Restaurant Inspection and Training Factors
Associated with Foodborne Disease and Food Handler Knowledge

BY

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THESIS
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DEDICATION

This dissertation is dedicated to my husband, Chris Kelso, who always inspires me to be the best version of myself.

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CONTRIBUTION OF AUTHORS

Chapter 1 is a brief overview that introduces the field of research and details the primary aims of this dissertation. Chapter 2 details background information and literature gaps to highlight the significance of my research. Chapter 3 represents an unpublished manuscript for which I was the primary author and principal investigator of the research. Dr. Mark Dworkin, my research mentor, contributed to the study design and writing of the manuscript. I anticipate this work will be published as a co-authored manuscript. Chapter 4 represents my own unpublished analysis examining certified food manager training in Illinois. Chapter 5 represents a published manuscript (Manes, M.R., Kuganantham, P., Jagadeesan, M., Laxmidevi, M., Dworkin, M.S. 2016. A step towards improving food safety in India: Determining baseline knowledge and behaviors among restaurant food handlers in Chennai. *Journal of Environmental Health, 78*(6), 18-25) for which I was the primary author and principal investigator of the research. Dr. Mark Dworkin contributed to the study design and writing of the manuscript. Dr. P. Kuganantham, Dr. M. Jagadeesan, and M. Laxmidevi assisted with research logistics in India, survey language translation, staff training and writing of the manuscript. Chapter 6 details overall research findings and conclusions.

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LIST OF ABBREVIATIONS

ANSI	American National Standards Institute
API	Association of Physicians of India
CDC	Centers for Disease Control and Prevention
CFP	Conference for Food Protection
CHEF	Chicago Educational Food Handler study
CNDSS	Canadian Notifiable Diseases Surveillance System
EHS	Environmental Health Specialist
FAFH	Food Away From Home
FDA	Food and Drug Administration
FERG	Foodborne Disease Burden Epidemiology Reference Group
FoodNet	Foodborne Diseases Active Surveillance Network
FSMA	Food Safety Modernization Act
FSSAI	Food Safety and Standards Authority of India
FSSMC	Food Service Sanitation Manager Certification
HAACP	Hazard Analysis and Critical Control Points
HSR	Human Subjects Research
HUS	Hemolytic Uremic Syndrome
NESP	National Enteric Surveillance Program
NEHA	National Environmental Health Association
NSF	National Science Foundation
QALY	Quality-adjusted life years
spp.	Species

LIST OF ABBREVIATIONS (continued)

SSRFHS	Smart Suburban Restaurant Food Handler Study
TCS	Time/temperature Control for Safety
UNICEF	United Nations Children's Fund
WHO	World Health Organization
ZIP	Zero-Inflated Poisson regression

SUMMARY

Restaurants are a major contributor to the burden of foodborne disease in the United States and throughout the world. In effort to protect public health and assure compliance with food safety laws, restaurants are routinely inspected by local health departments and food safety training is provided to food handlers. However, optimal inspection and training practices have not been established, and the implementation of these measures varies considerably across local jurisdictions. Furthermore, their effectiveness on the prevention of foodborne disease is unclear. The purpose of this project was to examine the relationships between restaurant-related factors, such as inspections and training, and selected outcomes; including foodborne disease outbreaks and knowledge of restaurant staff. We performed three distinct, but related, observational studies to address literature gaps in the field of food safety and help guide local food code regulation.

Using data from a nationwide survey, completed by local health departments from across the United States, we identified jurisdictional level restaurant-related factors associated with foodborne illness outbreaks. We found that outbreaks were more likely to occur among jurisdictions with a heavier workload among environmental health sanitarians. Our results are the first to suggest this association, but are consistent with fields such as nursing, which have shown adverse outcomes with increasing workload. Our data also revealed a positive correlation between proportion of "high risk" restaurants and outbreak rate, suggesting that although jurisdictions use varying classification schemas, restaurants at greater risk for outbreaks are being properly identified at the local level. In this study, restaurant inspection frequency was not correlated with the presence of outbreaks. The literature on this relationship is inconsistent and future research should examine restaurant inspections in a more controlled experimental study

design. Based on the results of this study, we recommend that health departments consider establishing workload capacity limitations, especially when a large proportion of high risk restaurants need to be inspected or when outbreaks have occurred. We also advocate for the continued practice of risk classification to identify high risk restaurants and set inspection frequencies, but propose coupling inspections with risk-based interventions, such as food handler food safety education.

To evaluate food handler training, we studied the relationship between food safety knowledge and the utilization of various certification programs. We analyzed food safety knowledge assessment data collected from restaurant managers employed in Chicago and the surrounding Suburbs. We found that higher food safety knowledge was associated with certification through ServSafe, which suggests that some program types in Illinois may be more effective than others in educating food managers. Although data comparing the effectiveness of food safety training is limited, our results align with other studies which have reported improved knowledge with accredited program certification. We also found primary language to be an important factor, with English-speaking managers having higher food safety knowledge than their Spanish-speaking counterparts. Regardless of certification program or primary language, however, food safety knowledge overall was low and we identified substantial knowledge gaps related to hygiene and optimal temperatures for cooking, holding and refrigeration. Our results suggest that food safety knowledge of many certified managers in Illinois is lacking, which may compromise their ability to adequately train restaurant staff. Additional research is needed to identify specific training methods and materials used by these programs and to examine their

relationship with food safety knowledge. We recommend the adoption of evidence-based methods and materials that are linguistically and culturally appropriate and have been shown to improve food safety knowledge and practices.

To establish restaurant food safety intervention priorities for a local health department in India, we identified knowledge gaps among food handlers and food safety barriers of restaurants located in Chennai, Tamil Nadu. Using food safety knowledge assessments, we found overall knowledge to be low and identified gaps related to cross contamination, hand hygiene, and proper food cooking and holding temperatures. We also found higher food safety knowledge to be correlated with having an Indian Medical Fitness Certification, which is a medical examination to determine health qualification for food handling and not a food safety training course. Our results are the first to suggest this relationship and are particularly relevant as newer regulation requires medical certification of all food handlers. Restaurant inspections revealed several areas for improvement including the availability and regular use of soap for hand hygiene and improper chilling and holding temperatures of food. The food safety barriers identified in this study are similar to those described for restaurants located in lower resource communities. Based on our findings, we advocate for the inclusion of an educational component as part of the medical certification process, with explanation of expected food safety behavior. In response to this need, we created an educational brochure that instructs on the food safety topics prioritized by the knowledge survey and restaurant inspections to be distributed to restaurants by the local health department.

I. INTRODUCTION

The global burden of foodborne disease is substantial, with an estimated 600 million foodborne illnesses and 420,000 deaths annually (Havelaar et al. 2015). Foodborne disease is an increasing public health concern, as a growing number of consumers are eating meals outside of the home. The consumption of food away from home is a known risk factor for foodborne illness throughout the world (Leman and Strachan 2001; Kassenborg et al. 2004a; Kassenborg et al. 2004b; Kimura et al. 2004; Ujjiga et al. 2015). In the United States, a considerable proportion of foodborne disease outbreaks are attributed to restaurants with improper handling practices that are frequently identified as contributing factors such as: food handlers working while ill, cross-contamination of ready-to-eat foods, and time and temperature abuse (Todd et al. 2007). In regions with fewer food safety resources, a lack of basic food sanitation, such as hot water and cleaning materials, may increase the risk of foodborne disease among restaurant patrons (Al-Khatib and Al-Mitwalli 2009).

Local health departments are often responsible for the prevention of restaurant-attributed foodborne illness in their jurisdiction. In the United States, restaurant inspections, which are designed to identify and halt improper food handling practices, determine momentary compliance with health regulation. However, optimal inspection requirements have not been established, implementation of inspection regulation can be dependent on factors other than food safety (such as health department staffing), and the effectiveness of inspections on the prevention of foodborne illness is unclear. Epidemiologic evidence suggests that poor restaurant inspection scores may be associated with increased risk for foodborne illness outbreaks, among restaurants in Seattle-King County (Irwin et al. 1989). However, other research found no relationship

between restaurant inspection results and foodborne illness (Cruz et al. 2001; Jones et al. 2004). Research correlating restaurant-related jurisdictional factors, such as inspection frequency and inspector workload, with foodborne illness is limited and inconsistent (Riben et al. 1994a; Riben et al. 1994b; Newbold et al. 2008; Zablotsky Kufel et al. 2011).

Epidemiologic data demonstrate a lack of food safety knowledge among restaurant food handlers (Lynch et al. 2003; DeBess et al. 2009; Dworkin et al. 2011; Panchal et al. 2012; Manes et al. 2013; Panchal et al. 2013; Brown et al. 2014; Manes et al. 2016). In effort to reduce the risk of foodborne disease from restaurants, legislation increasingly requires food safety training of food handlers throughout the world (Regulation of the European Parliament and of the Council 2004; Minnesota Administrative Code 2011; Pennsylvania Administrative Code 2014; Rules and Regulations of the State of Georgia 2015; Ontario Regulation 2017). Although food safety education and training have been shown to improve food safety knowledge (Egan et al. 2007; Roberts et al. 2008; Bush et al. 2009; York et al. 2009; Dworkin et al. 2012; Soon et. al. 2012; Manes et al. 2013), the effectiveness of training on food safety behavior and on restaurant inspection results remains inconclusive (Mathias et al. 1994; Riben et al. 1994a; Riben et al. 1994b; Clayton et al. 2002; Egan et al. 2007; Roberts et al. 2008; York et al. 2009; Park et al. 2010; Averette et al. 2011). Two food safety studies have reported a decrease in the incidence of outbreaks with the implementation of food safety training but poor food handler practices were observed after training in each study (Hammond et al. 2005; Hedberg et al. 2006).

As there is substantial foodborne disease burden throughout the world, with a considerable proportion of outbreaks attributed to restaurants, a reduction in restaurant-related foodborne disease illness is crucial to improve health overall. The purpose of this research was to examine the relationships between restaurant-related factors, such as inspections and training,

and selected outcomes; including foodborne disease outbreaks and knowledge of restaurant staff. The specific aims of this project were addressed through three independent, but related, observational studies with the following objectives:

1. Examine the association between foodborne illness outbreaks and restaurant inspection factors, such as inspection frequency and environmental health sanitarian workload, among local health departments across the United States;
2. Identify food handler training methods utilized in Illinois and evaluate how training relates to food safety knowledge among urban and suburban Chicago food handlers;
3. Assess knowledge gaps among food handlers and identify food safety barriers in a low resource setting, using knowledge assessments and restaurant inspections performed in Chennai, India.

II. BACKGROUND

A. Foodborne Disease

Foodborne disease, often known as foodborne illness or food poisoning, results from the consumption of food contaminated with pathogenic microorganisms and their toxins, marine organisms and their toxins, fungi and their related toxins, or non-biological chemicals (American Medical Association et al. 2004). Most foodborne diseases are caused by a variety of pathogens, such as bacteria, viruses and parasites, with differing contamination sources and resulting clinical manifestations, incubation periods and durations of infection. Table I details five organisms, Noroviruses, *Salmonella*, *Clostridium perfringens*, *Camplobacter spp*. and *Staphylococcus aureus*, that are most frequently the cause of foodborne disease in the United States (U.S. Food and Drug Administration 2016).

The common symptoms of foodborne illness include nausea, vomiting, abdominal cramps and diarrhea. Most illnesses are acute and non-life threatening, but some pathogens can cause serious, long-term, and life-threatening symptoms such as: bloody diarrhea, dehydration, fever, weight loss, and neurological involvement including motor weakness or cranial nerve palsies. Children, elderly and immuno-compromised populations are particularly vulnerable to severe complications and death. The clinical manifestations caused by a Shiga-toxin producing enterohemorrhagic *Escherichia coli* (EHEC) infections, such as those of Hemolytic Uremic Syndrome (HUS), exemplify the potential severity of foodborne illnesses. Hemolytic Uremic Syndrome is a clinical composite of thrombocytopenia (low blood platelet count), hemolytic anemia (destruction of healthy red blood cells) and thrombotic microangiopathy (blood clotting in the capillaries and arterioles) that contributes to acute kidney injury, often requiring dialysis and can progress to acute renal failure and death (Mayer et al., 2012). Young children are more

TABLE I

TOP FIVE FOODBORNE-DISEASE CAUSING ORGANISMS IN THE UNITED STATES [a]

Rank	**Organism**	**Onset Time**	**Signs & Symptoms**	**Duration**	**Food Sources**
#1	Norovirus	12-48 hours	Nausea, vomiting, abdominal cramping, diarrhea, fever, headache	12-60 hours	Food (after contact with infected food handler), raw produce, shellfish from contaminated water
#2	*Salmonella*	6-48 hours	Diarrhea, fever, abdominal cramping, vomiting	4-7 days	Eggs, poultry, meat, unpasteurized milk or juice, cheese, raw produce
#3	*Clostridium perfringens*	8–16 hours	Abdominal cramping, diarrhea (watery)	24 hours	Meat, poultry, gravy, time and/or temperature-abused foods
#4	*Campylobacter jejuni*	2-5 days	Diarrhea (may be bloody), abdominal cramping, fever, vomiting	2-10 days	Undercooked poultry, unpasteurized milk, contaminated water
#5	*Staphylococcus aureus*	1-6 hours	Sudden nausea and vomiting, abdominal cramping, diarrhea, fever	24-48 hours	Improperly refrigerated meats, egg and cream based foods

[a] Table adapted from *Foodborne Illness-Causing Organisms in the U.S., What you need to know*, The U.S. Food and Drug Administration, 2016, https://www.fda.gov/downloads/food/foodborneillnesscontaminants/ucm187482.pdf.

likely to develop severe HUS complications requiring hospitalization and kidney dialysis, and the elderly are more likely to die regardless of clinical complications (Meng and Schroeder 2007, p. 11; Mayer et al. 2012).

B. Foodborne Disease Burden

Foodborne diseases are a widespread problem and a growing public health concern throughout the world. Although food has been shown to be the most common vehicle of foodborne and waterborne outbreaks among global regions with varying surveillance sophistication, estimating the burden of foodborne disease is complex and difficult (DeWaal et al. 2010). Disease estimates are complicated by a number of factors. Gastrointestinal illnesses often go unrecognized or unreported to public health authorities, foodborne disease definitions vary considerably, and few illnesses can be definitively linked to food (World Health Organization 2008a). In addition, foodborne disease outbreaks in many countries are not often investigated by local health authorities due to limited funds and resources, lack of investigation guidelines, poorly functioning food control systems, and deficient collaboration among food law and regulations, food control management, inspection services, epidemiological and laboratory services and communication to the consumer (World Health Organization 2008a).

Despite these challenges, the World Health Organization (WHO) established the Foodborne Disease Burden Epidemiology Reference Group (FERG) in 2007 to estimate the global incidence, mortality and burden of 31 foodborne hazards (World Health Organization 2008b; Kuchenmuller et al. 2009). In 2010, WHO-FERG reported an annual incidence of 600 million foodborne illnesses and 420,000 deaths worldwide (Havelaar et al. 2015). These burden estimates are comparable to those of major infectious diseases including malaria, Tuberculosis

and HIV/AIDS. Highest estimates were among African, South-East Asian and Eastern Mediterranean sub-regions of the world and for children under the age of 5 years.

In the United States, foodborne diseases cause millions of illnesses annually resulting in thousands of deaths. In 2011, Scallan et al. published comprehensive estimates of US foodborne illnesses using data from the Foodborne Diseases Active Surveillance Network (FoodNet) and other pathogen-specific surveillance systems (Centers for Disease Control and Prevention 2017b; Scallan et al. 2011a; Scallan et al. 2011b). The disease estimates were developed using improvements made to previous methods of Mead et al. (Mead et al. 1999). The overall annual total burden of disease due to contaminated food consumed in the United States was estimated to be 47.8 million illnesses, 127,839 hospitalizations, and 3,037 deaths. Nineteen percent of these illnesses were the result of 31 known agents of foodborne disease with the remaining estimates attributed to unspecified agents. Among the known agents of foodborne disease, norovirus accounted for 58% of estimated illnesses, followed by nontyphoidal *Salmonella* spp. (11%) and *Clostridium perfrigens* (10%) (Scallan et al. 2011a).

National level foodborne disease estimates have also been reported in numerous countries throughout the world (Adak et al. 2002; Adak et al. 2005; Flint et al. 2005; Hall et al. 2005; Vaillant et al. 2005; OzFoodNet 2009; Gkogka et al. 2011; Havelaar et al. 2012; Thomas et al. 2013). In 2000, England and Wales estimated over 1.3 million foodborne illness cases, with nearly 21,000 hospitalizations and 500 deaths (Adak et al. 2002). In 2008, nearly 26,000 cases and 691 hospitalizations were reported to the Australian national surveillance network, OzFoodNet (OzFoodNet 2009). In 2013, Thomas et al. estimated 4.0 million cases of foodborne illnesses using data from the Canadian Notifiable Disease Surveillance System (CNDSS) and the National Enteric Surveillance Program (NESP) (Thomas et al. 2013). Like the US estimates,

these national studies reported a large proportion of illness attributed to unspecified agents, and Norovirus and *Salmonella* as leading causes of foodborne illness among the known agents.

C. Economic Impact

The economic burden due to foodborne disease is substantial across individual communities and throughout the world. Households whose members are ill, the food industry, and the public health and regulatory sectors incur monetizable and non-monetizable costs due to foodborne diseases (Buzby and Roberts 2009). Costs to households, include medical, psychological, and legal expenses, and the loss of income or productivity. Costs incurred by the food industry include product recalls, restaurant closures, loss of reputation, regulatory fines, and litigation expenses. Costs to the public health and regulatory sectors include expenses related to disease surveillance, outbreak investigation, and regulation enforcement (DeWall and Robert 2005; Buzby and Roberts 2009; Scharff 2012).

Various national-level economic models have been developed to estimate foodborne disease costs in the United States (Hoffmann et al. 2012; Scharff 2012; Minor et al. 2015). Using cost-of-illness (COI) models and disease estimates published by Scallen et al., Scharff estimated the average cost per case of foodborne illness to be $1,068 totaling to an annual cost of $77.7 billion (Scallan et al. 2011a; Scallan et al. 2011b; Scharff 2012). In 2015, Minor and colleagues calculated the average cost burden per illness to be higher at $3,630 for a total annual cost of $36 billion using an economic welfare-based method (Minor et al. 2015). In another study, Hoffman et al. (2012) estimated the annual cost due to foodborne illness to be $14.0 billion when accounting for the 14 pathogens responsible for 95% of foodborne illnesses and 98% of deaths (Hoffmann et al. 2012). The varying cost estimates are a reflection of the differences in estimation methodologies employed by the study researchers. Despite varying cost results

reported by these U.S.-specific economic models, the published findings consistently demonstrate substantial national economic burden due to foodborne illnesses.

D. Food Contamination

A food supply chain, also known as a food production chain or food system, refers to the processes that make food available for consumption. In a typical food supply chain, shown in Figure 1, food moves from "farm to table" through production, processing, distribution, preparation, and finally consumption. Production is the process of growing plants and raising or

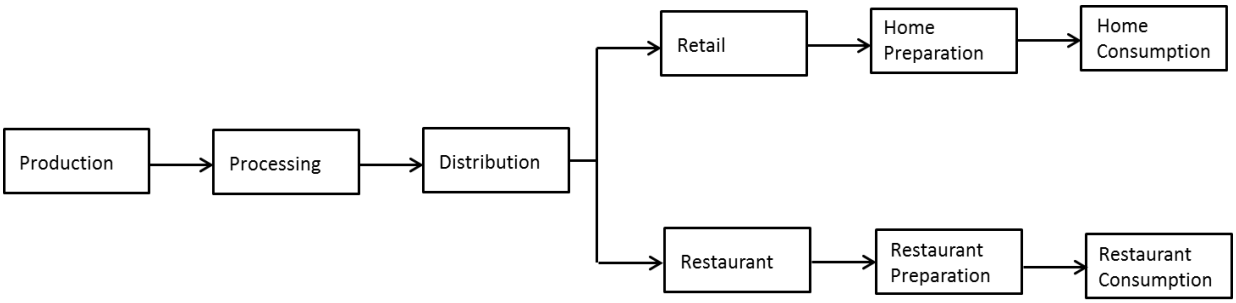

Figure 1. Diagram of an example food supply chain

harvesting animals from farms, ranches or the wild. Processing refers to the alteration of plants and animals into edible food, and includes but is not limited to, cleaning, cutting, slaughtering, pasteurizing, roasting, cooking, or freezing. Distribution is the transportation of food to a food service or retail facility, like a restaurant or grocery store. Preparation is the process of preparing

food to be ready to eat and can occur in the home or at a food service facility. Food supply chains commonly cross local, national and international boundaries.

Food contamination risks exist at every point along the supply chain, making risk management and contamination tracing complex and difficult. In effort to mitigate food contamination risk in the United States, legislation, such as the FDA Food Safety Modernization Act (FSMA) Preventive Controls for Human Food Rule, requires facilities to develop written food safety plans that include hazard analysis and preventative controls with monitoring and corrective actions (Food Safety Modernization Act 2011). Hazard Analysis Critical Control Point, or HACCP, is a commonly adopted food safety management system designed for use by all segments of the food supply chain (U.S. Food and Drug Administration 1997). Despite food safety efforts like HAACP, foodborne illness outbreaks regularly occur from food contamination at various points along the supply chain (Centers for Disease Control and Prevention 2013a; Choi et al. 2014; Crowe et al. 2015; Scott et al. 2015; Gieraltowski et al. 2016; Self et al. 2016).

Food preparation, as the last process in the supply chain before food is consumed, is a critical point in the prevention of foodborne illness. As an example, a restaurant food handler can prevent foodborne illness by properly cooking ground beef to the USDA recommended minimal 160 degrees F, which can kill *E. Coli* and *Salmonella* bacteria, even when beef is contaminated at an upstream point in the supply chain (National Research Council (US) Committee on an Evaluation of the Food Safety Requirements of the Federal Purchase Ground Beef Program 2010). Conversely, however, improper food preparation is commonly identified as an important factor contributing to foodborne illness outbreaks (Bhunia 2007; Centers for Disease Control and Prevention 2013b; Centers for Disease Control and Prevention 2015; McCarty et al. 2015; Rinsky et al. 2016). Outbreak investigations have revealed that even a single food handler with a lapse in

food safety can contaminate food and cause an outbreak affecting a large number of people. In 2007, a food handler suffering from typhoid fever who did not wash his hands while preparing food at a local sweet shop likely caused a typhoid fever outbreak in West Bengal, India that resulted in 103 suspected typhoid fever cases (Bhunia 2007).

E. Food Away from Home as Foodborne Illness Risk Factor

Food service establishments, specifically restaurants, are an increasingly critical point in the food supply chain as the frequent consumption of food prepared outside the home is becoming a more common lifestyle throughout the world (Guthrie et al. 2002; Nielsen et al. 2002; Ma et al. 2006; Gal et al. 2007; Islam et al. 2010; Poti and Popkin 2011; Drescher and Roosen 2013; Rasmussen Reports 2013; Rufino 2015; Cupak et al. 2016; Bezerra et al. 2017).

In the United States, agriculture, food, and related industries account for $992 billion and 5.5% of the US gross domestic product (USDA-ERS 2017). The food industry is substantial, with more than one million registered restaurants throughout the country and $800 billion in annual sales (National Restaurant Association 2017). Nearly 60% of Americans report eating meals outside of the home at least once per week (Rasmussen Reports 2013). Data provided by the United States Department of Agriculture Economic Research Service (USDA-ERS) demonstrate the growing trend in the consumption of food away from home (FAFH). The percentage of total household expenditure on FAFH increased by 65%, from 25.9% in 1970 to 42.7% in 2012 (Figure 2) (USDA-ERS 2017). Increasing trends have occurred across age groups, including among children (Guthrie et al. 2002; Nielsen et al. 2002; Poti and Popkin 2011). As an example, Guthrie and colleagues reported that from 1977-1978 through 1994-1996, the percentage of total caloric intake from fast-food sources increased from 2% to 13% and from full-service restaurants from 1% to 5%, among children aged 2 to 18 years (Guthrie et al. 2002).

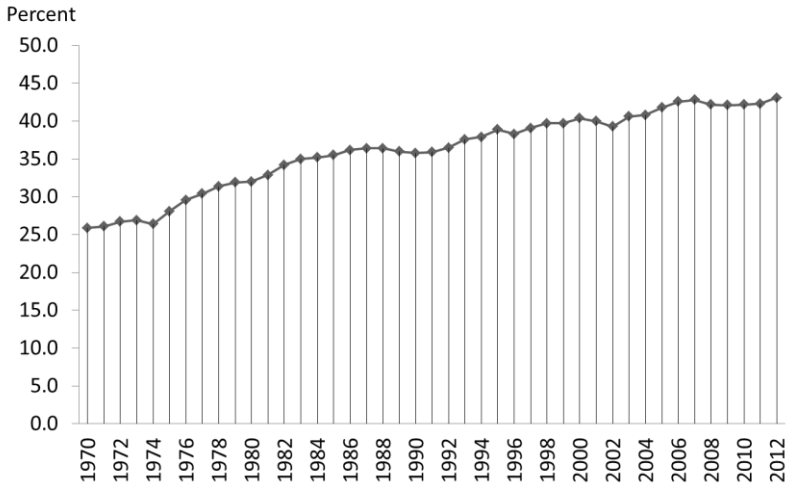

Figure 2. Percentage of total household expenditure on food away from home, United States, 1970-2012.

Research on the consumption of FAFH is also widely developed in the international literature (Ma et al. 2006; Gal et al. 2007; Islam et al. 2010; Drescher and Roosen 2013; Rufino 2015; Cupak et al. 2016; Bezerra et al. 2017). A Brazilian study, using data from the *Pesquisa de Orçamento Familiar* (Household Budget Survey) of 2008-2009, found that 41.2% of participants reported purchasing FAFH during a seven day expenditure period, with the highest percentage of food purchased from restaurants and snack bars (Bezerra et al. 2017). In a study examining the relationship between income growth and food consumption in urban China, researchers found that between 1995 and 2001 the share of household food expenditure on FAFH rose from 10% to 16% (Ma et al. 2006). Similarly, among households in the Philippines, Rufino reported a 9% increase in total expenditure on FAFH from 2003 to 2012 (Rufino 2015).

These growing trends are of public health importance, as research has consistently demonstrated risk of foodborne disease from food consumed away from home, and often from restaurants specifically (Leman and Strachan 2001; Rodrigues et al. 2001; Friedman et al. 2004; Glynn et al. 2004; Hennessy et al. 2004; Kassenborg et al. 2004a; Kassenborg et al. 2004b; Kimura et al. 2004; Mermin et al. 2004; Marcus et al. 2007; Varma et al. 2007; Janmohamed et al. 2011; Ujjiga et al. 2015). Domestic and international case-control studies, such as those detailed in Table II, consistently demonstrate an association between FAFH and foodborne disease.

In the United States, numerous studies have examined foodborne disease risk factors using data from the Foodborne Diseases Active Surveillance Network (FoodNet). The FoodNet, established in 1995, conducts surveillance on various foodborne disease pathogens, and is a collaboration between the CDC, ten state health departments, the USDA, and FDA (Centers for Disease Control and Prevention 2016). Data from the FoodNet studies support the link between FAFH and different types of foodborne diseases. In a case-control study to identify risk factors for sporadic *Escherichia coli* O157:H7 infection among FoodNet sites in Minnesota, Oregon, California, Connecticut and Georgia, eating at a table-service restaurant was associated with *E. coli* related illness (matched OR 1.7, 95% CI 1.0, 2.9) (Kassenborg et al. 2004a). Studies in other countries have shown similar results. For example, in a 2015 study of a cholera outbreak in South Sudan, *Vibrio cholera* infection was associated with eating food outside of the home (OR 9.17, 95% CI 1.9,44.4) (Ujjiga et al. 2015).

