X_1) - 0.1497(X_2) - 0.1555(X_3) - 1.2949(X_4) - 0.08280(X_5) - 0.0566(X_6) \\
+ 0.0786(X_7) + \varepsilon
\]

\[
\ln(y_{0.66}) = -1.4935 - 0.9361(X_1) - 0.1497(X_2) - 0.1555(X_3) - 1.2949(X_4) - 0.08280(X_5) - 0.0566(X) \\
+ 0.0786(X_7) + \varepsilon
\]

\(X_1=\) Percentage of employees with food handler’s cards - as the percentage of employees with food handler’s cards increases the odds of being in compliance slightly decrease by 0.08 (worsens)

\(X_2=\) Measure of similar competition with 1/2 miles - This is an index of market competition that indicates that as the level of competition increases in the local area that the odds of being compliance drop by 0.015 (worsens).
$X_3 =$ Inspector Gender – Having a male inspector increased the odds of being in compliance by 0.85 over a female inspector.

$X_4 =$ Priority 1 restaurants - Priority 1 (lowest level of food-handling) restaurants have on average 0.27 higher odds of being in compliance rate than a priority 5 restaurant.

$X_5 =$ Priority 2 restaurants - Priority 2 restaurants have on average 0.92 higher odds of being in compliance than a priority 5 restaurant.

$X_6 =$ Priority 3 restaurants - Priority 3 restaurants (typical cook and serve or fast food restaurants) have on average 0.95 higher odds of being in compliance than a priority 5 restaurant.

$X_7 =$ Priority 4 restaurants - Priority 4 restaurants have on average 1.08 higher odds of being in compliance than a priority 5 restaurant.

$Y_8 =$ Risk Factor – Protection from contamination from hands

N=81353 inspections

Distribution = Normal

* A higher result indicates better control of the risk factor

\[
y = 0.9104 + 0.0298(X_1) + 0.0141(X_2) + 0.0395(X_3) + 0.0354(X_4) + 0.0079(X_5) - 0.0150(X_6) + 0.0069(X_7) + \epsilon
\]

$X_1 =$ Percentage of employees with food handler’s cards - as the percentage of employees with food handlers cards increases the level of control for this factor increases (improves). For each 10% increase in employees with food handler cards the overall level of control increases 0.3%.

$X_2 =$ Certified Food Service Manager - Having a Certified Food Service Manager increases the level of control on average 1.4% (improves).

$X_3 =$ Priority 1 restaurants - Priority 1 (lowest level of food-handling) restaurants have on average 3.95% better compliance for this risk factor than a priority 5 restaurant.

$X_4 =$ Priority 2 restaurants - Priority 2 restaurants have on average 3.5% better control for this risk factor than a priority 5 restaurant.
$X_5=$ Priority 3 restaurants - Priority 3 restaurants (typical cook and serve or fast food restaurants) have on average 0.8% better control for this risk factor than a priority 5 restaurant.

$X_6=$ Priority 4 restaurants - Priority 4 restaurants have on average 1.5% lower control of this risk factor than a priority 5 restaurant.

$X_7=$ Certified Food Service Manager*Percentage of employees with food handler cards - There is a synergistic effect that having both a Certified Food Service Manager and employees increases the level of control for this risk factor by 0.7%.

$Y_9 = Risk Factor – Approved Source$

N=81270 inspections

Distribution = Ordinal Multinomial

* A higher result indicates better control of the risk factor

\[
\ln (y_0) = -3.7271 - 0.3294(X_1) - 0.4951(X_2) + \epsilon \\
\ln (y_{0.33}) = -3.7230 - 0.3294(X_1) - 0.4951(X_2) + \epsilon \\
\ln (y_{0.5}) = -3.2288 - 0.3294(X_1) - 0.4951(X_2) + \epsilon \\
\ln (y_{0.66}) = -3.1707 - 0.3294(X_1) - 0.4951(X_2) + \epsilon
\]

$X_1=$Measure of similar competition within 1/2 mile - This is an index of market competition of restaurants with similar level of food-handling in the local 1/2 mile area. As the level of competition of increases the odds of being in compliance with this risk factor decreases by 0.03 (gets worse).

$X_2=$ Percentage of employees with food handlers cards - as the percentage of employees with food handlers cards increases the level of control for this factor decreases (worsens). For each 10% increase in employees with food handler cards the odds of being in compliance drops by 0.046.
The majority of the facilities were in compliance with this risk factor. The effect from the predictors is very small and lacks practical significance, thus the results are not reported in the above table.

\[ Y_{10} - \text{Risk Factor – Protection from Contamination} \]

