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Trends in Foodborne Outbreaks, Los Angeles County, California, 2004-2013, With Focused Investigation on Comparison of Contributing Factors in "Dine-in" versus "Take-out" Settings of Food Consumption

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ABSTRACT

Trends in Foodborne Outbreaks, Los Angeles County, California, 2004-2013, With Focused Investigation on Comparison of Contributing Factors in "Dine-in" versus "Take-out" Settings of Food Consumption

By Erin O'Leary

Background: Analyzing trends in foodborne disease outbreaks is an important means of identifying risk factors and how risk has changed over time. In order to create prevention programs regarding food safety it is essential to determine whether risks differ in various settings of food consumption. This paper aims to identify where risks of foodborne outbreaks lie by summarizing trends in outbreaks occurring in Los Angeles County between 2004 and 2013 and by assessing the association between "dine-in" and "take-out" settings of food consumption.

Methods: Data on foodborne outbreaks occurring in Los Angeles County, 2004 to 2013 were obtained from county outbreaks reports. Patterns in number of outbreaks reported per year, number of illnesses per outbreak, etiologic agents, food items implicated, setting of outbreak, and laboratory confirmation change over time were summarized, taking into account changes in reporting systems. The association was examined between contributing factors relating to contamination, proliferation, and survival in outbreaks occurring in "dine-in" and "take-out" settings of food consumption.

Results: There was a statistically significant decline in the number of outbreaks reported in Los Angeles County between 2004 and 2013, though when taking into account changes in the National Outbreak Reporting System occurring in 2009, this trend was not significant. There was a statistically significant decrease in the number of illness over the 10-years, and a decline in the number of foodborne outbreaks occurring in private residences between 2009 and 2013. Controlling for food items implicated, there was an association between contamination factors contributing to outbreaks occurring in "take-out" settings (OR=2.56, p=0.06) and an association between proliferation (OR=2.67, p=0.09) and survival factors (OR=2.41, p=0.21) contributing to outbreaks occurring in "dine-in" settings.

Conclusion: Risk of foodborne outbreaks was highest in restaurants, workplaces, and private residences, and was most often attributed to dishes, vegetables, and poultry. These data suggest that further efforts are needed to improve food safety in these particular areas of concern. By providing associations between contributing factors and settings of food consumption, programs can target specific settings based on risk factors identified.

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CHAPTER I

INTRODUCTION

Foodborne disease poses a significant health burden in the United States, causing approximately 48 million illnesses each year, 128,000 hospitalizations and 3,000 deaths (1, 2). On average, foodborne illness costs the United States between $51 and $78 billion annually (5). According to the Centers for Disease Control and Prevention (CDC), in 2012 there were 831 foodborne disease outbreaks in the United States, resulting in 14,972 illnesses, 794 hospitalizations, and 23 deaths (8). Although most foodborne illness does not occur as part of an outbreak, outbreaks allow us to better understand patterns of transmission and shed light on common sources and settings. Such information aids in prevention measures and leads to more efficient outbreak responses. This paper will assess trends in foodborne disease outbreaks occurring in Los Angeles County between 2004 and 2013, and will investigate the association between an outbreak's setting and contributing factors. This association will be assessed by comparing contributing factors in outbreaks where consumers "dine-in" a food preparation facility versus outbreaks where consumers "take-out," taking a meal from the food preparation setting and eating it elsewhere.

Investigating ten year trends in key foodborne disease outbreak variables such as etiology, size, settings, food item implicated, spatial distribution, and seasonal temporality will provide investigators with a better understanding of where risks have been elevated in the past and how risks are changing over time. Public health professionals often have limited time and resources available to them while investigating foodborne disease outbreaks and they can benefit greatly by using this knowledge to determine how to most efficiently investigate outbreaks.

In addition to analyzing trends, this paper will specifically investigate whether foodborne outbreaks associated with violations in proper hand hygiene, improper cooking time or temperature, and improper holding time and temperature are more likely to be associated with "dine-in" or "take-out" settings of food consumption. An outbreak occurring when people "dine-in" will be defined as one in which food is consumed in the same physical location in which it is prepared. Examples include consuming food in a restaurant, banquet facility, or hotel. An outbreak occurring when people "take-out" will be defined in this paper as one in which food is prepared in a restaurant or catering facility but taken out of the facility and consumed elsewhere. Examples include catered events, or patrons taking food from a restaurant to eat at home or in a workplace. In both cases, food is prepared by paid professionals who have training/certification in proper food preparation practices and food safety techniques. Based on these definitions, it is expected that the prevalence of contamination and survival factors will be similar in both "dine-in" and "take-out" foodborne outbreaks, while amplification/proliferation factors relating to food holding temperatures/times will be more common in foodborne outbreaks occurring in "take-out" outbreaks, controlling for food item implicated.

The rationale behind this hypothesis is that most contamination factors and survival factors contributing to outbreaks are linked to violations occurring in the setting of food preparation during storage, prep, or cooking of food. Such factors may include improper hand hygiene by food handlers, cross contamination during food preparation, or inadequate cooking times. Because the setting of food preparation is the same for all outbreaks of interest, all should have the same likelihood of having a contamination or survival factor contributing to the outbreak. Factors enabling amplification of microbes,

however, may contribute to outbreaks even after food is removed from the food preparation facility. For example, the average person taking their food to-go may be unaware of how long food can be left at room temperature before it must be refrigerated, or how long food can be kept before it should be consumed or thrown out. In addition, food may be left unrefrigerated (to keep it warm) at a restaurant while workers wait for patrons to pick up their food, supporting the growth of microbial pathogens or toxin build-up. As a result, there may be an increased risk of amplification factors contributing to outbreaks when food is taken out of the food preparation facility and consumed elsewhere.

Most review papers summarize risk of various foodborne illnesses by setting type without regard to contributing factors. For example, the MMWR report on Surveillance for Foodborne Disease Outbreaks—United States 1998-2008, provides summary statistics regarding setting of preparation in which outbreaks occurred, stating 68% of 13,405 outbreaks were associated with food prepared in a restaurant, 9% with food prepared in a private home, and 7% with food prepared by a catering company or banquet facility (1). Fewer studies summarize risk of foodborne disease outbreak by setting type while incorporating contributing factors. One such study reviews *Bacillus cereus, Clostridium perfringens, and Staphylococcus aureus* outbreaks and finds that regardless of pathogen, errors in food processing and preparation accounted for 93% of factors contributing to outbreaks, with 45% of these violations occurring in restaurants and 16% in private homes (18). Other papers summarize contributing factors but only by investigating contributing factors in one specific setting type. For example, one study by Hannah Gould et al. reviewed factors contributing to outbreaks in restaurant settings to

determine which factors are most common and where risk of food contamination is highest. Authors found that 98% of foodborne disease outbreaks occurring in the United States between 2006 and 2008 reported at least one contributing factor and went on to report the three most common contamination, survival, and amplification factors contributing to foodborne outbreaks associated with restaurants (30). These papers give the reader a general idea of which contributing factors are most common, however, they do not demonstrate whether contributing factors differ depending on setting type.

Once food is removed from the facility of preparation it is no longer controlled by the food facility and may be subject to improper holding temperature or other types of mishandling. It is important to understand where contamination is occurring and whether risk of foodborne disease outbreak differs depending on whether food is consumed in the facility of preparation or taken and consumed elsewhere. There is a lack of information in the literature regarding whether contributing factors differ between these two setting types. This paper will address this gap by investigating whether hand hygiene violations, cooking time and temperature violations, and holding time and temperature violations are more or less commonly associated with outbreaks occurring when patrons "dine-in" versus "take-out."

Analyzing trends in foodborne disease outbreaks and investigating associations between setting of food consumption and contributing factors will provide information regarding areas where risks remain high, or areas where risk has declined over the ten year period. This will allow for more focused interventions which is important as many local and state health departments lack resources to intervene at all food processing steps.

BACKGROUND

A foodborne disease outbreak occurs when two or more persons become ill following consumption of food contaminated with some disease-causing agent (13). Bacteria, viruses, parasites, toxins, metals, chemicals, and prions can potentially contaminate food and cause illness in humans upon ingestion (1, 7). Contamination may occur at any point during the growing, harvesting, processing, or preparing of food. Investigation of foodborne outbreaks is complex due to the wide array of potential disease-causing microorganisms or chemical agents, the various settings in which contamination of food can occur, and the vast number of factors that can contribute to this contamination. Though complex, fast and efficient foodborne disease outbreak investigations are vital for identifying a source and halting further transmission, as well as determining gaps in the system to prevent future outbreaks (19).

Foodborne illnesses are reported and identified in various ways. Suspected foodborne illness can be reported by consumers to local health departments via online reporting forms or direct phone call. According to the CDC, consumer complaint to a health department is the most common reporting method (27). Illness can be reported to local health departments by physicians or public health nurses. If reports are similar in etiology, location, time, and setting, the department may investigate to determine if the illnesses are related, which would constitute an outbreak. Surveillance of foodborne illness is required in all states as it allows for more accurate recording of foodborne disease incidence and facilitates identification of foodborne disease outbreaks (1).

Certain foodborne illnesses such as botulism, cholera, hemolytic uremic syndrome, listeriosis, salmonellosis, Shiga toxin-producing *Escherichia coli* (STEC),

shigellosis, and Hepatitis A are deemed notifiable diseases and must be reported by physicians or laboratory professionals to their corresponding state or territorial public health agency (2). Illnesses such as norovirus, while not notifiable, pose a significant health burden in terms of number of people affected and are often reported if responsible for an outbreak. States conduct surveillance in order to identify outbreaks, and outbreaks must be investigated using standard forms which can be voluntarily submitted to the CDC via the electronic National Outbreak Reporting System (NORS) (9).