Consuming specific food types from restaurants have also been associated with increased likelihood of foodborne illness. Poultry consumption, for example, is a commonly identified risk factor. In a large study of seven FoodNet sites, Friedman and colleagues found that cases with

TABLE II
FOOD AWAY FROM HOME RISK FACTORS ASSOCIATED WITH FOODBORNE DISEASE

	Pathogen (or gastrointestinal illness)	No. of Cases	Odds Ratio, 95% CI	Setting	Reference
Eating Away From Home					
Eating at a table service restaurant	*Escherichia coli* O157:H7	196	1.7 (1.0-2.9)	Five US states	Kassenborg et al. 2004a
Eating fewer meals prepared at home	*Salmonella enterica*	182	2.4 (1.5-3.8)	Five US states	Kimura et al. 2004
Eating away from home	Gastrointestinal illness	112	2.41 (1.29-4.5)	London	Leman and Strachan, 2001
Eating food prepared outside the home	*Vibrio cholerae*	134	9.17 (1.9-44.4)	South Sudan	Ujjiga et al., 2015
Eating specific foods away from home					
Chicken	*Salmonella enterica*	182	2.8 (1.8-4.4)	Five US states	Kimura et al. 2004
Chicken	*Salmonella enterica*	218	2.6 (1.4-4.4)	Five US states	Marcus et al., 2007
Chicken, prepared at a restaurant	*Campylobacter* species	1316	2.2 (1.7-2.9)	Seven US states	Friedman et al. 2004
Chicken, prepared at a restaurant	*Campylobacter jejuni*	229	2.38	England	Rodrigues et al., 2001
Chicken or Turkey	*Campylobacter* species (drug-resistant)	33	10 (1.3-78)	Five US states	Kassenborg et al. 2004b
Chinese or Thai style food, prepared at a restaurant	*Salmonella enterica*	63	4.4 (1.3-14.8)	England and Wales	Janmohamed et al., 2011
Eggs	*Salmonella enterica*	63	5.1 (1.3-21.2)	England and Wales	Janmohamed et al., 2011
Eggs	*Salmonella* Heidelberg	44	6.0 (1.2-29.6)	Five US states	Hennessy et al. 2004
Eggs, fried	*Salmonella* Typhimurium	166	4.2 (1.4-12.9)	Five US states	Glynn et al. 2004
Eggs, scrambled	*Salmonella* Typhimurium (multidrug resistant)	61	5.7 (1.3-26.1)	Five US states	Glynn et al. 2004
Eggs, prepared at a restaurant	*Salmonella* serogroup B or C	463	1.6 (1.3-2.0)	Five US states	Mermin et al. 2004
Hamburger, pink	*Escherichia coli* O157:H7	196	5.0 (1.3-20.0)	Five US states	Kassenborg et al. 2004a

TABLE II (Continued)
FOOD AWAY FROM HOME RISK FACTORS ASSOCIATED WITH FOODBORNE DISEASE

	Pathogen (or gastrointestinal illness)	**No. of Cases**	**Odds Ratio, 95% CI**	**Setting**	**Reference**
Eating specific foods away from home					
Hummus	*Listeria monocytogenes*	249	2.6 (1.4-5.0)	Nine US states	Varma et al., 2007
Melons	*Listeria monocytogenes*	249	5.7 (1.7-19.1)	Nine US states	Varma et al., 2007
Non-poultry meat, prepared at a restaurant	*Campylobacter* species	1316	1.7 (1.3-2.2)	Seven US states	Friedman et al. 2004
Turkey, prepared at a restaurant	*Campylobacter* species	1316	2.5 (1.3-4.7)	Seven US states	Friedman et al. 2004
Vegetarian food, prepared at a restaurant	*Salmonella enterica*	63	14.6 (2.1-99.0)	England and Wales	Janmohamed et al., 2011

Campylobacter infection were more likely than controls to have eaten chicken, turkey, and non-poultry meat prepared by a restaurant (matched OR 2.2, 95% CI 1.7, 2.9, matched OR 2.3, 95% CI 1.3, 4.7, and matched OR 1.7, 95% CI 1.3, 2.2, respectively) (Friedman et al. 2004). In 2001 study also conducted in England, Rodrigues et al. found that cases with *Campylobacter jejuni* infection were more likely than controls to have eaten chicken prepared at a restaurant (OR 2.39, p=0.004) (Rodrigues et al. 2001). Even the consumption of non-meat foods have been associated with FAFH. In another FoodNet study conducted in 2004, Mermin et al. found the consumption of eggs prepared by a restaurant to be a risk factor for *Salmonella* serogroup B or C infection (Mermin et al. 2004). In a study examining food-specific factors related to *Salmonella enterica* infection in England and Wales, researchers reported an association between eating vegetarian foods at a restaurant and salmonellosis illness (OR 14.6, 95% CI 2.1, 99.0) (Janmohamed et al. 2011).

F. Outbreaks Investigations of Restaurants

In the United States, foodborne disease outbreaks are commonly attributed to food service establishments and are most frequently reported from restaurants. In 2013, 720 single setting foodborne outbreaks were reported to the Centers for Disease Control and Prevention (CDC) and approximately 60% were associated with restaurants (Gould et al. 2013). Therefore, the detection of and resulting response to restaurant-associated foodborne outbreaks are critical actions of local and state health departments to protect the public health.

Although outbreak investigation activities vary substantially (Selman and Green 2008), guidelines such as those developed by the Council to Improve Foodborne Outbreak Response (CIFOR) aid public health officials in detecting, investigating and controlling outbreaks (CIFOR

2009). Table III, adapted from the CIFOR Guidelines, summarizes investigation strategies when a food establishment, such as a restaurant, has been implicated in a foodborne disease outbreak.

Foodborne disease outbreaks are generally detected through pathogen-specific surveillance, notification or complaint systems, and/or syndromic surveillance. The WHO as defines foodborne illness outbreaks as

> "*the occurrence of two or more cases of a similar illness resulting from the ingestion of common food*" or "*when the number of observed cases of a particular [foodborne] disease exceeds the expected number*" (WHO 2008).

Similarly, the 2011 CDC case definition for nationally notifiable diseases defines a foodborne disease outbreak as

> "*an incident in which two or more persons experience a similar illness after ingestion of a common food, and epidemiologic analysis implicates the food as the source of the illness*" (Centers for Disease Control and Prevention 2011).

As shown in Figure 3, the three key components to a foodborne disease outbreak response include epidemiologic investigation, environmental assessment, and laboratory analysis.

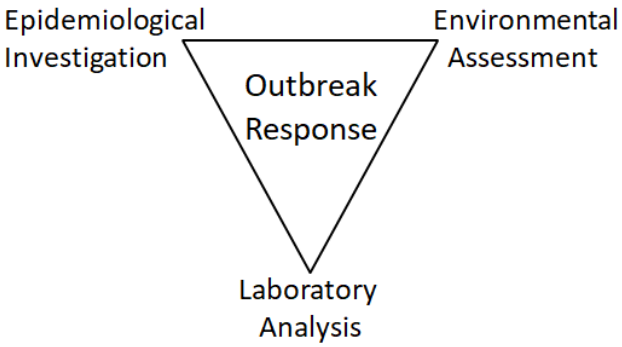

Figure 3. Diagram of foodborne disease outbreak activities

The CIFOR-recommended actions for each response component are detailed in Table III. Following the identification of a clustering of cases or complaints attributed to a particular establishment, investigation activities are conducted to find additional confirmed or epidemiologically-linked foodborne disease cases, isolate the disease-causing food source, identify behavioral or environmental risk factors attributed to the outbreak, and establish abatement procedures.

"An Outbreak of Hepatitis A Associated with Green Onions" provides an example of a restaurant investigation response leading to the identification of a contaminated food source and detection of unsafe food handling practices (Wheeler et al. 2005). During the outbreak, which ultimately resulted in 111 confirmed cases, the Pennsylvania Department of Health identified the contaminated food source at a specific restaurant located in Beaver County, Pennsylvania. The green onions were traced back through the food chain from the restaurant to several farms located in northern Mexico, which resulted in an import ban and a consumer alert. Although unsafe food handling practices were not identified as risk factor in this outbreak, investigators reported, "*many of these preparation practices could result in cross-contamination and are probably used in other restaurants*," identifying the restaurant process for washing vegetables as a specific area of concern.

G. Restaurant Food Handler Knowledge and Practices

Improper food handling practices among food workers, such as those identified in the Beaver County, Pennsylvania outbreak, are prevalent throughout the United States (Lynch et al. 2003; Lee et al. 2004; Green et al. 2006; Green et al. 2007; DeBess et al. 2009; Kirkland et al. 2009; Sumner et al. 2011; Brown et al. 2012; Brown et al. 2013; Bogard et al. 2013; Carpenter et al. 2013; Coleman et al. 2013; Manes et al. 2013; Brown et al. 2014).

TABLE III

CIFOR RECOMMENDED RESTAURANT-ASSOCIATED OUTBREAK INVESTIGATION ACTIVITIES [a]

Objective	Epidemiologic Investigation	Environmental Assessment	Laboratory Analysis
Identify etiologic agent	▪ Interview cases ▪ Establish case definition ▪ Collect stool samples	▪ Interview management and food workers ▪ Obtain samples of suspected food items	▪ Test stool samples to identify agent ▪ Test samples of food items
Identify persons at risk	▪ Determine attack rate and time period ▪ Identify cases	▪ Review reservations, credit card receipts, food inventory	▪ Contact labs to identify additional stool samples
Identify mode of transmission and vehicle	▪ Identify cases and controls about food exposures ▪ Determine relative risks of exposures	▪ Determine food handler responsibilities ▪ Identify points of contamination ▪ Obtain food and environmental samples	▪ Test implicated food and environmental samples to confirm agent
Identify source of contamination	▪ Build an outbreak model	▪ Evaluate food flow for implicated food item ▪ Trace food source up the food chain	▪ Evaluate results of all cultures
Identify contributing factors	▪ Summarize information on agent and food vehicle	▪ Evaluate results to identify factors most likely to contribute to the outbreak	▪ Summarize information from cultures
Determine control procedures	▪ Determine potential for additional cases ▪ Establish abatement procedures	▪ Implement control measures ▪ Train staff in safe handling practices	▪ Assess status of completed and pending cultures

[a] Table adapted from *Table 5.1. Investigation activities for outbreaks associated with events or establishments*, CIFOR *Guidelines for Foodborne Disease Outbreak Response*, Chapter 5: Investigation of Clusters and Outbreaks, p. 110-115, 2009.

Unsafe food handling practices have been associated with foodborne disease outbreaks across the country. In a large study of 816 foodborne outbreaks, the following improper food worker practices were found to frequently contribute to outbreaks: working while ill, bare hand contact with food, failure to properly wash hands, inadequate cleaning of equipment or utensils, cross-contamination of ready-to-eat foods, and temperature abuse (Todd et al. 2007).

Data related to the food handling behaviors of restaurant workers have come primarily from the Environmental Health Specialists Network (EHS-Net), a collaborative forum established to identify and prevent environmental factors contributing to foodborne illness outbreaks (Centers for Disease Control and Prevention 2017a). Key findings from EHS-Net studies are detailed in Table IV. In an observational study to identify factors related to hand hygiene practices of restaurant food handlers, Green and colleagues (2006) reported an appropriate handwashing rate of only 32% with workers frequently omitting the use of soap (Green et al. 2006). In 2011, Sumner et al. identified factors contributing to food handlers working while ill in a large study of 387 restaurant managers and 491 food workers (Sumner et al. 2011). In this study, 12% of food handlers reported that they had worked while experiencing vomiting or diarrhea over the last year, and high-volume restaurants were more likely to have food handlers work while ill than those with lower volumes. In a multistate study designed to identify high-risk egg preparation practices, Lee et al. reported that 26% of restaurants improperly stored eggs, 54% pooled raw eggs, and 42% improperly washed and sanitized utensils used during preparation (Lee et al. 2004). In 2013, Bogart et al. assessed the prevalence of risky beef handling policies and practices in restaurants in eight U.S. states. In this study, only 17% of restaurant managers reported using a thermometer to check the doneness of hamburgers (Bogart et al. 2013). In a another EHS-Net

TABLE IV

KEY FINDINGS OF EHS-NET LED OBSERVATIONAL STUDIES EXAMINING UNSAFE FOOD HANDLING PRACTICES OF RESTAURANT FOOD HANDLERS

Study Topic	Key Findings	N	Reference
Food Safety Knowledge			
General food safety	Only 55% of managers scored above 80% on a food knowledge assessment	387	Brown et al. 2014
Temperature abuse	Low knowledge of correct temperature to cook raw chicken among managers	448	Brown et al. 2013
Temperature abuse	Low knowledge of food cooling regulation among managers	420	Brown et al. 2012
Food Handling Practices			
Beef handling	81% of restaurants reported determining doneness of hamburgers through subjective measures	390	Bogard et al. 2013
Chicken handling	10% of managers reported not sanitizing chicken preparation surfaces	448	Brown et al. 2013
Egg handling	High risk practices including improper cold storage, pooling of eggs and improper sanitization of utensils were observed	153	Lee et al. 2004
Fresh produce handling	Median temperature of cut tomatoes was 49^{o}F, above the FDA recommended 41^{o}F	453	Kirkland et al. 2009
Fresh produce handling	Leafy greens were commonly received at temperatures above 45^{o}F	439	Coleman et al. 2013
Hand hygiene	Appropriate hand washing rates were low (32%)	321	Green et al. 2006
Hand hygiene	Hand washing was less likely when food handlers were busy	321	Green et al. 2007
Working while ill	12% of food workers worked two or more shifts while experiencing vomiting and diarrhea in the past year	878	Sumner et al. 2011
Working while ill	62% food workers recalled working while ill, 38% reported very likely to work with frequent cough	491	Carpenter et al. 2013

study designed to examine chicken cross-contamination and cooking practices of restaurants, only 54% of managers reported using a thermometer to determine cook temperature and 17% reported improperly cleaning and sanitizing surfaces where chicken was prepared (Brown et al. 2013).

Despite valuable information obtained from EHS-Net research, these studies are limited geographically to the following states within the network; California, Connecticut, New York, Georgia, Iowa Minnesota, Oregon, Rhode Island, and Tennessee. Few data related to food handler behaviors have been published from researchers or locations outside of those involved with the EHS-Net collaboration (Howells et al. 2008; Manes et al. 2013). In a 2013 study designed to assess knowledge and self-reported practices of food handlers in suburban Chicago, 32% of participants reported that they would work with a sore throat and cough, 24% would come to work with an infected wound, and 17% would come to work with diarrhea (Manes et al. 2013). In an exploratory study of focus groups comprised of food handlers working in restaurants in Kansas, Missouri and Iowa, Howells and co-authors identified inadequate training, time constraints, inadequate resources and inconvenience as important barriers to proper food handling behaviors (Howells et al. 2008).

Adequate food safety knowledge is an important precursor to optimal food handling practices and although research is limited, data demonstrate a lack of food safety knowledge among restaurant food handlers in the United States (Lynch et al. 2003; DeBess et al. 2009; Dworkin et al. 2011; Panchal et al. 2012; Manes et al. 2013; Brown et al. 2014). Using a survey designed to assess the knowledge and practices of restaurant workers in Oregon, DeBess and colleagues reported a mean knowledge score of 67% with food handlers lacking knowledge related to foodborne diseases and their transmission (DeBess et al. 2009). Similar scores were reported for

food handlers in Chicago and in surrounding suburban areas (71% and 72%, respectively) in a food safety knowledge survey reflecting local Illinois food code. In these studies, substantial knowledge gaps related to cooking and holding temperatures, cross contamination, and storage of food were identified (Panchal et al. 2012; Manes et al. 2013). In a multistate study assessing the knowledge of food handlers employed in restaurants in California, Minnesota, New York, Rhode Island, and Tennessee, Brown et al. reported a mean score of 75% for managers and 69% for workers with knowledge gaps similar to those reported in Illinois (Brown et al. 2014).

Data related to the knowledge and behaviors of food handlers employed outside of the United States have also been published (Sangole et al. 2001; Clayton et al. 2002; Singh, 2004; Cardinale et al. 2005; Udgiri and Yadavnnavar 2006; Lievonen et al. 2007; Malhotra et al. 2008; Al-Khatib and Al-Mitwalli 2009; Muinde et al. 2012; Onyeneho and Hedberg 2013; Panchal et al. 2013; Pichler et al. 2014; Shafie and Azman 2015; Manes et al. 2016). Although international studies tend to be small and local in nature, most identified knowledge gaps and unsafe food handling practices similar to those reported in the United States. In a study conducted in Neuchatel, Switzerland, 100 restaurant food handlers scored an average of 71% on food safety knowledge survey and substantial knowledge gaps related to cooking and holding temperatures were identified (Panchal et al. 2013). In 2005 study of restaurants in Dakar, Senegal, improper vegetable cleaning and peeling, dirty clothing for food handlers, and reheating previously cooked food were associated with the presence of Salmonella bacteria in poultry-dish meal samples (OR 3.58, OR 4.65, OR 5.2, respectively) (Cardinale et al. 2005). In a study to examine food handler beliefs and self-reported practices among food workers in Wales, Clayton and co-authors reported that although food handlers were aware of recommended food safety practices, two-thirds self-reported not always exhibiting these behaviors (Clayton et al. 2002). In regions with

fewer food safety resources, barriers related to basic food safety supplies and equipment can negatively impact ability to properly handle food regardless of food handler knowledge or intent. In 2009, Al-Khatib and Al-Mitwalli, found that many restaurants in the Ramallah and Al-Bireh districts of Palestine did not have hot water, cleaning materials, or gloves necessary for proper food handling practices (Al-Khatib and Al-Mitwalli 2009).

H. Food Safety Training of Food Handlers

Restaurants, and other food service establishments, are comprised of staff with varying food handling duties. As shown in Figure 4, food handling responsibilities, and therefore food

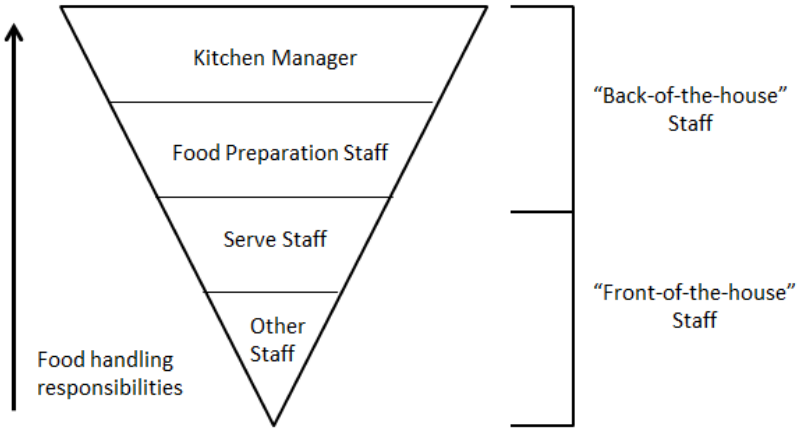

Figure 4. Increasing food handling responsibilities by restaurant staff type

safety responsibilities, increase with job type. In a restaurant, the "front-of-the-house" employees, such as servers, bartenders, and runners, tend to have few regular duties directly

involved with food cooking and preparation. These employees are considered "food handlers," however, since they serve food or "*work with unpackaged food, food equipment or utensils, or food-contact surfaces*" (Texas Administrative Code 2008). The "back-of-the-house" staff consists of employees with job titles such as cook, chef, sous chef, prep cook, line cook, or baker. These food handlers work primarily in the kitchen, and have more food handling responsibilities, preparing and cooking food to be served to restaurant patrons. The kitchen manager, who is often certified in food safety, is ultimately responsible for the food safety practices of the food preparation and serving teams.

Depending upon local regulation and restaurant policy, staff may receive food safety training through supervisory instruction from restaurant management, attend a food safety training course from a local health department or organization, or obtain food handler certification from an accredited training program. Despite this variability, food handler training typically includes topics on; foodborne diseases, food handler hygiene, time and temperature control of food (cooking and holding), prevention of cross-contamination, food receiving and storage, sanitizing, and pest control (ServSafe 2017a). Manager certification training commonly includes additional components such as HACCP procedures and the management of ill food handlers (ServSafe 2017b).

I. Food Handler Training Regulation

In the United States, training requirements for food service employees are not federally mandated. The 2013 FDA Food Code, which is a

> "*model that assists food control jurisdictions at all levels of government by providing them with scientifically sound technical and legal basis for regulating the retail and food service segment of the industry (restaurants and grocery stores and institutions such as nursing homes)*….",

provides detailed guidelines on food handler training requirements to the states, counties and cities responsible for regulation (U.S. Food and Drug Administration 2013). Specifically, the Food Code, Section 2-102.12 recommends that

> "*at least one employee that has supervisory and management responsibility and the authority to direct and control food preparation and service shall be a certified food protection manager who has shown proficiency of required information through passing a test that is part of an accredited program."*

To comply with the Food Code, restaurant managers must either have certification or demonstrate food safety knowledge in areas related to the prevention of foodborne disease, personal hygiene, safe food handling and cooking practices, allergens, and a have a defined HACCP plan (U.S. Food and Drug Administration 2013). The Food Code does not provide recommendations on the food safety training of non-manager food service workers.

Many local jurisdictions in the United States have adopted regulations similar to that recommended by the FDA Food Code. As an example, three states that have implemented legislation adhering closely to the FDA recommendations include Minnesota, Georgia and Pennsylvania. In Minnesota, state law requires that a "*person in charge*", with knowledge of foodborne disease prevention and application of HACCP, be present at the food establishment during all hours of operation. The law does not require, however, that the person-in-charge obtain certification or attend a food safety training course (Minnesota Administrative Code 2011). In Georgia, food establishments are required to employ food safety managers who have obtained certification from an accredited program by completing food safety training course and passing an examination or who can quickly and correctly answer food safety related questions when asked by a health department inspector (Rules and Regulations of the State of Georgia 2015). The State of Pennsylvania requires "…*at least one employee who holds a valid certificate present at the retail food facility or immediately accessible at all hours of operation…*"

Pennsylvania law also requires that the certification documentation be visibly posted in the food establishment (Pennsylvania Administrative Code 2014).

Gradually, local jurisdictions throughout the United States have developed regulations requiring all food handlers to complete food safety training. The following examples provide regulatory details. In 2011, California began requiring all food handlers to obtain a California Food Handler Card by completing an approved training course and pass an assessment with a score of at least 70 percent (California Health and Safety Code 2018). In 2014, Illinois began requiring, "…*all food handlers to obtain ANSI accredited training or Department approved training, in basic food handling principles*…" (Illinois Administrative Code 2014). Beginning in 2016, the Texas Department of State Health Services required that, "*all food employees shall successfully complete an accredited food handler training course, within 60 days of employment*" (Texas Administrative Code 2015). California, Illinois and Texas retained regulation requiring each food establishment to also have a certified food manager.

J. Training Evaluation

The evaluation of restaurant food handler training is a challenging area of food safety research. Specifically, no standard measures have been established to assess the effectiveness of food safety training. Various interdependent outcomes have been examined throughout the literature, including; food safety knowledge of food handlers, food handling practices, scores and violations identified during restaurant inspections, and the presence of foodborne illness outbreaks. Food handling practices are most often evaluated in conjunction with food handling knowledge or inspection scores. Figure 5 highlights the complex interrelations of these measures. In this figure, the arrows depict how each food safety training outcome may be impacted or may impact other outcome measures. For example, restaurant inspection results (scores) are often

partially dependent upon the knowledge and behavior of food handlers working in the restaurant. In turn, the results and recommendations of a restaurant inspection should promote change in food handling behaviors.

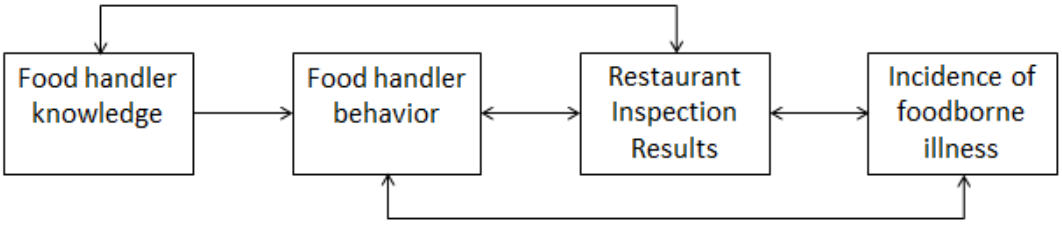

Figure 5. Schematic diagram showing interrelationships of food safety training outcome measures

In an effort to summarize the effectiveness of food safety training on improving outcomes, Egan et al. performed a worldwide review of the methods and results of forty-six food safety training studies based in the commercial sector of the food industry published from 1969 to 2003 (Egan et al. 2007). Thirty of the studies involved food handlers, many of which were employed in a restaurant setting. The dependent variables measured in these studies, though not always well-defined, included food handler knowledge, food safety practices, inspection scores, and foodborne illness incidence. Based on their summary, the authors concluded that training intervention improved food safety knowledge, but knowledge did not always translate into practice. The review revealed that, in general, the presence of a certified food manager was correlated with positive outcomes. Studies examining training with inspections or foodborne disease, however, produced mixed and inconclusive results. The review identified deficiencies in

training research related course content, site of training, duration of courses and refresher training and the authors recommended that future research be focused on these topics.

Subsequent research has produced similar results. Studies evaluating interventions designed to increase food safety knowledge of food handlers have shown favorable results, but those examining the effectiveness of training on improving practices, increasing inspection scores, or preventing outbreaks continue to be inconsistent and inconclusive.

K. Training and Food Safety Knowledge

Intervention studies, which utilize a pre-test, post-test knowledge assessment, are commonly used to evaluate the effectiveness of an educational tool or program among restaurant food handlers. As detailed in Table V, food safety knowledge improvement with food safety training is a consistent finding among data published since the Egan et al. review (Egan et al. 2007; Roberts et al. 2008; Bush et al. 2009; York et al. 2009; Dworkin et al. 2012; Soon et al. 2012; Manes et al. 2013).

In a pre- post-training study of 402 restaurant food handlers working in Kansas, Missouri, and Iowa, Roberts and co-authors examined the effectiveness of the ubiquitous training program, ServSafe (Roberts et al. 2008). Surveys and direct observation were used to evaluate improvement in food safety knowledge and behaviors. Overall knowledge scores and hand-washing composite scores increased significantly after training ($p<0.05$ and $p<0.001$, respectively). Significant increases in behavioral compliance ($p<0.001$) were reported as well, although compliance overall was relatively low and did not always correlate with knowledge score.

In a randomized intervention study of food handlers employed in the city of Chicago, Dworkin and colleagues (2012) reported a significant increase in food safety knowledge score

TABLE V

KEY FINDINGS OF STUDIES EVALUATING RESTAURANT FOOD HANDLER TRAINING MATERIALS AND PROGRAMS

	Study Design	Setting	Population	N	Outcome	Key findings	Reference
Training Materials							
Educational brochure and comic book	Pre-test, post-test design with intervention and control groups	Chicago, IL	Restaurant manager and non-managers	Intervention group, n=128, Control group n=101	Score on knowledge assessment	Improvement in knowledge among intervention group.	Dworkin et al., 2012
Educational Brochure and Comic Book	Pre-test, post-test design with intervention and control groups	Chicago Suburbs, IL	Restaurant manager and non-managers	Control group, n=56, Brochure group=54, Comic book group=83	Score on knowledge assessment	Improvement in knowledge among intervention groups, greater improvement in comic book group	Manes et al., 2014
Training Programs							
ServSafe training	Pre-test, post test	Missouri, Kansas, and Iowa	Restaurant food handlers	242 pre-training, 160 post-training	Knowledge assessment and direct observation	Improvement in knowledge and some behaviors after training, behavior compliance remained low.	Roberts et al. 2008
ServSafe training, Theory of Planned Behavior	2-year longitudinal study, participants serving as own control	Missouri, Kansas, and Iowa	Restaurant food handlers	33 completed all three phases of study	Knowledge quizzes and behavioral observation	ServSafe training alone improved knowledge, but TPB intervention improved behavioral compliance.	York et al. 2009
Lecture and demonstration program	Nonequivalent Pre-test, post-test with control group	Korea	Restaurant manager and non-managers	Intervention group n=41, control group, n=49	Knowledge questionnaire and direct observation	Knowledge improvement after training, no improvement of practices	Park et al., 2010
Interactive educational workshop based on Impact model	Retrospective pre/post self-assessment	California	Food service owners and managers	213 completed post-assessment, 10 follow up interviews	Self-assessment of knowledge and follow up interview	Increased knowledge, commitment, incorporation of training into practice.	Bush et al. 2009

among food handlers with exposure to food safety educational materials in bilingual brochure and comic book style formats compared to a control group (Dworkin et al. 2012). In a related study, Manes et al. (2012) reported similar findings among food handlers in the suburbs surrounding Chicago (Manes et al. 2012). Overall knowledge scores increased significantly from 73% to 83% for the comic book intervention group and from 75% to 81% for the brochure group, with no differences reported among the controls. Although the materials effectively improved food safety knowledge, they did not do so equally for English-speaking and Spanish-speaking food handlers. The authors concluded that food safety educational materials should be linguistically and culturally relevant.

In a small study of twelve restaurants in Korea, Park et al. examined the effectiveness of a training program utilizing lecture and demonstration techniques using a nonequivalent pretest-posttest control group design (Park et al. 2010). The researchers reported a significant increase in food safety knowledge score (from 49.3 to 66.6 out of 100) among the intervention group, whereas no such increase was observed in the control group. Based on their results, the researchers concluded that the frequency of training should be reinforced through goal setting and that concrete training programs should be designed to focus on motivating employees to maintain and self-regulate proper practices.

Although effective educational tools and programs have been identified, the adoption of training methods into real-life practice is rarely evaluated. In 2009, Bush and co-authors, demonstrated the effective implementation of a training program (Bush et al. 2009). In a study of 213 restaurant and food service owners and managers in California, researchers assessed a short, interactive educational workshop program developed to help managers educate staff to identify and address workplace hazards. Post training assessments revealed that participants improved

their knowledge of and commitment to health and safety and that they felt more confident training staff in these areas. In follow up interviews, nine out of ten managers had implemented the training at their food service establishment. The authors concluded that attending a workshop where managers can interact was important to the program's success and suggested that the model be disseminated more broadly.

These studies demonstrate that many different training methods and techniques are effective in increasing the overall knowledge scores of the participants. While increased knowledge of proper food safety practices is the first step to improving behavior, this knowledge must be put into practice to ensure the effectiveness of the training. With limited demonstration of evidence-based food handler training methods translated into practice, optimal training sources, styles, materials, and frequencies are left undefined for widespread implementation.

L. Training and Food Handling Practices

Although food safety training can improve knowledge, knowledge does not necessarily translate to an improvement in food handling practices (Clayton et al. 2002; Egan et al. 2007; Roberts et al. 2008; York et al. 2009; Park et al. 2010). In 2002, Clayton and colleagues found that although food handlers were aware of recommended food safety practices, two-thirds reported not always exhibiting these behaviors (Clayton et al. 2002). Roberts and colleagues reported overall knowledge and behavior improvement with ServSafe training, but concluded that knowledge alone does not always improve practice (Roberts et al. 2008). In the aforementioned Park et al. study, food handler knowledge improved with educational intervention but food safety practices did not (Park et al. 2010).