N=81339 inspections

Distribution = Normal

* A higher result indicates better control of the risk factor

\[ y = 0.8512 + 0.0340(X_1) + 0.0505(X_2) + 0.0466(X_3) + 0.0524(X_4) + 0.0181(X_5) - 0.0195(X_6) + \epsilon \]

\[ X_1 = \text{Measure of competition with 1/2 miles} - \text{This is an index of market competition that indicates that as the level of competition decreases in the local area that the control for this risk factor improves (gets better)} \]

\[ X_2 = \text{Percentage of employees with food handler’s cards} - \text{as the percentage of employees with food handlers cards increases the level of control for this risk factor increases (improves)} \]

\[ X_3 = \text{Priority 1 restaurants} - \text{Priority 1 (lowest level of food-handling) restaurants have on average 4.7% better control for this risk factor than a priority 5 restaurant.} \]

\[ X_4 = \text{Priority 2 restaurants} - \text{Priority 2 restaurants have on average 0.05% better control than a priority 5 restaurant.} \]

\[ X_5 = \text{Priority 3 restaurants} - \text{Priority 3 restaurants (typical cook and serve or fast food restaurants) have on average 1.8% better control for this risk factor than a priority 5 restaurant.} \]

\[ X_6 = \text{Priority 4 restaurants} - \text{Priority 4 restaurants have on average 1.95% lower control for this risk factor than a priority 5 restaurant.} \]

\[ Y_{11} - \text{Risk Factor – Potentially Hazardous Food} \]

N=80484 inspections

Distribution = Normal

* A higher result indicates better control of the risk factor
\[ y = 0.8826 + 0.0260(X_1) + 0.0233(X_2) + 0.0640(X_3) + 0.0426(X_4) + 0.0262(X_5) - 0.0068(X_6) + \varepsilon \]

\( X_1 \) = Percentage of employees with food handler’s cards - as the percentage of employees with food handlers cards increases the level of control for this risk factor increases (improves).

\( X_2 \) = Certified Food Service Manager - Having a Certified Food Service Manager increases the level of control for this risk factor by 2.3% (improves).

\( X_3 \) = Priority 1 restaurants - Priority 1 (lowest level of food-handling) restaurants have on average 6.4% better control for this risk factor than a priority 5 restaurant.

\( X_4 \) = Priority 2 restaurants - Priority 2 restaurants have on average 4.3% better control than a priority 5 restaurant.

\( X_5 \) = Priority 3 restaurants - Priority 3 restaurants (typical cook and serve or fast food restaurants) have on average 2.6% better control than a priority 5 restaurant.

\( X_6 \) = Priority 4 restaurants - Priority 4 restaurants have on average a 0.68% lower control than a priority 5 restaurant.

\( Y_{12} \) - Risk Factor – Consumer Advisory

No variables were statistically associated with this outcome variable.

\( Y_{13} \) - Risk Factor – Highly Susceptible Populations

No variables were statistically associated with this outcome variable.

\( Y_{14} \) - Risk Factor – Chemicals

\( N=81399 \) inspections

Distribution = Binomial

*A higher result indicates better compliance with the food code requirements*
\[ \ln(y) = -0.6223 - 0.5897(X_1) + 1.2235(X_2) - 1.0763(X_3) - 0.8328(X_4) - 0.2284(X_5) - 0.4151(X_6) \\
- 0.5968(X_7) - 0.2078(X_8) + 0.0935(X_9) + 0.0585(X_{10}) + \varepsilon \]

\( X_1 = \) Measure of competition with 1/2 miles - This is an index of market competition that indicates that as the level of competition decreases in the local area that the level of control for this risk factor increases (Improves). For a 10% decrease in market competition there are on average 0.03 fewer associated violations.

\( X_2 = \) Measure of competition of similar food-handling type restaurants within 3 miles - This is an index of market competition that indicates that as the level of competition decreases in the local area that the level of control for this risk factor increases (Worsens). For a 10% decrease in market competition there is an increase of 0.07 associated violations.

\( X_3 = \) Measure of competition of similar food-handling type restaurants within 5 miles - This is an index of market competition that indicates that as the level of competition decreases in the local area that the level of control for this risk factor increases (Improves). For each 10% decrease in market competition, the number of violations decreases 0.05.

\( X_4 = \) Percentage of employees with food handler’s cards - as the percentage of employees with food handler’s cards increases the level of control for this risk factor increases (Improves). For each 10% increase in the number of employees with food handlers cards the number of violations decreases by 0.04.

\( X_5 = \) Certified Food Service Manager - Having a Certified Food Service Manager on average provides 0.11 fewer violations (Improves).

\( X_6 = \) Inspector Gender - Male inspectors mark on average 0.18 fewer violations than female inspectors.

\( X_7 = \) Priority 1 restaurants - Priority 1 (lowest level of food-handling) restaurants have on average a level of control that is 0.24 lower than a priority 5 restaurant.

\( X_8 = \) Priority 2 restaurants - Priority 2 restaurants have on average a level of control that is 0.10 lower than a priority 5 restaurant.

\( X_9 = \) Priority 3 restaurants - Priority 3 restaurants (typical cook and serve or fast food restaurants) have a level of control 0.05 higher than a priority 5 restaurant.
\[ X_{10} = \text{Priority 4 restaurants} - \text{Priority 4 restaurants have on average a level of control that is 0.03 higher than a priority 5 restaurant.} \]

\[ Y_{15} - \text{Risk Factor – Conformance with Approved Procedures} \]

No variables were statistically associated with this outcome variable.

**Florida Routine Inspections**

Table 5 provides a summary of the results for the State of Florida routine inspections. As with the Maricopa County results, the direction of the arrow indicates improvement or diminishment on the outcome variable by the independent variable.