While each state is individually responsible for identifying and responding to foodborne disease outbreaks, a national surveillance system has been in place since 1973 allowing local and state health departments to voluntarily submit foodborne disease outbreak data to the CDC. Originally called the Foodborne Disease Outbreak Surveillance System, this centralized system allows for an understanding of foodborne illness at a national level and enables identification of large scale, multi-state outbreaks that may not be recognized at the local or state level (9). Since its implementation in 1973, this national surveillance system enabled reporting of food and waterborne disease via paper reports (1). In 1998, a web-based system was implemented and by 2001, all state, local, and territorial health departments were submitting online foodborne outbreak reports to the CDC using the electronic Foodborne Outbreak Reporting System (eFORS) (1). In 2009, the Foodborne Disease Outbreak Surveillance System was expanded to include reports of enteric disease transmitted through person-to-person contact, contact with animals, environmental contamination, and unknown/indeterminate means (9). This "enhanced reporting platform" is called the National Outbreak Reporting System (NORS) and incorporates a new electronic reporting form and data entry interface. With the

inclusion of these new modes of transmission, changes in the number of reports attributed to foodborne disease outbreaks were observed. Because this paper aims to investigate trends in foodborne disease outbreaks occurring from 2004 to 2013, it is important to understand how reporting has progressed and changed over the years.

According to Imanishi et al., in 2009 with the introduction of the enhanced surveillance system, NORS, the number of reported foodborne disease outbreaks declined by 32% compared with the mean of the preceding 5 years. This decline was largely associated with a drop in reported norovirus outbreaks (9). Norovirus can be transmitted through several routes and the exact mode of transmission is often difficult to identify. To determine the basis for this decline in reported foodborne disease outbreaks, the group surveyed public health officials responsible for entering outbreaks into NORS (9). Eighty percent of respondents reported difficulty in distinguishing between a foodborne outbreak and one transmitted from person to person. The majority of respondents reported that in the previous system (Foodborne Disease Outbreak Surveillance System) they would have marked an outbreak as foodborne if its mode of transmission was unable to be determined or if there was a problem distinguishing between person-to-person transmission, environmental contamination, or foodborne transmission. This suggests that the current system allows for more accurate reporting. This is important to take into consideration when analyzing trends in the number of outbreaks reported over time. If a decline in the number of foodborne disease outbreaks occurring in LA County is observed around the year 2009, further investigation is needed to assess whether this decline results from changes in the surveillance systems or a true decrease in outbreak incidence.

When a local, state, or national surveillance system identifies individual reports of acute gastroenteritis similar enough to be an outbreak, an investigation is conducted to determine if the illnesses are in fact related and whether transmission was foodborne. During the investigation, a case-control study is conducted, when possible, in which key variables are identified and recorded. Standardized questionnaires are created and completed by those reported ill and those eating with potential cases but who did not become ill. Questionnaires ask cases and controls to report food items consumed during the gathering, time and date items were consumed, whether they became ill, when symptoms began, what their symptoms were, and how long they lasted. Based on these responses, a case-control study is conducted to implicate a food item and determine likely etiology. Data collected from these questionnaires are used to create reports which include the date the outbreak began, the number of cases, number of hospitalizations, number of deaths, setting of food preparation, setting of food consumption, etiologic agent, whether etiology was laboratory confirmed, food items consumed, contributing factors, duration of outbreak investigation, and geographic distribution of cases. Although challenging, outbreak investigations are of utmost importance. Early detection and identification of the food source and mode of transmission allow for early removal of the source, which is critical for reducing burden of disease.

The CDC reviews foodborne disease outbreaks occurring in the United States annually to summarize key outbreak details. These summaries "provide important snapshots of the human health impact of foodborne outbreaks" and help us to "understand the pathogens, foods, settings, and contributing factors involved in these outbreaks" (28). In addition, outbreaks are often reviewed and summarized over a five or

ten year period to assess how foodborne disease outbreaks change over time. National ongoing surveillance "will help further elucidate trends, identify gaps, and assess the effects of future interventions on reducing epidemic gastroenteritis" (10 Hall).

Foodborne illness remains an important public health concern in the United States. In 2013 norovirus alone was responsible for 1,908 outbreaks, 69,145 illnesses, 1,093 hospitalizations, and 125 deaths (10 Hall). Reviewing outbreaks is an indispensable tool for determining where strengths and weaknesses of investigations lie, where improvements can be made, and where investigators should focus efforts with limited resources. Herein, this paper aims to review foodborne disease outbreaks occurring in Los Angeles County between 2004 and 2013 to investigate ten year trends in etiology, outbreak size, exposure settings, foods implicated, and laboratory confirmation. While most review papers, including annual and decadal CDC outbreak reviews, simply summarize information by combining years of data, this paper will analyze trends over the years to determine if there is a significant change in each of these variables between 2004 and 2013.

In addition to reviewing foodborne disease outbreaks, this paper aims to explore the association between the setting in which a foodborne outbreak occurs and factors contributing to that outbreak. Food travels a long way before making it to one's dinner plate. At each step along the path from farm to human consumption, there are risks of contamination and precautions one can take to prevent contamination. Risk may vary greatly from one step to the next and with limited resources, better understanding these risks enable more targeted prevention measures. While there is ample opportunity for contamination at the growing, harvesting, transporting, handling, and processing stages,

this paper will focus on risk in the food preparation and consumption setting. This setting has the greatest amount of information regarding risk and food safety breaches because it is the last step in the food process prior to consumption and is therefore investigated extensively. Other steps in the path from farm to fork may only be inspected in certain wide-spread foodborne disease outbreaks. Health inspectors and epidemiologists collect information regarding factors contributing to food contamination in the food preparation process and report these factors via official outbreak reports.

The CDC created three categories of contributing factors to aid in more accurate and efficient reporting via the National Outbreak Reporting System. These three categories include: contamination factors, amplification/proliferation factors, and survival factors (26). As described by the CDC, contamination factors "introduce or otherwise permit contamination," thereby contributing to viral and/or bacterial outbreaks (26). They relate to how the etiologic agent "got onto or into the food vehicle." There are 15 such CDC-defined contributing factors, as there are 15 potential mechanisms in which an etiologic agent can contaminate a food item. Amplification factors are factors that allow for proliferation or growth of etiologic agents and are primarily applicable to outbreaks in which bacterial agents are involved (26). There are 12 amplification factors. Survival factors are factors that allow for pathogen survival or fail to inactivate the contaminant during a kill step in the food preparation process (26). There are 5 such factors and are only applicable to outbreaks in which microbial agents are involved (26).

Contributing factors are identified in various ways. During an outbreak investigation, the setting of food preparation is inspected by health inspectors and such inspections may reveal violations in safety precautions which contributed to

contamination of food or survival and growth of microbial agents. In addition, public health workers may identify contributing factors while interviewing cases or controls or after assessing suspect food items and etiology. For example, if *Bacillus cereus* associated with a rice dish was implicated in an outbreak at a church pot-luck, contamination via a food worker is unlikely and it can be reasonably inferred that inadequate holding temperatures contributed to toxin buildup. Inferences such as this can be supported or contradicted once interviews are conducted. Restaurants and other public food preparation facilities are inspected during an outbreak, however private settings, such as homes, are not subject to inspection during an outbreak. As a result, factors contributing to outbreaks in private settings may be more subjective and must be assessed for possible biases.

Reviewing outbreaks' contributing factors allows for observation of patterns in food safety violations over time and highlight high-risk steps in the food preparation process. There are laws in place that professional food preparers and servers must follow to prevent the spread of foodborne illness. Studies usually focus on factors contributing to outbreaks in public settings, such as restaurants, because information can be obtained first-hand via facility inspection. The same laws are not in place in a private setting and information regarding food safety is usually obtained via second-hand interviews or logical deduction and inferences. While there may be potential bias or inaccuracy in this method of identifying contributing factors, epidemiologists can minimize bias by interviewing multiple people regarding food preparation methods as soon as possible to limit errors in reporting. They can also assess potential confounding or bias when analyzing data, and can control for such bias. This study will generally avoid this issue by

focusing on contributing factors in outbreaks occurring in public food preparation settings such as restaurants, banquet facilities, hotels, catering companies and so on.

Epidemiological studies investigating contributing factors usually summarize data from all setting types and seldom compare contributing factors between outbreaks in which food was consumed in a public food preparation facility versus taken out of that facility and consumed elsewhere. As a result, there is a knowledge gap surrounding this association between contributing factors and settings of food consumption. It is important to understand where contamination occurs and where risks are highest in order to best mitigate these risks. This paper aims to assess whether factors contributing to foodborne disease outbreaks are similar in "dine-in" versus "take-out" settings of food consumption. In doing so, it seeks to identify steps in the food preparation process where risks of contamination is highest and make targeted recommendations for areas in which improvements can be made based on setting type.

While there is a lack of information assessing whether contributing factors are the same in "dine-in" versus "take-out" settings of food consumption, a few studies have investigated and reported factors contributing to foodborne outbreaks in restaurants. This paper will use data from such studies as general baseline data to gain a better understanding of which factors are most common nationwide. It will investigate whether results are similar to what is expected by comparing factors contributing to foodborne outbreaks occurring in Los Angeles County to those occurring across the United States. One study by Gould et al. summarized contributing factors in restaurant-associated foodborne disease outbreaks occurring in the United States from 2006 to 2007. Authors found that of 457 outbreaks, 300 (66%) were associated with restaurants (30).

Contamination factors were reported in 78% of restaurant-associated outbreaks, with food handling by an infected person, bare-handed contact by a food handler, and inadequate cleaning of food preparation equipment being the three most commonly reported contributing factors. Proliferation factors were reported for 24% of outbreaks, with inadequate cold-holding temperatures and slow cooling being reported most often. Survival factors were reported for 12% of outbreaks, with insufficient time and/or temperature during reheating and during initial cooking being reported most often (30). These statistics will be used as a comparison to what is seen during a similar time period in Los Angeles County. While numbers may vary, we would expect to see similar common contributing factors.

