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# Timelines and practices in foodborne outbreak investigations: Implications for public health response

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## Abstract

This study used CDC surveillance data to investigate the relationship between operational delays and healthcare-seeking behavior during foodborne outbreak investigations. Descriptive statistics and nonparametric tests were used to investigate timelines such as onset to identification and first contact, as well as contextual variables such as establishment type and menu category. The relationships between investigation delays, healthcare utilization, and environmental response measures were investigated using correlation and regression analyses. Longer delays between illness onset and outbreak identification were found to be significantly associated with a higher proportion of people seeking medical attention. A higher number of environmental assessment visits was also associated with increased healthcare-seeking, but no significant associations were found for delays between identification and initial contact. Group comparisons revealed no significant differences in investigation timelines based on establishment or menu type. The model explained a small portion of the variation in healthcare-seeking behavior ($R^2$ = 0.083). These findings shed light on the timing and consistency of outbreak responses and highlight the importance of early detection in shaping public health engagement.

**Keywords:** Foodborne Outbreak; Outbreak Identification; Delay Analysis; Environmental Assessment; Healthcare Seeking

## 1. Introduction

Outbreaks of foodborne diseases reveal details about the foods and pathogens causing illness. The primary cause of foodborne illness outbreaks is still norovirus, underscoring the ongoing need for food safety enhancements that focus on employee hygiene and health in food service environments. Despite decades of progress in food safety in the United States [1, 15, 16], foodborne disease outbreaks continue to be a serious public health concern [17]. Understanding the epidemiology of foodborne disease outbreaks (FBDOs) is critical for developing investigative, control, and prevention strategies [2].

Methods for investigation, control, and prevention of foodborne disease outbreaks (FBDOs) must be informed by an understanding of their epidemiology [2]. Along the food chain from farm to fork, the possible roles of environmental contamination, cross-contamination, and the infected food handler are highlighted by the absence of a clear correlation between the other foods and aetiologias. [3]. 48 million Americans experience foodborne illnesses that are domestically acquired and linked to 31 known pathogens as well as a wide range of unknown agents. Economic studies that were based on earlier estimates are therefore no longer relevant. Foodborne outbreaks cause billions of dollars in damage, public health issues, and agricultural product loss, as well as the deaths of thousands of people from infections and intoxication [4,9].

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Local outbreaks of foodborne illness have grown to be a global concern in today's interdependent and linked world. Measuring the burden is inherently difficult because only a small percentage of those who get sick after eating tainted food seek medical attention. Only a small percentage of these are reported to official morbidity statistics or public health authorities. Foodborne illnesses would therefore always go unreported [5]. By means of restaurant closures, product recalls, and other measures, prompt outbreak detection lessens continuous transmission. [6]. Although integrated food chain surveillance is thought to be the best method for carrying out ongoing risk analysis for foodborne illnesses, it also necessitates more multisectoral cooperation and substantial ongoing resources than the other systems. Considering the resources at their disposal, each nation must choose the best design for its foodborne disease surveillance system [7].

Millions of people are impacted by foodborne outbreaks every year, making them a persistently difficult global and public health issue. The microbiological and environmental origins of the epidemics have been analyzed and investigated in several studies. According to research, the most frequent bacteria and pathogens responsible for foodborne outbreaks are Salmonella enterica [10], Escherichia coli, Staphylococcus, Bacillus cereus, and Vibrio. Most frequently documented biological causes of food outbreaks include parasites like Cyclospora and viruses like noroviruses and rotaviruses. Most outbreaks are linked to fresh produce and mycotoxins, and the risk of foodborne disease brought on by consuming these products is still high in both regions, affecting a sizable section of the population. These agents are more likely to be discovered in food derived from cattle and poultry meats. [11]. In addition to being present in food, these pathogens can occasionally be drawn in by how the food is handled [8,9].

Each of these outbreaks was identified in large part by Pulse Net, the national genetic subtyping network for foodborne disease surveillance [13]. It is now a vital laboratory surveillance tool for identifying food-borne outbreaks across multiple jurisdictions. Public health officials created PulseNet, a novel technology that links bacterial isolates to detect food-borne outbreaks spread across large geographic areas with a small number of cases. Numerous diseases and fatalities have been avoided because of the quicker outbreak investigations and the regulatory actions [12]

However, a lot of research has concentrated on identifying the causes of these foodborne outbreaks and linking various food sources to the illnesses. These studies' insights are crucial, but operational components of the epidemic investigation such as the timing of identification, public response patterns, and the function of environmental health assessments also need to be prioritized. There is a knowledge gap regarding the impact of epidemic management practices on public health outcomes.

The efficacy and promptness of outbreak response are significantly influenced by the operational aspects listed above. Better preventative techniques can be facilitated by tactics for prompt and efficient response that are informed by a thorough understanding of how investigation practices impact public health outcomes. By analyzing CDC foodborne outbreak data, this study seeks to close this gap by assessing the timeliness of epidemic detection, rates of healthcare seeking, and the importance of environmental assessment visits.