Proper hand hygiene is an important behavior that can reduce the spread of foodborne illness and is one of the more commonly evaluated practices related to food handler behavior. In

a 2007 commentary article, however, Mitchell and co-authors argued that the evidence base regarding the effectiveness of current interventions aimed to reduce poor hand hygiene behaviors in food service employees is weak, making it difficult to draw firm conclusions about normative hand hygiene practice (Mitchell et al. 2007). The authors did conclude that interventions designed to address both individual and organizational factors are most likely to be successful in creating more sustainable change with regard to safe food handling.

Relatedly, Soon and co-authors synthesized the results of nine studies published from 1990 through 2011 to evaluate the impact of food safety training on hand hygiene knowledge and attitudes (Soon et al. 2012). The meta-analysis included 465 food handlers employed in the commercial sector, including those working in processing facilities, packinghouses, greenhouses, hospitals and restaurants. Although the primary objective of the study was to review training with hand hygiene knowledge, a secondary analysis was performed on five of the studies that included data on food handler self-reported attitudes and practices. Forest plot analysis revealed the training effect on hand hygiene knowledge to be significantly higher than the effect of the controls (Hedges' g 1.284, 95% CI 0.830, 1.738). Similar results were reported for hand hygiene attitudes and practices, though the effect size was smaller than that of knowledge (Hedges' g 0.683, 95% CI 0.523, 0.843). The authors concluded that food safety training improved hand hygiene knowledge and attitudes and that refresher training and long-term reinforcement of good food handling behaviors may be beneficial for sustaining good hand washing practices.

Few additional studies have demonstrated an improvement in hand hygiene and other food handling behaviors with food safety training (Roberts et al. 2008; York et al. 2009; Adesokan et al. 2015). In a 2015 cross-sectional study of 2011 food workers in Ibadan, southwestern Nigeria, Adesokan and co-authors examined food handler training components,

including: self-reported food safety training, training area, duration, and refresher training, with food safety knowledge (Adesokan et al. 2015). Researchers found a significantly higher proportion of trained food service workers (31%) than untrained (14%) exhibiting excellent food safety practices. Participants with refresher training were more likely to have better food handling practices, but longer training duration was negatively associated with practices. The researchers concluded that short, frequent training provides food handlers more opportunities to rehearse and update skills, whereas food handlers may become disengaged during prolonged training due to "*the possibility of redundancy and boring repetitiveness*."

A two-year longitudinal study designed to evaluate the effectiveness of ServSafe training and an "*intervention encouraging perceived control over and positive attitudes toward food safety*" using the Theory of Planned Behavior (TPB), revealed significant improvement in food safety behavior with intervention (York et al. 2009). Results from this study demonstrated significant behavior score increases in behavioral compliance overall (45% to 63%, $p<0.001$), handwashing (38% to 58%, $p<0.01$), and thermometer usage (38% to 50%, $p<0.01$). Although results are promising, the researchers acknowledged that the small sample size of 33 participants, due to difficulty recruiting and retaining participants, is an important limitation of this study. Recruitment and attrition of restaurant food handlers is a common challenge in this area of research (Dworkin et al. 2012; Manes et al. 2012). Despite study limitations, York et al. concluded that food service managers should implement training with invention to reinforce positive attitudes towards food safety, to improve knowledge and behavioral compliance (York et al. 2009).

Studies designed to evaluate food safety behavior, such as those previously described, often employ a direct observation component to assess compliance. Egan and colleagues argued

that direct observation has limited value (Egan et al. 2007). After extensive review of early food safety training literature, the researchers concluded,

> *"Such observations are usually restricted to a small number of practices….Staff may also exhibit altered behaviours in the presence of an observer…There are also practical considerations in relation to time and cost involved in such observations."*

Direct observation is a limitation as it provides only a momentary snapshot of behavioral compliance and food handlers may alter their behavior because of their participation in the study or inspection, known as the Hawthorne (or Observer) effect. However, the Hawthorne effect is likely minimal since behavioral compliance is relatively low across food handler training studies.

While knowledge of proper food safety procedures are important, ultimately the behaviors exhibited by food handlers are key elements in preventing restaurant-related foodborne illness outbreaks. These studies indicate that although current training methods improve overall knowledge scores, this does not necessarily lead to an increase in proper food safety practices. These studies support the use of short, frequent trainings using culturally relevant materials supported by behavioral intervention as the most effective methods that have been developed thus far. Unfortunately, these studies also demonstrate that the effectiveness of these methods in improving food safety practices is still far below the level needed to ensure public health, calling for additional research in this vitally important area.

M. Training and Restaurant Inspection Results

Data on the effectiveness of food handler education on improving restaurant inspection scores has been largely inconsistent (Mathias et al. 1994; Riben et al. 1994a; Riben et al. 1994b; Averette et al. 2011). Mixed results are not unexpected, as there are complicated factors influencing both the independent (training) and dependent (inspection score) research variables. Figure 6 diagrams the casual relationship between food handler training and restaurant inspection

results. Various factors, such as local regulation, training costs, and restaurant workload can impact the quality and frequency of food handler training employed in restaurants. Local regulation, inspector workload, and inspection assessment tools may influence restaurant inspections. Human behavior driven components, such as the food safety culture of a restaurant, food handler practices, and on-site inspection violation corrections allowed by an inspector, greatly complicate the relationship.

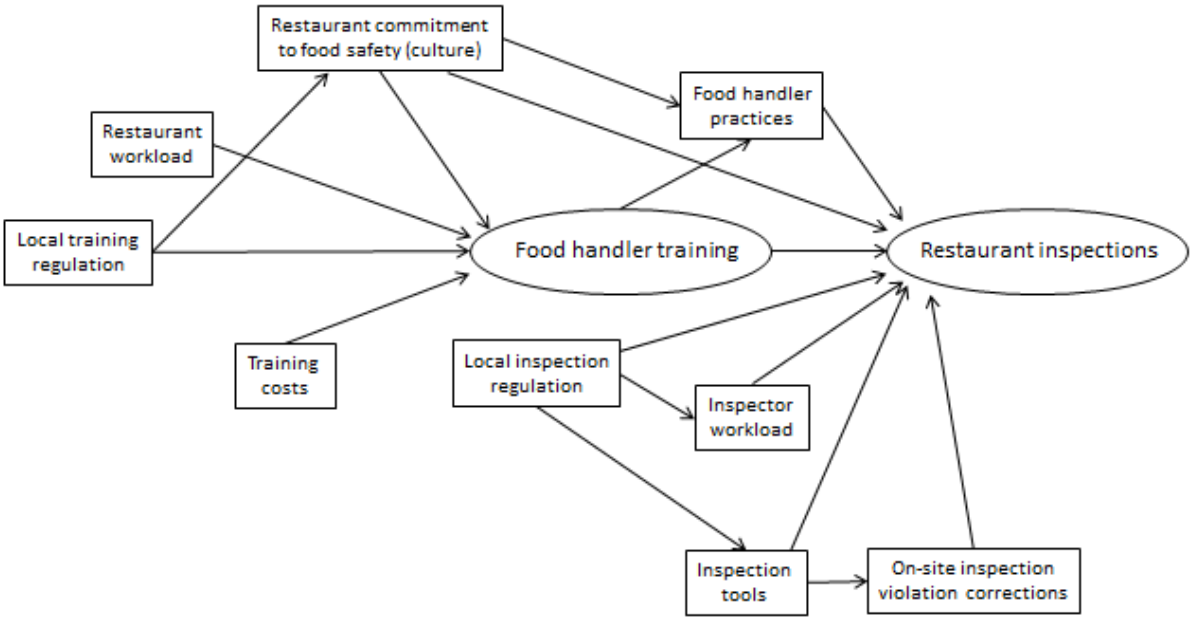

Figure 6. Causal diagram depicting factors influencing the relationship between food handler training and restaurant inspection results

Two published reviews synthesize early studies on food handler training and inspections (Riben et al. 1994a; Campbell et al. 1998). In 1994, Riben and colleagues performed a

systematic review of nine studies examining training and inspections published between December 1990 and November 1992 (Riben et al. 1994a; Riben et al. 1994b). This review evaluated only intervention studies performed in developing nations and did not report on risk factors associated with restaurants. Based on their findings, Riben and coauthors cautiously concluded that food handler education has some positive effect on inspection scores. In a slightly later 1998 review that focused on the effectiveness of food safety public health interventions in Canada, analysis results were inconclusive (Campbell et al. 1998). In this review, Campbell and colleagues found some studies reporting improvement in inspection scores after food safety training and other studies with no significant findings. Although comprehensive at the time, the results from these early studies are obsolete, as regulation and practices for training and inspections have changed considerably since time of publication and additional food service intervention studies have been completed since publication.

Examining the impact of restaurant manager certification on restaurant inspections is of particular importance to researchers, especially since manager certification is a recommended practice by the U.S. FDA (U.S. Food and Drug Administration 2013). Literature results are highly inconsistent. The presence of a certified manager has been shown to improve restaurant inspections in some research (Palmer et al. 1975; Kneller and Bierma 1990; Cotterchio et al. 1998; Cates et al. 2009), while other studies found no relationship (Clingman 1976; Cook and Casey 1979; Wright and Feun 1986; Kassa et al. 2010; Burke et al. 2014).

In 1998, Cotterchio et al. evaluated the effectiveness of a food manager training and certification program implemented in Boston (Cotterchio et al. 1998). The results demonstrated a significant increase inspection scores among restaurant with manager certification, compared to restaurants without manager certification. The researchers also found a significant decrease in

the number of critical violations one year after training, although this effect was not observed two years after training.

In a 2009 study of 4,461 restaurants in Iowa, Cates et al. examined the relationship between the occurrence of critical violations found during inspections and the presence of a certified kitchen manager (Cates et al. 2009). The results of the analysis suggested that having a certified manager was protective of most types of critical violations, such as those related to personnel (OR 0.73, $p<0.01$), food source and handling (OR 0.80, $p<0.01$), and facility and equipment requirements (OR 0.85, $p<0.01$). However, restaurants with a certified manager were equally likely to have temperature and time control violations, which are important factors that contribute to foodborne illness outbreaks.

In 2011, Averette and co-authors, studied the impact of a Kansas City, Missouri Health Department mandated two-hour lecture and exam training program on rates of restaurant inspection violations (Averette et al. 2011). The study compared violations related and unrelated to the responsibilities of food handlers using a quasi-experimental study design. Results demonstrated a significant reduction in total and critical violations after program implementation. The authors, however, were unable to attribute the reduction in violations to the program or to other contributing factors.

Several recent studies have found no relationship between manager certification and restaurant inspections. Kassa and coauthors (2010), explored the relationship between certification training of food service personnel and food safety violations using inspection reports from the Toledo/Lucas County Health Department in Ohio for a one-year period. In this study, restaurants with manager certification had fewer critical violations and more non-critical violations compared to restaurants without certification training ($p=0.065$ and $p=0.047$,

respectively) (Kassa et al. 2010). The authors concluded that certification did not have a major effect on the total number of violations, but that their findings may represent the inspection completeness rather than the impact of certification on inspection.

Similarly, in 2014, Burke and co-authors found no correlation between overall food safety knowledge of certified managers and restaurant inspection score in the first study designed to examine food safety knowledge of restaurant food handlers and restaurant inspection reports (Burke et al. 2014). The researchers reported, however, that critical violations related to hand hygiene were more likely to occur in restaurants where at least one certified manager missed at least one knowledge question related to hand hygiene on a food safety questionnaire. (RR 1.96, p=0.047). The researchers concluded that except for hand hygiene, inspection reports do not correlate well with certified manager food safety knowledge.

N. Training and Foodborne Illness Outbreaks

Research examining the relationship between restaurant food handler training and the prevention of foodborne illness outbreaks have shown promising results (Hammond et al. 2005; Hedberg et al. 2006). In a 2005 study, Hammond and colleagues examined the incidence of outbreaks in Florida after implementation of legislation mandating all restaurant food handlers to receive food safety training, in addition to managers, as previously required (Hammond et al. 2005). Study results demonstrated a decrease in overall rates of foodborne illness outbreaks in the three years subsequent to training. However, the data also revealed an increase in the incidence of poor food handling practices during restaurant inspections, such as improper food holding temperatures, inadequate cooking, contaminated equipment and poor hygiene. The authors concluded that multiple confounding factors complicated the analysis results and

suggested more research was needed to establish best methods and approaches related to restaurant food handler training.

In a 2006 study comparing restaurants with and without outbreaks, Hedberg and EHS-Net coauthors found that the presence of a certified kitchen manager reduced the risk for an outbreak and that certified managers were associated with the absence of bare-hand contact with food (Hedberg et al. 2006). However, the results also demonstrated that the presence of a certified manager did not reduce the role of ill food handlers as a major source leading to outbreaks. The authors concluded that training programs should better emphasize the control of food worker illnesses.

O. Restaurant Inspections

The primary objective of restaurant inspection is to determine momentary compliance with local health regulation. Inspections are designed to identify and halt improper practices and behaviors that have been identified as risk factors for foodborne illness. The regulatory personnel who perform inspections are often referred to as health inspectors, sanitarians, or environmental health officers.

In the United States, standardized inspection forms are utilized by health inspectors to determine local food code violations. Inspection forms vary from jurisdiction to jurisdiction, but share commonalities, especially related to the identification of critical violations. "Critical violations" are infractions that pose an immediate threat to food safety and are more likely to contribute to food contamination and/or foodborne illness. Examples of critical violations include food being held at improper temperatures and poor handwashing practices. "Non-critical violations" pose a lesser threat to food safety, but negatively affect the overall sanitation of an establishment. Examples of non-critical violations may include food stored on the floor (if not

already contaminated) or equipment with a buildup of dirt or debris (Licking County Health Department 2013). Violations can be corrected on-site during the inspection, and it is at the discretion of the inspector to mark all violations identified on the inspection form. Commonly, a scoring algorithm is used to generate an inspection score from the critical and non-critical violations identified during an inspection. Local health departments typically report the overall inspection score, as well as, as an inspection "pass/fail" grade.

P. Restaurant Inspection Regulation

Restaurant inspection requirements are not regulated at the national level by the United States. Rather, states, counties, or cities are responsible for inspection legislation. The U.S. FDA provides guidelines to local authority on restaurant inspection requirements in Section 8: Compliance and Enforcement of the 2013 Food Code. Section 8-401.10 details the following recommendation related to inspection frequency,

> "*the regulatory authority shall inspect a food establishment at least once every 6 months*," (U.S. Food and Drug Administration 2013)

fewer inspections can be performed, however, if the establishment has an approved and validated HACCP plan, serves only unpackaged or prepackaged food that is not time/temperature control, or if,

> "*the food establishment is assigned a less frequent inspection frequency based on a written risk-based inspection schedule that is being uniformly applied throughout the jurisdiction and at least once every six months the establishment is contacted by telephone or other means by the regulatory authority to ensure that the establishment manager and the nature of the food operation are not changed*" (U.S. Food and Drug Administration 2013).

The FDA Food Code also provides detailed guidelines for a three-tiered risk-based inspection system, with recommended frequencies ranging from one to four inspections per year with increasing risk category. As local jurisdictions are encouraged to develop risk categories

tailored to program needs, various risk schemas and corresponding inspection frequencies have been adopted throughout the United States.

Q. Effectiveness of Restaurant Inspections

Restaurant inspections are an important public health effort to reduce the incidence of foodborne illness and the evaluation of inspection is an important area of food safety research. The effectiveness of restaurant inspections, however, remains unclear.

Literature exploring the relationship between foodborne illness and inspection results, such as overall inspection score and presence of critical food safety violations is minimal and results are mixed (Irwin et al. 1989; Cruz et al. 2001; Jones et al. 2004; Simon et al. 2005). In a study to examine an association between foodborne illness outbreaks and overall inspection rating among restaurants in Seattle–King County, Irwin et al. performed a matched case-control study comparing inspection scores of outbreak restaurants to scores of control restaurants in the same county (Irwin et al. 1989). The mean inspection score was significantly lower for outbreak restaurants compared to the control restaurants (83.8 and 90.9 out of 100, respectively). The researchers also reported a relationship between outbreaks and the presence of specific food safety violations, such as those related proper food temperature control. The authors concluded that the Seattle-King County inspection form can successfully identify restaurants at increased risk of foodborne illness outbreaks, but also that more emphasis should be placed on education of restaurant staff in restaurants with poor inspection results. In 1995, Simon and colleagues reported on the impact of a restaurant grading hygiene system with a public posting on foodborne disease hospitalization in Los Angeles County by comparing hospital discharge data for Los Angeles County to data for the rest of California (Simon et al. 2005). After adjusting for temporal and geographic trends, restaurant grading was associated with a 13.1% decrease in the

number of foodborne-disease hospitalizations after program implementation and results were sustained for several years following. Although this study did not evaluate routine restaurant inspections, the results are applicable in that the hygiene card program utilized a scoring method not unlike those used to score inspections. The results of this study suggest that a regular scoring method may be effective in reducing foodborne disease illness.

Other studies, however, have found no relationship between restaurant inspection results and foodborne illness. In a study to evaluate the effectiveness of routine restaurant inspections Miami-Dade County, Cruz and colleagues, compared the inspection results of restaurants with outbreaks to those of randomly selected control restaurants (Cruz et al. 2001). The data revealed no difference in mean overall inspection score or number or critical violations when comparing outbreak and control restaurants, suggesting that inspection results do not reliably identify restaurants at higher risk of foodborne disease outbreaks in this particular county. Similarly, in a study examining the inspection scores of restaurants in Tennessee from 1993 through 2000, Jones et al. found no difference in the overall inspection scores of restaurants with foodborne disease outbreaks compared to all restaurant inspections performed during the study period (Jones et al. 2004). Among the restaurants with an outbreak, two critical violations "proper storage of toxic items and good handwashing and hygienic practices" were more likely to have been cited before the occurrence of an outbreak, however, as the number of reported outbreaks was small (n=49), inference from these results is limited.

Published data correlating inspection frequency with foodborne illness are inconsistent (Riben et al. 1994a; Riben et al. 1994b; Newbold et al. 2008; Zablotsky Kufel et al. 2011). Riben et al. found no association between number of inspections in the past year and proven restaurant-related outbreaks among jurisdictions in Canada using data from December 1990 to November

1992 (Riben et al. 1994a; Riben et al. 1994b). Despite a lack of evidence, the authors cautiously concluded that an effective number of inspections would be between one and two per year. Important study limitations should be noted for the review. Of the thirteen papers included in the review, only four examined inspection interventions, and although this review retrieved various descriptive papers that pointed to sources of risk in terms of foodborne illness outbreaks, these papers were not included in the review. In a more recent 2011 study to examine the impact of local environmental health capacity on foodborne illness, Zablotsky Kufel and colleagues found that Maryland counties with greater compliance to a set inspection frequency reported lower rates of foodborne illness (Zablotsky Kufel et al. 2011). The data also revealed lower rates of foodborne illness among counties with greater food budgets and number of full time sanitarian positions, suggesting that better resources in counties may be more effective in preventing foodborne illness compared to counties with fewer resources. The researchers of the study did not provide recommendations on optimal inspection frequencies, sanitarian workloads, or health department budgets to prevent foodborne illness.

III. RESTAURANT INSPECTION FACTORS RELATED TO FOODBORNE ILLNESS OUTBREAKS: A NATIONAL SURVEY OF LOCAL HEALTH JURISDICTIONS

A. Introduction

Foodborne disease causes millions of illnesses and thousands of deaths annually in the United States. Foodborne illness outbreaks are most commonly attributed to restaurants. In 2013, 720 single setting foodborne disease outbreaks were reported to the Centers for Disease Control and Prevention (CDC) and approximately 60% were associated with restaurants. (Gould et al. 2013) With nearly 60% of Americans eating meals outside of the home at least once a week, there is a need to better understand risk factors contributing to restaurant-related foodborne illness outbreaks (Rasmussen Reports 2013). Restaurant inspection frequency, environmental health specialist (EHS) workload and restaurant risk classification are such factors that deserve further investigation.

In the United States, restaurant inspections are an important feature of local health department efforts to protect the public health. Currently, there are no federal-level restaurant inspection requirements, but guidelines provided by the U.S. Food and Drug Administration (FDA) state that the goal of a food establishment inspection is to prevent foodborne disease. Risk-based classification systems are commonly utilized by local health departments to set routine inspection frequencies of food establishments. However, implementation of inspection regulation may be dependent on factors other than food safety. Local health departments are often understaffed and overworked, which may negatively impact their capacity to successfully implement requirements. Furthermore, heavy workload among local health sanitarians may hinder their ability to perform quality inspections.

Few studies exist on the effects of restaurant inspection frequency and workforce capacity with respect to foodborne illness outbreaks. This study was designed to help fill this gap and to provide data to local policy-makers for the development of evidence-based food code. This nationwide study identified jurisdictional-level factors, environmental health sanitarian (EHS) inspection workload, high-risk restaurant classification, and restaurant inspection frequency as factors associated with restaurant-related foodborne illness outbreak rates.

B. Methods

1. Study Design and Sample

We conducted a national cross-sectional study using a Web-based survey of local health departments designed to examine restaurant-related foodborne illness outbreak rates with reported restaurant inspection frequencies and EHS workload. From April 2013 through May 2014, each of the 2,000 local health jurisdictions throughout the United States was contacted by email to participate in the study. Each health department was sent up to three emails containing a study invitation letter and web link directly to the online survey. Jurisdictions that initiated, but did not complete a survey, were contacted directly by phone to maximize participation. Approval from the University of Illinois at Chicago Institutional Review Board for the Protection of Human Subjects was received prior to health department contact and survey initiation.

2. Instrument Development and Data Collection

The 47-question survey tool was developed to examine restaurant-related foodborne illness outbreaks at the local-level only and no restaurant names or locations were reported. The survey was used to collect health department self-report data related to outbreaks, inspections and environmental health specialist (EHS) workload including; total number of restaurant-related foodborne illness outbreaks, registered restaurants, routine inspections, and restaurant visits.

Additional information was collected related to high risk restaurants, food handler training requirements, CDC Food Net Site designation, database to track restaurant violations, and type of inspection forms/systems utilized by the jurisdiction. Outbreak data and jurisdictional characteristics were collected for three consecutive years (2010, 2011, and 2012), while EHS workload data were collected for 2012 only. To examine local demographic factors, we also obtained the following local level data from the 2010 Census; census region, population size, county type (metro, micro, rural), and median household income (United States Census Bureau 2018).

3. Statistical Analysis

Statistical analyses were performed using SAS 9.4 (SAS Institute, Cary, NC) with data from all participating local health jurisdictions. The foodborne illness outbreak rate for 2012 was calculated for each jurisdiction as the total number of restaurant-related outbreaks out of the total number of local registered restaurants in the given year. To examine EHS workload, we calculated the mean restaurant to EHS ratio (the average number of restaurants assigned to each EHS) and the mean inspection to EHS ratio (the average number of inspections performed by each EHS). The average number of inspections per restaurant was calculated as the total number of restaurant inspections performed out of the total number of registered restaurants for each jurisdiction.

Bivariate analyses were performed to identify local jurisdictional variables associated with restaurant-related outbreaks. Chi-square p values were calculated to examine proportional differences among categorical characteristics for local health jurisdictions with one or more foodborne illness outbreaks. To identify factors associated with the restaurant-related outbreaks, an adjusted zero-inflated Poisson (ZIP) regression model design was employed as 65% of the

local health jurisdictions did not have a restaurant-related outbreak during the study period (excessive zero values). This hierarchical two-stage model design was built to predict the likelihood of a jurisdiction having at least one restaurant-related outbreak (Logit model) and predict the estimated outbreak rate among those jurisdictions with at least one outbreak event (Poisson model). A stepwise elimination method with a probability of Type I Error of α=0.05 was used to determine the significant local-level variables to remain in the final model.

C. Results

1. Jurisdictional Characteristics

A total of 167 of the nearly 2,000 local health jurisdictions that perform inspections throughout the United States participated in the study by completing a survey, resulting in a participation rate of 8.3%. The participating jurisdictions represented 36 US states from all four census regions. Among the 167 health departments, 68% (114) performed restaurant inspections in single, full county and 57% (96) were located in a metropolitan area. (Table VI) Although most local jurisdictions required food safety certification of restaurant workers (managers and/or food handlers), 29% (49) reported having no regulated certification requirements. Seventeen percent (29) of the health departments were a CDC designated FoodNet site.

Of the total 167 health departments, 148 (89%) reported using a classification schema to identify risk of restaurants. The following qualitative examples highlight the variation in risk tier categorization schemas;

- “Low risk: 1-3 critical control points (CCP's); Medium risk: 4-5 CCP's; High risk: 6-7 CCP's”

- **TABLE VI**
- CHARACTERISTICS OF LOCAL HEALTH JURISDICTIONS PARTICIPATING IN A NATIONAL WEB-BASED SURVEY OF RESTAURANT-RELATED FOODBORNE ILLNESS OUTBREAKS, 2012 (N=167)

Jurisdictional Characteristics	Frequencies N (%)
US Census Region	
Northeast	42 (25)
South	36 (22)
Midwest	42 (25)
West	47 (28)
Number of Registered Restaurants	
Up to 200	40 (24)
> 200-500	52 (31)
>500-1000	36 (22)
>1000	39 (23)
County type	
Metropolitan	94 (56)
Micropolitan	36 (22)
Rural	37 (22)
Median Household Income (thousands)	
<$40	26 (16)
$40-50	58 (35)
$50-75	59 (35)
>$75	24 (14)
CDC FoodNet Site	
Yes	29 (17)
No	138 (83)
Food Handler Training Requirements	
No Certification Training	48 (29)
Manager Certification	54 (32)
All Food Handlers Certification	65 (39)
Proportion of Restaurants designated as High Risk	
<50%	118 (71)
>50%	49 (29)
Database to track Restaurant Inspection violations	
Yes	101 (60)
No	66 40)

-

- "Low risk: non-potentially hazardous foods, do not prepare TCS [time/temperature control for safety] foods, no cooling, etc.; Medium risk: limited menu, prepare, cook, serve immediately; High risk: complex menu"
- "No classification officially, but use FDA unofficially.

During 2012, a median of 441 registered restaurants (mean 1,073, range 6-24,875 restaurants) was reported. Nearly 30% of the health departments designated at least half of their restaurants "high risk". Forty percent of the health departments did not maintain a database to log critical violations cited during restaurant inspections. (Table VI) The total number of EHS per jurisdiction ranged from 0.5 to 243 full time employees (FTEs) (mean 6.7 EHS per jurisdiction). On average, an EHS visited 160 restaurants (range 12-546 visits per EHS) and performed 296 inspections (range 17-1,012 inspections per EHS) in 2012. For 20% of the local jurisdictions, each EHS performed over 400 restaurant inspections. Each restaurant averaged two inspections per year (range 0.65-4.9 inspections per restaurant) with 8% (12) of the local jurisdictions reporting less than one inspection per year. (Table VII)

2. Factors Associated with Restaurant-related Foodborne Illness Outbreaks

A total of 59 (35%) jurisdictions reported at least one restaurant-related foodborne illness outbreak during 2012 (Total: 187 outbreaks; Range: 0-27 outbreaks per jurisdiction). The restaurant-related outbreak rate for all jurisdictions in the study was 11.8 outbreaks per 10,000 registered restaurants (Range: 0-224 outbreaks per 10,000 restaurants). Among the jurisdictions reporting at least one outbreak, the rate was 33.4 outbreaks per 10,000 registered restaurants (Standard deviation = 37.6) with 23 (39%) of the health departments reporting a total of 33 hospitalizations and one death.

TABLE VII

RESTAURANT-RELATED OUTBREAK RATES AND RESTAURANT INSPECTION CHARACTERISTICS OF LOCAL HEALTH JURISDICTIONS, 2012 (N=167)

Variables of Interest	Frequencies N (%)
Restaurant-related Outbreak Rate (per 10,000 restaurants)	
0	108 (65)
>0-10	15 (9)
>10-30	21 (12)
>30-50	10 (6)
>50	13 (8)
Mean (SD)	11.8 (27.4)
Number of Restaurants Visited Per EHS per Year	
< 100	53 (32)
100-200	63 (38)
>200	51 (30)
Mean (SD)	160 (94)
Number of Inspections Performed Per EHS per Year	
<200	57 (34)
200-400	79 (47)
>400	31 (19)
Mean (SD)	296 (175)
Number of Inspections Performed Per Restaurant per Year	
0-1.5	48 (29)
>1.5-2.5	77 (46)
>2.5	42 (25)
Mean (SD)	2 (0.8)

On average, jurisdictions that reported no outbreaks completed 255 restaurant inspections per EHS in a year, whereas, jurisdictions with outbreaks completed a significantly and substantially greater number of inspections per EHS (mean 369, p<0.0001) (Table VIII).

TABLE VIII
MEAN INSPECTIONS PER EHS, INSPECTIONS PER RESTAURANT AND NUMBER OF OUTBREAKS PER EHS, BY OUTBREAK STATUS AND RATE, 2012 (N=167 LOCAL HEALTH JURISDICTIONS)

	Outbreak Status		**Outbreak Rate per 10,000 restaurants**			
Jurisdictional Measure	No Outbreaks n=108	Outbreaks n=59	>0-10 n=15	>10-30 n=21	>30-50 n=10	50+ n=13
Average Number of Inspections Performed Per EHS per Year	255	369*	380	384	338	352
Average Number of Inspections Performed Per Restaurant per Year	2.04	1.98	1.67	2.05	2.26	1.99
Average Number of Outbreaks Per EHS Per Year	0	0.6*	0.16*	0.30*	0.69*	1.50*

*Significant at $p < 0.05$

Among the 59 jurisdictions reporting outbreaks, those with outbreak rates greater than 30 per 10,000 restaurants also had higher EHS workload averages, but this correlation was not significant in the unadjusted analyses (p= 0.37). As expected, the average number of outbreaks per EHS increased with increasing outbreak rate. No relationship between average number of inspections per restaurant and outbreak status or rate was observed.