EXPANDED METHODS

This aim of this study is to investigate how foodborne disease outbreaks have changed from 2004 to 2013 and to assess the association between an outbreak's food preparation setting and its contributing factors. The hypothesis of this study is that a decrease in foodborne disease outbreaks from 2004 to 2013 will be observed as stricter food safety laws are implemented. For example, in 2010 California state legislation was passed requiring that nearly all (more than 1 million) food handlers in the state become certified in safe food handling (14). In addition, a significant decrease in the number of foodborne outbreaks reported in 2009 is expected as a result of changes in reporting with the implementation of NORS. Lastly, it is expected that violations in holding times and temperatures will be more closely associated with outbreaks occurring in "take-out" consumption settings while violations leading to contamination and survival of pathogens will be similar in "dine-in" and "take-out" settings.

This paper is a secondary review of de-identified data cleared by the Emory Institutional Review Board. No individual names were included in the data, all food service facility names were excluded after setting type was determined. Data used in this paper originated from previously compiled outbreak investigation reports. Reports were created following the case-control study used to investigate a foodborne disease outbreak. This study includes all foodborne disease outbreaks occurring in Los Angeles County between 2004 and 2013. There were 294 foodborne disease outbreaks investigated between these ten years, however, only 216 were determined to be truly foodborne upon further investigation. The other 78 were discovered to be transmitted from person-to-person, via water, or via infected animal.

Outbreak counts included in this study may not exactly match foodborne outbreak counts documented in annual Los Angeles County reports. Official reports contained a few outbreaks that were not suspected to be foodborne but were included because exact source and mode of transmission could not be determined. This paper is conservative in its inclusion criteria as only true foodborne outbreaks are of interest. Therefore, only outbreaks suspected or confirmed to be foodborne based on epidemiological evidence were included. In addition, four outbreaks were moved to another year, resulting in yearly count differences between this paper and official annual reports. This was done when an outbreak had a date of investigation beginning in January but an illness onset occurring in the December of the previous year. Because all other outbreaks are categorized in date and time by outbreak onset (rather than investigation onset), outbreaks were moved to the previous year. For example, one outbreak was included in 2005 in official county reports,

but onset of the outbreak occurred December of 2004, and was therefore included with 2004 outbreaks.

Variables included in this study originate from official outbreak records and include: outbreak number, foodborne incident report (FBIR) number, date of outbreak onset, date investigation began, facility type where contaminated food was prepared, facility type where contaminated food was consumed, contributing factors, food implicated, etiologic agent, whether the outbreak was laboratory confirmed, number reported to be exposed, number determined to have been exposed upon epidemiological investigation, number of persons reported ill, number determined ill upon epidemiological investigation, and the number of persons hospitalized as a result of foodborne illness linked to the outbreak.

In outbreak investigations occurring in Los Angeles County, the number of illnesses is reported in various ways. A case is defined as a person who became ill after eating the suspected contaminated food item during the time period the outbreak occurred. A control was someone attending the gathering during that same time period at that same location, but who did not become ill. There was often a difference in the number of persons reported ill in the initial report and the number of persons determined to meet the case definition after being investigated epidemiologically. For accuracy in reporting of illnesses, this study primarily included only persons who were determined to be true cases after a full investigation. If this information was absent from the report, the number of persons reported ill was used as a substitute measure.

In order to more effectively and efficiently analyze trends in foodborne disease outbreaks, supplementary variables were created. One such variable is called Food

Category, where implicated food items were categorized using CDC's food groupings. To aid in the attribution of foodborne outbreaks and illness to a particular food item, the CDC created 17 mutually exclusive food commodities: 3 for aquatic animals (fish, crustaceans, and mollusks), 6 for land animals (dairy, eggs, beef, game, pork, and poultry), and 8 for plants (grains/beans, oils/sugars, fruits/nuts, fungi, leafy vegetables, root vegetables, sprouts, and vine/stalk vegetables) (29). In this study, for simplification, leafy vegetables, root vegetables, sprouts, and vine/stalk vegetables were combined into one "vegetable" group. In addition to these 17 CDC food commodities, the categories "multiple," "dish," and "sauce" were created for this study. The category "multiple" was used when there was more than one food item implicated in an outbreak. "Dish" was used when a dish, such as a casserole or burrito, was implicated but the exact ingredient, or likely ingredient, responsible for illness could not be determined. Sauce included food items such as mole sauce or a dipping sauce that included multiple ingredients but were separate from the main dish and were consumed via dipping or pouring onto main dish. Implicated food items were usually suspected or confirmed using statistical evidence from epidemiological investigation, occasionally confirmed using laboratory evidence after testing of suspected food item was positive for etiologic agent of interest, or suspected using other supportive or compelling data (29).

The variable Setting was also created for this study and was based on the facility of food consumption. Setting types were created according to categories used in the National Outbreak Reporting System (NORS), used by Los Angeles County for reporting foodborne disease outbreaks to the CDC. These include, but are not limited to, assisted living facility, banquet facility, camp, catered event, church/temple, daycare, fair,

hospital, jail/juvenile detention center, park picnic, residence, restaurant, school, and workplace. For outbreaks not fitting into these official setting types, additional categories were created, including: bar, community, drug treatment center, food truck, gym, hotel, and other. "Other" was created in SAS if there was only one outbreak occurring in that particular setting category; therefore, all other setting types have at least two outbreaks occurring in that setting of food preparation.

Certain settings were more difficult to categorize than others. For example, an outbreak occurring in a hotel was categorized as "hotel" to add specificity although the event could have technically been called restaurant or banquet. A banquet is defined here as a setting in which food was prepared on the premises for a large group of people. This includes weddings or certain large parties. It differs from a restaurant in that the menu is chosen in advance, tailored for that particular group of people, and it closed off to the public. A catered event is defined in this study as one in which food was prepared by professionals off site (from consumption) and delivered to consumers, usually paying (partially) in advance for the food.

In order to assess whether risks of food contamination are different when patrons "dine-in" versus "take-out" a variable called Setting Type was created and settings of consumption were categorized as "dine-in", "take-out," or "unknown." A setting was categorized as "dine-in" if the setting of food consumption was the same as the setting of food preparation. Outbreaks with this setting type include restaurants, hotels, and banquets. A setting was categorized as "take-out" if the setting of food consumption was different than the setting of food preparation. Outbreaks with this setting type include catered events, private residences, workplaces, and church/temples where food was

brought to that location from a restaurant. A setting type was categorized as “unknown” if it was unknown whether food was homemade or purchased from another facility.

One goal of this paper is to highlight settings and steps in the food preparation process where risk of foodborne illness is highest. To best determine where risks lie, it would be ideal to know exactly when, where, and how food became contaminated. In reality, this is difficult, if not impossible, and for many outbreaks public health professionals can only use observation and deductive reasoning to estimate when and where contamination occurred. Contributing factors are the most effective way to assess risk and will be used here to assess whether taking food out of a restaurant or other food preparation facility increases the risk of foodborne disease outbreaks resulting from amplification factors.

CHAPTER II

Title:
Trends in Foodborne Disease Outbreaks, Los Angeles County, California, 2004-2013, Associations between Contributing Factors and "Dine-in" versus "Take-out" Settings of Food Consumption

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INTRODUCTION

In 2012 there were 831 foodborne disease outbreaks in the United States, resulting in 14,972 illnesses, 794 hospitalizations, and 23 deaths (8). With a few exceptions, a foodborne disease outbreak occurs when two or more cases experience similar illness after consuming a common food item contaminated by bacteria, viruses, parasites, toxins, metals, chemicals, or prions (1, 7). Although most foodborne illness does not occur as part of an outbreak, describing trends in foodborne outbreaks can demonstrate patterns of transmission and shed light on common sources and settings. Such information can aid in prevention and lead to more efficient outbreak responses.

All 50 states are responsible for conducting surveillance in order to identify outbreaks, and outbreaks must be investigated using standard forms which can be voluntarily submitted to the CDC (1). In 1998, foodborne outbreaks reporting began shifting from paper forms to online submission and by 2001 all state, local, and territorial health departments were submitting foodborne outbreak reports to the CDC using the electronic Foodborne Outbreak Reporting System (eFORS) (1). This system (eFORS)

allowed for reporting of food and waterborne disease and in 2009 was expanded to include reports of enteric disease transmitted through person-to-person contact, contact with animals, environmental contamination, and unknown/indeterminate means (9). This expanded system was renamed the National Outbreak Reporting System (NORS), and with its introduction, the number of reported foodborne disease outbreaks declined by 32% compared with the mean of the preceding 5 years (9). This decline was largely associated with a drop in reported norovirus outbreaks (9).

The decline in reporting of foodborne outbreaks after the implementation of NORS was thought to result from difficulty pinpointing a mode of disease transmission, particularly for norovirus outbreaks, when the reporting system was expanded to include enteric disease transmitted through means other than food and water (9). In one survey, eighty percent of public health officials responsible for entering outbreaks into NORS reported difficulty in distinguishing between a foodborne outbreak and one transmitted from person to person (9). These officials stated that they would have reported outbreaks as foodborne in the previous system, even if the exact mode was unable to be determined or if there was a problem distinguishing between person-to-person transmission, environmental contamination, or foodborne transmission (9). This change is important to take into consideration when analyzing trends in the number of outbreaks reported over time. If a decline in the number of foodborne disease outbreaks occurring in LA County is observed around the year 2009, further investigation is needed to assess whether this decline resulted from changes in the reporting systems or a true decrease in disease incidence.

Investigation of foodborne disease outbreaks is complex due to the wide array of potential disease-causing agents, the various settings in which contamination can occur, and the vast number of factors that can contribute to such contamination. During the investigation process, epidemiologists work to gather information such as the number of cases, hospitalizations, and deaths resulting from the outbreak, the outbreak setting, food item implicated, etiologic agent, and any factors contributing to pathogen transmission. Although challenging, outbreak investigations are of utmost importance, as rapid identification of food source and mode of transmission allow for early removal of the source, a critical step in reducing burden of disease.

In Los Angeles County, between 2004 and 2013, 216 outbreaks were investigated and determined to be true foodborne disease outbreaks. With almost 10 million people residing in the 4,752 square miles of Los Angeles County, the department of public health has a large area and population they must monitor. With limited time and resources available to investigate outbreaks, studies are needed to demonstrate where attentions should be focused and how efficiency of control programs can be maximized. This study aims to investigate trends in foodborne disease outbreaks occurring in Los Angeles County from 2004 to 2013. This information may allow for observation of common patterns that may highlight areas where interventions can be implemented and improvements in food safety practices can be made. This analysis will take into consideration how reporting has changed during the study period.