**Table 5. Florida routine inspections summary of relevant independent variables.**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>HHI(^a) within ½-mile</th>
<th>HHI(^a) within 1-mile</th>
<th>HHI(^a) within 3-mile</th>
<th>HHI(^a) within 5-mile</th>
<th>Certified Kitchen Manager (CKM) (1=Yes, 0=No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Y_2) - Total Critical violations</td>
<td>↑</td>
<td>↑</td>
<td></td>
<td>↑</td>
<td></td>
</tr>
<tr>
<td>(Y_3) - Total Non-critical violations</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td></td>
</tr>
<tr>
<td>(Y_4) - Total violations marked</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td></td>
</tr>
<tr>
<td>(Y_{16}) - Food Source (^b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Statistically significant independent variables were identified however the effect was negligible</td>
</tr>
<tr>
<td>(Y_{17}) - Temperature Control (^b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Y_{18}) - Food Protection (^b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Y_{19}) – Personnel (^b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Y_{20}) – Food Equipment and Utensils (^b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Y_{21}) - Single-service and Single-use Articles (^b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Y_{22}) – Water and Sewerage/Plumbing (^b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Y_{23}) - Toilet and Hand washing facilities (^b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Y_{24}) - Garbage and Refuse Disposal (^b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y_{25} - Insect, Rodent, and Animal control</td>
<td>b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y_{26} - Floors, Walls, and Ceilings</td>
<td>b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y_{27} - Lighting and Ventilation</td>
<td>b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y_{28} - Other Areas</td>
<td>b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A ↑ indicates that the independent variable improves the outcome variable, a ↓ indicates that it worsens the outcome variable. A blank result indicates that the independent variable was either not statistically significant or lacked practical significance.

\(^a\) Refer to Page 24 footnote 3 for the calculation of the modified HHI. A larger value reflects less competition.

\(^b\) While the model may have statistical significance, the effect from the individual predictors lacks sufficient effect to be of practical significance.

The following independent variables lacked either statistical or practical significance and were excluded in all models: The percentage of the population that is over 60 years of age; The percentage of the population in food-handling occupations; The percentage of the population without a vehicle; The socio-economic status of the block group; The level of social deprivation of the block group and; The regional office for the inspector. The predominant race was excluded as a small minority of block groups was driving the statistical difference.

\(Y_2 \cdot Total \text{ Critical violations}\)

N=261389 inspections

Distribution = Negative Binomial

*A higher result indicates lower compliance with food safety requirements

\[
\ln(y) = 1.8642 - 0.0770(X_1) - 0.1211(X_2) - 0.6461(X_3) + \varepsilon
\]

\(X_1\)=Measure of competition within \(\frac{1}{2}\) mile - This is an index of market competition that indicates that as the level of competition within \(\frac{1}{2}\) mile decreases that the number of critical violations has a slight decrease (Improves). For each 10% decrease in the level of competition there is a 0.05 drop in the number of critical violations.
$X_2 =$ Measure of competition with 3 miles - This is an index of market competition that indicates that as the level of competition decreases by 10% there is 0.07 decrease in the number of critical violations (Improves).

$X_3 =$ Certified Food Service Manager - Having a Certified Food Service Manager decreases the number of critical violations by 3.07 (Improves).

$Y_3 =$ Total Non-critical violations

N=261389 inspections

Distribution = Negative Binomial

*A higher result indicates lower compliance with food safety requirements

\[ \ln(y) = 0.9639 - 0.1297(X_1) - 0.2837(X) - 0.1992(X_3) + \varepsilon \]

$X_1 =$ Measure of competition within ½ mile - This is an index of market competition that indicates that as the level of competition within ½ mile decreases that the number of non-critical violations has a slight decrease (Improves). For each 10% decrease in the level of competition there is a 0.034 drop in the number of non-critical violations.

$X_2 =$ Measure of competition with 3 miles - This is an index of market competition that indicates that as the level of competition decreases by 10% there is 0.07 decrease in the number of non-critical violations (Improves).

$X_3 =$ Certified Food Service Manager - Having a Certified Food Service Manager decreases the number of non-critical violations by 0.47 (Improves).

$Y_4 =$ Total violations marked

N=261389 inspections

Distribution = Negative Binomial

*A higher result indicates lower compliance with food safety requirements
\[ \ln(y) = 2.1729 - 0.1043(X_1) - 0.2010(X_2) - 0.4468(X_3) + \varepsilon \]

**X1**= Measure of competition within ½ mile - This is an index of market competition that indicates that as the level of competition within ½ mile decreases, the number of violations has a slight decrease (Improves). For each 10% increase in the level of competition there is a 0.09 drop in the number of non-critical violations.

**X2**= Measure of competition with 3 miles - This is an index of market competition that indicates that as the level of competition decreases by 10% there is 0.17 decrease in the number of violations (Improves).