In the final zero-inflated Poisson model, EHS workload was the single significant variable in the logit part predicting the likelihood of reporting a restaurant-related foodborne illness outbreak (Table IX). Local jurisdictions with moderate (200-400 inspections per EHS) and heavy (>400 inspections per EHS) EHS workload were significantly more likely to report a restaurant-related outbreak compared to jurisdictions averaging fewer than 200 inspections per EHS (OR 4.85, 95% CI 2.03, 11.6, p=0.0004 and OR 6.48, 95% CI 2.34, 18.2, p=0.0003, respectively) (Table IX). EHS workload was also significant when entered into the model as a continuous variable and revealed that with each additional 100 inspections performed per EHS, the odds of having an outbreak increased by 4% (β=0.0038, p<0.0001) (data not shown).

For the Poisson (or rate) part of the ZIP regression model, EHS workload and several additional local-level characteristics were found to have a significant relationship with outbreak rate for jurisdictions reporting at least one restaurant-related foodborne illness outbreak. Among jurisdictions with outbreaks, jurisdictions with heavy EHS workload had lower estimated outbreak rates compared to those with lighter workloads (RR 0.64, 95% CI 0.54, 0.75, p<0.0001). These results are in contrast to those found for the logit part of the model where jurisdictions with heavy EHS workload were more likely to have an outbreak. Restaurant inspection frequency was also a significant covariate. Among the jurisdictions with outbreaks, the expected outbreak rate was positively correlated with restaurant inspection rate (RR 2.29 95% CI 2.01, 2.58, p<0.0001 and RR 1.72, 95% CI 1.46, 2.01, p<0.0001, respectively). The absence of a database to log critical violations found during restaurant inspections increased the outbreak rate by 18% when compared to those with an inspection database (β=0.18, p=0.001). Greater percentage (>50%) of self-designated high risk restaurants was associated with increased outbreak rate when compared to jurisdictions with fewer than 50% high risk

TABLE IX

LOCAL HEALTH JURISDICTION CHARACTERISTICS ASSOCIATED WITH RESTAURANT-RELATED OUTBREAK RATE, ZERO-INFLATED POISSON REGRESSION ANALYSIS (N=167), 2012

Zero-inflated part (Y=1)	**Estimate**	**Odds Ratio (95% CI)**	***p* value**
Average EHS Workload			
Low (<200)	Ref		
Moderate (200-400)	1.58	4.85 (2.03, 11.6)	0.0004
Heavy (>400)	1.87	6.48 (2.34, 18.2)	0.0003
Poisson Part (Y>0)	**Estimate**	**Rate Ratio (95% CI)**	***p* value**
Average EHS Workload (inspections per sanitarian)			
Low (<200)	Ref		
Moderate (200-400)	-0.02	0.98 (0.85, 1.12)	0.76
Heavy (>400)	-0.45	0.64 (0.54, 0.75)	<0.0001
Average Restaurant Inspections (inspections per restaurant)			
Low (<1.5)	Ref		
Medium (1.5-2.5)	0.83	2.29 (2.01, 2.58)	<0.0001
High (>2.5)	0.54	1.72 (1.46, 2.01)	<0.0001
Percentage of high-risk restaurants			
<50%	Ref		
>50%	0.51	1.67 (1.51, 1.81)	<0.0001
Jurisdiction type			
Metro	Ref		
Micro	-0.05	0.95 (0.84, 1.09)	0.49
Rural	0.70	2.01 (1.75, 2.31)	<0.0001
Inspection Citation Database			
Yes	Ref		
No	0.18	1.19 (1.07, 1.32)	0.001

restaurants (RR 1.67, 95% CI 1.51, 1.81, p<0.0001). Rural jurisdictions reported lower restaurant-related outbreak rates relative to jurisdictions in metropolitan areas.

D. Discussion

Our findings reveal considerable heterogeneity in EHS workload and number of inspections per restaurant among local health jurisdictions across the United States. Notably the number of restaurant inspections completed per EHS varied widely, with some performing fewer than 100 inspections and others completing over a thousand each year. Despite this variation, however, heavy workload was common among the jurisdictions participating in this research. We defined "workload" simply as the average number of restaurant inspections performed per EHS, but these public health workers usually have additional responsibilities including; inspections of non-restaurant facilities like daycares and nursing homes; participation in sewage disposal, involvement in vector control and water quality programs; investigations of illness outbreaks; and responding to public health nuisances and emergencies (New York State Department of Health 2012). EHS workload is likely a proxy for overall health department strain. These results suggest limited workforce capacity for many jurisdictions throughout the country. The heavy burden reported by the participating jurisdictions is consistent with recent data relating increased workload to reductions in staff support reported by local health departments (National Environmental Health Association 2013; National Association of County and City Health Officials 2013).

Our results also reveal EHS workload to be the only significant predictor of the presence of restaurant-related foodborne illness outbreaks. Jurisdictions with heavy workloads were more likely to report an outbreak compared to those with lower workloads. Our findings are similar to those of a small study of local health departments in Maryland. Zablotsky Kufel et al. reported

that counties with more full-time registered sanitarians had lower rates of foodborne illness when compared to those with fewer sanitarians (Zablotsky Kufel et al. 2011). Our data also suggest that approximately 300 inspections per EHS per year may be an important threshold when considering restaurant-related outbreak rates, as EHS employed in outbreak jurisdictions averaged more than 300 inspections, regardless of outbreak rate category (<0-10, 10-30, 30-50 or over 50 outbreaks per 10,000 restaurants). In this study, we did not examine whether high inspection volume signifies lower inspection quality, but the quantity-quality dichotomy model should be considered, as high workload has commonly been shown to negatively impact outcomes across various business types and industries (Stanton and Rutherford 2004; Benner 2011; Huntsman 2008; Elliott et al. 2014). For example, hospitals with low nurse staffing levels tend to have poor patient quality outcomes, like pneumonia and urinary tract infections. (Stanton and Rutherford 2004). For the EHS in this study, busy work schedule may impede their ability to adequately identify and correct critical violations during routine restaurant inspections. Future studies are needed to determine if there are differences in the quality of inspections performed by sanitarians with higher workload burden. These data would be valuable as local health authorities have begun implementing changes around workforce capacity. For example, in a survey conducted by the National Environmental Health Association (NEHA), local jurisdictions commonly reported decreases in their ability to perform routine inspections, with some developing new programs that stress quality of inspections, rather than quantity (National Environmental Health Association 2013).

Among jurisdictions reporting at least one outbreak, our data, revealed lower estimated outbreak rates for jurisdictions with heavy EHS workload when compared to those with lighter workloads. These findings run contrary to our hypothesis that workload would positively

correlate with outbreak rate. Our results, however, suggest that average number of inspections per inspector may not serve as a reliable proxy for EHS workload among the jurisdictions with high outbreak rates. Routine responsibilities, like restaurant inspections, may be hindered (both in terms of frequency and quality), as EHS are often tasked with additional duties including developing food history questionnaires, collaborating with epidemiologists and public health nurses and taking stool or food samples during an outbreak investigation. (Selman and Greene, 2008) An increase in outbreak frequency and the related strain on each EHS, may be lead to the decrease in routine responsibilities that we observed. As shown in Table VIII, we find that somewhere in the range of 0.3 to 0.6 outbreaks per EHS is the critical point when this effect becomes important and the inspection workload of the EHS begins to decrease.

Although most health jurisdictions in our study reported using a risk-based system to set restaurant inspection frequencies, we observed substantial differences in how restaurants were classified into risk tiers. The FDA provides detailed guidelines for risk-based inspections with recommended frequencies ranging from one to four with increasing risk category. Local jurisdictions, however, are ultimately responsible for developing and implementing regulations. Health departments are encouraged to develop risk categories tailored to their specific program needs and to reassess the risk categories on an annual basis (U.S. Food and Drug Administration 2013). With these recommendations, the observed differences in classification schemas are not unexpected. Although different classification methods are utilized, our findings suggest that restaurants at risk for foodborne illness outbreaks are being appropriately identified, as we found jurisdictions with more than 50% of restaurants classified as high risk to have higher outbreak rates. The stratification of high risk restaurants provides an opportunity for the development of risk-based interventions beyond the normal practice of increasing inspection frequency.

Coupling routine inspections with an educational component designed to improve food safety knowledge and behavior among restaurant food handlers is one such option. The use of evidence-based, culturally and linguistically appropriate, educational materials can be utilized by EHS to emphasize the severity of foodborne diseases and the importance of preventing outbreaks through safe food handling practices (Dworkin et al. 2012; Manes et al. 2014). This approach may be especially beneficial as one-third of the participating jurisdictions in our study did not require food safety certification of food handlers. Although we did not observe a significant correlation between certification requirement and outbreak rate, certification and training have been associated with greater food safety knowledge and behavioral compliance and fewer critical violations identified during inspections (Lynch et al. 2003; Cates et al. 2009; York et al. 2009; Kassa et al. 2010; Panchal et al. 2012; Manes et al. 2013; Brown et al. 2014; Burke et al. 2014). Food service employees without certification may benefit from training provided from an expert like an environmental health specialist. Restaurant inspections currently function primarily to identify momentary compliance with local food code, but have the potential to also act as a conduit for risk-based interventions, especially for high risk restaurants. Furthermore, with high quality, targeted interventions aimed to prevent foodborne illness, health departments may consider modifications to routine inspection frequencies requirements to help alleviate heavy EHS inspection workload.

Related to risk-classification, our findings reveal substantial variability with respect to restaurant inspection frequencies. While some jurisdictions averaged less than one inspection per restaurant, others completed nearly five inspections per restaurant in the study year. Despite this variation, restaurant inspection frequency was not found to be a significant predictor of foodborne illness outbreaks. We did observe, however, that increasing number of inspections

was associated with higher outbreak rate among jurisdictions with outbreaks in the adjusted model. Published data correlating inspection frequency and foodborne illness are limited and inconsistent (Riben et al. 1994a; Riben et al. 1994b; Newbold et al. 2008; Zablotsky Kufel et al. 2011). Riben et al. (1994) found no association between number of inspections and proven restaurant-related outbreaks among jurisdictions in Canada (Riben et al. 1994a; Riben et al. 1994b). Whereas, Zablotsky Kufel and colleagues found that Maryland counties with high food service facility inspection rates reported lower rates of foodborne illness (Zablotsky Kufel et al. 2011). These inconsistent results likely highlight the dynamic nature of restaurant inspection implementation, especially with the occurrence of an outbreak. Health departments can initiate inspection modifications, both in terms of quantity and quality, with the identification of critical violations or when an outbreak is associated with a restaurant. In a focus-group study to identity outbreak investigation practices, environmental health specialists reported conducting routine-like inspections or outbreak-specific inspections (focused more on food handling practices than on noncritical violations) as part of their responsibilities during an outbreak (Selman and Greene, 2008). In our study, one health department reported that restaurant risk categorization (and therefore inspection frequency) is "based on performance during the last inspection cycle." The potential dependence of the inspection frequency variable on the presence of an outbreak, is a limitation of this research and of those with similar observational design methods. Further research is needed to determine the minimum inspection frequency necessary for maximum food safety and the prevention of restaurant-related outbreaks. Despite this need, restaurant inspections should remain a high priority for local health authorities and we recommend the utilization of a risk stratification system to set inspection frequencies and to develop interventions for restaurants at high risk for foodborne illness.

Although all local health departments were contacted, participation in this survey was low. It is possible that local authorities were reluctant to participate due to various reasons, including the inability to provide the staff and time required to complete the survey. Health departments received no financial compensation for participating in the research. Anecdotally, jurisdictions reported “no time available” as a common reason for not participating. Non-response bias is, therefore, a potential limitation of this research. As an example, if non-participating jurisdictions had higher workload burden compared to those participating, the results from this study would underestimate workload. We invited health departments to participate online and follow up calls were made only to those who started but did not complete the survey. A more active process may have improved recruitment. Despite these limitations, the participating jurisdictions represented all but fourteen states across the US and provide the first nation-wide data examining inspection frequencies and outbreaks.

IV. FOOD SAFETY KNOWLEDGE OF CERTIFIED RESTAURANT MANAGERS: ARE SOME CERTIFICATION PROGRAMS MORE EFFECTIVE THAN OTHERS?

A. Introduction

According to the Centers for Disease Control and Prevention (CDC), two-thirds of foodborne illness outbreaks reported in the United States are associated with restaurants or delicatessens (Gould et al., 2013). To prevent restaurant-related outbreaks, local jurisdictions commonly require food safety certification of restaurant managers, as certification has been shown to be an important predictor of food safety knowledge (Lynch et al. 2003; DeBess et al. 2009; Panchal et al. 2012; Manes et al. 2013; Brown et al. 2014). In our previously published research, we reported greater knowledge among certified managers compared to noncertified managers and food handlers working in restaurants in Chicago and the northern suburbs (Dworkin et al. 2011; Panchal et al. 2012; Manes et al. 2013). Similarly, Brown and colleagues (2014) recently reported that certified food managers and certified workers had greater food safety knowledge than noncertified managers and workers in six demographically diverse populations (Brown et al. 2014).

Food safety certification requirements vary substantially throughout the country. Federal, state and local jurisdictions set certification and training guidelines and standards independently. Private and non-governmental organizations, like the Conference for Food Protection (CFP), have also been established to develop guidelines and make recommendations to promote food safety and consumer protection (Conference for Food Protection 2012). At the time of this study, the Illinois Food Code required that certified food managers attend a Food Service Sanitation Manager Certification (FSSMC) training course with 16 contact hours and pass a certification exam with a score of at least 75% (Illinois Administrative Code 2008). Managers were also required to renew their certification after 5 years, in which they could elect to take a full course, sit passively in a 5-

hour refresher course, or pass a certification exam without any additional training. State law did not mandate the certification of non-manager food handlers and it was at the discretion of each restaurant to determine how to train their staff in food safety.

The food safety certification courses for restaurant managers in Illinois are offered by various programs throughout the State and include (but are not limited to) private companies (like ServSafe), restaurants, local health departments and colleges and universities. Although all programs are required to provide the minimum training contact hours and an approved certification exam, the presentation may not have equal effect in acquisition or retention of food safety knowledge among certified managers. The objective of this study was to describe which certification training methods in Illinois are commonly utilized by restaurant managers and examine the association between these certification programs and food safety knowledge.

B. Methods

1. Sample and Participants

We interviewed 460 certified food managers from 279 participating restaurants in Chicago and the surrounding Suburbs (Suburban Cook, Kane, Lake and DuPage Counties), as part of two larger intervention studies designed to assess food safety knowledge and develop evidence-based educational materials for the specific urban and suburban food handler populations in northern Illinois. Detailed information regarding study samples, methods, survey questions, intervention materials, and results for the Chicago Educational Food Handler (CHEF) project and the Smart Suburban Restaurant Food Handler Study (SSRFHS) have been previously described (Dworkin et al. 2011; Manes et al. 2013). The survey data for the certified food managers interviewed for both the CHEF and SSFRHS projects were pooled for this analysis.

2. Survey Instrument and Data Collection

Certified food managers working in Chicago were interviewed between January to July 2009 and in Suburban Cook, Kane, Lake and DuPage Counties between June 2009 and March 2012. The survey instruments collected restaurant characteristics and food handler knowledge, behavior, personal hygiene information, and type of certification program. Survey development included input from the City of Chicago, Cook County, DuPage County, Kane County, and Lake County health departments, the Illinois Department of Public Health, and the University of Illinois at Chicago Survey Research Laboratory. The 44 food safety knowledge questions included true-false, multiple-choice, and fill-in-the-blank format and tested knowledge of the optimal temperatures for bacterial growth, appropriate temperatures for heating and cooling foods, cross contamination and when to discard food. The CHEF and SSRFHS survey tools to assess food safety knowledge were nearly identical, with the exception of very minor wording differences for two hand hygiene related questions. As there was no difference in the overall mean knowledge score when including or excluding these two questions (data not shown), we elected to include all 44 knowledge questions for this analysis.

Certified managers were also asked several additional knowledge questions specifically related to their restaurant responsibilities. The following manager-specific questions were included as part of the overall knowledge score for this analysis, all of which should have been answered with "Yes."

- "Should a restaurant close during a sewer back-up?"
- "Should a restaurant close during a power outage?"
- "Should a restaurant close when you have no running water?
- "Should a restaurant close when you have cold water but not hot water?"

Certified manager demographic information included primary language (English, Spanish with or without the ability to speak English and other language with the ability to speak English), race/ethnicity, years of food handling experience, and frequency of specific food handling tasks (including handling and cooking raw meat/poultry, seafood, eggs and vegetables/fruits). Managers were also asked to self-report their certification training course. Certification program types were categorized into the following: local health department, restaurant, ServSafe (self-reported as ServSafe, National Restaurant Association or Illinois Restaurant Association), college/university, other (including, but not limited to, non-ServSafe organizations and out-of-state health departments), or unknown program.

Restaurant characteristics were also obtained including service style, food type and average entrée price. Restaurants were categorized by size: small (≤ 10 tables or seating ≤ 40 seats), medium (11 to 29 tables or seating 41 to 119 seats), and large (≥ 30 tables or seating ≥ 120 seats).

3. Statistical Analysis

Statistical analysis was performed using SAS 9.4 (SAS Institute Inc., Cary, NC). An overall knowledge score was calculated as the proportion of correctly answered knowledge questions of the 44 from the survey. Bivariate analyses were performed to identify certified manager or restaurant variables associated with the knowledge score. T-tests were performed to compare the mean knowledge scores between two category variables. Analysis of Variance models with Tukey's pairwise comparisons were employed to compare the mean knowledge scores for variables with more than two categories. Pearson correlation coefficients were calculated to describe the relationship between the knowledge score and continuous variables. To identify factors associated with the knowledge score, multivariable analysis was performed using

mixed-effects regression models. A random restaurant effect was used to account for the potential correlations between certified managers from the same restaurant. Variables of primary research interest such as certification program type and those significantly associated ($p<0.1$) with the knowledge score were included in the multivariate analysis. To predict the knowledge score the initial regression model included all significant certified manager and restaurant characteristics. A backward elimination method with a probability of Type I Error of $\alpha = 0.10$ was used to determine the significant certified manager and restaurant characteristic variables to remain in the final mixed-effects regression model.

C. Results

1. Restaurant and Certified Manager Characteristics

Of the 279 participating restaurants, 99 (35%) were located within the city of Chicago and 180 (65%) in the surrounding Suburbs. Thirty-nine percent (108) of the restaurants were medium-sized and 62% (175) had an average entrée price of $10.00 or less (Table X). Approximately half of the restaurants served American cuisine with no ethnic focus (147, 52%). Fifty-five percent (154) of the restaurants had informal service style, with the proportion of formal style restaurants greater in Chicago compared to the Suburbs (30% and 13%, respectively, p=0.0001). A range of one to eight certified food managers were interviewed at each restaurant (median=1, mean=1.6).

Among the 460 certified managers interviewed, 178 (39%) managed a restaurant in the city of Chicago and 282 (61%) managed a restaurant in the suburbs (Table X). The mean age was 36 years (range 18 to 70 years) and 67% (310) were male (Table XI). Fifty-five percent of the participants reported English as their primary language, 34% (157) spoke Spanish as their primary language, and 11% (49) reported another language. Forty-two percent (193) described themselves as Non-Hispanic White, 37% (170) as Hispanic/Latino, 7% (31) as Non-Hispanic Black, 8% (36)

TABLE X

CHARACTERISTICS OF RESTAURANTS PARTICIPATING IN A KNOWLEDGE SURVEY IN THE CITY OF CHICAGO AND SUBURBAN COOK, LAKE, KANE AND DUPAGE COUNTIES ILLINOIS, 2014 (*N* = 279) AND SCORE OF CERTIFIED MANAGERS OUT OF 44 FOOD SAFETY KNOWLEDGE QUESTIONS

Characteristic	**Frequencies**		**Bivariate Analysis**	
	Restaurant *n* (%)	Certified Managers *n* (%)	Mean Score (%)	*p* value
Restaurant Location				0.3895
City	99 (35)	178 (39)	35.0 (80)	
Suburb	180 (65)	282 (61)	35.3 (80)	
Restaurant size				
Small (≤10 tables or ≤40 seats)	94 (34)	152 (33)	35.0 (80)	0.788
Medium (>10 tables or >40 seats but <30 tables or <120 seats)	108 (39)	165 (36)	35.1 (80)	
Large (≥30 tables or seating ≥120 seats)	77 (27)	143 (31)	35.4 (80)	
Food service style				0.0364
Fast food	79 (28)	135 (29)	34.4 (78)	
Informal	154 (55)	234 (51)	35.6 (81)	
Formal	46 (17)	91 (20)	35.2 (80)	
Cuisine				0.0076
American (no primary ethnic focus)	147 (52)	260 (57)	35.7 (81)	
Mexican	36 (13)	58 (13)	35.2 (80)	
Italian	47 (17)	71 (15)	34.1 (78)	
Other	49 (18)	71 (15)	34.3 (78)	
Average entrée price				.0104
≤$10	175 (62)	267 (58)	34.8 (79)	
>$10 but <$20	89 (32)	146 (32)	35.3 (80)	
≥$20	16 (6)	47 (10)	36.8 (84)	

TABLE XI

CHARACTERISTICS OF CERTIFIED FOOD MANAGERS PARTICIPATING IN A KNOWLEDGE SURVEY IN THE CITY OF CHICAGO AND SUBURBAN COOK, LAKE, KANE AND DUPAGE COUNTIES ILLINOIS, 2014 (N=460) AND SCORE OF CERTIFIED MANAGERS OUT OF 44 KNOWLEDGE QUESTIONS

	Frequencies	**Bivariate Analysis**	
Characteristic	N (%)	Score (%)	*p* value
Age			0.9111
18-29 years	142 (31)	35.2 (80)	
30-39 years	147 (32)	35.2 (80)	
40-49 years	90 (19)	34.9 (79)	
≥ 50 years	81 (18)	35.3 (80)	
Gender			0.8959
Males	310 (67)	35.2 (80)	
Females	150 (33)	35.1 (80)	
Race/Ethnicity			0.0001
Non-Hispanic White	193 (42)	37.0 (84)	
Hispanic/Latino	170 (37)	33.5 (76)	
Non-Hispanic Black	31 (7)	34.6 (79)	
Asian or Pacific Islander	36 (8)	33.5 (76)	
Other/Multiracial	30 (6)	35.9 (81)	
Education			0.0001
Less than 12th grade	59 (13)	33.0 (75)	
High school diploma or graduate equivalent	116 (25)	34.6 (79)	
Some college/ Associate's degree	162 (35)	35.9 (82)	
Four year college degree or more	123 (27)	35.8 (82)	
Primary Language			0.0001
English only	254 (55)	36.5 (83)	
Spanish but speaks English well	88 (19)	33.3 (76)	
Spanish but does not speak English well	69 (15)	33.4 (76)	
Other (survey performed in English)	49 (11)	34.1 (78)	
Food Safety Training Course			<0.0001
Health Department	83 (18)	34.8 (79)	
Restaurant/Corporation	102 (22)	34.8 (79)	
Serv-Safe	69 (15)	37.1 (84)	
College/University	90 (20)	35.6 (81)	
Other	49 (10)	35.1 (80)	
Unknown	67 (15)	33.7 (77)	

TABLE XI (Continued)

CHARACTERISTICS OF CERTIFIED FOOD MANAGERS PARTICIPATING IN A KNOWLEDGE SURVEY IN THE CITY OF CHICAGO AND SUBURBAN COOK, LAKE, KANE AND DUPAGE COUNTIES ILLINOIS, 2014 (N=460) AND SCORE OF CERTIFIED MANAGERS OUT OF 44 KNOWLEDGE QUESTIONS

	Frequencies	**Bivariate Analysis**	
Characteristic	N (%)	Score (%)	*p* value
Years Working as a Food Handler			
< 1	9 (2)	35.6 (81)	0.0825
1-3	78 (17)	34.2 (78)	
4-6	75 (16)	35.0 (80)	
≥7	298 (65)	35.5 (81)	
Years Working in current Certified Manager Position			
< 1	52 (11)	36.1 (82)	0.3220
1-3	159 (35)	35.0 (80)	
4-6	98 (21)	35.3 (80)	
≥7	151(33)	35.1 (80)	
Frequency of Food Handling Tasks			
0 (no food handling tasks performed)	32 (7)	35.8 (81)	0.5275
1	38 (8)	35.2 (80)	
2	51 (11)	35.3 (80)	
3	56 (12)	34.5 (78)	
4	49 (11)	35.4 (80)	
5	55 (12)	34.6 (79)	
6	45 (10)	34.9 (79)	
7	134 (29)	35.4 (80)	

as Asian/Pacific Islander, and 6% (30) as Multi-racial or Other race/ethnicity. A greater proportion of certified managers in the suburbs described themselves as Non-Hispanic White, compared to those in Chicago (46% and 35%, respectively, p=0.02). Sixty-two percent (285) of the certified managers reported at least some college education. The proportion of college educated managers was greater in the city than in the suburbs (70% and 57%, respectively, p=0.001). On average, the participants had worked in their current position as certified food manager for 6.9 years (range 1 to 45 years) and as a food handler in general for 12.8 years (range 1 to 50 years). The average time spent working in food service or as a certified manager did not differ by gender, race/ethnicity or certification training program.

The majority of food managers (393, 85%) were able to recall the training program they had utilized for certification. Among those with a known training program 66% (258) were male, 34% (133) were of Hispanic ethnicity, and 31% (123) spoke Spanish as their primary language. By comparison, among the managers unable to recall their training program, 78% (52) were male, 55% (37) were of Hispanic ethnicity, and 51% (34) spoke Spanish as their primary language, Twenty-two percent (102) of the managers who recalled their training program were certified through a restaurant, 20% (90) from a university/college, 18% (83) were trained by a local health department, 15% (69) directly through ServSafe and 11% (49) from another source (including but not limited to non-ServSafe training organizations and out-of-state health departments). Significant differences in the proportions of the certification programs were found by urban versus suburban restaurant managers ($p<0.0001$). Among Chicago managers, 16% (29) were certified through a restaurant, 19% (34) through a college/university, 18% (32) by a local health department, 24% (42) through ServSafe, 13% (24) by another program and 10% (17) did not remember the program. Among the Suburban managers, 26% (73) utilized a restaurant, 20% (56) were certified

by a college/university, 18% (51) by a local health department, 10% (27) through ServSafe, 9% (25) by another program and 18% (50) were unsure.

Preferred learning styles varied. Thirty-three percent (156) preferred to learn about food safety by looking at information with pictures, 12% (56) preferred hearing new information and 40% (181) learned best by reading information. Reading information was reported most frequently as the preferred learning mode for both English-speaking and Spanish-speaking managers (38% and 46%, respectively) and among managers of any certification training program or any education level. Sixty-seven certified managers selected "other" and provided additional learning styles, 10% (48) wanted a "hands-on" learning environment, 2% preferred a combination of learning modes, 1.3% of managers enjoyed watching videos and less than 1% reported learning best through test-taking. There was no significant difference in knowledge score by preferred learning style.

2. Identifying Knowledge Gaps

The overall average food safety knowledge score was 79.5% (35 correct of 44 questions, standard deviation 4.0, range 19 (43.2%) to 44 (100%)). Thirty-one percent (144) of the managers had very low food safety knowledge with a score of 43% to 75% on the survey, while only 15% (71) had very high knowledge with a score of 90% or above.