In addition to analyzing trends, this study aims to investigate the role of on-site food consumption by assessing whether contributing factors differ in regard to whether food was prepared and consumed in the same location. Factors contributing to “dine-in”

foodborne disease outbreaks in restaurants or banquet facilities, where food is prepared and consumed in the same location, are well studied. However, little information is available regarding whether contributing factors are similar in "take-out" outbreaks where food is removed from the setting of food preparation and consumed elsewhere. This paper seeks to compare contributing factors in "dine-in" versus "take-out" settings to investigate whether there are differences in food handling by infectious persons, cooking times and temperatures, and holding times and temperatures in these two food consumption setting types. Such information may be used to create more focused prevention measures, tailored to setting type, at the county level by providing policy makers with reliable and accurate food-safety information (4).

More than half of all foodborne disease outbreaks reported to the CDC occur in restaurants (30). Restaurant outbreaks are well studied, and the most common factors contributing to their occurrence are handling of food by an infected worker, bare-handed contact by a handler/preparer/worker, inadequate cold holding temperatures, slow cooling, inadequate cleaning of processing/preparation utensils, insufficient time/temperature during reheating, and insufficient time/temperature during initial cooking (30). Catered events, private residences, and workplaces are also common settings of consumption associated with foodborne disease outbreaks but there is little information available in the literature discussing risks of taking food from its setting of preparation for consumption in these off-site locations.

Risks involved with "dining-in" versus "taking-out" may differ due to unsafe handling/storage of food by consumers once food is removed from the facility of preparation, or due to inherent differences in restaurants that offer "take-out" options,

such as differences in food type, frequency of restaurant inspections, intensity/duration of food processing/handling, or number of food handlers. For example, fast-food restaurants are more closely associated with "take-out" food consumption than most sit-down restaurants. One study found a significant increase in risk of gastroenteritis in people eating fast-food ≥5 times a week compared to people eating fast-food <5 times a week, but found no association between increased risk of gastroenteritis and eating ≥5 times a week at a full-service/"dine-in" restaurant (31). Another study found that 51% of Americans do not know the proper temperature for reheating leftovers and 48% rely on their senses to determine if leftover food is spoiled (32). Factors such as these may lead to increased risk of foodborne disease outbreaks in "take-out" settings of food consumption over "dine-in" settings. While true risk cannot be determined with information available in this study, contributing factors in "dine-in" and "take-out" outbreaks can be compared to see if certain risk factors are more common in one setting type over the other. This papers reports 1) trends in etiologic agent, setting, number of cases, implicated foods, and contributing factors for 216 outbreaks investigated over ten-years in Los Angeles County, and 2) the association between setting and contributing factors in "dine-in" versus "take-out" settings.

METHODS

Los Angeles County Outbreak Investigation Details:

To assess trends in foodborne disease outbreaks occurring in Los Angeles (LA) County between 2004 and 2013, data and reports from previously conducted investigations were collected and analyzed. The outcome of interest was any foodborne disease outbreak occurring in Los Angeles County between 2004 and 2013, and was

defined as two or more individual illnesses resulting from ingestion of a common food item within LA County boundaries. Two exceptions are botulism and pufferfish tetrodotoxin poisoning in which only one case is necessary to constitute an outbreak. Of the 294 outbreaks investigated, 216 were included in the final review, as they were considered true foodborne disease outbreaks, while 78 were excluded as they were determined to have some source of infection other than food upon further investigation.

Foodborne outbreaks were reported to the LA County Department of Public Health via online forms, a direct phone call to the department, or from reporting healthcare providers or public health nurses. When a report showed more than two persons becoming ill after a common meal, or if multiple reports with similar location/symptom/food-histories arrived, an investigation into the potential outbreaks was conducted. A list of persons in each of the reporting parties was obtained and phone interviews were made to discuss food-histories and symptoms; the goal being to reach everyone present when the potential outbreak occurred. Each point of contact was asked to report food items consumed during the gathering, time and date items were consumed, whether they became ill, when symptoms began, what their symptoms were, and how long they lasted. Based on these responses, a case-control or cohort study was conducted, to implicate a food item and determine likely etiology. The outcome of interest was a foodborne disease outbreak with some suspected or confirmed etiology. Etiology could have been suspected based on symptoms and duration. To confirm etiology, two or more case samples had to test positive for the same agent. The date associated with each outbreak was the date of first illness linked to that outbreak. An outbreak where the first case reported symptoms on December 31st of a year was included in outbreaks for that

year, regardless of whether the investigation of the outbreak began in the next calendar year.

Thesis Study Methods:

Exposure variables of interest were setting, preparation/consumption pattern ("dine-in"/"take-out"), implicated food item, and contributing factors. Setting, the primary exposure variable of interest in this study, was defined as the facility type in which the contaminated food item was consumed. Settings included assisted living facilities, banquets, catered events, churches/temples, communities, hotels, jails/juvenile detention centers, private residences, restaurants, schools, workplaces, and other. A banquet setting included facilities where attendees gathered and food was prepared on site, such as an event lodge, country club, or wedding. Catered event was a setting in which food was prepared off site and delivered and consumed at a separate location. A foodborne outbreak occurring in a hotel can occur in any part of the hotel including a private room, the restaurant, or in a conference room. Settings categorized as "Other" are those in which only one outbreak occurred in that particular setting and included a bar, camp, fair, food truck, gym, and park picnic.

To investigate the role of on-site consumption, the association between contributing factors and setting type was analyzed and settings were further categorized into one of three preparation/consumption patterns: "dine-in," "take-out," or "other." Outbreak data collected contains both settings of food preparation and food consumption. An outbreak was categorized as "dine-in" if the setting of food preparation was the same as the setting of food consumption. "Dine-in" outbreaks include foodborne disease outbreaks occurring in restaurants, hotels, and banquet facilities. An outbreak was

categorized as “take-out” if the setting of food preparation was different than the setting of food consumption. “Take-out” outbreaks include foodborne disease outbreaks occurring in a private residence, workplace, church/temple where food originated in a restaurant or any catering facility. An outbreak was categorized as “other” if either the setting of food preparation or food consumption was missing or it was unclear whether food was consumed in the same location as where food was prepared.

Food items were implicated based on the results of the case-control studies and/or by testing food samples in a public health laboratory. Most outbreaks implicated food items after calculating etiologic fractions, odds ratios, p-values, and confidence intervals for each item on the food-history questionnaire. For analysis of trends, implicated food items were categorized using CDC’s food groupings. There are three major groups including aquatic animals, land animals, and plants. Each group is further divided into categories. Aquatic animals include fish, crustaceans, and mollusks. Land animals include dairy, eggs, beef, game, pork, and poultry. The plant group includes grains/beans, oils/sugars, fruits/nuts, fungi, leafy vegetables, root vegetables, sprouts, and vine-stalk vegetables. For simplicity leafy, root, sprout, and vine-stalk vegetables were combined into one vegetable category under the plant group. In addition to these CDC food groupings, three additional groups, called “Multiple”, “Dish,” and “Sauce,” were added to account for complexities in food items. When there were multiple non-related food items implicated in one outbreak, the implicated food was categorized as “Multiple.” When the implicated food item was a dish that includes multiple ingredients from different CDC groups, such as a casserole, where the exact ingredient that was contaminated remained unknown, the food was categorized as “Dish.” An implicated

food item was categorized as a "Sauce" when there were multiple ingredients in liquid form that were contaminated and added to the meal via dipping or pouring.

According to the CDC, contributing factors are factors that contribute to contamination, proliferation/amplification, or survival of etiologic agents (26). As used in the National Outbreak Reporting System, there are 15 possible contamination factors, 12 proliferation/amplification factors, and 5 possible survival factors (26). In an outbreak, these factors are usually identified by health inspectors during inspection of the facility, and are reported by epidemiologists who either observe or talk to someone who observed such factors.

Definition of contributing factors where C=Contamination Factor, P=Proliferation/Amplification Factor, S=Survival Factor

C1	Toxic substance part of tissue
C2	Poisonous substance intentionally/deliberately added
C3	Poisonous substance accidentally/inadvertently added
C4	Addition of excessive quantities of ingredients that are toxin in large amounts
C5	Toxic container
C6	Contaminated raw product—food was intended to be consumed after a kill step
C7	Contaminated raw product—food was intended to be consumed raw or undercooked/under-processed
C8	Foods originating from sources shown to be contaminated or polluted (such as a growing field or harvest area)
C9	Cross-contamination of ingredients (cross-contamination does not include ill food workers)
C10	Bare-handed contact by a food handler/worked/preparer who is suspected to be infectious
C11	Glove-hand contact by a food handler/worked/preparer who is suspected to be infectious
C12	Other mode of contamination (excluding cross-contamination) by a food handler/worker/preparer who is suspected to be infectious
C13	Foods contaminated by non-food handler/worker/preparer who is suspected to be infectious
C14	Storage in contaminated environment
C15	Other source of contamination
P1	Food preparation practices that support proliferation of pathogens (during food preparation)

P2	No attempt made to control temperature of implicated food or length of time food was out of temperature control (during food service or display of food)
P3	Improper adherence of approved plan to use Time as a Public Health Control
P4	Improper cold holding due to malfunctioning refrigeration equipment
P5	Improper cold holding due to an improper procedure or protocol
P6	Improper hot holding due to malfunctioning equipment
P7	Improper hot holding to due improper procedure or protocol
P8	Improper/slow cooling
P9	Prolonged cold storage
P10	Inadequate modified atmosphere packaging
P11	Inadequate processing (acidification, water activity, fermentation)
P12	Other situations that promoted or allowed microbial growth or toxic production
S1	Insufficient time and/or temperature during cooking/heat processing
S2	Insufficient time and/or temperature during reheating
S3	Insufficient time and/or temperature control during freezing
S4	Insufficient or improper use of chemical processes designed for pathogen destruction
S5	Other process failures that permit pathogen survival

For quality control, during outbreak investigations, outbreak reports and case-control studies were assessed by multiple team members to ensure accurate information. In addition, interviews were conducted by the Acute Communicable Disease Control Program at LA County as soon as possible, usually within a day or two of notification of a potential outbreak, to minimize recall bias. Variables included for each outbreak in this review paper are number of cases, number of people hospitalized, date of outbreak, setting, food implicated, contributing factors, and etiologic agent.