**X3**= Certified Food Service Manager - Having a Certified Food Service Manager decreases the number of violations by 3.17 (Improves).

\[ Y_{16} - Food\ Source \]

N=261389 inspections

Distribution = Poisson

* A higher result indicates lower compliance with food safety requirements

\[ \ln(y) = -0.6931 + 0.045(X_1) - 0.2815(X) + \varepsilon \]

**X1**= Measure of competition within 1 mile - This is an index of market competition that indicates that as the level of competition within 1 mile decreases that the number of violations slightly increases (gets worse). For a 10% decrease in market competition there is an associated increase of 0.0023 more violations noted.

**X2**= Certified Food Service Manager - Having a Certified Food Service Manager decreases the number of violations by 0.12 (improves)

While the model is statistically significant, the effect from individual covariates lacks practical significance and is not reported in the above table.
**Y_{17} - Temperature Control**

N=261389 inspections

Distribution = Poisson

* A higher result indicates lower compliance with food safety requirements

\[ \ln(y) = -0.3830 - 0.1801(X_1) - 0.2057(X_2) - 0.3464(X_3) + \varepsilon \]

\( X_1 = \) Measure of competition within \( \frac{1}{2} \) mile - This is an index of market competition that indicates that as the level of competition within \( \frac{1}{2} \) mile decreases that the score decreases (Improves). For a 10% decrease in market competition there are 0.012 fewer violations noted.

\( X_2 = \) Measure of competition with 3 miles - This is an index of market competition that indicates that as the level of competition within 3 miles decreases that the score decreases (Improves). For each 10% decrease in competition there are 0.014 fewer violations marked.

\( X_3 = \) Certified Food Service Manager - Having a Certified Food Service Manager decreases the number of associated violations on average by 0.2 (improves)

While the model is statistically significant, the effect from individual covariates lacks practical significance and is not reported in the above table.

**Y_{18} - Food Protection**

N=261389 inspections

Distribution = Poisson

* A higher result indicates lower compliance with food safety requirements

\[ \ln(y) = -0.1741 - 0.1350(X_1) - 0.2005(X_2) - 0.1444(X_3) + \varepsilon \]

\( X_1 = \) Measure of competition within \( \frac{1}{2} \) mile - This is an index of market competition that indicates that as the level of competition within the local area decreases that the score decreases (Improves). For each 10% decrease in market competition there are 0.01 fewer associated violations marked.
$X_2=$ Measure of competition with 3 miles - This is an index of market competition that indicates that as the level of competition within 3 miles decreases that the number of associated violations decreases (gets better). For a 10% decrease in competition there is on average a 0.017 reduction in associated violations.

$X_3=$ Certified Food Service Manager - Having a Certified Food Service Manager decreases the number of associated violations on average by 0.11 (improves).

While the model is statistically significant, the effect from individual covariates lacks practical significance and is not reported in the above table.

$Y_{19} - \text{Personnel}$

N=261389 inspections

Distribution = Poisson

* A higher result indicates lower compliance with food safety requirements

\[
\ln(y) = -0.7460 - 0.1287(X_1) - 0.1387(X_2) - 0.2995(X_3) + \varepsilon
\]

$X_1=$ Measure of competition within ½ mile - This is an index of market competition that indicates that as the level of competition within ½ mile decreases that the number of associated violations decreases (Improves). For each 10% decrease in the amount of local market competition there is an associated decrease of 0.006 violations.

$X_2=$ Measure of competition with 3 miles - This is an index of market competition that indicates that as the level of competition decreases within a 3 mile range the score decreases (Improves). For each 10% decrease in market competition there is on average a 0.0065 decrease in associated violations.

$X_3=$ Certified Food Service Manager - Having a Certified Food Service Manager decreases the number of associated violations on average by 0.12 (improves).
While the model is statistically significant, the effect from individual covariates lacks practical significance and is not reported in the above table.

\[ Y_{20} \text{ – Food Equipment and Utensils} \]

N = 261389 inspections
Distribution = Poisson

* A higher result indicates lower compliance with food safety requirements

\[ \ln(y) = 0.6982 - 0.1053(X_1) - 0.2612(X_2) - 0.1877(X) + \varepsilon \]

\(X_1\) = Measure of competition within ½ mile - This is an index of market competition that indicates that as the level of competition within ½ mile decreases that the number of associated violations decreases (Improves). For each 10% decrease in competition there is an associated 0.021 decrease in the number of violations.

\(X_2\) = Measure of competition with 3 miles - This is an index of market competition that indicates that as the level of competition decreases within a radii of 3 miles that the number of associated violations decreases (Improves). For each 10% decrease in competition there is an associated 0.05 fewer violations marked.

\(X_3\) = Certified Food Service Manager - Having a Certified Food Service Manager decreases the number of associated violations by 0.34 (improves).

While the model is statistically significant, the effect from individual covariates lacks practical significance and is not reported in the above table.

\[ Y_{21} \text{ - Single-service and Single-use Articles} \]

N = 261389 inspections
Distribution = Poisson
* A higher result indicates lower compliance with food safety requirements

\[ \ln(y) = -2.0646 + 0.3363(X_1) - 0.6354(X_2) + 0.3861(X_3) - 0.0721(X) + \epsilon \]

\(X_1\)=Measure of competition within 1 mile - This is an index of market competition that indicates that as the level of competition within 1 mile decreases that the number of violations increase (gets worse). For a 10% decrease in market competition, there is on average 0.004 more associated violations marked.