Substantial knowledge gaps were identified and related to optimal temperatures for cooking, holding and refrigeration, and hygiene (Table XII). Only 24% of the managers were able to correctly provide the temperature range of the danger zone for pathogen growth. Managers certified through ServSafe had the highest proportion answering the range correctly, but still very low at 32%. Overall, certified managers also performed poorly when asked to identify the proper temperature to cook hamburger and the correct internal temperature to cook

TABLE XII

FREQUENCIES OF CORRECT RESPONSES TO SELECTED KNOWLEDGE QUESTIONS ASKED OF CERTIFIED FOOD MANAGERS OF RESTAURANTS IN CHICAGO AND SUBURBAN COOK, KANE, LAKE AND DUPAGE COUNTIES, OVERALL AND BY CERTIFICATION TRAINING TYPE, 2014 (N=460)

Questions (*Answers*)	Overall n = 460	ServSafe n = 69	Health Department n = 83	Restaurant n = 102	College/ University n = 90	Other n = 49	Unknown n = 67
Time and Temperature Hamburger and other ground beef mixtures, such as meatloaf, should be cooked to at least what temperature on a meat thermometer? (*155°F or 160°F*) [a]	125 (27.2)	17 (24.6)	20 (24.1)	27 (26.4)	29 (32.2)	14 (28.6)	18 (26.8)
Germs that make people sick grow well between which temperatures? (*40°F or 41°F to 135°F or 140°F*)[a]	110 (23.9)	22 (31.9)	17 (20.5)	25 (24.5)	24 (26.7)	13 (26.5)	9 (13.4)
What is the proper minimum internal temperature to cook chicken for at least 15 seconds? (*165°F*)	161 (35.0)	34 (49.2)	25 (30.1)	31 (30.4)	34 (37.8)	20 (45.5)	17 (25.4)
Cold food must be kept at 55ºF (13ºC) or lower. (*False*)	316 (68.7)	58 (84.1)	66 (79.5)	64 (62.7)	58 (64.4)	27 (55.1)	43 (64.2)
If hot, roast beef has been held in a steam table below 135ºF (57ºC) for over 4 hours, it should be… (*Thrown away*)	337 (73.3)	52 (75.4)	52 (62.7)	74 (72.3)	72 (80.0)	37 (75.5)	50 (74.6)
Food Storage Raw meat can be stored anywhere in a refrigerator as long as it is wrapped in plastic. *(False)*	333 (72.4)	56 (81.2)	56 (67.5)	79 (77.5)	66 (73.3)	37 (75.5)	39 (58.2)
Storing products with the earliest expiration dates in front of products with later dates is a safe food storage practice. (*True*)	366 (80.0)	55 (80.0)	66 (79.5)	81 (79.4)	76 (84.4)	39 (79.6)	49 (73.1)
If fish (such as raw tuna) has been stored at a temperature that is too warm, but then is properly cooked to the correct internal temperature, it becomes safe to eat. (*False*)	339 (73.7)	52 (75.4)	68 (81.9)	63 (61.7)	68 (75.6)	37 (75.5)	51 (76.1)
Raw eggs in shells may be stored above a prepared salad in the refrigerator. (*False*)	385 (83.7)	63 (91.3)	72 (86.7)	78 (76.5)	74 (82.2)	41 (83.7)	57 (85.0)

TABLE XII (Continued)

FREQUENCIES OF CORRECT RESPONSES TO SELECTED KNOWLEDGE QUESTIONS ASKED OF CERTIFIED FOOD MANAGERS OF RESTAURANTS IN CHICAGO AND SUBURBAN COOK, KANE, LAKE AND DUPAGE COUNTIES, OVERALL AND BY CERTIFICATION TRAINING TYPE, 2014 (N=460)

Questions (*Answers*)	Overall n = 460	ServSafe n = 69	Health Department n = 83	Restaurant n = 102	College/ University n = 90	Other n = 49	Unknown n = 67
Thawing Food							
It is safe to put frozen chicken breast on the counter to thaw. (*False*)	411 (89.3)	68 (98.6)	73 (88.0)	90 (88.2)	77 (85.6)	45 (91.8)	58 (86.6)
Germs							
You can be sure food is safe to eat when it smells and tastes normal. (*False*)	343 (74.6)	61 (88.4)	67 (80.7)	78 (76.4)	59 (65.6)	33 (67.3)	45 (67.2)
Uncooked beef is potentially contaminated with germs that can cause people to be hospitalized or die. (*True*)	441 (95.9)	69 (100)	81 (98.0)	97 (95.1)	86 (95.6)	46 (93.8)	62 (92.5)
Vegetables for a salad splashed with a few drops of raw chicken juice should not be rinsed, but instead must be thrown away. (*True*)	417 (90.7)	65 (94.2)	69 (83.1)	94 (92.2)	82 (91.1)	46 (93.8)	61 (91.0)
Cooked rice can have germs that can make people sick. (*True*)	240 (52.2)	45 (65.2)	43 (51.8)	46 (45.1)	48 (53.3)	23 (46.9)	35 (52.2)
Hand Washing							
Do you need to have thoroughly washed hands if you use single-use gloves to handle food? (*Yes*)	423 (92.0)	67 (97.1)	75 (90.4)	95 (93.1)	83 (92.2)	46 (93.9)	57 (85.1)
At work if you only urinated, and did not have a bowel movement, you do not need to wash your hands. (*False*)	383 (83.2)	64 (92.8)	77 (92.8)	76 (74.5)	68 (75.5)	38 (77.6)	60 (89.6)
Restaurant Closure							
Should a restaurant close if you have cold water but not hot water? (*Yes*)	370 (80.4)	59 (85.5)	63 (75.9)	85(83.3)	70 (77.8)	39 (80.0)	(80.6)

chicken (27% and 35%, respectively). With regard to food storage, more than one in four certified managers answered incorrectly as "true" that raw meat can be stored anywhere in a refrigerator as long as it is wrapped in plastic. Similarly, over a quarter of the managers did not know that when fish (such as tuna) is stored at a temperature too warm and then cooked that it is unsafe to eat. Although nearly all certified managers knew that beef may have germs that can cause people to become sick (96%), much fewer knew this fact about rice (52%). For questions regarding hygiene, nearly all (92%) answered correctly that hands must be thoroughly washed when using single-use gloves. However, 17% incorrectly answered the question, "At work if you only urinated, and did not have a bowel movement, you do not need to wash your hands."

For certain food safety questions, there were substantially more ServSafe trained managers that answered correctly compared to those trained by a health department. Eighty-one percent of the managers with ServSafe certification correctly answered false to the question, "Raw meat can be stored anywhere in a refrigerator as long as it is wrapped in plastic," while only 68% of the managers certified by a health department answered this question correctly. Ninety-four percent of ServSafe certified managers and 83% of health department certified managers knew that vegetables for a salad splashed with raw chicken juice should be thrown away. A greater percentage of ServSafe certified managers compared to health department trained managers answered correctly that a restaurant should close when there is cold but not hot water (86% and 76%, respectively). Although both groups performed poorly when asked to identify the proper temperature to cook chicken, more ServSafe certified managers (49%) knew the correct temperature of 165^{o}F than did the health department certified managers (30%).

3. Factors Associated With the Knowledge Score

Bivariate analysis indicated restaurant characteristics significantly associated with the knowledge score. The mean knowledge score for informal and formal restaurants was significantly but not substantially greater compared to fast food restaurants (81%, 80% and 78%, respectively, p=0.04) and for restaurants serving American or Mexican cuisine compared to those serving Italian and other cuisines (81%, 80% and 78%, 78% respectively, p=0.008) (Table X). The mean knowledge score for restaurants with entrée meals priced greater than $20.00 was higher compared to those with lower meal costs (84%, 80% and 79%, respectively, p=0.01). There was not a significant difference in score for Chicago compared to Suburban restaurants or for restaurants of different sizes.

Certified manager characteristics significantly associated with knowledge score were also identified. Managers with English primary language scored higher than those with Spanish primary language or other languages (83% versus 76% and 78% respectively; p=0.0001) (Table XI). Non-Hispanic White managers scored higher than those who identified themselves as Hispanic/Latino, Non-Hispanic Black, Asian/Pacific Islander, or Multi-racial/Other race/ethnicity (84%, 76%, 79%, 76%, and 81%, respectively, p=0.0001). Certified managers with at least some college education scored higher than those with a high school or lower education (82% versus 79%, 75% respectively, p=0.0001). Those certified through ServSafe scored significantly higher than managers trained in any other program (ServSafe, 84%; college/university; 81%, other program; 80%, local health department; 79%, restaurant; 79% unknown program, 77%; p=<0.0001). Mean score did not differ significantly by age, gender, years working as a certified manager or frequency of food handling tasks.

In the final mixed-effects regression model predicting knowledge, a significant covariance between knowledge scores of certified managers from the same restaurants was detected (random restaurant effect, σ 3.34, standard error 1.26, p=0.0041). In the final model, managers certified through a ServSafe training program scored significantly higher than all other training programs after controlling for other factors (health department certified managers scored 1.4 points lower in a scale of 0 to 44, p=0.02; restaurant certified managers scored 1.6 points lower, p=0.007; college/university certified managers scored 1.2 points lower; managers scored p=0.05; managers with another certification scored 1.5 points lower, p=0.03; and those with unknown certification scored about 2.2 points lower, p=0.003, respectively) (Table XIII). Managers whose primary language was Spanish (with or without the ability to speak English) scored significantly lower than those for whom English was their primary language (p=0.02). In addition, managers who identified themselves as Hispanic/Latino, Non-Hispanic Black and Asian/Pacific Islander scored significantly lower compared to Non-Hispanic White managers (p=0.007, p=0.001 and p=0.0006, respectively).

D. Discussion

The absence of food safety knowledge can lead to poor food handing behaviors that contribute to foodborne illness outbreaks (Shapiro et al. 1999; Clayton et al. 2002; Cody et al. 2003; Pragle et al. 2007; Yiannas 2008). Restaurant manager certification improves food safety knowledge and is commonly employed by State and local jurisdictions in effort to prevent restaurant-related outbreaks. In Illinois, the Illinois Food Code requires managers to complete a training course and pass a food safety certification exam to be certified in food safety. Our findings indicate that many certified managers did not have high knowledge even though they are responsible for food safety

TABLE XIII

CERTIFIED FOOD MANAGER CHARACTERISTICS ASSOCIATED WITH KNOWLEDGE SCORE, MIXED-EFFECTS REGRESSION ANALYSIS (N=460)

	Multivariate analysis	
	Estimate (SE)	***p* value**
Manager Characteristics	Scale of 0-44	
Intercept	38.18 (0.59)	<0.0001
Certification Training		
ServSafe	Ref	
Health Department	-1.44 (0.60)	0.0186
College/University	-1.15 (0.59)	0.0503
Restaurant/Corporation	-1.61 (0.59)	0.0067
Other	-1.47 (0.69)	0.0344
Unknown	-2.32 (0.64)	0.0004
Primary Language		
English	Ref	
Spanish	-1.59 (0.68)	0.0210
Other	-1.08 (0.66)	0.1064
Race/Ethnicity		
White	Ref	
Hispanic/Latino	-1.90 (0.68)	0.0057
Black/African American	-2.45 (0.72)	0.0009
Asian/Pacific Islander	-2.78 (0.77)	0.0004
Multi-racial/Other	-0.23 (0.75)	0.7550

at their restaurants but that some food safety certification programs may be more effective than others in educating food managers.

In this analysis, higher food safety knowledge was independently associated with certification through ServSafe compared to all other self-reported certification program types. Although data comparing the effectiveness of food safety training is limited, our results align with other studies suggesting that accredited certification programs, like ServSafe, improve food safety knowledge (Roberts et al. 2008; York et al. 2009; Brown et al. 2014). For example, Brown et al. (2014) found that managers with certification from an accredited program were significantly more likely to pass a food safety knowledge assessment compared to those with certification from a non-accredited program (Brown et al. 2014). In a 2008 intervention study, Roberts and colleagues reported that food service employees completing a 4-hour ServSafe training course showed an improvement in overall food safety knowledge and with compliance of standards of behaviors compared to a control group (Roberts et al. 2008). Conversely, however, Lynch and colleagues (2003) found that restaurant managers with training from a local health department had greater knowledge than those trained by a "corporate training source" (Lynch et al. 2003). Their study categorized all non-governmental organizations as corporate training sources and did not specify training by restaurants or programs like ServSafe. A limitation to any food safety training course is that an improvement in knowledge does not guarantee an improvement of behavior (Clayton et al. 2002; Roberts et al. 2008; York et al. 2009). For example, Clayton and colleagues found that although food handlers were aware of recommended food safety practices, two-thirds reported not always exhibiting these behaviors (Clayton et al. 2002). Nevertheless, knowledge is an important component of intervention to

improve behavior since behavior is often influenced by information, such as risk for causing disease and severity of that disease.

In this study, our objective was to evaluate the food safety knowledge of managers certified by different training programs, but not to examine the differences among the training sources offered in Illinois. As all certified managers were required to attend a 16-hour course and pass a certification exam, it is unclear why ServSafe certified managers demonstrated higher knowledge compared to those trained by other programs. One explanation may be that the certification programs in Illinois utilize different training materials to teach food safety concepts. In a survey of environmental health sanitarians attending a National Environmental Health Association (NEHA) annual conference, trainers indicated that to provide effective food safety training they needed a variety of materials, including photographs/graphics, Powerpoint slides, video clips, fact sheets, evaluation tools, posters and even press releases (Fraser and Nummer 2010). An evaluation of such training materials could help direct the development and use of effective evidence-based resources. Another explanation for the differences among certification groups, may be that the method of presentation of food safety concepts is critical for the acquisition and retention of food safety knowledge. It is possible that some training programs in our study (like the local health departments, colleges/universities, or restaurants) were using concepts and materials from ServSafe. In fact, Fraser and Nummer (2010) found that over 25% of food safety trainers across the US use the ServSafe exam during their certification courses (Fraser and Nummer 2010). This would suggest that presentation of similar materials is important when examining the effectiveness of a certification program. For example, York and colleagues found that coupling ServSafe training with a Theory of Planned Behavior program improves food safety knowledge and behavior above that of ServSafe training alone (York et al.

2009). Similarly, food safety trainers have reported that the best teaching methods involve using activities or demonstrations to teach content (Fraser and Nummer 2010). Another hypothesis to explain the knowledge differences among certified managers may be that factors beyond the educational components are contributing to the effectiveness of these programs. Cost, for example, has been cited as is a primary barrier to food safety training among restaurant food handlers (Seaman and Eves 2006; Fraser and Nummer 2010). In addition, restaurants and local health departments are often overworked and understaffed which may impact their ability to educate food managers. It is likely that the combination of the materials used during training, the presentation of food safety concepts, and the influence of outside factors all contribute to a program's ability to effectively train and certify food safety managers.

Primary language and race/ethnicity were independently associated with food safety knowledge score. Managers with English primary language had greater food safety knowledge than managers with Spanish primary language. These findings are consistent with published literature (Brown et al. 2014). Similarly, managers who reported White race/ethnicity had higher knowledge compared to managers of Hispanic/Latino, Non-Hispanic Black and Asian/Pacific Islander race/ethnicity. Environmental health sanitarians and food safety trainers have emphasized the importance of developing materials in languages other than English (Foster and Kaferstein 1985, Worsfold et al. 2004, Fraser and Nummer 2010). Culturally tailored interventions have shown promising results in promoting knowledge and healthy behaviors, especially among Spanish-speaking research participants (Liebman et al. 2007, Larkey et al. 2009). Our previous research has shown that comic books designed to target food safety knowledge gaps that are provided in both English and Spanish languages are effective in improving food safety knowledge among restaurant food handlers (Manes et al. 2014). There

remains a need, however, to examine how food safety information is presented during training to diverse food service populations and how that presentation impacts food safety knowledge and behaviors of restaurant employees.

On average, the certified managers in this study scored 79% on our survey, which is four percentage points higher than is the required 75% to pass a food safety certification examination in Illinois. We are not aware of any studies that determine the minimum score on a certification exam that displays adequate food safety knowledge to prevent sporadic cases and outbreaks of foodborne disease. According to the ANSI-CFP *Standards for the Accreditation of Food Protection Manager Certification Programs*, food safety examination development including setting the passing score, should be in compliance with the *Standards for Educational and Psychological Testing* and federal requirements (Conference for Food Protection 2012). The CFP, however, does not provide instruction for setting a passing score to ensure greatest food safety knowledge retention. In a study conducted by Brown et al. (2014), only half of already-certified managers passed a food safety assessment with a passing score set by the research team of 80% (Brown et al. 2014). Although 60% (278 managers) scored 80% or higher and 76% (348 managers) scored 75% or higher on our survey (the score needed on a certification exam to pass in Illinois), we identified substantial knowledge gaps related to holding and cooking temperatures, food storage and hygiene. For example, only one in four certified managers were able to recall the correct temperature of the danger zone. Only a third knew the correct internal temperatures to cook chicken and beef and more than 25% did not know that fish held in temperatures within the danger zone may be unsafe if reheated and consumed. This lack of knowledge is concerning, as poultry, fish and beef are among the top three food sources implicated in foodborne illness outbreaks reported from the Foodborne Disease Outbreak

Surveillance System (1999-2008) (Gould et al. 2013). Our results suggest that baseline knowledge of many certified managers in northern Illinois is lacking, which may compromise their ability to adequately train the restaurant staff.

At the time of this study, the Illinois Food Code required that certified food managers attend a Food Service Sanitation Manager Certification (FSSMC) training course with 16 contact hours and pass a certification exam (Illinois Administrative Code 2008). Recertification was required every five years by passing another examination with a score of at least 75%. Illinois State law did not mandate certification of non-manager food handlers. Recently however, Illinois has passed new regulations for restaurant managers and food handlers with standards set forth by the Conference for Food Protection (CFP). As of 2014, the requirements for manager certification changed substantially. Contact hours for training have been reduced to only 8 hours, but recertification requirements increased from zero to 8 hours of training combined with passing a certification exam with a minimum score of 75%. Furthermore, all food handlers in Illinois are required to obtain an ANSI-accredited Food Handler certificate within 30 days of hire (Illinois Administrative Code 2014). This analysis and our previously published research, provide a rare look into baseline food handler knowledge before substantial regulation changes.

Our study collected self-report data. Certification documents were not acquired for verification of training program (15% of the certified managers were unable to recall their training program). It is possible that some managers may have reported their certification program incorrectly. Furthermore, some training programs (like the local health departments, colleges/universities, or restaurants) may actually use training concepts and materials from other organizations (like ServSafe) but the extent to how often this occurs in Illinois is not known. Additionally, we did not ask about when certification was obtained. Time since certification

may have varied among the managers. However, as recertification is required in Illinois every five years, all managers should have had at least some exposure to food safety refresher knowledge with each recertification. In addition, our data did not reveal a correlation between length of time in current manager role and knowledge score. Selection bias may be a limitation to this research, as it is possible that the certified managers who selected ServSafe as their training program may also be those with higher baseline knowledge or with greater ability to learn the information. Although our sample size of certified managers is large (n=460) and we selected restaurants from five large jurisdictions using random sampling, the data from this analysis may not be generalizable to all certified managers in Illinois or to certified managers throughout the United States.

V. A STEP TOWARDS IMPROVING FOOD SAFETY IN INDIA: DETERMINING BASELINE KNOWLEDGE AND BEHAVIORS AMONG RESTAURANT FOOD HANDLERS IN CHENNAI

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A. Introduction

Foodborne diseases are a growing public health problem worldwide. The World Health Organization estimates that foodborne and waterborne illnesses account for 1.8 million childhood deaths annually, predominantly in developing countries (World Health Organization 2005). In India, a substantial amount of illness and death can be attributed to diarrheal disease, but the burden of foodborne illness is not fully recognized or understood. A review conducted by the Food and Drug Toxicology Research Center in Hyderabad, India, found 37 foodborne disease outbreaks from 1980 to 2009. Researchers concluded that foodborne disease in India is highly underreported and that a national surveillance system would improve effective detection and prevention of outbreaks (Sudershan et al. 2012).

Increasingly, food is consumed outside the home with the potential for exposure to poor hygiene in commercial foodservice settings (World Health Organization 2008a). A 2007 food safety study of knowledge, attitudes and practices reported that mothers in southern India consider home cooked meals to be safer than prepared meals bought outside the home and they were even reluctant to eat meals prepared by "reputed hotels or eateries" (Subba Rao et al. 2007).

In the United States, working while ill, failing to properly wash hands, inadequately cleaning equipment, cross-contamination, and temperature abuse are known risk factors associated with foodborne illness outbreaks (Todd et al. 2007; U.S. Food and Drug Administration 2011). A lack of food safety knowledge can lead to these unsafe food handling behaviors that increase risk for food poisoning. Limited research has been published assessing food handler knowledge and behaviors in developing regions, such as India (Al-Khatib and Al-Mitwalli 2009; Malhotra et al. 2008; Onyeneho and Hedberg 2013; Sangole et al. 2001; Singh 2004; Udgiri and Yadavnnavar 2006). Given that behavior may change as a result of several factors including knowledge, an assessment of food handler knowledge of safe food handling practices is necessary and can be useful in designing educational interventions that target these knowledge gaps and related behaviors (DeBess et al. 2009; Dworkin et al. 2012; Manes et al. 2013; Manes et al. 2014; Panchal et al. 2012).

The Indian Parliament, with the Food Safety and Standards Act (2006) and the Food Safety and Standards Authority of India (FSSAI), is taking action to reduce foodborne illness in India. Food safety in restaurants and other food service establishments is one area of regulatory focus. The purpose of this study was to assess knowledge gaps among food handlers in restaurants in Chennai, Tamil Nadu, India in order to use that information to guide the development of future interventions in restaurant food safety.

B. Materials and Methods

1. Sample and Participants

From April through June 2011, a survey of restaurant food handlers in Chennai, Tamil Nadu was administered by the local health department, known as the Corporation of Chennai. Restaurants of varying sizes, food prices, food types and cuisines were selected using purposive

sampling methodology. Health inspectors selected two to three restaurants within their normally assigned geographic zone to approach for the study (Corporation of Chennai 2008).

Restaurant managers were approached in-person by trained Corporation of Chennai sanitarians for approval to conduct interviews with the staff at each restaurant. A signed consent was obtained which required participants be 18 years or older. Eligible participants were food handlers defined as a restaurant employee who prepares food (washing, cutting, cooking, and/or placing food onto a plate) to be consumed by patrons. Surveys were administered in either Tamil or English language and completed discreetly at the restaurants. Approval from the Corporation of Chennai Ethics Board and the University of Illinois at Chicago Institutional Review Board was received prior to survey initiation.

2. Instrument Development and Data Collection

A 44-question survey instrument was developed to determine baseline knowledge and to collect self-reported behaviors among the food handlers. The survey was adapted from one used to assess baseline knowledge of food handlers in the suburbs of Chicago (Manes et al. 2013). Survey modifications and language translations were provided by staff from the Corporation of Chennai. The survey included 23 food safety knowledge questions and tested knowledge of germs, appropriate temperatures for heating and cooling of foods, handling of raw and ready-to-eat food and cross contamination. Participants were also asked about behavior practices including hand hygiene and working while ill. Food handler demographic information was collected and included, history of food safety training and certification, restaurant job type, frequency of specific food handling tasks, and typhoid vaccination. Restaurant characteristics including size, service style, food type and average entrée price were also obtained.

A restaurant inspection form was adapted and modified from inspection forms utilized by local health departments in the suburbs of Chicago. The 17-question form included inspection of the availability of hand washing sinks and soap, hot water dish sanitizers, working temperature gauges on the refrigerators/chillers, and meat thermometers. Temperatures of the following items were obtained and recorded with NSF-approved thermometers: refrigerator, chilled ready-to-serve foods (like yogurt), warm ready-to-serve meat, warm ready-to-serve sauces (like curry) and eggs. Restaurant characteristics including service style, food type and average entrée price were also obtained. Restaurants were categorized by size: small (≤ 10 tables), medium (11 to 29), and large (≥ 30 tables).

3. Statistical Analysis

Statistical analysis was performed using SAS 9.3 for Windows (SAS, Cary, NC) with data from all participating food handlers. An overall knowledge score was determined by the proportion of correctly answered knowledge questions of the 23 from the survey. An overall vegetarian knowledge score was determined by the proportion of correctly answered knowledge questions of the 15 vegetarian-only questions by removing all questions involving meat temperatures or preparation.

Bivariate analyses were performed to identify food handler or restaurant variables associated with knowledge score. Analysis of Variance models with Tukey's pairwise comparisons were employed to compare the mean knowledge scores for categorical variables. To identify factors associated with the food handler knowledge score, multivariable analysis was performed using mixed-effects regression models. A multi-level random restaurant and geographic zone effect was used to account for the potential correlations between food handlers from the same restaurant and zone. Variables that had a statistically significant association ($p<0.1$) with the

knowledge score were included in the multivariate analysis. A backward elimination method with a probability of Type I Error of $\alpha = 0.10$ was used to determine the significant variables to remain in the final regression model.

C. Results

From April through June 2011, 36 restaurants from six of the 15 geographical zones in Chennai, Tamil Nadu were approached and participated in the study. Among the 36 restaurants, 56% (20) were medium-sized, 69% (25) had informal/casual dining, and 56% (20) had an average entrée price of INR 100 or less (INR 100 was equivalent to US$ 2.25 at the time of this study) (Table XIV). Approximately half were chain restaurants (19, 53%) and two-thirds (24, 67%) served non-vegetarian meal options.

Among the 156 food handlers interviewed, the mean age was 29.3 years (range 19 to 51 years) and 92% (144) were male (Table XV). Seventy-one percent (111) of the food handlers had no more than a high school education. The average time spent working as a food handler was 2.4 years (range 0.2 to 40 years). Forty-four percent of the food handlers worked as the restaurant chef or cook, 21% maintained a supervisory role and 21% served as other restaurant staff. Many (60, 38%) of the participating food handlers reported not obtaining the Corporation of Chennai required Medical Fitness Certificate (a health exam administered by a Chennai clinic certifying the food handler healthy enough to work with food served to the public) or not receiving food safety training at their current job (87, 56%). A history of college education and of receiving food safety training was more common among food handlers reporting a Medical certificate than those without a certificate (38% versus 13%, p=0.008 and 59% versus 20%, p<0.001, respectively). Of the 156 food handlers, only 17% (27) reported ever hearing about India's Food and Safety Standards (2006) regulation.

There were important food safety barriers identified during the restaurant inspections. Thirty-five restaurants (97%) had a sink available for hand washing in the kitchen area and 34 (94%) also had soap available (Table XVI). Among all food handlers, 12% (17) did not know that there was

TABLE XIV

CHARACTERISTICS OF RESTAURANTS PARTICIPATING IN A KNOWLEDGE SURVEY IN CHENNAI, INDIA, 2011 (N = 36) AND SCORE OUT OF 23 FOOD SAFETY KNOWLEDGE QUESTIONS

Characteristics	**Frequencies**		**Bivariate Analysis**	
	Restaurant N (%)	**Food Handler N (%)**	**Mean Score (%)**	**P value**
Restaurant size				0.3225
Small (≤10 tables)	5 (14)	22 (14)	12.0 (52)	
Medium (>10 tables but <30 tables)	20 (56)	94 (60)	11.0 (48)	
Large (≥ 30 tables)	11 (30)	40 (26)	11.2 (49)	
Food service style				0.0007
Fast food	6 (17)	23 (15)	13.3 (58)	
Informal (casual)	25 (69)	114 (73)	10.8 (47)	
Formal	5 (14)	19 (12)	10.9 (47)	
Food specialization				0.1263
Vegetarian	12 (33)	46 (29)	10.6 (46)	
Non-Vegetarian	24 (67)	110 (71)	11.4 (50)	
Chain or Independent				0.0231
Chain	19 (53)	69 (44)	11.8 (51)	
Independent	17 (47)	87 (56)	10.7 (46)	
Average entrée price				0.0244
≤ 100 INR	20 (56)	93 (57)	10.8 (47)	
>100 INR	16 (44)	63 (39)	11.8 (51)	

TABLE XV

CHARACTERISTICS FOOD HANDLERS PARTICIPATING IN A KNOWLEDGE SURVEY IN CHENNAI, INDIA, 2011 (N=156) AND SCORE OUT OF 23 KNOWLEDGE QUESTIONS

Characteristic	Frequencies N (%)	Bivariate Score (%)	Analysis P value
Age			0.006
18-29 years	93 (59)	11.8 (51)	
30-39 years	43 (28)	10.3 (45)	
≥40 years	20 (13)	10.2 (44)	
Gender			
Male	144 (92)	11.3 (49)	0.1188
Female	12 (8)	9.9 (43)	
Education			
Attended or completed primary	38 (24)	10.2 (44)	0.0003
Attended or completed high school	73 (47)	10.8 (47)	
Attended or completed college	45 (29)	12.6 (55)	
Medical Fitness Certificate			
Self-reported certificate	96 (62)	11.8 (51)	0.0009
No certificate	60 (38)	10.2 (44)	
Food Safety Training from Restaurant			
Self-reported training	69 (44)	12.3 (53)	0.0001
No training received	87 (56)	10.3 (48)	
Current Position at Restaurant			
Manager/supervisor	32 (21)	12.2 (53)	0.0239
Chef/cook	70 (44)	10.5 (46)	
Other restaurant staff	32 (21)	11.9 (52)	
Unknown position	22 (14)	10.8 (47)	
Time Working as a Food Handler			
<1 year	36 (23)	11.2 (49)	0.0465
1-5 years	54 (35)	11.9 (52)	
6-10 years	38 (24)	10.2 (44)	
≥ 11 years	28 (18)	11.1 (48)	
Meat Food Handling Task			
Handles Meat	80 (51)	11.8 (51)	0.0112
Does not handle meat	76 (49)	10.6 (46)	
Seafood Food Handling Task			
Handles seafood	76 (49)	11.7 (51)	0.0250
Does not handle seafood	80 (51)	10.7 (47)	
Egg Food Handling Task			
Handles eggs	78 (50)	11.4 (50)	0.2201
Does not handle eggs	78 (50)	10.9 (47)	
Vegetable/Fruit Food Handling Task			
Handles vegetables/fruit	135 (4)	11.2 (49)	0.7558
Does not handle vegetables/fruit	21 (25)	11.0 (48)	

TABLE XV (Continued)

CHARACTERISTICS FOOD HANDLERS PARTICIPATING IN A KNOWLEDGE SURVEY IN CHENNAI, INDIA, 2011 (N=156) AND SCORE OUT OF 23 KNOWLEDGE QUESTIONS

Characteristic	Frequencies N (%)	Bivariate Score (%)	Analysis P value
Personal Dietary Restrictions			0.0249
No restrictions	103 (66)	11.6 (50)	
Vegetarian diet only	35 (22)	10.3 (45)	
Other diet restrictions	18 (12)	10.3 (45)	
Typhoid Vaccination (self-reported)			0.1676
Vaccinated	51 (33)	11.6 (50)	
Unvaccinated	74 (47)	11.2 (49)	
Unknown vaccination status	31 (20)	10.4 (45)	
Previous Diarrhea or Vomiting Associated Hospitalization			0.0613
Previously hospitalized	17 (11)	10.5 (46)	
Not hospitalized	124 (79)	11.5 (50)	
Unknown	15 (10)	9.7 (42)	

a sink to use for hand washing during their work shift and 80% (124) stated that soap is always available at the hand washing facilities. Although 71% (110) of the food handlers reporting always having clean paper towels for drying hands after washing, only 61% (22) of the restaurants had clean paper towels available at the time of inspection. All of the 35 restaurants with restroom facilities had a sink available for washing hands. However, while 91% (32) had soap, only 46% (16) had clean paper towels at the restroom sinks.