Trends and associations were analyzed using SAS software version 9.4 (SAS Institute, Cary, North Carolina). Tables and figures were created using both SAS and Microsoft Excel. To determine if observed trends in the number of outbreaks per year, number of illnesses per year, etiology, setting, and food items implicated were significant, data from the previous five year (1999-2003) were used as a baseline average and compared to changes observed during the study period. Trend data was grouped into

two-year periods and compared to what would be expected during those two years based on averages of previous five years. A Chi-square test was conducted to analyze whether what was observed was significantly different than what was expected. To account for changes in reporting in 2009, a second analysis of trends was conducted where outbreaks were grouped into pre-2009 (2004-2008) and post-2009 (2009-2013) categories. Linear regression was run to obtain a correlation coefficient (Pearson's) and p-value to determine whether observed number of outbreaks, illnesses, etiology, food item implicated, setting, and laboratory confirmation have changed significantly over the two five-year periods.

To investigate the association between setting type and contributing factors, factors of interest were categorized into three groups. Contamination factors relating to food handling by an infectious person were grouped together and included factors C10, C11, C12, and C13. Proliferation factors relating to how food was stored (time, temperature, process) were grouped together and included all proliferation factors except for P10 and P11. All survival factors were grouped together and included S1, S2, S2, S4, and S5. Unadjusted odd ratios were conducted for observed setting-contributing factor associations. To assess and adjust for potential confounding by etiology and food items implicated, logistic regression was run and adjusted odds ratios were calculated. If odds ratios changed by greater than 10% when controlling for either etiology or a food item, that variable was considered a confounder and adjusted for by including it in the final logistic model. Significance for all tests was evaluated at the alpha 0.05 level of significance.

RESULTS

In Los Angeles County from 2004 to 2013 there were 216 foodborne disease outbreaks, resulting in 3,964 illnesses and 179 hospitalizations (Table 1). Norovirus was responsible for the greatest number of outbreaks (n=101) and illnesses (n=1551) (confirmed and suspected combined), followed by Salmonella (n=46 outbreaks, n=1312 illnesses). Salmonella was responsible for the greatest number of hospitalizations (n=117 of 179 total hospitalizations); however *Clostridium botulinum* and pufferfish tetrodotoxin led to hospitalization in all persons affected (Table 1). Overall, 45% of outbreaks (97 out of 216) and 62% of illnesses (2444 of 3964) had a laboratory confirmed etiology.

A food item was implicated in 51% of outbreaks. Food categories most often implicated in an outbreak were dishes (n=18), vegetables (n=16), and poultry (n=14) (Table 2). On average, poultry caused the greatest number of illnesses per outbreak with a mean of 29.1 illnesses. Outbreaks associated with fish, on average, caused the fewest number of illnesses, with a mean of 5.3 illnesses per outbreak. Restaurants (n=80), workplaces (n=40), and private residences (n=37) were the most common settings of consumption associated with foodborne outbreaks (Table 2). School outbreaks, on average, were associated with the greatest number of illnesses, with an average of 123 illnesses per outbreak, while outbreaks occurring in jails/juvenile detention centers were associated with the fewest number of illnesses per outbreak, with an average of 9 illnesses per outbreak.

Trends:

From 2004 to 2013, there was a statistically significant decrease in the number of foodborne outbreaks reported per year ($r = -0.71$, $p=0.02$) (Figure 1, Table 4). The number

of norovirus outbreaks observed in 2006-2007 is significantly higher than expected based on the previous five-year average (1999-2003), while in 2008-2009 there is a statistically significant decline in the number of norovirus outbreaks reported, consistent with results Gould et al. observed following the implementation of NORS in 2009 (Table 3). The number of outbreaks occurring in restaurants is statistically significantly lower than expected from 2008 to 2013 ($p=0.0001$, $p=0.0001$, $p=0.006$) (Table 3). The number of combined outbreaks resulting from meat, poultry, and fish is statistically significantly lower than expected from 2008 to 2013 ($p=0.05$, $p=0.01$, $p=0.02$) (Table 3). There is a statistically significantly decline in the number of illnesses per year over the 10-year study period compared to what is expected based on the previous five years of outbreak data (Table 3).

Taking into account the expansion of the foodborne outbreak reporting system that occurred in 2009, data was dichotomized into pre-2009 and post-2009 outbreaks. From 2004-2008 there appeared to be an overall decline in the number of foodborne outbreaks occurring each year, however this trend was not statistically significant ($r= -0.69$, $p=0.20$) (Table 4). Post-2009 there appeared to be an increase in the number of foodborne outbreaks occurring per year, however, again this trend was not statistically significant ($r=0.29$, $p=0.63$). When dichotomizing time into two five-year periods, etiology, setting, and food items implicated did not change significantly over time, with the exception of outbreaks occurring in private residences, in which the number reported per year had a statistically significant decline from 2009-2013 ($r= -0.92$, $p=0.03$). The overall change in the number of illnesses between 2004 and 2013 was not statistically significant ($r= -0.52$, $p=0.12$), however upon removal of two outliers (outbreaks with

greater than 180 illnesses), the 10-year trend in illnesses showed a statistically significant decrease over time (r= -0.65, p=0.05).

Association between Contributing Factors in "dine-in" and "take-out" Settings:

Of the 216 total foodborne disease outbreaks, 106 were categorized as "dine-in," 56 were categorized as "take-out," and 54 were categorized as "other." There were 79 outbreaks with at least one contributing factors reported, 128 outbreaks where contributing factors were unknown, 8 with missing information, and 1 reported as having an unlicensed caterer as a contributing factor, which does not fit into NORS contributing factors categories and was not included in the analysis. Food item implicated was found to be a confounder of the association between setting and contributing factor (greater than 10% difference in OR when controlling for food item implicated), while etiologic agent was not found to be a counfounder. Therefore, food item was included in the final model to control for confounding.

The odds of having a hand hygiene violation contributing to a foodborne outbreak in a "take-out" setting, controlling for food category implicated, was 2.59 times higher than the odds of having hand hygiene issues contributing to a "dine-in" outbreak (p=0.06) (Table 5). Both proliferation factors and survival factors were more likely to contribute to "dine-in" outbreaks compared to "take-out" outbreaks, although neither association was statistically significant. Adjusting for food category implicated, the odds of a proliferation factor contributing to a "dine-in" outbreak was 2.67 times higher than the odds of a proliferation factor contributing to a "take-out" outbreak (p=0.09) and the odds of a survival factor contributing to a "dine-in" outbreak was 2.41 times higher than the odds of a survival factor contributing to a "take-out" outbreak (p=0.21) (Table 5).

DISCUSSION

Results of this study suggest an overall decline in the number of foodborne outbreaks reported in Los Angeles County between 2004 and 2013, though changes made to the national reporting system in 2009 make it difficult to distinguish between decline in true incidence and a decline in reporting. Further analysis should be conducted to see how trends continue after 2013. This work presents differences in contributing factors between "dine-in" and "take-out" setting, and suggests that contamination factors are more common in "take-out" settings, while proliferation factors are more common in "dine-in" settings. Although there was no statistical significance, the difference observed warrants some consideration and further investigation. This result will aid in program development by allowing public health professionals to better understand where risks lie and create programs that address these specific risks. There is a lack of data in the literature to support or refute this finding, and further research using national data may be helpful in determining if this pattern is consistent across counties and states.

In Los Angeles County, between 2004 and 2013, there was a statistically significant decline in the number of foodborne outbreaks reported per year. However, when separating outbreak data into pre-2009 and post-2009 time periods, this trend is not upheld. These results are consistent with previous research (9) which show a significant decline in the number of foodborne outbreaks reported in 2009 after the expansion of NORS, compared to the previous five and ten year periods, and then a slight increase in reporting from 2010-2013. According to Imanashi et al. (9), this result could suggest more accurate reporting of acute gastroenteritis outbreaks after implementation of the new system, as public health experts must now distinguish between foodborne,

waterborne, animal-origin, environmental-contamination, person-to-person transmission, and undetermined routes, rather than simply food and waterborne transmission (9). The increase in the total number of foodborne outbreaks reported per year between 2010 and 2013 could suggest personnel in charge of reporting became better at distinguishing between different routes of transmission, primarily between foodborne and undetermined means. As a result, they might have been more likely to report something as foodborne rather than undetermined as time went on and more experience with the system was gained.

Etiology observed in Los Angeles County (2004-2013) was consistent with national data, with norovirus being the largest contributor to foodborne disease outbreaks, followed by Salmonella (1, 10). Overall, 45% of foodborne outbreaks reported in Los Angeles County between 2004 and 2013 were laboratory confirmed, compared with 63% of outbreaks in the United States between 1998 and 2008 (1). This statistically significant difference ($p=0.02$) may result in part from the demonstrated importance of norovirus as a pathogen in outbreaks in Los Angeles (47% in documented outbreaks in Los Angeles vs. 39% nationally). Individuals infected with Salmonella, *E. coli,* or Shigella are often more likely to seek care from a physician compared to a person infected with norovirus, and therefore norovirus is often less likely to be laboratory confirmed than other etiologies (35). In addition, norovirus symptoms tend to have a shorter duration compared to other foodborne infections and obtaining permission to collect stool from norovirus cases is often more difficult (35). Symptoms can clear quickly and cases may feel better and are therefore uninterested in providing stool for testing. Salmonella or Shigella infections have longer durations, on average, and cases are often more willing to submit

stool to receive a diagnosis. Also, physicians are more likely to test patients for bacterial infections than for viral infections (35). For these reasons, having a higher percentage of outbreaks attributed to norovirus, which in Los Angeles is most often suspected rather than confirmed, may decrease the overall lab confirmation in this study. To increase lab confirmation, cases should be contacted as soon as possible, be told about the importance of lab testing, and asked if they would be willing to submit stool for laboratory testing and confirmation of suspected etiology. It is often difficult for the public to provide stool due to lack of time/transportation to laboratories. Increasing resources, such as hiring public health nurses and community health workers to pick up specimens is one option for increasing laboratory confirmation. Laboratory confirmation provides the county with more accurate data regarding disease incidence and can be improved by providing overburdened health departments with additional resources.