\(X_2\)=Measure of competition with 3 miles - This is an index of market competition that indicates that as the level of competition decreases within a 3 mile radii the number of associated violations decreases (gets better). For a 10% decrease in market competition there is an associated 0.008 fewer violations noted.

\(X_3\)=Measure of competition within 5 miles - This is an index of market competition that indicates that as the level of competition within 5 miles decreases that the number of violations increase (gets worse). For a 10% decrease in market competition, there is on average 0.005 more associated violations marked.

\(X_4\)=Certified Food Service Manager - Having a Certified Food Service Manager decreases the number of associated violations by 0.0088 (improves).

While the model is statistically significant, the effect from individual covariates lacks practical significance and is not reported in the above table.

\(Y_{22} \) – Water and Sewerage/Plumbing

N=261389 inspections

Distribution = Poisson

* A higher result indicates lower compliance with food safety requirements

\[ \ln(y) = -1.3522 - 0.1330(X_1) + 0.924(X_2) - 0.3603(X_3) + \epsilon \]

\(X_1\)=Measure of competition within 1 mile - This is an index of market competition that indicates that as the level of competition within 1 mile decreases that the number of associated violations decreases
(Improves). For each 10% decrease in market competition, there is on average a 0.0034 reduction in the number of violations marked.

$X_2=$ Measure of competition with 3 miles - This is an index of market competition that indicates that as the level of competition decreases within a 3 mile radii the number of violations increase (Worsens). For each 10% decrease in market competition there is on average 0.025 more violations marked.

$X_3=$ Certified Food Service Manager - Having a Certified Food Service Manager decreases the number of associated violations by 0.078 (Improves).

While the model is statistically significant, the effect from individual covariates lacks practical significance and is not reported in the above table.

$Y_{23}=$ Toilet and Hand washing facilities

N=261389 inspections

Distribution = Poisson

* A higher result indicates lower compliance with food safety requirements

$$\ln(y) = -0.1781 - 0.2179(X_1) - 0.5519(X_2) - 0.5352(X_3) + \varepsilon$$

$X_1=$ Measure of competition within ½ mile - This is an index of market competition that indicates that as the level of competition within the local area decreases, so do the number of associated violations (Improves). For each 10% decrease in market competition there is on average a reduction of 0.018 violations.

$X_2=$ Measure of competition with 3 miles - This is an index of market competition that indicates that as the level of competition decreases within a 3 mile radii, there is an associated decrease in the number of associated violations (Improves). For each 10% decrease, there is on average a 0.045 decrease in the number of associated violations.
$X_3$=Certified Food Service Manager - Having a Certified Food Service Manager decreases the number of associated violations on average by 0.35 (improves).

While the model is statistically significant, the effect from individual covariates lacks practical significance and is not reported in the above table.

$Y_{24}$ - Garbage and Refuse Disposal

N=261389 inspections

Distribution = Poisson

* A higher result indicates lower compliance with food safety requirements

$$\ln(y) = -2.6366 - 0.126(X_1) + \varepsilon$$

$X_1$=Certified Food Service Manager - Having a Certified Food Service Manager decreases the number of associated violations on average by 0.009 (Improves).

While the model is statistically significant, the effect from individual covariates lacks practical significance and is not reported in the above table.

$Y_{25}$ - Insect, Rodent, and Animal control

N=261389 inspections

Distribution = Poisson

* A higher result indicates lower compliance with food safety requirements

$$\ln(y) = -1.8409 + 0.4235(X_1) - 0.4059(X_2) + \varepsilon$$

$X_1$=Measure of competition within 3 miles - This is an index of market competition that indicates that as the level of competition within 3 miles decreases that the number of associated violations increases (Worsens). For each 10% decrease in market competition there is an associated increase of 0.007 violations.
\( X_2 = \text{Certified Food Service Manager} \) - Having a Certified Food Service Manager decreases the number of associated violations on average by 0.053 (improves).

While the model is statistically significant, the effect from individual covariates lacks practical significance and is not reported in the above table.

\( Y_{26} = \text{Floors, Walls, and Ceilings} \)

N=261389 inspections

Distribution = Poisson

* A higher result indicates lower compliance with food safety requirements

\[
\ln(y) = -0.7567 - 0.2541(X_1) - 1.1267(X_2) - 0.1430(X_3) + \epsilon
\]

\( X_1 = \text{Measure of competition within ½ mile} \) - This is an index of market competition that indicates that as the level of competition within the local area decreases, there is an associated decrease in the number of associated violations (Improves). For each 10% decrease in market competition, there is an associated 0.12 decrease in the number of violations noted.

\( X_2 = \text{Measure of competition with 3 miles} \) - This is an index of market competition that indicates that as the level of competition decreases within a 3 mile radii there is an associated drop in the number of related violations (Improves). For each 10% decrease in market competition there is an associated 0.05 reduction in the number of associated violations.

\( X_3 = \text{Certified Food Service Manager} \) - Having a Certified Food Service Manager decreases the number of associated violations on average by 0.06 (Improves).