The availability of food safety equipment was limited for many of the restaurants in this study. Among the 36 restaurants, only 7 (19%) had a hot water dish sanitizer on the premises, although 83% (30) were washing dishes in hot, soapy water. Among the 24 non-vegetarian restaurants, 10 (43%) had a meat thermometer available on the premises. During the inspection, 15 restaurants had ready-to-serve meat available for testing. Two of these restaurants were serving meat with temperatures at 49°C and 54°C, within the temperature danger zone set by the Food Safety and Standards Authority of India (5°-60°C [40°-140°F]). Seventeen restaurants had ready-to-serve warm sauce/curry, of which 47% (8) were in the temperature danger zone. Thirty-four restaurants had refrigerators, but only 15 (44%) of those had a working refrigerator thermometer. Among the 28 refrigerators inspected, 46% (13) had temperatures higher than the recommended 5°C (range -12°C to 23°C). Fourteen restaurants had ready-to-eat chilled foods available for testing and all 14 samples had temperatures within the danger zone. Similarly, as eggs are not routinely chilled in India, 9 out of 9 eggs sampled also had temperatures in the danger zone (range 30°C to 35°C). Twenty-one restaurants were storing raw meat or eggs at the time of inspection, and 24% (5) of the restaurants had these items improperly stored above ready-to-serve food.

TABLE XVI

INSPECTION RESULTS AND FOOD SAFETY EQUIPMENT AVAILABILITY OF PARTICIPATING RESTAURANTS IN CHENNAI, INDIA, 2011 (N = 36)

Inspection Categories	Applicable Restaurants N (%)[a]	Inspection Frequencies N (%)
Hand Washing Facilities		
Kitchen	36 (100)	
Sink available for hand washing		35 (97)
Soap available for hand washing		34 (94)
Clean paper towels available		22 (61)
Restroom	35 (97)	
Sink available for hand washing		35 (100)
Soap available for hand washing		32 (91)
Clean paper towels available		16 (46)
Food Safety Equipment		
Meat thermometer available on premises	24 (67)	10 (42)
Working temperature gauge on refrigerator	34 (94)	15 (44)
Hot water dish washer on premises	36 (100)	7 (19)
Dishes washed in hot, soapy water	36 (100)	30 (83)
Temperature of Refrigerator Checked with Thermometer		
Temperature of refrigerator >40^{o} F	28 (78)	13 (46)
Temperatures of Foods Checked with Thermometer		
Ready-to-eat chilled food with temperatures in danger zone [b]	14 (39)	14 (100)
Ready-to-eat warm meat with temperatures in danger zone	15 (42)	2 (13)
Ready-to-eat warm sauce/curry with temperatures in danger zone	17 (47)	8 (47)
Raw eggs in shells with temperatures in danger zone	9 (25)	9 (100)
Food Storage		
Storage of raw meat or eggs above ready-to-serve food	21 (58)	5 (24)

[a] The number of applicable restaurants varies for each inspection question. For example, restaurants that did not serve warm ready-to-eat sauce or those that did not have sauce ready at the time of inspection, were excluded from frequency analysis for that particular question.
[b] The temperature range of the danger zone is 40-140F^{o}

1. Identifying Knowledge Gaps

The overall mean knowledge score was 49% (11.2/23, SD=2.9) and the overall mean knowledge score for vegetarian-only questions was 38% (5.7/15, SD=2.1). Most food handlers were knowledgeable of how the spread of germs can be related to personal hygiene. The following responses highlight this awareness; "unhygiene behavior causes germs and bacteria in hands and body" and "germs are live bacteria and can cause some disease." However, food handlers performed poorly when asked to identify the danger zone for pathogen growth (14, 9%), the proper temperature to cook meat (1, 0.6%), and the proper holding temperatures for hot and cold foods (1, 0.6% and 4, 3%, respectively) (Table XVII). Only 21% (33) and 53% (83) of the food handlers knew that cooked rice and uncooked eggs can have germs that can make people sick, respectively. By contrast, a much greater proportion of participants were aware that uncooked chicken and beef can have germs that can make people sick (145, 93% and 141, 90%, respectively) and that uncooked meat can cause serious conditions, like bloody diarrhea (127, 81%). A substantial proportion of food handlers were aware that storing raw eggs and meat above ready-to-serve food is an unsafe food storage practice (121, 78% and 126, 81%, respectively), however, only 57% correctly identified that "vegetables for a salad splashed with raw chicken juice should not be rinsed, but instead must be thrown away," as true. For the hand hygiene questions, 72% (113) of the food handlers correctly answered true that "you need to thoroughly wash hands when using single-use gloves to handle food." Approximately half knew to use warm water when washing hands and to use a clean paper towel to dry hands (71, 46% and 77, 49%, respectively). However, the majority of food handlers stated that using bare hands or clothing to turn off the water after washing hands was acceptable (59, 38% and 29, 19%), rather than the recommended method of using a paper towel.

TABLE XVII

FREQUENCIES OF CORRECT RESPONSES TO KNOWLEDGE QUESTIONS ASKED OF CHENNAI, TAMIL NADU RESTAURANT FOOD HANDLERS, 2011 (N=156)

Questions (*Answers*)	**Question type**	**n (%)**
Temperature		
Germs that make people sick grow well within which temperature range? (*5-57^{o} C*)	Fill-in-the-blank	8 (5)
What is the temperature of the "Danger Zone"? (*5-57^{o} C*)	Fill-in-the-blank	14 (9)
Hot foods, such as biryani at a buffet table, should be held at what temperature or above? (*57^{o} C*)	Fill-in-the-blank	1 (0.6)
Cold foods, such as yogurt, should be stored at what temperature or lower? (*5^{o} C*)	Fill-in-the-blank	4 (3)
Cooked meat, for example chicken, should be cooked to at least what internal temperature? (*70^{o} C*)	Fill-in-the-blank	1 (0.6)
Where should a meat thermometer be inserted to accurately check the temperature? (*The thickest part of the meat*)	Multiple-choice	29 (24)
It is safe to put frozen chicken breast on the counter to thaw? *(False)*	True/False	88 (56)
Cross Contamination		
In the refrigerator, it is safe to store raw eggs in shells above ready-to-serve raw vegetables? *(False)*	True/False	121 (78)
Raw meat can be stored above ready-to-serve food. *(False)*	True/False	126 (81)
Gloves used to handle ready-to-eat food should be thrown in the trash when interruptions occur in operations *(True)*	True/False	82 (53)
Vegetables for a salad splashed with a few drops of raw chicken juice should not be rinsed, but instead must be thrown away? (True)	True/False	89 (57)
Cleaning and sanitizing mean the same thing? *(False)*	True/False	39 (25)
Germs		
Did you know that eating cooked rice could cause you to become ill enough to need to go to the hospital? (*Yes*)	Yes/No	33 (21)
Did you know that eating uncooked eggs could cause you to become ill enough to need to go to the hospital? (*Yes*)	Yes/No	83 (53)
Did you know that eating uncooked chicken could cause you to become ill enough to need to go to the hospital? (*Yes*)	Yes/No	145 (93)
Did you know that eating uncooked meat could cause you to become ill enough to need to go to the hospital? (*Yes*)	Yes/No	141 (90)
Eating ground meat that is not completely cooked can cause bloody diarrhea? *(Yes)*	Yes/No	127 (81)
A food handler who has a small infected cut on his or her finger prepares food that is kept warm but not hot. The person who eats the food could become ill with vomiting and diarrhea? *(True)*	True/False	128 (82)

TABLE XVII (Continued)
FREQUENCIES OF CORRECT RESPONSES TO KNOWLEDGE QUESTIONS ASKED OF CHENNAI, TAMIL NADU RESTAURANT FOOD HANDLERS, 2011 (N=156)

Questions (*Answers*)	**Question type**	**n (%)**
Hand Hygiene		
At work if you only urinated, and did not have a bowel movement, you do not need to wash your hands before returning to food handling? *(False)*	True/ False	65 (42)
Do you need to have thoroughly washed hands if you use single-use gloves to handle food? *(Yes)*	Yes/No	113 (72)
When you wash your hands at work should you use cold or warm water? (*Warm/hot water*)	Multiple-choice	71 (46)
When you wash your hands at work, what do you use to dry your hands? *(Clean paper towel)*	Multiple-choice	77 (49)
After you wash your hands at work, how should you turn off the water? (*Using the paper towel used to dry hands or automatic tap*)	Multiple-choice	36 (23)

There were also important unsafe behaviors identified, particularly with regard to hand hygiene and working while ill. Twenty-three percent of the participants stated that they would come to work with a sore throat and cough and 14% would come to work with diarrhea. Eighty-seven percent (135) of the food handlers stated that they always washed their hands after using the restroom at work, whereas, 42% (65) answered the question "If you only urinated and did not have a bowel movement, you do not need to wash your hands" incorrectly as true.

2. Factors Associated With the Knowledge Score

Bivariate analysis revealed restaurant characteristics significantly associated with the knowledge score. The mean knowledge score for fast food style restaurants was significantly greater compared to informal (casual) and formal restaurants (58%, 47% and 47%, respectively, p=0.0007) (Table XIV). Similarly, the mean knowledge score for chain restaurants was significantly but not substantially greater compared to non-chain restaurants (51% and 46%, respectively, p=0.02) and for restaurants serving less expensive meals compared to those serving more expensive meals (51% and 47%, respectively, p=0.02).

Food handler characteristics significantly associated with the knowledge score were also identified. Food handlers ages 18 to 29 years had a greater mean knowledge score compared to those in the age ranges of 30 to 39 years and 40 years and older (51%, 45% and 44%, respectively, p=0.006) and those with at least some college education scored higher than those with less education (55% versus 47% and 44%, respectively; p=0.0003) (Table XV). Managers/supervisors and "other restaurant staff" scored higher than chefs/cooks (53% and 52% versus 46% respectively; p=0.023). The mean knowledge score for food handlers who reported having the Chennai required Medical Fitness Certificate or those having received food safety training at the

restaurant was greater than for those who did not have the certificate or received training (51% versus 44% respectively; p=0.0009 and 53% versus 48% respectively; p=0.0001).

In the final mixed-effects regression model predicting knowledge, a significant covariance between knowledge scores of food handlers from the same restaurants was detected (random restaurant effect, σ=3.35, SE=1.09, p=0.001) (Table XVIII). The random zone effect was not

TABLE XVIII
FOOD HANDLER CHARACTERISTICS[a] ASSOCIATED WITH KNOWLEDGE SCORE, MIXED-EFFECTS REGRESSION ANALYSIS (N=156), 2011

	Estimate (SE) Scale of 0-23	p value
Intercept	13.35 (0.88)	<0.0001
Medical Fitness Certificate (self-reported)	1.04 (0.48)	0.0210
Education		
Attended or completed college	Ref	
Attended or completed high school	-1.18 (0.49)	0.0189
Attended or completed primary school	-1.23 (0.61)	0.0467
History of food safety training (self-reported)	1.12 (0.37)	0.0215

[a] No Restaurant Characteristics were significant in the final model.

significant and removed from the final model. No restaurant characteristics were significant in the final model. Food handlers with only primary or secondary education scored significantly lower compared to persons who had at least some college education (1.23 points lower, p=0.046 and 1.18 points lower, p=0.019, respectively). Food handlers who reported receiving food safety training in the participating restaurant had higher knowledge scores than those without training

(p=0.022) and having reported a Medical Fitness Certificate was associated with a slight increase of 1.04 points in knowledge score (p=0.02).

D. Discussion

The Food Safety and Standards set by FSSAI has established a new precedent of higher standards for food safety in restaurants in India. (Food Safety and Standards Authority of India 2011). Our study provides a rare look into baseline conditions related to food safety in a large Indian, urban area. The food handlers in our study had an average overall food safety knowledge score of 49%, demonstrating substantial gaps that need to be addressed. The main areas in need of improvement involved hand hygiene practices, temperatures for cooking, and holding foods and cross contamination.

Inadequate hand hygiene knowledge and behavior among restaurant food handlers has contributed to many foodborne illness outbreaks *(*Angelillo et al. 2000; Clayton et al. 2002; Green et al. 2007; Guzewich and Ross 1999; Lynch et al. 2006; Scallan et al. 2011a). Although many food handlers in our study understood how the spread of germs can be related to personal hygiene, hand hygiene knowledge was poor. More than one in ten reported not always washing their hands after using the restroom at work, and fewer than half (42%) knew that hands should be washed after urination. Compared to data reported in a study of food handlers working in a medical college in Delhi, India, restaurant food handler knowledge of proper hand washing was low. Malhotra and colleagues (2008) reported that 98.5% of food handlers knew that hands should be washed after micturition (urination) although only 82% reported actually washing their hands after urination (Malhotra et al. 2008). Discordance between food handler knowledge and proper hand washing behavior is important and has also been reported from studies in the U.S. and Wales. This

discordance highlights the importance of addressing both knowledge and behavior (Clayton et al. 2002; Green et al. 2007).

For the food handlers in our study, even knowledge and intent to properly wash hands could not necessarily ensure compliance. Hand washing barriers, including the lack of soap and clean paper towels at kitchen and restroom sinks, make proper hand washing nearly impossible. Al-Khatib and Al-Mitwalli (2009) reported similarly limited resources in restaurants in Ramallah and Al-Bireh districts of Palestine (Al-Khatib and Al-Mitwalli 2009). In developing regions, like Chennai and Palestine, the cost of soap and paper towels may contribute to the absence of these materials some in restaurants. However, cost of soap has not been shown to be a significant barrier to hand washing, even among households in countries like Uganda, Kenya and Peru (UNICEF 2013). The availability of effective and low-cost hand washing materials coupled with an emphasis on use may help to improve compliance. Educational interventions designed to improve hand hygiene knowledge and to promote a positive perception about the importance of hand washing among restaurant management may be beneficial to restaurants in India.

Our study also identified knowledge gaps related to proper temperatures for cooking and holding food. The questions about the range of the temperature danger zone, the internal temperature to cook chicken, and the proper holding temperatures for hot and cold foods were answered correctly by fewer than 10% of the food handlers. Similarly poor results have been reported among food handlers in Illinois and Switzerland, suggesting that such lack of knowledge is a widespread problem (Dworkin et al. 2012; Manes et al. 2013; Panchal et al. 2012; Panchal et al. 2013). Under the new FSSAI regulations, all licensed food businesses (including restaurants) are to be inspected annually by the regulating authority and help to set a precedent of higher standards for food safety in restaurants in India. Thermometers and other food safety equipment

commonly used during restaurant inspections may not be affordable or available to local health departments in India, but the new inspection requirements are a prime opportunity for the environmental health sanitarians to emphasize the importance of maintaining proper food temperatures, encourage restaurants to invest in meat and refrigerator thermometers, and couple inspections with a food safety educational component. Building a positive learning environment and using educational materials, during an inspection may augment food safety education and raise its importance among some food handlers.

The newly regulated Food Safety and Standards Act emphasizes that local health departments provide a list of food handlers with a Medical Fitness Certificate to FSSAI on an annual basis. Although the certification process is not new, reporting to FSSAI may help to ensure compliance. At the time of the study, food handlers employed in restaurants in Chennai were required to obtain a certificate, but only 38% reported having one. To obtain the certificate, food handlers visit a public health clinic, receive a physical health exam, provide blood and/or urine samples for testing and receive a pamphlet listing hygienic practices. The purpose of the Medical Fitness Certificate is to determine if food handlers are free from infectious diseases, like typhoid. Although there is not a food safety educational component, in our study the self-reported Medical Fitness Certificate was independently associated with the food safety knowledge score after controlling for food safety training and education. Potential hypotheses for this association include that those food handlers already knowledgeable about food safety are those who make the effort to obtain the certificate, and that food handlers who undergo the process of obtaining the certificate may gain an appreciation of the importance of food safety and therefore seek knowledge related to the subject. According to the Theory of Motivated Information Management, the association between Medical Fitness Certificate screening and food safety knowledge is possible through an iterative

process consisting of an awareness of the transmission of infectious disease, evaluation of the pursuance of food safety knowledge, and the decision to seek further information regarding the safe handling of food (Afifi and Weiner 2004). It is also possible that the food handlers working at a restaurant that required the medical certificate are working at restaurants that maintain a culture of food safety (in our study 59% of the food handlers with a medical certificate also reported food safety training).

Food handlers working while ill is another area of concern identified by our study and underscored by foodborne illness outbreaks. For example, in West Bengal, India a typhoid fever outbreak with 103 suspected cases likely resulted from an infected food handler who did not wash his hands (Bhunia et al. 2007). Although the typhoid vaccine is recommended for adolescents (The India Academy of Pediatrics 2012), our study showed that a substantial proportion of the food handlers were either unvaccinated or of unknown vaccination status (67%). Current Association of Physicians of India (API) guidelines do not recommend routine typhoid immunization of adults and no recommendations have been provided by the group for food service workers in India (Association of Physicians of India 2009). Because ill food handlers can shed pathogenic organisms that may be transferred through food, it is critical that they understand the substantial consequences of working while ill and how to prevent the spread of disease.

A limitation of our study was that restaurants were selected using purposive sampling, as the city did not have a list of all Chennai restaurants from which to generate a random sample. Since the study was intended to guide educational intervention, rather than produce a broadly generalizable statistic, this limitation was considered acceptable. Six of 15 geographical zones are represented in these data and geographical zone was examined as a potential confounding factor. Unlike the restaurant level, the zone was not significant in the multi-level random effects

regression model. As with any smaller sized study, the limited number of restaurants and participants may bias results and reduce generalizability.

VI. CONCLUSIONS

With no national regulation for frequency of restaurant inspections, local health authorities need data-driven best practices to develop local food codes. Data from this research suggest that heavy EHS inspection workload is common and that higher workload is associated with the presence of restaurant-related outbreaks. Health departments may consider using three hundred inspections per EHS per year as a maximum guideline when establishing workload capacity limitations, especially when a large proportion of high risk restaurants need to be inspected or when outbreaks have occurred. Restaurant inspection frequency was not correlated with the presence of outbreaks, but data on this relationship is inconsistent. Future research should examine restaurant inspection quantity and quality in a more controlled experimental study design. A large number of local jurisdictions in this study reported not having a database to track critical violations identified during inspections. A collection of inspection related data can be used by monitor common violations and provide insight when an outbreak does occur. We recommend the continued practice of risk classification to identify high risk restaurants and set inspection frequencies, but suggest coupling routine inspections with the implementation of risk-based interventions, like food handler food safety education that is culturally and linguistically appropriate and highlights the severity of foodborne illness.

With regard to food handler training, our results indicate that some food safety certification programs in Illinois may be more effective than others in educating food managers. Food safety knowledge overall, however, was lacking and we identified important food safety knowledge gaps among certified restaurant managers. Further research is needed to examine the training methods and materials utilized by these certification programs and determine the differences attributed to food safety knowledge acquisition and retention. Furthermore, research

should evaluate which methods and material best motivate and improve behavioral change after certification training. In addition, we recommend that food safety experts and legislators reevaluate the minimum certification scores of restaurant food managers to maximize food safety knowledge. As Illinois has recently made significant changes to the Food Code regarding food safety education requirements for restaurant managers and food handlers, this analysis may help serve as a baseline to assess changes in food safety knowledge after new regulation has been fully implemented.

There are also substantial food safety knowledge gaps among food handlers in Chennai. The main areas in need of improvement involved hand hygiene, cross contamination, and temperatures for cooking and holding foods, common themes for food handler education. To our knowledge this is the first study examining an association between the Indian Medical Fitness Certificate and food safety knowledge. Future research should further evaluate the effectiveness of having this certificate on food safety knowledge and behavior, especially with the new FSSAI standards requiring all food handlers to have it. Consideration should be given to including an educational component to this certification with an explanation of expected food safety behavior. In response to this need, the investigators have created an educational brochure that instructs on the food safety topics prioritized by the knowledge survey and restaurant inspections. The brochure was adapted from educational interventions shown to be effective in improving food safety knowledge among restaurant food handlers in Chicago (Dworkin et al. 2012; Manes et al. 2014).

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APPENDICES

APPENDIX A

UNIVERSITY OF ILLINOIS AT CHICAGO HUMAN SUBJECTS APPROVAL FOR STUDY TITLED "A NATIONAL SURVEY OF LOCAL HEALTH JURISDICTIONS: RESTAURANT INSPECTION FACTORS RELATED TO FOODBORNE ILLNESS OUTBREAKS"

UNIVERSITY OF ILLINOIS
AT CHICAGO

Office for the Protection of Research Subjects (OPRS)
Office of the Vice Chancellor for Research (MC 672)
203 Administrative Office Building
1737 West Polk Street
Chicago, Illinois 60612-7227

Exemption Granted

July 9, 2012

Mindi Manes, BA
Epidemiology and Biostatistics
2314 West 35th Place
Chicago, IL 60609
Phone: (303) 502-6831

RE: Research Protocol # 2012-0580
"An Epidemiologic Investigation of Restaurant Inspection Frequency and Food Handler Training with Foodborne Illness Outbreaks in the US"

Exemption Approval Period: July 9, 2012 – July 8, 2015
PAF#: 2012-03452
Grant/Contract No: Not available
Grant/Contract Title: An Epidemiologic Investigation of Restaurant Inspection Frequency and Food Handler Training with Foodborne Illness Outbreaks in the US
Sponsors: USDA - U.S. Department of Agriculture

Dear Ms. Manes:

Your Claim of Exemption was reviewed on July 9, 2012 and it was determined that your research protocol meets the criteria for exemption as defined in the U. S. Department of Health and Human Services Regulations for the Protection of Human Subjects [(45 CFR 46.101(b)]. You may now begin your research.

APPENDIX A (continued)

The specific exemption category under 45 CFR 46.101(b) is:

(4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

Please Note: Current funding information is identified as "Pending." Updated information must be provided via an Amendment as soon as possible upon receipt.

You are reminded that investigators whose research involving human subjects is determined to be exempt from the federal regulations for the protection of human subjects still have responsibilities for the ethical conduct of the research under state law and UIC policy. Please be aware of the following UIC policies and responsibilities for investigators:

1. Amendments You are responsible for reporting any amendments to your research protocol that may affect the determination of the exemption and may result in your research no longer being eligible for the exemption that has been granted.

2. Record Keeping You are responsible for maintaining a copy all research related records in a secure location in the event future verification is necessary, at a minimum these documents include: the research protocol, the claim of exemption application, all questionnaires, survey instruments, interview questions and/or data collection instruments associated with this research protocol, recruiting or advertising materials, any consent forms or information sheets given to subjects, or any other pertinent documents.

3. Final Report When you have completed work on your research protocol, you should submit a final report to the Office for Protection of Research Subjects (OPRS).

Please be sure to:

→Use your research protocol number (#2012-0580) on any documents or correspondence with the IRB concerning your research protocol.

APPENDIX A (continued)

We wish you the best as you conduct your research. If you have any questions or need further help, please contact me at (312) 413-3202 or the OPRS office at (312) 996-1711. Please send any correspondence about this protocol to OPRS at 203 AOB, M/C 672.

Sincerely,

Teresa D. Johnston, B.S., C.I.P.
Assistant Director
Office for the Protection of Research Subjects

APPENDIX B

USDA-NIFA PRE-DOCTORAL GRANT FUNDING AWARD FOR STUDY TITLED "A NATIONAL SURVEY OF LOCAL HEALTH JURISDICTIONS: RESTAURANT INSPECTION FACTORS RELATED TO FOODBORNE ILLNESS OUTBREAKS"

United States Department of Agriculture
National Institute of Food and Agriculture
AWARD FACE SHEET

1. Award No. / Amendment No.	2. Proposal Number	3. Period of Performance	4. Type of Instrument
2012-67011-20021	2012-01222	09/01/2012 through 08/31/2014	Grant

5. Type of Action	6. CFDA Number	7. CAN	8.M0	9. Method of Payment	10. CRIS Number
New	10.310			ASAP 67011200216701112000	0230275

11. Authority:
7 U.S.C. 450(b), Section 7406 of FCEA of 2008, P.L. 110-246, AFRI

12. Agency (Name and Address)
Awards Management Division
National Institute of Food and Agriculture/USDA
Washington, DC 20250-2271

13. Awardee Organization
University of Illinois at Chicago
Chicago, IL 60612-7227

14. Program Point of Contact:
Ray Ali
Telephone: 202 720-2727
rali@nifa.usda.gov

Administrative Point of Contact:
Tracey Roy
Telephone: 202-401-3681
troy@nifa.usda.gov

15. Project Director/Performing Organization
Mindi Rae Manes
The University of Illinois of at Chicago
Chicago, IL 60612-4394

16. Funding:	Federal	Non-Federal
Previous Total	$0.00	$0.00
+ or -	$74,341.00	$0.00
Total	$74,341.00	$0.00
Grand Total	$74,341.00	

17. Funds Chargeable

FY - FDC	Amount	FY - FDC	Amount
11- 162-67011	$74,341.00		

18. Title of Proposal
An Epidemiologic Investigation of Restaurant Inspection Frequency and Food Handler Training with Foodborne Illness Outbreaks in the US

PROVISIONS

This Award incorporates the following:

1. The referenced proposal and any revision thereto - incorporated by reference
2. Research Terms and Conditions (6/11) and NIFA Agency Specific Terms and Conditions (05/12) at http://www.nifa.usda.gov/business/awards/awardterms.html
3. This institution is a signatory to the Federal Demonstration Partnership (FDP) Phase V Agreement which requires active institutional participation in new or ongoing FDP demonstrations and pilots.
4. 7 CFR Part 3015, 7 CFR Part 3017, 7 CFR Part 3018, and 7 CFR Part 3019, 7 CFR 3430 - incorporated by reference (http://www.nifa.usda.gov/business/awards/fedregulations.html)
5. The Approved Award Budget
6. CRIS Forms AD-416 and AD-417 - incorporated by reference
7. The obligation of funds may be terminated without further cause unless the recipient commences the timely drawdown of funds; initial drawdown must be made within the first year of the project.
8. The Predoctoral Fellow is required to attend the annual Project Director's workshop/conference as stipulated in the RFA.

FOR THE UNITED STATES DEPARTMENT OF AGRICULTURE

This award, subject to the provisions above, shall constitute an obligation of funds on behalf of the Government. Such obligation may be terminated without further cause unless the recipient commences the timely drawdown of funds; such drawdowns may not exceed one year from issuance date of the award.

Typed Name	Signature	Date
Adriene Woodin Authorized Departmental Officer	AWOODIN	08/15/2012

NIFA-2009 Page No: 1 / 1

APPENDIX C

HEALTH DEPARTMENT STUDY INVITATION LETTER FOR STUDY TITLED "A NATIONAL SURVEY OF LOCAL HEALTH JURISDICTIONS: RESTAURANT INSPECTION FACTORS RELATED TO FOODBORNE ILLNESS OUTBREAKS"

University of Illinois
at Chicago

Division of Epidemiology and Biostatistics (MC 923)
School of Public Health
1603 West Taylor
Chicago, IL 60612-4336

February 2013

Dear Health Department Official:

This letter invites you to participate in a research study being performed by the University of Illinois at Chicago and funded by the United States Department of Agriculture. The objective is to perform a cross-sectional epidemiologic study at the national level to determine if frequency of restaurant-related foodborne illness outbreaks is associated with frequency of restaurant inspection and levels of food handler training when controlling for local demographic factors.

This survey is being distributed to all 2,900 local health departments across the United States. We are collecting information regarding food safety and will ask you questions about foodborne illness outbreaks, restaurant inspections and food handler training in your local jurisdiction. As we are obtaining information at the county/ jurisdiction level only, no restaurant, food handler or health inspector names will be collected.

The collection instrument is being electronically distributed with this email and data will be collected using the secure web survey program SurveyGizmo. Please follow the link below and follow the on screen instructions to complete the survey. The questionnaire will take approximately 30-45 minutes to complete. You can log on to SurveyGizmo as many times as necessary to complete the survey.

Survey link: http://www.surveygizmo.com/s3/1113363/NIFA-Survey-2

Participation in this research study is entirely voluntary and refusal to participate will not affect the health department in anyway. Your input is very important and your participation is greatly appreciated. If you have any questions, please feel free to contact me directly at 303.502.6831.

APPENDIX C (continued)

Thank you in advance for your assistance.

Mindi Manes
PhD Candidate
University of Illinois at Chicago School of Public Health
Division of Epidemiology and Biostatistics
1603 West Taylor Street (MC 923)
Chicago, Illinois 60612

APPENDIX D

HEALTH DEPARTMENT SURVEY FOR STUDY TITLED "A NATIONAL SURVEY OF LOCAL HEALTH JURISDICTIONS: RESTAURANT INSPECTION FACTORS RELATED TO FOODBORNE ILLNESS OUTBREAKS"

A National Study on Restaurant Inspections, Food Handler Training and Outbreaks.

This study is funded by the United States Department of Agriculture.