Of the most commonly implicated food items, only implication of beef differed significantly between Los Angeles and the rest of the nation, (4% Los Angeles vs. 13% of national outbreaks 1998-2008) ($p<0.0001$). Time could affect this difference, as national data were collected prior (1998-2008) to some of the Los Angeles data (2004-2013), and outbreaks relating to beef in Los Angeles have decreased since 2008. In this study there were two Los Angeles outbreaks attributed to beef in 2004, one in 2006, one in 2009, and none reported after 2009. Understanding differences over time and among different geographic locations can provide investigators with insight as to what food items to suspect when investigating outbreaks.

Factors Associated with Setting:

Results of this study are similar to national data for setting type, with restaurants being the most commonly reported setting for foodborne outbreaks (1, 33). Comparing outbreaks observed during the study period to those expected based on the five years prior to the study, the number of outbreaks reported in restaurants significantly decreased from year 2008 to year 2013. Despite this drop, over the ten year study period, restaurants were responsible for significantly more foodborne outbreaks than any other setting. Outbreaks associated with restaurants are more likely to be investigated and outbreaks occurring in homes may be underreported (33). Improving surveillance to reduce reporting bias would provide a better idea of which settings are truly most commonly responsible for outbreaks. There is work being done to improve food safety in restaurants, such as requiring trained kitchen managers and food safety certification in employees (23). One recommendation for improving food safety in restaurants is to provide food handlers with updated food safety information more frequently and re-test them more often after their initial certification (35).

In this study, private residences were commonly associated with foodborne outbreaks in years 2008-2011. This finding suggests that additional priority should be given to private homes for improving food safety. This study shows that risk of food contamination is higher when food is taken to-go and consumed off-site. Many consumers lack appropriate food safety knowledge for preparation of food at home and for handling of food brought home after being prepared elsewhere. Contamination factors relating to hand-hygiene are 2.56 times more common in “take-out” settings and therefore, while more can be done to decrease risk in restaurants, more can and should

also be done with regards to risk of "take-out" meals and food prepared in a private residence.

Adjusting for food item implicated, there are increased odds of contamination factors due to hand-hygiene contributing to "take-out" outbreaks and increased odds of a proliferation and survival factors contributing to "dine-in" outbreaks; associations are not statistically significant. To the best of the author's knowledge, there is no data currently available in the literature in which to compare these findings. Therefore, despite lack of statistical significance, results are still discussed here, as they provide important new clues as to how contributing factors may differ between setting types. Associations between contamination factors and proliferation factors and setting type were close to statistical significance and are epidemiologically interesting and worth investigating further.

Prior to analysis of data, it was expected that the number of outbreaks resulting from contamination factors (those relating to hand-hygiene) and survival factors would be similar in "dine-in" versus "take-out" settings of food consumption while the number of outbreaks resulting from proliferation factors would be more common in "take-out" settings of food consumption. Results from this study differ from what was initially hypothesized. This suggests that there may be certain factors that differ between "dine-in" and "take-out" settings that are associated with differences in risks and rates of violations of food safety protocols. Identifying what factors differ between these setting types will provide information as to why risks vary and how to mitigate these risks.

Results show adjusted odds of an outbreak attributed to hand-hygiene violations occurring in "take-out" settings to be 2.56 times higher than those occurring in "dine-in"

settings. Hand-hygiene violations may be more common in "take-out" settings for various reasons. First, there may be more people handling food in "take-out" settings compared to "dine-in" settings, as employees often handle food to package it to-go. Second, restaurants offering "take-out" may have different adherence to hand-washing protocols than those primarily offering "dine-in" consumption of food. Last, restaurants primarily offering "dine-in" consumption may be more likely to have a manager in charge of checking hand-hygiene and may be more likely to offer paid sick-leave for employees compared to restaurants or other settings where "take-out" is more common.

Results of this study show adjusted odds of a proliferation factor contributing to an outbreak occurring in a "dine-in" setting to be 2.67 times higher than the odds of a proliferation factor contributing to an outbreak in a "take-out" setting. This result differs from what was initially hypothesized. It was hypothesized that proliferation factors contributing to outbreaks would be more common in "take-out" settings because food could be exposed to inadequate holding temperatures during transportation, could be left out at room temperature at setting of consumption for longer than recommended, or could be kept for later consumption past expiration dates, all potentially leading to amplification of pathogens. However, study results show proliferation factors were more of a problem in "dine-in" settings. There may be inherent differences, on average, in the length of time food is held before given to a customer in "dine-in" versus "take-out" settings. For example, in "dine-in" settings, food may be prepared and immediately delivered to the customer's table for consumption. In "take-out" settings, food may be held at room temperature for long periods of time, while workers wait for the customer to pick the food up. If this is the case, "dine-in" restaurants should ensure food handlers are

aware of risks involved with leaving food unrefrigerated by providing specific and targeted training sessions.

Results show adjusted odds of a survival factor contributing to an outbreak in a "dine-in" setting to be 2.41 times higher than the odds of a proliferation factor contributing to an outbreak in a "take-out" setting. However, this result was not statistically significant ($p=0.21$) and results are similar to what was initially hypothesized. Prior to analysis it was hypothesized that survival factors contributing to foodborne outbreaks would be more-or-less equally likely in "dine-in" and "take-out" settings of food consumption, as these factors are related to cooking times and temperatures and freezing times and temperatures occurring at the setting of food preparation. Because food is prepared at the same location, regardless of where food was actually consumed, it was expected that these survival factors would not differ significantly between settings of food consumption. Results show an association, but the association is not close to statistical significance, suggesting what was observed is not significantly different than what was initially hypothesized.

While the exact reason for the difference in odds between setting types is unknown, identifying that there is in fact a difference is valuable in that it provides reason to further investigate setting-specific risk factors. Once setting-specific risk factors are identified more targeted prevention programs can be implemented.

Limitations:

Results from this study may not be generalizable, as population characteristics of Los Angeles may differ from other cities across the nation. In addition, sample size was small when comparing contributing factors, as only 79 of 216 outbreaks had contributing

factors confirmed and reported in outbreak summaries. As a result, confidence intervals around odds ratios comparing "dine-in" and "take-out" settings are wide. This may limit the ability to extrapolate data to different geographies and different populations. Because the sample size was small, odds ratios may be more greatly affected by reporting bias; with a bias away from null if "dine-in" outbreaks are more likely to be reported than "take-out." While this is possible, there is no evidence in this study's results to suggest that reporting bias is highly prevalent.

Another potential limitation of the study is that outbreaks occurring in restaurants may be more likely to be reported than those occurring in private residences or workplaces (33). When experiencing foodborne illness symptoms, people usually suspect food consumed outside of the home as the source of infection, rather than food that was home-made or brought home from another location (31). This could result in a greater number of "dine-in" outbreaks reported compared to "take-out." In addition, contributing factors are determined upon investigation of the facility involved in the outbreak, whether a restaurant or banquet hall, and via interviews with cases and controls. Through direct observation during outbreak investigations, is was noticed that many times people who become ill after dining in a restaurant may be more upset and willing to answer questionnaires. It can be speculated that people who take food out may not be willing to admit to leaving food out longer than they should or for storing food for more days than recommended. This could lead to overrepresentation of contributing factors reported in "dine-in" outbreaks and an underestimation of true contributing factors reported in "take-out" outbreaks. If this is the case, odds ratios for proliferation and survival factors may be an overestimate of what actually occurs.

Lastly, prior to the expansion of NORS in 2009, outbreaks may have been included even if the exact mode of transmission was unknown. Because there were only two options when reporting outbreaks of enteric disease (foodborne or waterborne), outbreaks were often included as being foodborne in official reports, even if epidemiologists could not distinguish between person-to-person transmission and foodborne transmission. As a result, numbers of foodborne outbreaks reported between 2004 and 2008 could be greater than the true number of foodborne outbreaks. If this were the case, the decline in the number of outbreaks over the 10-year study period may not be significant. In an attempt to minimize this potential artifact, data from 2009 to 2013 was analyzed separately and presented in results.

Strengths:

When collecting data, epidemiologists at Los Angeles County department of public health worked to obtain a line list (names and telephone numbers) for each and every person involved in the potential outbreak. From that list, epidemiologists interviewed all persons willing to answer food-history questionnaires, regardless of whether they were deemed ill by the reporting party, allowing for inclusion of the maximum number of people into each study as possible. Then, upon further epidemiological investigation, each person was determined to be a case or control based on symptom type and duration. Including more people in a case-control study allows for more power when implicating a food item and etiologic agent, providing more accurate reports. In addition, each person on the line list was contacted as soon as possible, usually within a day or two of their names being provided to the department, which minimizes

potential recall bias associated with providing responses to the food-history questionnaire.

This is the first paper, to the author's knowledge, that compares contributing factors in specific settings of food consumption to identify potential risk differences between "dine-in" and "take-out" settings.