This paper's remaining sections are organized as follows: The dataset and analysis techniques are described in the following section. A presentation of the findings, including significant findings and summary data, comes next. Following an interpretation of the findings considering the body of previous literature, the report concludes with policy implications and recommendations for future research.

## 2. Materials and Methods

This study used data from the Centers for Disease Control and Prevention (CDC) [14]. focusing on operation and investigative variables. The dataset includes outbreak-level records reported through the CDC's surveillance systems, covering multiple establishment types and investigation contexts within the United States.

### 2.1. Inclusion and Exclusion Criteria

Inclusion: If an epidemic record had valid entries for at least one important operational or outcome variable, it was included. Imputation was used to keep records that had partial missingness in time-delay or outcome measures. Exclusion: Outbreaks with entirely missing data on all important variables, including outcome indicators (percentage of people who sought medical attention, food identified), and time-delay metrics (onset to identification, identification to first contact), were not included. Furthermore, records with obviously implausible values (such as negative durations) were examined and, if repairs were not possible, removed from pertinent analyses.

### 2.2. Analytical Approach

Python (3.12) was used to analyze the data. For every time-delay variable, including OnsettoIdentification and Identification to First Contact, descriptive statistics such as means, medians, and standard deviations were calculated. For categorical variables such as EstablishmentType, Menu Type, and Agent Identified, frequency distributions were produced. The Shapiro-Wilk test, which measures normality, verified that all delay variables were significantly right-skewed ($p < 0.001$). This supported the use of Spearman's rank correlation as the main indicator of association because it is robust to skewness and outliers and does not assume normalcy.

Nonparametric approaches were given priority due to the significant right-skewedness of operational delay variables (Shapiro-Wilk, $p<0.001$). Associations between delays and outbreak outcomes were evaluated using Spearman's rank correlations, and when necessary, group comparisons were performed using the Mann-Whitney U and Kruskal-Wallis tests.

To investigate variations in response measures among outbreak contexts, group comparisons were performed. In particular, the grouping variables were EstablishmentType (restaurant vs other) and Menu Type (American vs International). For normally distributed groups, One-Way ANOVA and independent t-tests were employed, whereas Kruskal-Wallis tests were employed for non-parametric comparisons. Percent Who Sought Healthcare factors, such as OnsettoIdentification, IdentificationtoFirstContact, and VisitsforEnvironmentalAssessment, were found using regression models to better evaluate the influence of operating procedures.

## 3. Results and Discussions

This section outlines the main conclusions drawn from the examination of CDC foodborne outbreak data and talks about how they may affect public health responses. The findings center on how healthcare-seeking behavior and investigation techniques are related to various phases of outbreak investigation, specifically delays in identification and follow-up. The interpretation of these results considers operational effectiveness, uniformity among establishment types, and possible avenues for enhancing outbreak response schedules.

**Table 1** Descriptive Statistics

| | **Mean** | **Median** | **std** | **Skewness** |
|---|---|---|---|---|
| Onset Identification | 2.66 | 3 | 0.54 | -1.35 |
| Identification to first Contact | 1.4 | 1 | 0.63 | 1.33 |
| Identification to Manager Interview | 2.44 | 3 | 0.8 | -0.97 |
| Identification to Observation | 1.69 | 1 | 0.81 | 0.63 |

Across outbreaks, the average onset identification time was 2.66 days, indicating that recognition of cases typically occurred quickly. The identification to first contact delay averaged 1.4 days while identification to manager interview and identification to observation delays were 2.4 and 1.69 days respectively, as shown by table 1