Instructions:
This questionnaire will take approximately 30-45 minutes to complete. You can log on to the this secure website SurveyGizmo as many times as necessary to complete the survey. Please follow the on screen instructions as you complete the questions. You will be asked about foodborne illness, restaurant inspections and food handler training requirements in your jurisdiction for 2010, 2011 and 2012. If you are having any trouble with the website, or you have any questions regarding the survey, please contact Mindi Manes at 303.502.6831.

Please provide us with the contact information for your county/jurisdiction.

1. What is the name of this local health department?
_____ local health department

2. What is the address of this local health department?

_____ health department address

3. What is main phone contact for this local health department?

_____ health department main phone contact

4. What is the primary email contact for this local health department?

_____ health department primary email contact

5. What is the name of the health department employee completing this survey?

_____ employee name

6. What is the phone contact for the health department employee completing this survey?

_____ employee phone contact

APPENDIX D (continued)

7. What is the email contact for the health department employee completing this survey?

_____ employee email contact

The first questions are general questions regarding foodborne outbreaks, restaurant inspections and food handler training in your county/jurisdiction in 2010, 2011 and 2012.

8. How many foodborne illness outbreaks were reported in your county/jurisdiction in 2010?
_____ outbreaks

9. How many of the foodborne outbreaks in 2010 were associated with restaurants in your jurisdiction?
_____ restaurant outbreaks

10. How many foodborne illness outbreaks were reported in your county/jurisdiction in 2011?
_____ outbreaks

11. How many of the foodborne outbreaks in 2011 were associated with restaurants in your jurisdiction?
_____ restaurant outbreaks

12. How many foodborne illness outbreaks were reported in your county/jurisdiction in 2012?
_____ outbreaks

13. How many of the foodborne outbreaks in 2012 were associated with restaurants in your jurisdiction?
_____ restaurant outbreaks

14. How many restaurants were registered in your county/jurisdiction in 2010?
_____ restaurants

15. How many restaurant inspections were performed in your county/jurisdiction in 2010?
_____ performed restaurant inspections

APPENDIX D (continued)

16. How many restaurants were registered in your county/jurisdiction in 2011?
_____ restaurants

17. How many restaurant inspections were performed in your county/jurisdiction in 2011?
_____ performed restaurant inspections

18. How many restaurants were registered in your county/jurisdiction in 2012?
_____ restaurants

19. How many restaurant inspections were performed in your county/jurisdiction in 2012?
_____ performed restaurant inspections

20. What type of food handler training was required by law in your county/jurisdiction in 2010? Please check all that apply:

- No food handler training was required
- One certified manager per restaurant
- One certified manager per restaurant per day
- Short-course food handler in-person training
- Long-course food handler in-person training
- On-line training
- Food handler certification
- Food handler certification with food handler card,
- Other, specify

21. What type of food handler training was required by law in your county/jurisdiction in 2011? Please check all that apply:

- No food handler training was required
- One certified manager per restaurant
- One certified manager per restaurant per day
- Short-course food handler in-person training
- Long-course food handler in-person training
- On-line training
- Food handler certification
- Food handler certification with food handler card,
- Other, specify

APPENDIX D (continued)

22. What type of food handler training was required by law in your county/jurisdiction in 2012? Please check all that apply:

- No food handler training was required
- One certified manager per restaurant
- One certified manager per restaurant per day
- Short-course food handler in-person training
- Long-course food handler in-person training
- On-line training
- Food handler certification
- Food handler certification with food handler card,
- Other, specify

The next questions are regarding foodborne outbreaks in your county/jurisdiction in 2012 only.

23. How many of the restaurant-associated outbreaks in your jurisdiction in 2012 resulted in at least one hospitalization?

_____ outbreaks resulting in hospitalization

24. How many hospitalizations resulted from restaurant-associated outbreaks in your jurisdiction in 2012?

_____ hospitalizations

25. How many of the restaurant-associated outbreaks in your jurisdiction in 2012 resulted in at least one death?

_____ outbreaks resulting in death

26. How many deaths resulted from restaurant-associated outbreaks in your jurisdiction in 2012?

_____ restaurant-associated deaths

APPENDIX D (continued)

27. Of the restaurant-associated outbreaks in your jurisdiction in 2012, how many outbreaks had the following identified (the number of outbreaks reported in this section should add to the number of outbreaks reported in Question 13)?

Unknown:
Unknown etiology_____ restaurant-associated outbreaks

Multiple:
Multiple disease-causing agents _____ restaurant-associated outbreaks

Bacterial:
Bacillus cereus _____ restaurant-associated outbreaks
Campylobacter species _____ restaurant-associated outbreaks
Cryptosporidium parvum_____ restaurant-associated outbreaks
Escherichia coli: Shiga Toxin (including 0157:H7)_____ restaurant-associated outbreaks
Listeria monocytogenes_____ restaurant-associated outbreaks
Salmonella species_____ restaurant-associated outbreaks
Shigella species_____ restaurant-associated outbreaks
Staphylococcus aureus_____ restaurant-associated outbreaks
Salmonella Typhi_____ restaurant-associated outbreaks
Vibrio cholerae_____ restaurant-associated outbreaks
Vibrio parahaemolyticus_____ restaurant-associated outbreaks
Yersinia enterocolitica_____ restaurant-associated outbreaks
Other bacterial_____ restaurant-associated outbreaks

Chemical:
Scombrotoxin_____ restaurant-associated outbreaks
Other Chemical_____ restaurant-associated outbreaks

Parasitic:
Cyclospora cayetanensis_____ restaurant-associated outbreaks
Cryptosporidium_____ restaurant-associated outbreaks
Giardia lamblia_____ restaurant-associated outbreaks
Other Parasite_____ restaurant-associated outbreaks

Viral:
Calcivirus (including Norovirus) _____ restaurant-associated outbreaks
Hepatitis A_____ restaurant-associated outbreaks
Rotavirus_____ restaurant-associated outbreaks
Other Virus_____ restaurant-associated outbreaks

APPENDIX D (continued)

28. How many restaurant-associated outbreaks in your jurisdiction in 2012 had the following identified as the primary contributing factors (the number of outbreaks reported in this section should add to the number of outbreaks reported in Question 13)?

Cross contamination_____ restaurant-associated outbreaks
Employee working while ill_____ restaurant-associated outbreaks
Improper cooling_____ restaurant-associated outbreaks
Inadequate cooking_____ restaurant-associated outbreaks
Inadequate hot-holding_____ restaurant-associated outbreaks
Inadequate refrigeration_____ restaurant-associated outbreaks
Inadequate reheating_____ restaurant-associated outbreaks
Unclean equipment_____ restaurant-associated outbreaks
Other, specify contributing factor and how many outbreaks associated_____
Unknown_____ restaurant-associated outbreaks

29. How many restaurant-associated outbreaks in your jurisdiction in 2012 had the following identified as the restaurant type (the number of outbreaks reported in this section should add to the number of outbreaks reported in Question 13)?

American (no primary ethic focus) restaurant-associated outbreaks
Italian_____ restaurant-associated outbreaks
Mexican_____ restaurant-associated outbreaks
Chinese_____ restaurant-associated outbreaks
Thai_____ restaurant-associated outbreaks
Indian_____ restaurant-associated outbreaks
Other_____ restaurant-associated outbreaks
Unknown_____ restaurant-associated outbreaks

30. How many restaurant-associated outbreaks in your jurisdiction in 2012 had the following identified as the restaurant style (the number of outbreaks reported in this section should add to the number of outbreaks reported in Question 13)?

Fast food_____ restaurant-associated outbreaks
Informal (diner, deli, other casual dining) _____ restaurant-associated outbreaks
Formal_____ restaurant-associated outbreaks
Unknown_____ restaurant-associated outbreaks

31. How many of the restaurants in your jurisdiction were closed due to the restaurant-associated outbreaks in 2012?

_____restaurants closed due to outbreak

APPENDIX D (continued)

32. How many of the closed restaurants in 2012 were re-opened after remediation?

_____restaurants re-opened

The next questions are regarding restaurant inspections and food handler training requirements in your county/jurisdiction in 2012

33. Please describe the restaurant classification system utilized by your county/jurisdiction in 2012.
Some examples include:
Low (includes most convenience stores, some taverns, and coffee shops with minimal food handling), Medium (includes most fast food chain-type facilities, bakeries, donut shops, and convenience stores with some hot food sales) and Hisk Risk restaurants (full service restaurants, supermarkets with food preparation);
or Risk type 1 (extensive menus and complex food processes that include preparing (washing, cutting), cooking, cooling, and reheating of food.) , Risk Type 11 (Food is typically delivered frozen or refrigerated; is made per order; is not cooled or reheated.) and Risk Type 3 (Food is prepackaged, not handled or cooked)

_____

34. How many registered restaurant inspections would be classified as high, moderate or low risk in your county/jurisdiction in 2012 (this number should add to the number of registered restaurants reported in Question 18)?
_____ high risk restaurants
_____ moderate risk restaurants
_____ low risk restaurants

35. Considering the restaurant classification scheme utilized by your county/jurisdiction, how many restaurant inspections were expected to be performed in your county/jurisdiction in 2012?
_____ expected number of restaurant inspections

36. How many restaurant inspections were actually performed in your county/jurisdiction in 2012?
_____ performed restaurant inspections

37. How many health inspectors/sanitarians were employed to perform restaurant inspections in your county in 2012?
_____ Full- time restaurant inspectors
_____ Part- time restaurant inspectors

APPENDIX D (continued)

38. What was the total number of FTE (full time employee) hours dedicated to performing restaurant inspections in your county/jurisdiction in 2012? (For example, an employee preforming restaurant inspections for 20 hours each week would have an FTE time=0.5)

_____ FTE hours dedicated to inspections

39. Does your county/jurisdiction maintain a database logging the violations reported on restaurant inspection forms? (If No, please skip to question 34)

_____ Yes, we have a database with restaurant inspection data
_____ No, we do not have a database with restaurant inspection data

40. How many critical violations in total were reported on inspection forms for the restaurants in your county/jurisdiction in 2012?
_____ total number of critical violations
_____We do not calculate the total number of critical violations in our jurisdiction

41. Were restaurants in your county/jurisdiction required by law to have at least one certified food manager to be on restaurant premises during all business hours?

_____ Yes, a certified food manger is required to be at the restaurant during all business hours
_____ No, but certified food manger is required to be employed
_____ No, a certified food manger is not required to be at the restaurant during all business hours

42. How many food handlers total were certified for the restaurants in your county/jurisdiction in 2012?
_____ certifications
_____We do not track number of certified food handlers in our jurisdiction

43. How many food handlers were newly certified for the restaurants in your county in 2012?
_____ certifications
_____We do not track number of newly certified food handlers in our jurisdiction

44. How many food handler in-person training facilities were available for the restaurants in your county/jurisdiction in 2012?
_____ training facilities
_____We do not track number of training facilities in our jurisdiction

APPENDIX D (continued)

Please feel free to provide us with any additional information that you feel is related to this survey.

Restaurant inspection forms for 2010, 2011, 2012

45. Please upload a copy of a blank restaurant inspection form utilized by your county/jurisdiction in 2010. An electronic version or a clear, scanned copy is adequate.

46. Please upload a copy of a blank restaurant inspection form utilized by your county/jurisdiction in 2011. An electronic version or a clear, scanned copy is adequate.

47. Please upload a copy of a blank restaurant inspection form utilized by your county/jurisdiction in 2012. An electronic version or a clear, scanned copy is adequate.

APPENDIX E

UNIVERSITY OF ILLINOIS AT CHICAGO HUMAN SUBJECTS APPROVAL FOR STUDY TITLED "FOOD SAFETY KNOWLEDGE OF CERTIFIED RESTAURANT MANAGERS: ARE SOME CERTIFICATION PROGRAMS MORE EFFECTIVE THAN OTHERS?"

Approval Notice
Continuing Review

July 2, 2018

Mark S. Dworkin, MD, MPH
Epidemiology and Biostatistics
Phone: (312) 413-0348 / Fax: (312) 996-0064

RE: Protocol # 2008-0549
"A Knowledge Assessment and Intervention to Reduce Food Poisoning Risk Factors Related to Restaurant Food Handlers"

Dear Dr. Dworkin:

Your Continuing Review was reviewed and approved by the Expedited review process on July 2, 2018. You may now continue your research.

APPENDIX E (continued)

Please note the following information about your approved research protocol:

Protocol Approval Period: July 2, 2018 - July 2, 2019
Approved Subject Enrollment #: 1090
Additional Determinations for Research Involving Minors: These determinations have not been made for this study since it has not been approved for enrollment of minors.
Performance Sites: UIC
Sponsor: USDA - U.S. Department of Agriculture
PAF#: 00040618
Grant/Contract No: pending
Grant/Contract Title: "A Knowledge Assessment and Intervention to Reduce Food Poisoning Risk Factors Related to Restaurant Food Handlers"
Research Protocol(s):

a) Project Narrative: "A Knowledge Assessment and Intervention to Reduce Food Poisoning Risk Factors Related to Restaurant Food Handlers," Version 6; 08/24/2012

Informed Consent(s):

a) N/A-Study Closed to Enrollment

Your research meets the criteria for expedited review as defined in 45 CFR 46.110(b)(1) under the following specific category:

(7) Research on individual or group characteristics or behavior (including but not limited to research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

APPENDIX E (continued)

Please note the Review History of this submission:

Receipt Date	Submission Type	Review Process	Review Date	Review Action
06/29/2018	Continuing Review	Expedited	07/02/2018	Approved

Please remember to:
→ Use your **research protocol number** (2008-0549) on any documents or correspondence with the IRB concerning your research protocol.

→ Review and comply with all requirements on the guidance,
"**UIC Investigator Responsibilities, Protection of Human Research Subjects**"
(http://tigger.uic.edu/depts/ovcr/research/protocolreview/irb/policies/0924.pdf)

Please note that the UIC IRB has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

Please be aware that if the scope of work in the grant/project changes, the protocol must be amended and approved by the UIC IRB before the initiation of the change.

We wish you the best as you conduct your research. If you have any questions or need further help, please contact OPRS at (312) 996-1711 or me at (312) 413-3788. Please send any correspondence about this protocol to OPRS at 203 AOB, M/C 672.

Sincerely,
Rachel Olech, B.A., CIP
Assistant Director, IRB # 3
Office for the Protection of Research Subjects

Enclosure(s): None

cc: Ronald C. Hershow, Epidemiology and Biostatistics, M/C 923
OVCR Administration, M/C 672

APPENDIX F

FOOD HANDLER CONSENT FORM FOR STUDY TITLED "FOOD SAFETY KNOWLEDGE OF CERTIFIED RESTAURANT MANAGERS: ARE SOME CERTIFICATION PROGRAMS MORE EFFECTIVE THAN OTHERS?"

University of Illinois at Chicago
Consent for Participation in Research
"A knowledge assessment and intervention to reduce food poisoning risk factors related to restaurant food handlers. "

Why am I being asked?

The University of Illinois at Chicago School of Public Health is performing interviews of restaurant food handlers to determine what are the priority areas for improving food handler knowledge related to safe food handling. Your restaurant was selected for participation because it is in north or northwestern Cook County, Kane County, Lake County or DuPage County and food handlers who work at the restaurant are being asked to volunteer to participate in this survey. We ask that you read this form and ask any questions you may have before agreeing to be in the research.

Your participation in this research is voluntary. Your decision whether or not to participate will not affect your current or future relations with the University. If you decide to participate, you are free to withdraw at any time without affecting that relationship.

Dr. Mark Dworkin is leading this project and it is funded by the United States Department of Agriculture.

Why is this research being done?

To ensure food safety in restaurants, food handlers must be knowledgeable about safe food handling. Sometimes, restaurant patrons become sick as a result of problems with food handling. Therefore, this research is being performed to learn what are the priority areas for the instruction of food handlers. These priority areas will guide the creation of educational material that will be created for food handlers to use. This research will also determine which kind of training material (a brochure or an educational illustrated story) works best at educating food handlers.

What is the purpose of this research?

The purpose of this research is to help create educational material that can effectively become part of food handler training to minimize the risk of foodborne illness.

APPENDIX F (continued)

What procedures are involved?

If you agree to be in this research, we would ask you to do the following things:

A survey will be performed where you are asked questions about food handling. This interview will be performed in English or Spanish according to your language of fluency and may take approximately 20 minutes. Surveys will be conducted at your restaurant during work time if your manager agrees to this or at a convenient location and time for you (such as just before opening) nearby if you prefer.

Approximately 1000 food handlers may be involved in this research.

What are the potential risks and discomforts?

There is no substantial risk to you for participating in this research. You may feel uncomfortable revealing to the interviewer that you do not know the answer to a question. Your name is not collected on the survey but it is collected on the consent form so there is a potential of the loss of confidentiality that you participated in the survey but not of how you answered the questions.

Are there benefits to taking part in the research?

There is no immediate benefit to you for participating in this research. However, because of your participation in this research, educational materials that target what restaurant food handlers need to know will be created and that could help you be a safer food handler in the future.

What other options are there?

The only other option is not to participate in this study.

Will I be told about new information that may affect my decision to participate?

Your participation in this study involves the time of this consent. The consent is followed by the interview. After the interview is finished, your participation in the study is over. If another interview is to be performed, you will be asked to consent again with a new consent form.

APPENDIX F (continued)

What about privacy and confidentiality?

Your name is not collected as part of this research. No individual food handler's or restaurant's results will be shared with others. Instead, a unique study number will be assigned and your answers will be coded with a number that only Dr. Mark Dworkin and the study staff can trace to a name.

If the results of the research are published or discussed in conferences, no information will be included that would reveal your identity or your restaurant's identity. If any information were obtained in connection with this study and that could identify you, then it would remain confidential and would only be disclosed with your permission or as required by law.

What if I am injured as a result of my participation?

This research involves the collection of information and education about safe food handling. As such, it does not involve any practices that cause injury.

What are the costs for participating in this research?

There are no costs for participating in this research.

Will I be reimbursed for any of my expenses or paid for my participation in this research?

There are no expenses associated with participation in this study. An incentive of $15.00 cash is offered to all participating food handlers as compensation for their time.

Can I withdraw or be removed from the study?

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you don't want to answer and still remain in the study.

Who should I contact if I have questions?

The researchers conducting this study are Dr. Mark Dworkin and his research staff. You may ask any questions you have now, or later by contacting the research staff at: (312) 413-0348

What are my rights as a research subject?

If you feel you have not been treated according to the descriptions in this form, or you have any questions about your rights as a research subject, you may call the Office for the Protection of Research Subjects (OPRS) at 312-996-1711 (local) or 1-866-789-6215 (toll-free) or e-mail OPRS at uicirb@uic.edu.

APPENDIX F (continued)

What if I am a UIC student?

You may choose not to participate or to stop your participation in this research at any time. This will not affect your class standing or grades at UIC. The investigator may also end your participation in the research. If this happens, you class standing or grades will not be affected. You will not be offered or receive any special consideration if you participate in this research.

What if I am a UIC employee?

Your participation in this research is in no way a part of your university duties, and your refusal to participate will not in any way affect your employment with the university, or the benefits, privileges, or opportunities associated with your employment at UIC. You will not be offered or receive any special consideration if you participate in this research.

Remember: Your participation in this research is voluntary. Your decision whether or not to participate will not affect your current or future relations with the University. If you decide to participate, you are free to withdraw at any time without affecting that relationship.
You may make a copy of this form for your information and to keep for your records.

Signature of Subject

I have read (or someone has read to me) the above information. I have been given an opportunity to ask questions and my questions have been answered to my satisfaction. I agree to participate in this research. I have been given a copy of this form.

_____ _____
Signature Date

_____
Printed Name

_____ _____
Signature of Researcher Date (must be same as subject's)

APPENDIX G

FOOD HANDLER KNOWLEDGE SURVEY FOR STUDY TITLED "FOOD SAFETY KNOWLEDGE OF CERTIFIED RESTAURANT MANAGERS: ARE SOME CERTIFICATION PROGRAMS MORE EFFECTIVE THAN OTHERS?"

Suburban Food Handler Survey, Pre-Intervention

Instructions to Interviewer:
Read the instructions to the interviewee. Assure the interviewee that the information they provide is completely confidential. Complete the restaurant information after the interview.

Instructions to Interviewee:
This interview will take about 15 minutes. We'd like you to answer the questions as best as you can, without guessing. If you don't know the answer to a question, just answer "don't know." If you need me to repeat a question, just say so. You can also look at the question and read it for yourself. We thank you in advance for your time.

I will first ask you some true/false questions about food safety. Please tell me if you think the statement is true, false, or if you do not know.

Is it true or false that …	True	False	Don't know
1. Uncooked beef is potentially contaminated with germs that can cause people to be hospitalized or die?	1☐	2☐	8☐
2. .Uncooked chicken is potentially contaminated with germs that can cause people to become very ill?	1☐	2☐	8☐
3. .If fish (such as raw tuna) has been stored at a temperature that is too warm, but then is properly cooked to the correct internal temperature, it becomes safe to eat?	1☐	2☐	8☐
4. Raw eggs can have germs that can make people sick?	1☐	2☐	8☐
5. Cooked rice can have germs that can make people sick?	1☐	2☐	8☐
6. It is safe to put frozen chicken breast on the counter to thaw?	1☐	2☐	8☐
7. You can be sure food is safe to eat when it smells and tastes normal?	1☐	2☐	8☐
8. Cold food must be kept at 55°F (13°C) or lower?	1☐	2☐	8☐

APPENDIX G (continued)

9. Raw eggs in shells may be stored above a prepared salad in the refrigerator?	1☐	2☐	8☐
10. Cooling hot food in the refrigerator is a safe practice?	1☐	2☐	8☐
11. Storing products with the earliest expiration dates in front of products with later dates is a safe food storage practice?	1☐	2☐	8☐
12. Eating ground meat that is not completely cooked can cause bloody diarrhea?	1☐	2☐	8☐
13. If a food handler who has a small infected cut on his or her finger prepares a sandwich that is kept warm but not hot, is it true or false that. the person who eats that sandwich could become ill with vomiting and diarrhea	1☐	2☐	8☐
14. Gloves used to handle ready-to-eat food should be thrown in the trash when interruptions occur in operations	1☐	2☐	8☐
15.At work if you only urinated, and did not have a bowel movement, you do not need to wash your hands	1☐	2☐	8☐
16.…Vegetables for a salad splashed with a few drops of raw chicken juice should not be rinsed, but instead must be thrown away	1☐	2☐	8☐

17. Would you come to work if you had…

	Yes	No	Don't know
a.A sore throat and cough but you do not feel very sick?	1☐	2☐	8☐
b.Diarrhea, but you do not feel very sick?	1☐	2☐	8☐
c.An infected wound and you feel well?	1☐	2☐	8☐

18. Please state whether the following statements are true or false. In Illinois, a food handler should not work if they have…

	True	False	Don't know
a. A respiratory infection that started 1 day ago?	1☐	2☐	8☐
b.An infected wound?	1☐	2☐	8☐
c.Diarrhea?	1☐	2☐	8☐

APPENDIX G (continued)

18d. When was the last time you had diarrhea? Would you say…

1☐ In the past month,
2☐ In the past year, or
3☐ More than a year ago

18d. Were you working as a food handler at that time?

1☐ Yes 2☐ No → END INTERVIEW 8☐ Don't know → END INTERVIEW

18e. Did you tell your supervisor?

1☐ Yes 2☐ No 8☐ Don't know

Please tell me if the following statements are true, false, or if you do not know.

	True	False	Don't know
19.Beef may be placed in the refrigerator to defrost	1☐	2☐	8☐
20.Beef may be placed on the counter to defrost.....	1☐	2☐	8☐
21.Beef may be placed in cold water to defrost.....	1☐	2☐	8☐
22.Beef may be placed in the microwave to defrost.....	1☐	2☐	8☐
23.....Raw meat can be stored anywhere in a refrigerator as long as it is wrapped in plastic	1☐	2☐	8☐
24.Raw meat can be stored above ready to serve food.....	1☐	2☐	8☐
25.Raw meat can be stored below ready to serve food	1☐	2☐	8☐
26.Raw meat can be stored on foil-lined shelves to prevent dripping onto other foods	1☐	2☐	8☐

Next I have some yes / no questions. Please answer yes or no, or if you do not know an answer you can just say so.

27. Have you ever been employed at a restaurant when several people got sick from eating the food (sometimes this is called an outbreak)?

1☐ Yes 2☐ No 8☐ Don't know

APPENDIX G (continued)

28. Do you need to have thoroughly washed hands if you…

	Yes	No	Don't know
a.Use deli tissue to handle food?	1☐	2☐	8☐
b.Use a spatula or tongs to handle food?	1☐	2☐	8☐
c.Use single-use gloves to handle food?	1☐	2☐	8☐

29. Is it okay to put ice in a glass by….

	Yes	No	Don't know
a.Using tongs?	1☐	2☐	8☐
b.Using an ice scoop?	1☐	2☐	8☐
c.Scooping the glass into the ice?	1☐	2☐	8☐
d.Picking up ice with your bare hands?	1☐	2☐	8☐

30. Now I'm going to ask you about the steps involved in washing your hands.

a. Is it better to wet your hands with warm or cold water?

1☐ Warm/hot 2☐ Cold 3☐ It does not matter 8☐ Don't know

b. About how many seconds should you lather your hands with soap?

_____ seconds OR 98☐ Don't know

c. On what should you dry your hands? (SELECT ALL THAT APPLY.)

1☐ Your apron
2☐ Your clothes
3☐ Paper towel
4☐ Kitchen towel
5☐ Bathroom towel
6☐ Air dryer
7☐ Nothing, I do not dry my hands
8☐ Other → SPECIFY:

APPENDIX G (continued)

d. How should you turn off the water? (SELECT ALL THAT APPLY.)

1☐ With your apron
2☐ With your clothes
3☐ With a paper towel
4☐ With a kitchen towel
5☐ With a bathroom towel
6☐ With your bare hands
7☐ Other → SPECIFY:

For these next questions, I'd like you to answer with numbers. If you don't know the answer, just say so.

31. Germs that make people sick grow well between which temperatures?

_____ (F / C) to _____ (F / C) OR 998☐ Don't know
(circle the appropriate units, do not leave units blank if temperatures are given)

32. Hamburger and other ground beef mixtures, such as meatloaf, should be cooked to at least what temperature on a meat thermometer?

_____ (F / C) OR 998☐ Don't know
(circle the appropriate units, do not leave units blank if temperatures are given)

33. What is the proper minimum internal temperature to cook chicken for at least 15 seconds?

_____ (F / C) OR 998☐ Don't know
(circle the appropriate units, do not leave units blank if temperatures are given)

This next group of questions is multiple choice. Please select only one answer.

34. Which response is most true for you: I wash my hands after using the bathroom during my work shift never, rarely, sometimes, often, or always?

1☐ Never
2☐ Rarely
3☐ Sometimes
4☐ Often
5☐ Always

APPENDIX G (continued)

35. Where should meat thermometers be inserted to accurately check the meat's temperature? Would you say…

1☐ Any place is fine,
2☐ the thickest part of the meat, or
3☐ the thinnest part of the meat?
8☐ Don't know

36. Which type of thermometer is best to check the temperature of a chicken breast? Would you say…

1☐ A time-temperature indicator,
2☐ A metal stem thermometer,
3☐ An air-probe, or
4☐ A hang-type thermometer?
8☐ Don't know

37. The difference between cleaning and sanitizing is…

1☐ Cleaning is to remove food or other types of soil from a surface, but sanitizing is to reduce the number of germs on a clean surface to safe levels,
2☐ Cleaning is to remove food or other types of soil from a surface but sanitizing is to wipe a wet surface dry, or
3☐ Cleaning and sanitizing mean the same thing?
8☐ Don't know

38. If hot roast beef has been held in a steam table below 135ºF (57ºC) for over 4 hours, should it be…

1☐ Reheated to 165°F (74°C) for 15 seconds,
2☐ Thrown away,
3☐ Mixed with food that has been held at the proper temperature, or
4☐ Properly cooled and then reheated?
8☐ Don't know

Finally, I'm going to ask you some questions about yourself.

39. What is your age in years? ____

40. (DO NOT ASK UNLESS NECESSARY) Sex:
1☐ Male 2☐ Female

APPENDIX G (continued)

41. What is your day of birth? (not month)—*for example 08 if born on May 8th*: _____

42a. Do you consider yourself to be of Hispanic or Latino origin?

1☐ Yes 2☐ No

42b. With what racial or ethnic group do you identify yourself? Are you… (SELECT ALL THAT APPLY)

1☐ American Indian or Alaskan Native,
2☐ Asian or Pacific Islander,
3☐ Black,
4☐ White, or
5☐ Are you multiracial?
6☐ Something else → SPECIFY:_____

43. In what country were you born?_____

44. What is the highest level of education you have completed? (SELECT ONE ANSWER)

1☐ Less than 8th grade
2☐ From 8th grade to 12th grade, without high school diploma
3☐ High school diploma or GED
4☐ Some college but no degree completed
5☐ Two-year college degree/Associate's degree
6☐ Four-year college degree or more

45. Which of the following best describes you? (Would you say…) (SELECT ONE ANSWER)

1☐ English is your primary language,
2☐ Spanish is your primary language but you also speak English well,
3☐ Spanish is your primary language and you speak English but not well, or,
4☐ Something else? → SPECIFY:_____

46. How long have you worked in a job where handling food is part or all of your job in total?

_____ YEARS (record less than 1 year as an approximate proportion of a year, such as 0.5 for half a year)

APPENDIX G (continued)

47. Now tell me how often you have the following tasks in your job.

	Not at all	Sometimes	Often
a. You handle raw meat or poultry(Would you say…)	1☐	2☐	8☐
b. You handle raw seafood	1☐	2☐	8☐
c. You handle raw eggs.....	1☐	2☐	8☐
d. You handle raw vegetables or fruit	1☐	2☐	8☐
e. You are responsible for cooking meat or poultry	1☐	2☐	8☐
f. You are responsible for cooking raw seafood	1☐	2☐	8☐
g. You are responsible for cooking raw eggs.....	1☐	2☐	8☐

48. Which best describes how you like to learn new information? (Would you say…)

1☐ By looking at information with pictures,
2☐ By hearing information, or
3☐ By reading information?
4☐ Other → SPECIFY: _____

49. If you could choose between an educational brochure or a comic book that taught about food safety, which would you prefer?