While the model is statistically significant, the effect from individual covariates lacks practical significance and is not reported in the above table.
\( y_{27} \cdot \text{Lighting and Ventilation} \)

N=261389 inspections

Distribution = Poisson

* A higher result indicates lower compliance with food safety requirements

\[
\ln(y) = -2.3138 - 0.2751(X_1) + \varepsilon
\]

\( X_1 = \) Certified Food Service Manager - Having a Certified Food Service Manager decreases the number of associated violations on average by 0.024 (improves).

While the model is statistically significant, the effect from individual covariates lacks practical significance and is not reported in the above table.

\( y_{28} \cdot \text{Other Areas} \)

N=261389 inspections

Distribution = Poisson

* A higher result indicates lower compliance with food safety requirements

\[
\ln(y) = -1.0680 - 0.0330(X_1) - 0.2069(X_2) + 0.4979(X_3) - 0.2120(X_4) + \varepsilon
\]

\( X_1 = \) Measure of competition within ½ mile - This is an index of market competition that indicates that as the level of competition within the local area decreases there is a reduction in the number of associated violations (Improves). For each 10% decrease in market competition, there is an associated 0.001 drop in the number of associated violations.

\( X_2 = \) Measure of competition with 3 miles - This is an index of market competition that indicates that as the level of competition decreases within a 3 mile radii, there is a decrease in the number of associated violations (Improves). For each 10% decrease in competition, there is an associated 0.007 decrease in the number of violations.
$X_3 =$ Measure of competition within 5 miles – This is an index of market competition that indicates that market competition decreases within a 5 mile radii, there is an associated increase in the number of associated violations (Worsens). For each 10% decrease in competition, there is an associated increase of 0.017 violations.

$X_4 =$ Certified Food Service Manager - Having a Certified Food Service Manager decreases the number of associated violations on average by 0.07 (improves).

While the model is statistically significant, the effect from individual covariates lacks practical significance and is not reported in the above table.

**State A and B Risk Factor Studies**

Table 6 provides a summary of the State A and B risk factor study results. As with the other datasets previously, the direction of the arrow is associated with the increase or decrease on the outcome variable from the independent variables.

**Table 6. State A and B risk factor study summary of relevant independent variables.**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>State</th>
<th>Certified Kitchen Manager (CKM) (1=Yes, 0=No)</th>
<th>Facility Type (Lower level food handling compared to Full-service restaurants)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y_{29} - Risk Factor – Food Source</td>
<td>A</td>
<td>No statistically significant independent variables were identified</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y_{30} - Risk Factor – Pathogen Destruction</td>
<td>A</td>
<td>No statistically significant independent variables were identified</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y_{31} - Risk Factor – Limitation of Growth of Organisms of Public Health Concern</td>
<td>A</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y_{32} - Risk Factor – Personal Hygiene</td>
<td>A</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y_{33} - Risk Factor – Protection from Contamination</td>
<td>A</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y_{34} - Risk Factor – Other</td>
<td>A</td>
<td>No statistically significant independent variables were identified</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A ↑ indicates that the independent variable improves the outcome variable, a ↓ indicates that it worsens the outcome variable. A blank result indicates that the independent variable was either not statistically significant or lacked practical significance. While the model may have statistical significance, the effect from the individual predictors lacks sufficient effect to be of practical significance.
The following independent variables lacked either statistical or practical significance and were excluded in all models: The percentage of the population that is over 60 years of age; The percentage of the population in food-handling occupations; The percentage of the population without a vehicle; The socio-economic status of the block group and; The level of social deprivation of the block group. The predominant race was excluded as a small minority of block groups was driving the statistical difference.

The dependent variables were tested between the States and found to be statistically significant different. Due to this, the results are reported independently for each State.

\[ y_{29} \cdot Risk \ Factor \ – \ Food \ Source \]
No statistically significant independent variables were identified with either study.

\[ y_{30} \cdot Risk \ Factor \ – \ Pathogen \ Destruction \]
No statistically significant independent variables were identified with either study.

\[ y_{31} \cdot Risk \ Factor \ – \ Limitation \ of \ Growth \ of \ Organisms \ of \ Public \ Health \ Concern \]
State A
N=200
*A higher result indicates better compliance with the risk factor

\[ y = 0.5329 + 0.1229(X_1) + 0.0204(X_2) + \varepsilon \]

\( X_1 \) = Type of facility – This indicates that fast food restaurants are in compliance in 12.2% more of the evaluations than a full service restaurant.

\( X_2 \) = Certified Food Service Manager - Having a Certified Food Service Manager increases the compliance rate by 2% (improves).
State B

N=181

No factors were found to be statistically significant.

\[ y_{32} \cdot Risk \ Factor \ – \ Personal \ Hygiene \]

State A

N=200

*A higher result indicates better compliance with the risk factor

\[ y = 0.2827 + 0.1222(x_1) + 0.1463(x_2) + \varepsilon \]

\[ x_1 \text{=Type of facility – This indicates that fast food restaurants are in compliance in 12.2\% more of the evaluations than a full service restaurant.} \]

\[ x_2 \text{=Certified Food Service Manager - Having a Certified Food Service Manager increases the compliance rate by 14.6\% (improves).} \]

State B

N=181

No factors were found to be statistically significant.

\[ y_{33} \cdot Risk \ Factor \ – \ Protection \ from \ Contamination \]

State A

N=200

*A higher result indicates better compliance with the risk factor

\[ y = 0.5476 + 0.1249(x_1) + \varepsilon \]
$X_1=$Type of facility – This indicates that fast food restaurants are in compliance in 12.5% more of the evaluations than a full service restaurant.