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TABLES

Table 1. Number of outbreaks, illnesses, and hospitalizations by etiologic agent (n=216) Los Angeles County 2004-2013

	Outbreaks			Illnesses			Hospitalizations	
Etiologic Agent	**CE[a]**	**SE**	**Total**	**CE**	**SE**	**Total**	**No.**	**(%)**
Bacterial								
Campylobacter jejuni	3	3	6	31	16	47	3	6
Clostridium botulinum	1	1	2	2	2	4	4	100
Clostridium perfringens	3	3	6	221	69	290	1	0
Escherichia coli, Enterotoxigenic	2	0	2	75	0	75	1	1
Salmonella	45	1	46	1282	30	1312	117	9
Shigella sonnei	4	1	5	127	32	159	21	13
Staphylococcus enterotoxin	0	2	2	0	23	23	0	0
Unknown Bacterial-Toxin	0	15	15	0	193	193	2	1
Viral								
Hepatitis A	7	0	7	64	0	64	7	11
Norovirus	25	76	101	619	932	1551	13	1
Chemical and Toxin								
Buffalo fish toxin	0	1	1	0	2	2	1	50
Glacial acetic acid[b]	1	0	1	-	-	8	0	0
Pufferfish tetrodotoxin	0	1	1	0	2	2	2	100
Scombroid	6	0	6	23	0	23	3	13
Unknown	-	-	15	-	-	211	4	2
Total	97	104	216	2444	1301	3964	179	

Abbreviations: CE=confirmed etiology; SE=suspected etiology.

[a]Confirmed etiology is defined as 2 or more persons with a laboratory confirmed etiology, with the exception of botulism where only 1 laboratory confirmed case is needed, and scombroid where clinical symptoms are confirmatory, as laboratory confirmation is difficult

[b]Individuals persons can not be tested for this chemical toxin

Table 2. Outbreaks, illnesses, and hospitalizations attributed to implicated food items, categorized using modified CDC Food Groupings (n=109),[a] and attributed to setting of food consumption (n=214)

Variable	Number of Outbreaks	Number Illnesses	Hospitalizations	Mean Number Cases per Outbreak
Food Category				
Dish[b]	18	324	5	18
Vegetable	16	314	13	19.2
Poultry	14	408	10	29.1
Multiple[c]	12	347	13	28.9
Fish	11	58	12	5.3
Egg	9	104	13	11.6
Grain/Bean	6	84	2	14
Fruit/Nut	5	656	33	131
Oil/Sugar[d]	4	46	5	11.5
Beef	4	45	4	11.3
Pork	3	66	4	22
Dairy	3	31	3	10.3
Sauce	2	25	3	12.5
Game	1	19	0	19
Ice	1	8	-	8
Setting				
Restaurant	80	985	49	12.3
Workplace	40	710	8	17.8
Private Residence	37	512	25	13.8
Hotel	15	339	1	22.6
Banquet	10	244	18	24.4
Catered Event	7	136	4	19.4
School	6	738	33	123.0
Other[e]	5	75	5	15.0
Community	5	66	16	13.2
Church/Temple	5	57	6	11.4
Assisted Living Facility	2	61	5	30.5
Jail/Juvenile Detention	2	18	1	9.0

[a]Number of outbreaks with an implicated food

[b]The outbreaks implicated a dish with multiple food items, where exact ingredient implicated unknown

[c]More than one food was implicated in the outbreak

[d]Includes items such as donuts, bread, muffins, and tortillas

[e]Settings in which only one single outbreak occurred

Table 3. Significance of observed trends for number of total outbreaks, illnesses, lab confirmation, etiology, setting type, and food item implicated, significance based on Chi-square test at alpha 0.05 level of significance using average from 1999-2003 as reference (expected) and number observed in each category as comparison (observed)

Variable	Average 1999-2003	Two-Year Average 1999-2003	2004-2005	2006-2007	2008-2009	2010-2011	2012-2013
Outbreaks			Number Observed (p-value)				
Total	36.2	72.4	61 (0.18)	60 (0.15)	**28 (<0.0001)**	**34 (<0.0001)**	**33 (<0.0001)**
Norovirus	11.8	23.6	25 (0.77)	**34 (0.03)**	**8 (0.001)**	16 (0.12)	18 (0.25)
Salmonella	8.2	16.4	11 (0.18)	10 (0.11)	13 (0.40)	**7 (0.02)**	**5 (0.005)**
Restaurant	13.6	27.2	24 (0.54)	29 (0.73)	**7 (0.0001)**	**7 (0.0001)**	**13 (0.006)**
Residence	5.6	11.2	6 (0.12)	6 (0.12)	9 (0.51)	12 (0.81)	**4 (0.03)**
Workplace	4.25	8.5	10 (0.61)	12 (0.23)	4 (0.12)	5 (0.23)	9 (0.86)
Side Dish	2.5	5	6 (0.65)	4 (0.65)	1 (0.07)	4 (0.65)	3 (0.37)
Multiple Items	2.5	5	2 (0.18)	4 (0.65)	2 (0.18)	2 (0.18)	2 (0.18)
Meat/Poultry/Fish	6.6	13.2	9 (0.25)	9 (0.25)	**6 (0.05)**	**4 (0.01)**	**5 (0.02)**
Fruit/Vegetable	4.75	9.5	**3 (0.03)**	4 (0.07)	5 (0.14)	5 (0.14)	4 (0.07)
Illnesses	675.2	1350.4	**985 (<0.0001)**	**700 (<0.0001)**	**945 (<0.0001)**	**523 (<0.0001)**	**370 (<0.0001)**
Lab Confirmation	51.8%	103.6%	**82% (0.03)**	93% (0.30)	114% (0.31)	89% (0.15)	**77% (0.009)**

Table 4. Significance of observed trends for number of total outbreaks, illnesses and lab confirmation, and outbreaks by etiology, setting type, and food items implicated. Significance based on linear regression, Pearson's correlation coefficient, at alpha 0.05 level of significance

Variable	10-Year 2004-2013	5-Year 2004-2008	5-Year 2009-2013
Outbreaks	Pearson's r (p-value)		
Total	**-0.71 (0.02)**	-0.69 (0.20)	0.29 (0.63)
Bacterial-Toxin	0.33 (0.34)	-0.36 (0.55)	-0.19 (0.76)
Norovirus	0.13 (0.71)	-0.29 (0.64)	0.61 (0.28)
Salmonella	0.07 (0.85)	0.74 (0.15)	-0.34 (0.58)
Restaurant	-0.31 (0.39)	-0.28 (0.65)	0.76 (0.14)
Residence	0.31 (0.38)	0.58 (0.30)	**-0.92 (0.03)**
Workplace	0.23 (0.52)	-0.33 (0.59)	0.08 (0.89)
Side Dish	0.19 (0.59)	-0.56 (0.33)	0.59 (0.30)
Multiple Items	0.25 (0.48)	0.45 (0.45)	-0.29 (0.64)
Meat/Poultry/Fish	-0.004 (0.99)	0.38 (0.53)	-0.50 (0.40)
Fruit/Vegetable	0.38 (0.28)	0.85 (0.07)	0.16 (0.79)
Illnesses	-0.52 (0.12)	0.43 (0.47)	0.20 (0.75)
Illnesses (w/o outliers[a])	**-0.64 (0.05)**	-0.53 (0.36)	0.20 (0.75)
Lab Confirmation	0.02 (0.96)	0.79 (0.11)	-0.23 (0.72)

[a]Outlier is an outbreak with greater than 180 illnesses, there were two such outliers

[b]Trends based on percentage of outbreaks each year attributed to that variable

Table 5. Unadjusted and adjusted odds ratios for hand hygiene contamination factors (C10, C11, C12, C12), all proliferation factors, and all survival factors in "dine-in" outbreaks compared to "take-out" outbreaks

Variable	Unadjusted OR (95% CI)	P-Value	Adjusted[a] OR (95% CI)	P-Value
Contamination	0.70 (0.31-1.59)	0.40	0.39 (0.14-1.06)	0.06
Proliferation	1.63 (0.64-4.12)	0.30	2.67 (0.86-8.25)	0.09
Survival	2.05 (0.56-7.66)	0.29	2.41 (0.61-9.52)	0.21

[a]Adjusted for implicated food item

FIGURES

Figure 1. Number of total outbreaks, outbreaks from norovirus, and outbreaks from salmonella per year

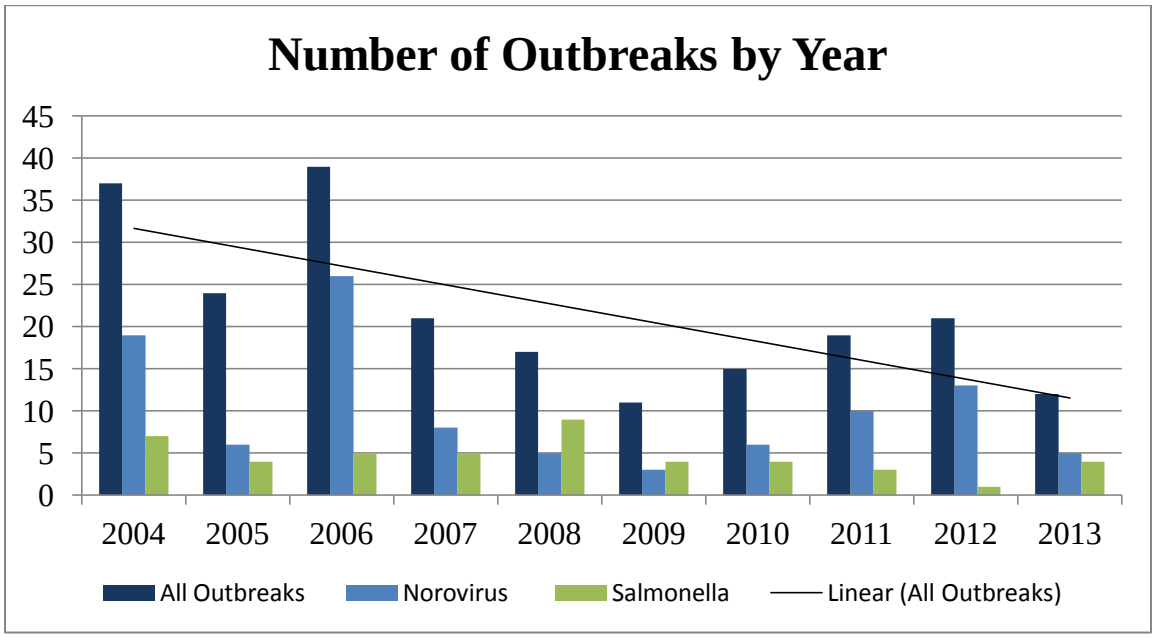


Figure 2. Observed trends in lab confirmation and number of outbreaks by most commonly implicated food items, etiology, and setting