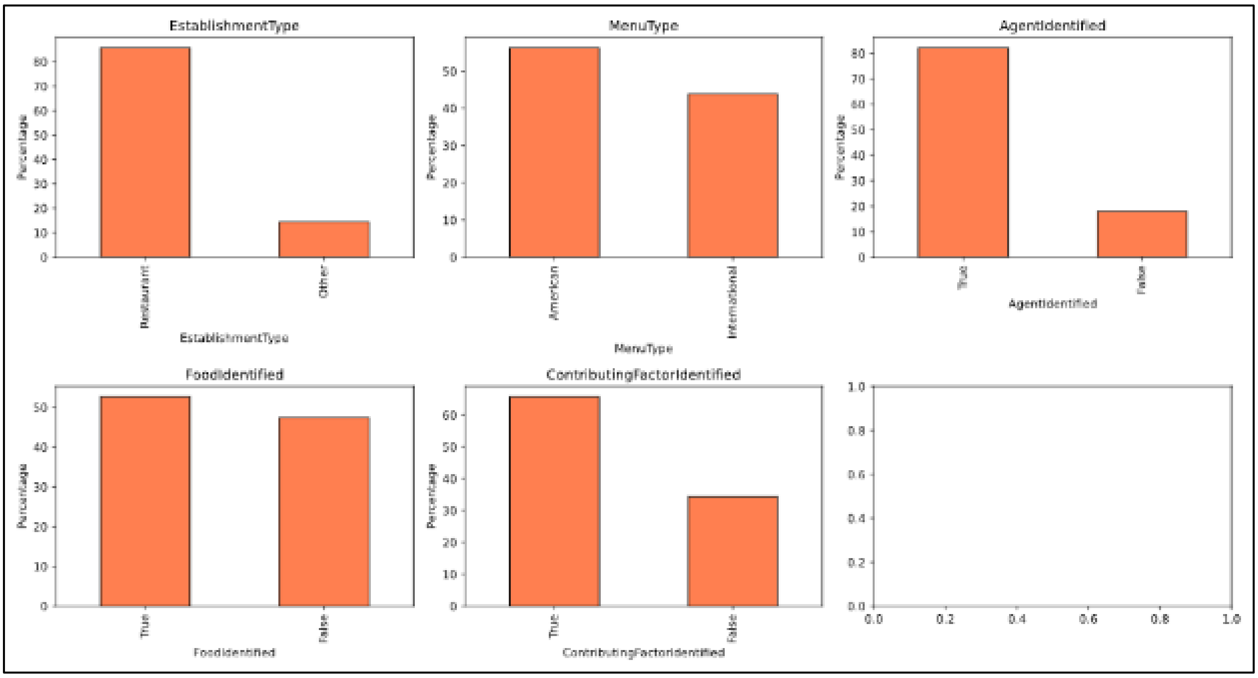


**Figure 1** Frequency Distribution of Categorical Variables

Fig 1 shows that outbreaks were more common in American menu establishments (56.2%). In 82 % of outbreaks, a causal agent was successfully identified. Food vehicles were identified in 52.6% of outbreaks at the same time contributing factors are documented in 65.7% of the outbreaks

### 3.1. Correlation between the variables under investigation

The percentage of people seeking medical attention was positively correlated with Onset to Identification ($\rho = 0.145$, $p = 0.011$) according to Spearman correlation analyses, suggesting that outbreaks with higher healthcare utilization experienced longer recognition delays. However, there was no correlation between Identification to First Contact and the number of environmental assessment visits ($\rho = 0.013$, $p = 0.819$), indicating that initial contact delays had little effect on the intensity of follow-up investigations.

### 3.2. Group Comparisons

Nonparametric group comparisons revealed no statistically significant differences in operational delays between outbreak contexts. Establishment Type (restaurant vs. institutional) and Menu Type (American vs. international) did not significantly differ in Onset to Identification, Identification to First Contact, Manager Interview, or Observation delays (all Mann–Whitney U $p > 0.05$). These findings suggest that outbreak investigation timelines for different establishment types and menu categories are essentially the same.

**Table 2** Regression Analysis

| | Coefficient | Std. Error | 95% CI Lower | 95% CI Upper | p-value |
|---|---|---|---|---|---|
| Intercept | 0.959 | 0.204 | 0.558 | 1.359 | 0 |
| OnsettoIdentification | 0.21 | 0.064 | 0.084 | 0.335 | 0.001 |
| IdentificationtoFirstContact | 0.035 | 0.07 | -0.102 | 0.171 | 0.62 |
| VisitsforEnvironmentalAssessment | 0.216 | 0.054 | 0.111 | 0.321 | 0 |

Table 2 shows that longer Onset to Identification delays were significantly linked to higher proportions of people seeking healthcare, according to robust OLS regression ($\beta = 0.21$, 95% CI: 0.08-0.34, $p = 0.001$). Increased Environmental Assessment Visits were associated with higher healthcare seeking ($\beta = 0.22$, 95% CI: 0.11-0.32, $p < 0.001$). In contrast, identification to first contact had no significant predictive value ($p = 0.62$). The model explained approximately 8% of the variation in healthcare seeking behavior ($R2 = 0.083$).

## 4. Conclusion

Using CDC data, this study investigated the association between operational delays and healthcare-seeking behavior during investigations of foodborne outbreaks. Both robust regression and correlation analyses revealed that higher proportions of people seeking medical attention were significantly correlated with longer delays between the onset of illness and the identification of the outbreak. Furthermore, outbreaks with a higher number of environmental assessment visits were also associated with higher healthcare utilization, indicating that more severe or conspicuous outbreaks trigger both individual care-seeking and public health response. It's interesting to note that neither healthcare-seeking behavior nor the frequency of environmental assessments were significantly impacted by the time between identification and first contact with establishments, suggesting that this stage may not be as important for influencing the intensity of subsequent investigations.

The lack of significant differences in investigation delays by establishment type (restaurant vs. institutional) or menu type (American vs. international), despite presumptions about variability across outbreak settings, suggests procedural consistency in the way outbreaks are investigated across contexts. Overall, even though only a small percentage of the variation in healthcare-seeking behavior was explained (R2 = 0.083), the results point to important areas that could improve community-level outcomes and public health response during foodborne illness outbreaks, especially earlier identification.

## Compliance with ethical standards

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### *Disclosure of conflict of interest*

The author declares no conflict of interest.

### *Statement of ethical approval*

This study did not involve human subjects and instead relied on publicly available, de-identified data from the CDC. As a result, it was exempt from IRB oversight.

### *Statement of informed consent*

This study relied on data from open-access, publicly available datasets. No identifiable personal information was used, so informed consent was not required.

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