State B

N=181

*A higher result indicates better compliance with the risk factor

$$y = 3.585 - 2.41(X_1) - 2.346(X_2) - 2.59(X_3) + 0.164(X_4) + \varepsilon$$

$X_1=$Type of facility – Deli - This indicates that delis are in compliance with this risk factor on average 18% more than full service restaurants.

$X_2=$Type of facility – Fast Food Restaurant - This indicates that Fast Food Restaurants are in compliance with this risk factor on average 24% more than full service restaurants.

$X_3=$Type of facility – Full Service Restaurant - This indicates that Full service Restaurants are the least in compliance with this risk factor.

$X_4=$Certified Food Service Manager - Having a Certified Food Service Manager increases the compliance rate by 16.4% (improves).

$y_{34}$ - Risk Factor – Other

No factors were found to be statistically significant.

**Chain Restaurant Inspections**

Two chain restaurants were tested for the effect of neighborhood on the overall score. Chain A is predominantly a cook and serve style restaurant and Chain B is primarily a no cook restaurant. No neighborhood socio-demographics were statistically associated with the restaurant’s food safety performance.

Chain A (cook and serve restaurant)

N=1125
*A lower result indicates better compliance with the risk factor

\[ y = 22.5827 - 8.8405(X_1) + \varepsilon \]

\( X_1 = \) Percentage of employees that are Certified Food Handlers - This indicates that for each increase in the number of employees with a certified food handler card that the score decreases by 0.88 points.

Chain B (no cook restaurant)

N=1178

*A lower result indicates better compliance with the risk factor

\[ y = 22.9446 - 7.574(X_1) - 4.8737(X_2) + \varepsilon \]

\( X_1 = \) Certified Kitchen Manager - This indicates that having a Certified Kitchen Manager decreases the overall score by 7.6 points.

\( X_2 = \) Percentage of employees that are Certified Food Handlers - This indicates that for each 10% increase in the number of employees with a certified food handler card that the score decreases by 0.49 points.
Chapter 6. Discussion

This study is superior to other studies that have examined food safety performance with socio-demographic indicators. It has examined a broader range of socio-demographic indicators along with analyzing multiple larger jurisdictions. This study is the first to use multiple outcome measures compared to an aggregate count of the number of violations, and is the first to examine market pressures on food safety performance. This study further strengthens previous research which has held that an educational intervention can reduce the occurrence of the conditions that can lead to foodborne illness. This chapter discusses the four primary research questions and also addresses some unexpected findings.

Research Questions

RQ1: Do external factors to a restaurant influence the overall food safety in a restaurant?

This study identified that socio-demographic indicators of the surrounding community do not have either a statistically significant or a practical impact on the outcome variable. This result was further confirmed by examining two different sets of chain restaurants within Maricopa County. With these restaurants it would be anticipated that they would have similar designs and management systems in place so that if there were a significant impact from the surrounding community the results would be pronounced. In this study, there were no additional impacts on the restaurant’s food safety performance.

The level of market competition was found to have a mixed impact. In general, increased competition at a further distance led to increased food safety performance. At the local level, it was found that restaurants with less competition performed better. Perhaps this is due at the local level due to the pressure of increased competition there is a greater need to attract customers and restaurant owners and managers may become more focused on their competition and basic sanitation practices get overlooked. While having competition at a further distance requires them to maintain a minimum level of sanitation.
RQ2: What is the level of influence exhibited by both the internal and external factors on a restaurants food safety performance?

Within a restaurant this study identified two primary factors that affected food safety performance: 1) The level of food-handling; and 2) The level of food-safety education of the employees. The level of food-handling could only be assessed for Maricopa County and generally amongst the State A and B risk factor studies. In these settings, as the level of food-handling increased (e.g. from a fast-food restaurant to a full service restaurant or a cook and serve restaurant to a restaurant doing advanced preparation) there was a commensurate increase in the number of violations. This is not wholly unexpected, as a restaurant that is performing more operations has additional relevant code sections applied. Observing that many of the outcome variables for a risk level 4 (full service) restaurant were worse than for a risk level 5 (facility serving a highly susceptible population or caterer) restaurant, does provide suggestive evidence that having a food safety management system may decrease the occurrence of the risk factors for foodborne illness. This is extrapolated from the requirement in the Joint Commission patient care standard 7.10 (Joint Commission on Accreditation of Healthcare Organizations, 2008) for a food safety system.

Education was seen to provide a protective effect in general across almost all of the outcome variables. The Certified Kitchen Manager variable was present in all of the data sets and generally had either a positive or no effect. For Maricopa County, there was also a requirement for food service workers to have obtained a Certified Food Handler Card, this was found to have either no effect or a positive effect, except with the outcome variable for good hygienic practices. The outcome variable for good hygienic practices did not have a significant effect for a Certified Kitchen Manager and as the percentage of employees with a Certified Food Handler increased the rate of compliance had a slight decrease. The effect was minimal, however it could be concluded that education does not translate into actions for this variable and other methods should be examined to increase compliance in this area. The aggregate measures of compliance in Maricopa County and the risk factor for protection from
contamination showed a synergistic effect between having both a Certified Food Manager and increasing levels of Certified Food Handlers.