1☐ An educational brochure
2☐ An educational comic book
8☐ Don't know

50a. Have you ever taken a food safety training course?

1☐ Yes, and I am a certified food safety manager at this restaurant
2☐ Yes, but I am not a certified food safety manager at this restaurant
3☐ No → SKIP TO #50d

50b. Where did you take the course? ___ (ANSWER SHOULD NOT BE A LOCATION LIKE A CITY BUT A SOURCE, SUCH AS "THE HEALTH DEPARTMENT" OR "IN THIS RESTAURANT")

_____
_____
_____

APPENDIX G (continued)

50c. Should a restaurant close…

	Yes	No	Don't know
i.During a sewage back up?	1☐	2☐	8☐
ii.During a power outage?	1☐	2☐	8☐
iii.When you have no running water?	1☐	2☐	8☐
iv.When you have cold water but not hot water?	1☐	2☐	8☐

50d. Have you been given any food safety training in your current job?

1☐ Yes 2☐ No 8☐ Don't know

50e. For how many years have you been in your current job? ____ years

End of Pre-intervention Interview
Conclude Interview and Thank for Participation

APPENDIX H

PUBLICATION REPRINT PERMISSION FOR STUDY TITLED "A STEP TOWARDS IMPROVING FOOD SAFETY IN INDIA: DETERMINING BASELINE KNOWLEDGE AND BEHAVIORS AMONG RESTAURANT FOOD HANDLERS IN CHENNAI"

NATIONAL ENVIRONMENTAL HEALTH ASSOCIATION
720 South Colorado Blvd.
Suite 1000-N
Denver, Colorado 80246-1926
Phone (303) 756-9090
Fax (303) 691-9490
www.neha.org

November 9, 2017

Mindi Manes
PhD Candidate in Epidemiology
School of Public Health
University of Illinois at Chicago

Dear Ms. Manes,
As requested, permission is granted to reprint in your dissertation the article "A Step Towards Improving Food Safety in India: Determining Baseline Knowledge and Behaviors Among Restaurant Food Handlers in Chennai," which was published in the January/February 2016 issue of the *Journal of Environmental Health* (volume 78, number 6).
This permission extends only to the reprinting of the above referenced article in your dissertation. Please be sure to cite the source the article accordingly.
Thank you for your contribution to the *Journal of Environmental Health*.

Sincerely,

Kristen Ruby-Cisneros
Managing Editor
Journal of Environmental Health
National Environmental Health Association

APPENDIX I

UNIVERSITY OF ILLINOIS AT CHICAGO HUMAN SUBJECTS APPROVAL FOR STUDY TITLED "A STEP TOWARDS IMPROVING FOOD SAFETY IN INDIA: DETERMINING BASELINE KNOWLEDGE AND BEHAVIORS AMONG RESTAURANT FOOD HANDLERS IN CHENNAI"

UNIVERSITY OF ILLINOIS
AT CHICAGO

Office for the Protection of Research Subjects (OPRS)
Office of the Vice Chancellor for Research (MC 672)
203 Administrative Office Building
1737 West Polk Street
Chicago, Illinois 60612-7227

Approval Notice
Initial Review (Response To Modifications)

May 16, 2011

Mindi Manes
Epidemiology and Biostatistics
2314 West 35th Place
Chicago, IL 60609
Phone: (303) 502-6831

RE: **Protocol # 2011-0255**
"A Knowledge Survey to Assess Food Poisoning Risk Factors Related to Restaurant Food Handlers in Chennai, Tamil Nadu, India"

Dear Ms. Manes:

Your Initial Review application (Response To Modifications) was reviewed and approved by the Expedited review process on May 16, 2011. You may now begin your research.

Please note the following information about your approved research protocol:

Protocol Approval Period: May 16, 2011 - May 14, 2012
Approved Subject Enrollment #: 200
Additional Determinations for Research Involving Minors: The Board determined that this research satisfies 45CFR46.404, research not involving greater than minimal risk. Please see waiver of parental permission below.
Performance Sites: UIC, Department of Public Health, Corporation of Chennai
Sponsor: None
Research Protocol:

a) A Knowledge Survey to Assess Food Poisoning Risk Factors Related to Restaurant Food Handlers in Chennai, Tamil Nadu India; Version 1; 03/22/2011

Recruitment Materials:

a) Chennai Food Handler Study Recruitment Points (English); Version 1; 03/22/2011
b) Restaurant Manager Letter (English); Version 1; 04/27/2011
c) Chennai Food Handler Study Recruitment Points (Tamil); Version 1; 05/11/2011
d) Restaurant Manager Letter (Tamil) (no footer)

APPENDIX I (continued)

Informed Consents:

a) Consent Form (English); Version 2; 04/28/2011
b) Consent Form (Tamil); Version 2; 05/11/2011

Parental Permission:

a) A waiver of parental permission has been granted under 45 CFR 46.116(d) and 45 CFR 46.408(c) for food handlers who are older adolescents (minimal risk, food handlers may be working in an area distant from their parents, investigators may not know the adolescent food handler is not an adult without collecting additional data, adolescent food handlers will be consented and enrolled using the adult consent document which is acceptable to the local health department)

Your research meets the criteria for expedited review as defined in 45 CFR 46.110(b)(1) under the following specific category:

(7) Research on individual or group characteristics or behavior (including but not limited to research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Please note the Review History of this submission:

Receipt Date	Submission Type	Review Process	Review Date	Review Action
03/22/2011	Initial Review	Expedited	04/17/2011	Modifications Required
05/12/2011	Response To Modifications	Expedited	05/16/2011	Approved

Please remember to:
→ Use your **research protocol number** (2011-0255) on any documents or correspondence with the IRB concerning your research protocol.
→ Review and comply with all requirements on the enclosure,
"**UIC Investigator Responsibilities, Protection of Human Research Subjects**"

Please note that the UIC IRB has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

Please be aware that if the scope of work in the grant/project changes, the protocol must be amended and approved by the UIC IRB before the initiation of the change.

We wish you the best as you conduct your research. If you have any questions or need further help, please contact OPRS at (312) 996-1711 or me at (312) 996-2014. Please send any correspondence about this protocol to OPRS at 203 AOB, M/C 672.

Sincerely,

Sandra L Costello

Sandra Costello
Assistant Director, IRB # 2
Office for the Protection of Research Subjects

APPENDIX J

ENGLISH-LANGUAGE FOOD HANDLER CONSENT FORM FOR STUDY TITLED "A STEP TOWARDS IMPROVING FOOD SAFETY IN INDIA: DETERMINING BASELINE KNOWLEDGE AND BEHAVIORS AMONG RESTAURANT FOOD HANDLERS IN CHENNAI"

Consent Form for Surveys with Food Handlers in Chennai

Study Investigators:
Mindi Manes, Graduate Research Assistant, University of Illinois at Chicago, SPHPI 827, MC 923, Chicago, IL 60101, 001-303-502-6831, mmanes3@uic.edu
Dr. Mark Dworkin, Assistant Professor, University of Illinois at Chicago, SPHPI 945, MC 923, Chicago, IL 60101, 001-312-413-0348, mdworkin@uic.edu
Dr. P Kuganantham, City Health Officer, Corporation of Chennai Public Health Department, 9445190744/9444415060, drkugan@yahoo.com

Consent Form

Research

This is a research study that involves collecting data on you and the food establishment where you work. The data will be collected by asking you questions.

Purpose of Study

To ensure food safety in restaurants, food handlers must be knowledgeable about safe food handling. Sometimes, restaurant patrons become sick as a result of problems with food handling. Therefore, this research is being performed to learn about the priority areas for the instruction of food handlers regarding food safety information.

Methods

About 200 food handlers are being asked to participate in this study. You will be asked a series of questions lasting about 15-20 minutes.

APPENDIX J (continued)

Risks

The only discernable risk is that your survey answers may be disclosed outside this research study. However, every attempt will be made to ensure that your confidential information is protected.

Benefits

There are no direct benefits to you for your participation in this study. Your information will benefit Indian society at large by informing researchers on how to improve food safety policy and programs.

Confidentiality

Any information about you obtained from this research will be kept as confidential (private) as possible. All staff dealing with data collection will undergo special training regarding confidentiality. All the data will be stored in locked file cabinets of locked file rooms. Computerized data will be protected by passwords. Data analysis and reporting will be conducted in a way that will not be linked to your name and/or household address. You will not be identified by name in any report or publication.

Furthermore, if collaborations involving your data are developed with investigators not listed on the first page of this consent form, your data will be only identified by an ID number. No personal identifier will be attached to these data.

In addition, to the investigators listed on the first page of the consent form and their research staff, authorized representatives of the University of Illinois at Chicago or the Indian government may review study information, which may include your identifiable response, for the purpose of monitoring the appropriate conduct of this research study, or if required to by a court of law.

The investigators may continue to use and disclose, for the purposes described above, unidentifiable information related to your participation in this research study indefinitely.

Complaints about Research

Any complaints about the way this research is being conducted should be directed to the Corporation of Chennai Ethics committee. The contact information is as follows:

Dr. P Kuganantham, City Health Officer, Corporation of Chennai Public Health Department, 9445190744/9444415060, drkugan@yahoo.com

APPENDIX J (continued)

Right to Withdraw

You may withdraw, at any time, your consent for participation in this research study. Any identifiable information collected prior to time of withdrawal may continue to be used and disclosed by the investigators for the purposes described above.

Your decision to withdraw your consent for participation in this research study will have no effect on your current or future relationship with the public health care system of Chennai.

Voluntary Consent

All of the above information has been explained to me and all of my current questions have been answered. I understand that I am encouraged to ask questions about any aspect of this research study during the course of this study. Any questions I have about my rights as a research participant will be answered by the co-investigator, Dr. P Kuganantham, 9445190744 or by the Institutional Review Board (IRB) Office, University of Illinois at Chicago (001-312-996-1711 or uicirb@uic.edu).

By signing this form, I agree to participate in this research study. A copy of this consent form will be given to me.

_____

Participant Name (Please Print)

_____ _____

Participant Signature or Mark Date

_____

Researcher Name (Please Print)

_____ _____

Researcher Signature Date

APPENDIX K

ENGLISH-LANGUAGE FOOD HANDLER KNOWLEDGE SURVEY FOR STUDY TITLED "A STEP TOWARDS IMPROVING FOOD SAFETY IN INDIA: DETERMINING BASELINE KNOWLEDGE AND BEHAVIORS AMONG RESTAURANT FOOD HANDLERS IN CHENNAI"

Chennai Food Handler Survey

Instructions to Interviewer:
Read the instructions to the interviewee. Remember to complete the restaurant information after the interview.

Put temperature thermometer into primary refrigerator/chiller before beginning interview and leave it there until end of survey.

Interviewer Name:_____

Instructions to Interviewee:
"This interview will take about 15 minutes. We'd like you to answer the questions as best as you can, without guessing. If you don't know the answer to a question, just answer "don't know." If you need me to repeat a question, just say so. You can also look at the question and read it for yourself. We thank you in advance for your time."

"I will first ask you a question about germs. If you do not know the answer, please say that you do not know."

---

1. Can you please tell me, what are germs? 8☐ Don't know

_____
_____
_____

If "Don't know" or answered incorrectly, provide participant with the following definition:

Germs are tiny organisms, or living things, that can cause disease.

APPENDIX K (continued)

2. I am now going to list some foods. Did you know that eating these foods could cause you to become so sick that you would need to go to the hospital?

	YES	NO
a.Uncooked chicken.....	1☐	2☐
b.Uncooked beef	1☐	2☐
c.Uncooked eggs.....	1☐	2☐
d.Cooked rice	1☐	2☐

"I will now ask you some true/false questions about food safety. Please tell me if you think the statement is true, false, or if you do not know."

	True	False	Don't know
3. It is safe to put frozen chicken on the counter to thaw	1☐	2☐	8☐
4. .In the refrigerator, it is safe to store raw eggs in shells above ready-to-serve raw vegetables	1☐	2☐	8☐
5. .....Eating ground meat that is not completely cooked can cause bloody diarrhea	1☐	2☐	8☐
6. .....A food handler who has a small infected cut on his or her finger prepares food that is kept warm but not hot. The person who eats the food could become ill with vomiting and diarrhea....	1☐	2☐	8☐
7. .... Gloves used to handle ready-to-eat food should be thrown in the trash when interruptions occur in operations	1☐	2☐	8☐
8. ..... At work if you only urinated, and did not have a bowel movement, you do not need to wash your hands before returning to food handling	1☐	2☐	8☐
9. . Vegetables for a salad splashed with a few drops of raw chicken juice should not be rinsed, but instead must be thrown away	1☐	2☐	8☐
10.Raw meat can be stored above ready-to-serve food.....	1☐	2☐	8☐
11. Cutting boards should be washed between cutting raw meat and cutting vegetables	1☐	2☐	8☐
12.Cleaning and sanitizing mean the same thing.....	1☐	2☐	8☐

APPENDIX K (continued)

If Question 12 is answered FLASE, ASK 12a and 12b (otherwise SKIP to Q13):

12a. Can you please tell me, what does cleaning mean?

_____

12b. What does sanitizing mean?

_____

Now, I am going to ask you some questions about washing your hands.

13. Is there a sink at your food establishment where you can wash your hands?

1☐ Yes 2☐ No 8☐ Don't know

14. How often is there soap available for you to use at your food establishment when you wash your hands?

1☐ Never (SKIP TO QUESTION 16)
2☐ Rarely
3☐ Sometimes
4☐ Often
5☐ Always

15. Which type of soap is available for you to use?

1☐ Bar soap
2☐ Liquid soap
3☐ Other

16. Which response is most true for you: I wash my hands after using the bathroom during my work shift.

1☐ Never
2☐ Rarely
3☐ Sometimes
4☐ Often
5☐ Always

17. When you wash your hands at work do you wet your hands with warm/hot or cold water?

1☐ Warm/hot 2☐ Cold 8☐ Don't know

APPENDIX K (continued)

18. When you wash your hands at work how long does it take you (in seconds)?

_____ seconds OR 98☐ Don't know

19. After you wash your hands at work, what do you use to dry your hands? (CHOOSE AS MANY AS YOU AGREE WITH.)

1☐ Your apron
2☐ Your clothes
3☐ Paper towel
4☐ Kitchen towel
5☐ Bathroom towel
6☐ Air dryer
7☐ Nothing, I do not dry my hands
8☐ Other → SPECIFY: _____

20. How do you turn off the water?

1☐ With your bare hands
2☐ With your clothes
3☐ With a paper towel
4☐ With a kitchen towel
5☐ With a bathroom towel
6☐ With your apron
7☐ With the foot tap
8☐ Other → SPECIFY:-
_____

21. How often are there clean paper towels available at your food establishment for you to dry your hands?

1☐ Never
2☐ Rarely
3☐ Sometimes
4☐ Often
5☐ Always

APPENDIX K (continued)

22. Do you need to have thoroughly washed hands if you use single-use gloves to handle food?

1☐ Yes 2☐ No 8☐ Don't know

"For these next questions, I'd like you to answer with temperature numbers. For example, you might say 200 degrees. If you don't know the numbers, just say so. "

---

23. Germs that make people sick grow well within which temperature range?

_____ (°C) to _____ (°C) OR 998☐ Don't know

24. Cooked meat, for example chicken, should be cooked to what internal temperature?

_____ (°C) OR 998☐ Don't know

25. Hot foods, such as biryani at a buffet table, should be held at what temperature?

_____ (°C) OR 998☐ Don't know

26. Cold foods, such as yogurt, should be stored at what temperature or lower?

_____ (°C) OR 998☐ Don't know

27. What is the temperature "Danger Zone"?

_____ (°C) to _____ (°C) OR 998☐ Don't know

"Now I am going to ask some questions about this food establishment"

---

28. Is there a meat thermometer available for you to use at this food establishment to check the temperature of the meat? (If YES ask Question 31, otherwise skip to Question 32)

1☐ Yes
2☐ No
3☐ Not applicable, meat not served at this restaurant
8☐ Don't know

29. Where should meat thermometers be inserted to accurately check the meat's temperature?

1☐ Any place is fine
2☐ Thickest part of the meat
3☐ Thinnest part of the meat
8☐ Don't know

APPENDIX K (continued)

"Finally, I'm going to ask you some questions about yourself."

30. What is your age (in years)? ____

31.Sex: 1☐ Male 2☐ Female

32. Please tell me which of these applies to you? (SELECT ALL THAT APPLY)

1☐ I am a vegetarian,
2☐ I eat only halal food,
3☐ I have no dietary restrictions, or
4☐ Something else → SPECIFY:_____

33. What is the highest level of education you have completed? (SELECT ONE ANSWER)

1☐ Never attended school
2☐ Attended but did not complete primary school
3☐ Completed primary school
4☐ Attended but did not complete high school
5☐ Completed high school
6☐ Attended any college
7☐ Completed any college degree

34. Do you travel a long distance to work at this job?

1☐ Yes
2☐ No

If Question 34 is answered YES, ASK 34a (otherwise SKIP to Q35):

34a. How far do you travel to get to your job_____(kilometers)?

35. Overall, how many years of your life have you spent working as a food handler?

_____ YEARS (record less than 1 year as an approximate proportion of a year, such as 0.5 for half a year)

APPENDIX K (continued)

36. Now tell me how often you have the following tasks in your job.

	Not at all	Sometimes	Often
a. You handle or cook raw meat or poultry.....	1☐	2☐	8☐
b. You handle or cook raw seafood.....	1☐	2☐	8☐
c. You handle or cook raw eggs	1☐	2☐	8☐
d. You handle raw vegetables or fruit	1☐	2☐	8☐

37. Would you come to work if you had…

	Yes	No	Don't know
a. A sore throat and cough but you do not feel very sick?.....	1☐	2☐	8☐
b. Diarrhea, but you do not feel very sick?	1☐	2☐	8☐

38. Do you have a Medical Fitness Certificate for Food Handlers?

1☐ Yes
2☐ No

39. Do you have a Food Handler License?

1☐ Yes
2☐ No

40. Have you received any food safety training from this restaurant?

1☐ Yes
2☐ No

41. Please tell me what is the name of your position at this food establishment? (for example, the head chef?)

-

_____

_____

42. Have you heard of the Food Safety and Standards Act, 2006?

1☐ Yes 2☐ No 8☐ Don't know

APPENDIX K (continued)

43. Have you ever been vaccinated against typhoid?

1☐ Yes
3☐ No
3☐ Don't Know

If Question 41 is answered YES, ASK 41a (otherwise SKIP to Q42):

43a. How long ago did you receive your last typhoid vaccination? _____(years)

44. Have you ever been hospitalized for vomiting or diarrhea?

1☐ Yes
3☐ No
3☐ Don't Know

End of Interview (Complete Restaurant Information)
Conclude Interview and Thank for Participation

APPENDIX L

ENVIRONMENTAL ASSESSMENT FOR STUDY TITLED "A STEP TOWARDS IMPROVING FOOD SAFETY IN INDIA: DETERMINING BASELINE KNOWLEDGE AND BEHAVIORS AMONG RESTAURANT FOOD HANDLERS IN CHENNAI"

Instructions to Interviewer:

Complete one inspection form for each participating food establishment.

Put temperature thermometer into primary refrigerator/chiller before beginning interview and leave it there until end of the inspection.

Complete all inspection questions about the food establishment after completing the interviews with the participants.

Restaurant Demographics

1. Name of food establishment:_____
2. Location of food establishment (ZONE, STREET):_____
3. Classification of food establishment by size:
   - 1☐ Small (<10 tables OR seating <40 seats)
   - 2☐ Medium (>10 tables OR seating >40 seats BUT <30 tables OR seating 120 seats
   - 3☐ Large (>30 tables OR seating >120 seats)
   - 4☐ Vendor, no seating available
   - 5☐ Take-Out Food, no seating available
4. Classification of food establishment by food service style:
   - 1☐ Tiffin
   - 2☐ Street Vendor (not tiffin)
   - 3☐ Informal (not tiffin)
   - 4☐ Fast food (chain, for example, Subway)
   - 5☐ Formal (not hotel)
   - 6☐ Hotel

APPENDIX L (continued)

5. Is the food establishment part of a regional or national chain?
   1☐ Yes, specify:_____
   2☐ No
6. What is the average menu price for an entrée?
   1☐ <100 Rupees
   2☐ 100-400 Rupees
   3☐ >400 Rupees

Restaurant Inspection

7. Is there a sink at this food establishment for employees to wash their hands?
   1☐ Yes 2☐ No
8. Is there soap available at this food establishment for employees to wash their hands?
   1☐ Yes, liquid soap
   2☐ Yes, bar soap
   3☐ Yes, other (for example, alcohol based hand sanitizer),
   Specify:_____
   4☐ No

9. Are there paper towels available at this food establishment for employees to dry their hands?
   1☐ Yes 2☐ No
10. Is there a hot water dish sanitizer on the premises?
   1☐ Yes (SKIP TO QUESTION 12)
   2☐ No
11. Are dishes washed in **HOT**, SOAPY water?
   1☐ Yes
   2☐ No

APPENDIX L (continued)

12. Is there a working temperature gauge on the refrigerator/chiller?
    - 1☐ Yes
    - 2☐ No
    - 3☐ There is no refrigerator/chiller on the premises
13. Is there a meat thermometer on the premises to check the temperature of meat?
    - 1☐ Yes
    - 2☐ No
    - 3☐ Meat is not served at this food establishment

14. Are raw meat or raw eggs stored above ready-to-serve food in the refrigerator/chiller?
    - 1☐ Yes, specify_____
    - 2☐ No
    - 3☐ There is no refrigerator/chiller on the premises

15. Is there a toilet facility at this food establishment?
    - 1☐ Yes
    - 2☐ No (SKIP TO QUESTION 16)

15a. What kind of toilet is available at this food establishment?
    - 1☐ Western style seat
    - 2☐ Squat over hole
    - 3☐ Other, specify:_____

15b. What kind of hand washing soap is available in/near the toilet facility?
    - 1☐ Liquid soap and there is soap in the bottle at this time
    - 2☐ Liquid soap, but there is **NO** soap in the bottle at this time
    - 3☐ Bar soap
    - 4☐ Other (for example, alcohol based hand sanitizer),
      Specify:_____
    - 5☐ No soap available

APPENDIX L (continued)

15c. What is available for drying hands in/near the toilet facility?

1☐ Paper towels
2☐ Cloth towel
3☐ Other, specify:_____
4☐ Nothing is available for drying hands

16. Using the provided metal stem thermometer check and record the temperature for the following foods: (REMEMBER TO SANITIZE THE THERMOMETER BEFORE INSERTING IT INTO THE FOOD USING THE WIPES PROVIDED)

a. Ready-to-serve chilled foods (like yogurt) _____(°C) or
   1 ☐ No chilled food available at this time
   2 ☐ No chilled food served at this food establishment
b. Warm, ready-to-serve meat _____(°C) or
   1 ☐ No warm meat available at this time
   2 ☐ No meat served at this food establishment
c. Warm, ready-to-serve sauce (like curry) _____(°C) or
   1 ☐ No warm sauce available at this time
   2 ☐ No warm sauce served at this food establishment
d. Raw eggs in shells _____(°C) or
   1 ☐ No eggs in shells available at this time
   2 ☐ No eggs served at this food establishment

17. Remove the thermometer from the refrigerator/cooler and record the temperature:_____ (°C) or ☐ no refrigerator on the premises

VITA

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PUBLICATIONS:

Manes, M.R., Liu, L., Dworkin, M.S. 2013. Baseline knowledge survey of restaurant food handlers in suburban Chicago: Do restaurant food handlers know what they need to know to keep consumers safe*? Journal of Environmental Health*, 76(1), 18-26.

Burke, A., Manes, M.R., Liu, L., Dworkin, M.S. 2014. Do food handler knowledge gaps predict critical violations and inspection scores identified during local health department restaurant inspections? *Food Protection Trends, 34*(2), 101-110.

Manes M.R., Burke, A., Liu, L., Dworkin, MS. 2014. Food for thought: Effective evidence-based brochure and comic book interventions designed for restaurant food handlers. *Food Protection Trends, 34*(2), 68-82.

Manes M.R., Kuganantham, P., Jagadeesan, M., Laxmidevi, M., Dworkin, M.S. 2016. A step towards improving food safety in India: Determining baseline knowledge and behaviors among restaurant food handlers in Chennai. *Journal of Environmental Health, 76*(6), 17-25

CONFERENCE PRESENTATIONS:

Manes, M.R., Liu, L., Dworkin, M.S. "Preliminary results of a food safety knowledge survey of suburban Chicago restaurant food handlers". 2010 Annual Meeting and Food Expo of the Institute of Food Technologists, National Research Initiative (NRI) and Agriculture and Food Research Initiative (AFRI) Project Directors' Meeting, Chicago, IL, July 16-17, 2010.

Dworkin, M.S., Manes, M.R., Liu, L. "Preliminary results of a food safety knowledge survey of suburban Chicago restaurant food handlers". 99th Annual Meeting of the International Association of Food Protection, Anaheim, CA, August 1-4, 2010.

Manes, M.R., Burke, A., Dworkin, M.S. "A knowledge survey and restaurant inspection to assess food poisoning risk factors related to restaurant food handlers in Chennai, Tamil Nadu, India". 60th Annual Meeting of the American Society of Tropical Medicine and Hygiene, Philadelphia, PA, December 4-8, 2011.

Manes, M.R., Burke, A., Liu, L., Dworkin, M.S. “Lessons learned recruiting restaurant food handlers to participate in a food safety survey: implications for future research”. 100th Annual Meeting of the International Association of Food Protection, Milwaukee, WI, July 31-August 3, 2011.

Chakrabarti, S, Manes, M.R., Dworkin, M.S. “Vaccine knowledge, attitude and practices in a suburb of Hyderabad, India”. Global Health and Innovation Conference, New Haven, CT, April 21-22, 2012.

Burke, A., Manes, M.R., Liu, L., Dworkin, M.S. “Do restaurant food handler knowledge gaps predict violations identified during inspections?” 7th Annual School of Public Health Research and Practice Awards Day, Chicago, IL, April 3, 2012.

Burke, A., Manes, M.R., Liu, L., Dworkin, M.S. “Do restaurant food handler knowledge gaps predict violations identified during inspections?” 76th Annual Meeting of the National Environmental Health Association, San Diego, CA, June 28-30, 2012.

Manes, M.R., Pyper, J., Jackson, D., Nakashima, A. “Testing a practical system to detect aberrations in surveillance data in Utah. Could we have detected the increase in influenza hospitalizations during the 2012-2013 season earlier?” 2013 Annual Meeting of the Council of State and Territorial Epidemiologists, Pasadena, CA, June 9-13, 2013.

Manes MR, Burke A, Liu L, Dworkin, MS. Effective evidence-based food safety materials for restaurant food handlers: interventions designed to target knowledge gaps. 102nd Annual Meeting of the International Association of Food Protection, Charlotte, NC, 2013 July 28-31, 2013.

Manes, M.R., Dworkin, M.S. “Preliminary results of a national survey of local health departments designed to examine restaurant-related foodborne illness outbreaks, restaurant inspections and food handler training”. 103rd Annual Meeting of the International Association of Food Protection, Indianapolis, IN, August 3-6, 2014.

Manes, M.R., Dworkin, M.S. "Analysis of restaurant-related foodborne illness outbreaks and restaurant inspections data from local health departments: Are sanitarians having to inspect too many restaurants?" Annual Meeting of the International Association of Food Protection, Portland, OR, July 25-28, 2015.

Manes, M.R., Dworkin, M.S. "Knowledge of certified restaurant managers in northern Illinois: Are some certification programs more effective than others?" Annual Meeting of the International Association of Food Protection, Portland, OR, July 25-28, 2015.

Benechiuk, J., Manes, M.R., Reber, D. "Utilizing Patient Activation Measures to identify high risk patients in Medicare bundled payment models". Annual Meeting of the American Congress of Rehabilitation Medicine, Atlanta, GA, October 23-28, 2017.

INVITED PRESENTATIONS:

Manes, M.R. "A food safety knowledge assessment of restaurant food handlers in Chennai, India". UIC School of Public Health Friday Seminar, Chicago, IL, September 2011.

Manes, M.R. "Restaurant food handler knowledge and environmental conditions in Chennai, India". Indo-US Global Health Consortium, Naperville, IL, September 2011.

Manes, M.R. Panel discussion about successful grant proposals for doctoral students. UIC Community Health Sciences Brown Bag Seminar, Chicago, IL, October 2012.

Manes, M.R. "Surveillance update: BioSense and Utah Department of Heath Aberration Detection System". Emerging Issues in Emergency Preparedness: Bio-Terrorism and Early Warning Workshop, Salt Lake City, UT, December, 2013.

Manes, M.R., Brumfield, J., Harris, C., Reber, D. "Patient experiences using wearable devices during a 60-day post-acute episode of care." We Are Brooks Research Event, Jacksonville, FL, September, 2018.