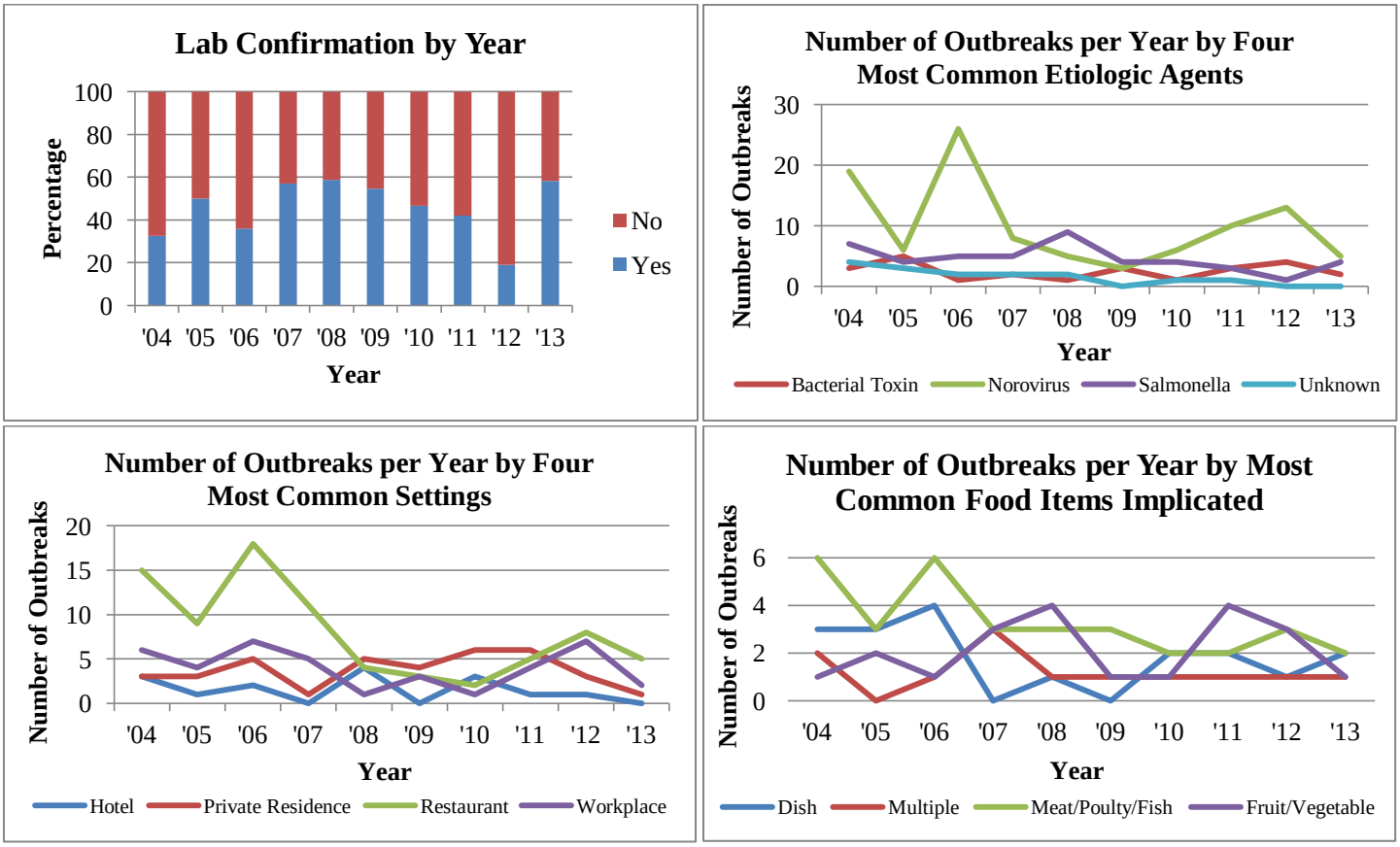
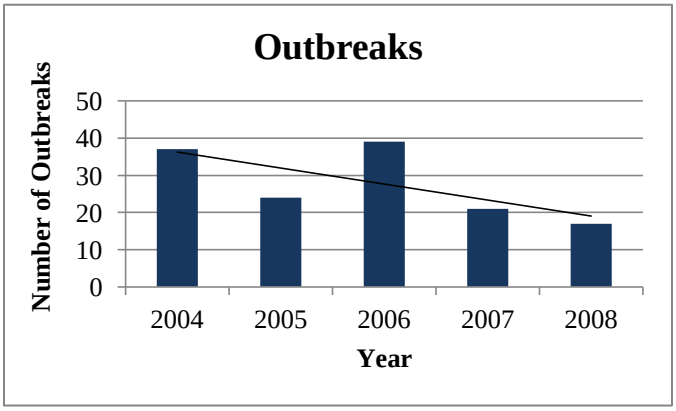
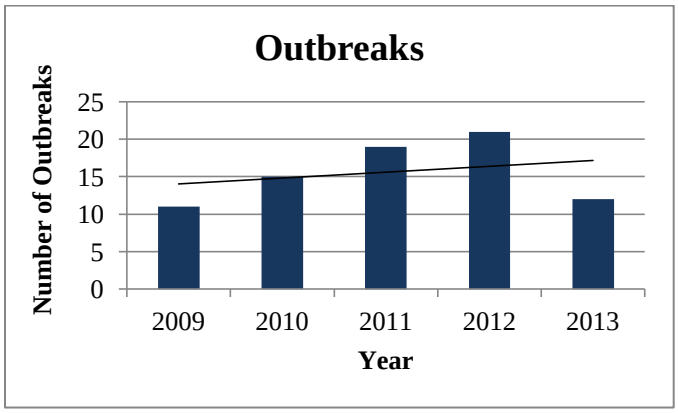


Figure 3. Total number of outbreaks per year, with time dichotomized according to pre-NORS implementation (2004-2008) and post-NORS implementation (2009-2013), with linear trend lines





CHAPTER III

SUMMARY

In summary, foodborne disease outbreaks reported in Los Angeles County have declined, on average, between 2004 and 2013. There have not been significant changes in etiology, food items implicated, or setting over that period with the exception of a statistically significant decline in the number of outbreaks occurring in private residences between 2009 and 2013. There has been a statistically significant decline in the number of illnesses associated with foodborne disease outbreaks in LA County between 2004 and 2013, suggesting better detection and prevention of further transmission.

An important association was found between an outbreak's setting of consumption ("dine-in" and "take-out") and its contributing factors. Although not statistically significant, "dine-in" settings of consumption were associated with higher odds of having proliferation and survival factors contributing to outbreaks, while "take-out" settings of consumption were associated with higher odds of having contamination factors contributing to foodborne outbreaks. This result will aid in program development by allowing public health professionals to better understand where risks lie and create programs that address these specific risks. There is a lack of data in the literature to support or refute this finding, and further research using national data may be helpful in determining if this pattern is consistent across counties and states.

PUBLIC HEALTH IMPLICATIONS

Presentation here of ten-year trends in overall number of outbreaks, illnesses, etiology, food items implicated, setting, and lab confirmation, gives an idea of where risks remain high and where they have declined. With limited resources and many

possible choices of intervention, data such as these are essential for creating targeted, specific food safety measures.

This paper identified potential differences in contributing factors between "dine-in" and "take-out" settings of food consumption. It is important to know which contributing factors are most common in what setting in order to manage these risks through setting-specific food safety interventions. For example, finding that hand-hygiene violations are more prevalent in settings where food is removed from its original site of preparation for consumption elsewhere is important in developing interventions targeting "take-out" settings.

POSSIBLE FUTURE DIRECTIONS

Future studies analyzing the association between contributing factors and setting of food consumption using larger datasets, preferably at that national level, are needed to provide more precise associations regarding differences in risk between "dine-in" and "take-out" settings. In addition, analysis of trends in foodborne outbreaks occurring in Los Angeles County should be continued to see whether the number of outbreaks reported continues to decline over time. If the number continues to decline, this would suggest decline in true disease incidence, assuming there are no further changes made to the reporting system. Ongoing surveillance will help to "elucidate trends, identify gaps, and assess the effects of future interventions on reducing epidemic gastroenteritis" (10).

Further studies are needed to provide more information on what differences between "dine-in" and "take-out" settings are associated with higher risks of contributing factors. For example, comparisons can be made between types of food items served at "dine-in" versus "take-out" settings to see if overall differences affect rates of

proliferation factors and survival factors contributing to outbreaks. Another such study can compare food safety knowledge, presence of kitchen managers, and food safety certification in food handlers in "dine-in" versus "take-out" settings to see if such factors contribute to differences in contributing factors. It may be interesting to compare contributing factors in restaurants with paid sick-leave to those without paid sick-leave to see if such policies directly affect rates of hand-hygiene violations by food handlers.

Currently, many food-workers are not provided paid sick leave or feel obligated to work, even while sick for fear or job-loss or loss of pay (15). Laws requiring paid sick leave for employees handling food may help this situation (30). In addition, many states, such as California, have passed laws requiring restaurant workers to be certified in food safety techniques and protocols, and restaurants with certified kitchen managers have lower odds of having an outbreak (13). This law was passed in California in 2010, though the number of foodborne outbreaks reported in restaurants did not decrease significantly between 2010 and 2013, suggesting more needs to be done. Evidence shows despite food safety certification and many years of experience in the industry, many food handlers lack adequate knowledge of foodborne illness risk factors, especially those relating to cross contamination, cooking, and holding and storage of food (35). Certified kitchen managers only tested slightly better (79% compared to 72% on food safety questionnaires) than other food handlers (35). Language was a large factor contributing to low questionnaire scores, with Spanish-speaking food handlers showing a significantly lower understanding of food safety (35). One recommendation for improving food safety in restaurants is to re-test food handlers more frequently after their initial certification to

decrease chances of forgetting proper protocols (35). Future studies can test effectiveness of such programs aimed at decreasing foodborne outbreaks in restaurants.