The gender of the inspector was found to have an effect on the risk factors for good hygienic practices and chemicals, which led to a change in the aggregate counts of violations in Maricopa County. In these instances, males were found to mark fewer violations than females. This may be related to gender-associated standards of cleanliness (Armstrong, 2005), in which there is a difference between what would be considered clean for a male versus a female.

RQ3: Are these factors consistent in alternate settings?

Due to the un-standardized method in which jurisdictions record violations, it was not possible to consider all of the variables in all of the situations. In this instance, we did find that the market competition and having a Certified Kitchen Manager did increase the level of food safety performance in both Maricopa County and in Florida. For the risk factor studies, a Certified Kitchen Manager was also found to be protective.

RQ4: Does having a centralized support structure affect these factors?

Two separate chain restaurants in Maricopa County were analyzed and no socio-demographic or market variables were statistically significant. Education was found to have an effect. The Certified Kitchen Manager was not statistically associated with increased food safety performance in Chain A. This could be due to the high rate of compliance with this risk factor for this chain (95.5% of facilities had a Certified Kitchen Manager). In both chains, the increasing level of employees that had obtained a Certified Food Handler card improved the overall score. The lack of an influence of market competition suggests that the centralized marketing strategies allow the individual restaurants to focus on food preparation and service and not on their competition. Additionally, the intercept for the chain restaurants
is lower than for all restaurants by almost seven points before accounting for covariates (Chain A = 22.6, Chain B = 22.9, Overall, 29.4). These results do provide support that a centralized structure and established procedures can increase restaurant food safety performance.

Other Results

The results for this study indicate that the factors that affect food safety performance are small and require a large sample size to detect an influence. This is likely due to most restaurants being in compliance and needing a sufficient sample size to capture non-compliant restaurants at a rate that is higher than by chance.

The results from Florida in which only violations are debited illustrates one of the inherent flaws in using an aggregate count of violations as an outcome variable. The use of the In-compliance, Out of compliance, Not observed, and Not applicable rating for the risk factors is superior to just recording violations. As evidenced in the difference between Maricopa County and Florida, with the sole recording of violations an artificially expanded denominator is created assuming that all restaurants are performing all of the tasks, which dilutes the actual rate of occurrence of the risk factors for foodborne illness. This also minimizes the effect from covariates.

Limitations

This study has limitations. The largest limitation relates to measurement bias. A food safety inspection is a snapshot of a facility’s operation. It will only record the conditions that are present at that time, but may not adequately reflect the actual overall food safety performance of the restaurant. The role of the inspector is an additional source of measurement bias, as has been noted in previous research; the inspector is allowed professional judgment in whether to document a violation, which could lead to underreporting. Lastly, while food safety inspections utilize a similar set of rules; the results are not reported in a uniform manner, which decreases the ability for comparison between jurisdictions.
Chapter 7. Conclusions and Recommendations

The development of a food safety management system can have a positive effect on a restaurant's food safety performance. This is evidenced by both chain restaurants in Maricopa County performing better than their independent counterparts and by risk level 5 restaurants performing better than risk level 4 restaurants. In both of these instances, the facilities typically have a food safety management system in place, either through a corporate-franchise agreement or through a third-party requirement.

This study has established the importance of education as an intervention. In all of the datasets, having a Certified Kitchen Manager had either a protective or no effect, but in no instances did it provide a negative effect. In general, having a trained staff has provided a positive effect on restaurant food safety performance. Due to the anomalous result for the risk factor for good hygienic practices, it would be recommended that additional research be completed to understand the factors that translate from knowledge to practice and alternate interventions be designed that incorporate additional methodologies to foster compliance.

The role of market competition has not been previously studied. Recognizing that restaurants with multiple competitors in the local area may be distracted from their food safety obligations may allow a local health department to assign resources in a manner to minimize this effect, such as by increased inspection frequency. Other socio-demographic factors were not associated with restaurant performance.

The gender differences related to good hygienic practices and chemical usage was somewhat unexpected. While it had been previously noted as affecting total violations (Pothukuchi et al., 2008), it has not been studied to see what drives this difference. While this difference was not present with the most common causes of foodborne illness, it would be worth additional research into potential gender-based standards of cleanliness.

This study further supports the need to perform food safety performance using a multivariable model. Throughout this study, the outcome variable has been a function of multiple variables. Utilizing a sole
predictor variable may mislead the investigator into identifying a relationship that may be mitigated by including a covariate.

Lastly, this study has illustrated the utility of assessing the compliance status of each risk factor to obtain a representative denominator of the occurrence of the practices. From a risk quantification perspective having an accurate baseline of the occurrence of practices will provide a standardized framework for assessing the risk to a community and the effectiveness of intervention strategies.

References


doi:http://dx.doi.org/10.1006/pmed.2000.0796


