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Analysing Food Safety Compliance in Toronto: Identifying Current Hazards and Challenge

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Abstract. This research conducts an in-depth investigation into the current state of food safety compliance in Toronto, thoroughly examining the present condition of food safety in the city. By utilizing a comprehensive dataset that includes a wide variety of dining establishments and their respective inspection results, the study employs advanced statistical methods for both analysis and visualization. These methods include the development of logistic regression models to identify significant patterns and trends. The goal is to highlight areas that require immediate attention or policy adjustments through a detailed examination of inspection reports, types of violations, violation frequencies, inspection dates, and the nature of the violations. Finally, the findings of the study strongly suggest that the government should increase the frequency of inspections, particularly during certain seasons, across various types of food businesses, and for specific types of violations, to enhance local food safety and protect the health of every Toronto resident.

Keywords: Food safety, challenge, Toronto.

1. Introduction

Food safety is a critical issue that affects the health of every resident in Toronto. It involves a variety of factors, including the freshness and hygiene of ingredients, as well as compliance with the expiration dates of products sold in supermarkets. Unfortunately, some suppliers engage in practices such as improper food storage and maintaining substandard sanitary conditions, which compromise food safety standards. Given that systemic food safety risks evolve and change over time, it is critical to continuously adapt and review current practices [1]. Conducting a comprehensive study of the current state of food safety in Toronto is crucial. The research will provide the public and regulatory authorities with a clearer understanding of the challenges and risks associated with food safety in the city and facilitate policy adjustments and improvements to further enhance Toronto's food safety.

The focus of this study is on the Toronto Open Dataset, which documents the results of food safety inspections at a variety of establishments. The main objective is to explore the factors that influence the level of compliance in these establishments. The estimated objective of this study is the impact of various operational and environmental factors on the likelihood of an establishment's compliance with food safety regulations. This includes analysing aspects such as the type of food establishment, frequency of inspections, and record of previous violations.

Leverage the official dataset provided by Open Data Toronto to conduct an in-depth analysis of food safety compliance across the city's dining establishments [2]. approach involves utilizing R, to

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meticulously clean and preprocess the dataset, ensuring the reliability and validity of subsequent analyses [3]. By employing a combination of descriptive statistics and predictive modelling techniques, including logistic regression, this paper seeks to estimate the influence of these factors on compliance rates. The insights gained aim to pinpoint specific risk factors and recommend targeted interventions for improving compliance, thereby enhancing public health safety in Toronto.

Existing literature on food safety in Canada has primarily focused on food safety inspection systems, evaluating the effectiveness of regulatory efforts and measurement methods. For example, the Hazard Analysis Critical Control Point HACCP system has been applied to assess food processing enterprises, analysing both the strengths and weaknesses of the current regulatory framework. HACCP is a scientific and systematic system for assuring food safety HACCP emphasizes in ‐ process control rather than post ‐ process inspection" [4]. Canada's vision for the agri-food industry in the 21st century is the establishment of a national food safety system employing hazard analysis and critical control point HACCP principles and microbiological verification tools [5]. On the other hand, research can also be conducted from the perspective of consumers, studying their feedback on food safety issues. This could include whether health impacts arise from improper handling or whether there are inherent price-related defects in the food itself, providing another angle for investigation. Establishing a set of standard food safety questions that can be compared between future surveys would contribute to a comprehensive baseline against which future food safety interventions could be measured [6]. Additionally, some studies have evaluated the effectiveness of government regulation and examined whether existing food laws are effective in ensuring food safety. These studies also compared the differing perspectives on food laws in Canada and the United States, analysing the differences in regulatory measures, law enforcement, and policy formulation between the two countries [7, 8].

To date, the existing literature has predominantly analysed food safety issues in Canada from a macro perspective, covering a broad scope but lacking in-depth analysis of food safety concerns specific to individual cities [9]. Furthermore, there has been little evaluation of certain factors that influence food safety, and detailed analysis of food business violations is also scarce. This paper aims to address these gaps by focusing on Toronto, using cross-comparative analysis to investigate the specific factors impacting local food safety.

2. Methodology

2.1. Data source

Please follow these instructions as carefully as possible so all articles within a conference have the same style to the title page. The dataset used in this study comes from the Dine Safe program managed by Toronto Public Health, available through Open Data Toronto [2]. Dine Safe is an inspection program that targets all establishments providing and preparing food in Toronto. The significance of this dataset lies in its comprehensive coverage of food safety compliance, offering insights into the operational standards of local food enterprises. The main entity of the dataset is a CSV file named Dine Safe, which contains operational information about various dining establishments, including the results of each inspection categorized as pass, conditional pass, or closure, compliance status, and the regulatory efforts of related government agencies, involving inspection frequency and penalties. This dataset is crucial for assessing the current state of food safety in Toronto and identifying areas needing improvement. Although similar datasets exist from other jurisdictions or private entities, the Dine Safe dataset was chosen for its direct relevance to Toronto, its authoritative nature, assured accuracy, and the detailed granularity of the inspection data it provides [10]. Local focus is essential for formulating policy recommendations and interventions tailored to Toronto’s unique food safety challenges. The data collection process is conducted by Toronto Public Health through regular administrative inspections of dining establishments, ensuring the data’s reliability and high reference value.

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2.2. Variable introduction

The dataset is a complete CSV file encapsulating various indicators pertinent to food safety analyses. The primary variables include:

Establishment Type: Categorizes each food service entity into various types, such as restaurants, cafes, fast food outlets, and food trucks. This classification assists in assessing the specific risks associated with different service models.

Inspection Date: Records the dates on which food safety inspections were conducted, allowing for temporal analysis of compliance and identification of any seasonal trends in food safety issues.

Establishment Status: Indicates the outcome of each inspection. This variable is crucial for evaluating the compliance levels of food establishments.

Severity of Violations: Details the severity of any violations found during inspections, categorized into minor, significant, or critical. This helps in understanding the extent of non-compliance and potential health risks.

Min. Inspections Per Year: This column typically refers to the minimum number of inspections that an establishment, such as a restaurant or food service provider, is required to undergo annually.

2.3. Model introduction

Through the data analysis presented in this paper, discover that there is a correlation between Establishment Type, Severity, the minimum number of inspections per year and the result. To further analyse the relationships, construct a logistic regression model to model the relationship [11]. Define the model as follows: $Yi \mid \pi i \sim Bernoulli(\pi i)$, $logit(\pi i) = \alpha + \beta_1 \cdot Establishment\ Typei + \beta_2 \cdot Severityi + \beta_3 \cdot Min\ Inspections\ Per\ Yeari$, $\alpha \sim N(0,10)$, $\beta_j \sim N(0,10) for\ j = 1,2,3$.

The outcome variable Yi represents whether a food establishment passes (1) or conditionally passes (0) an inspection, where the probability of establishment i passing the inspection is denoted by πi. The outcome variable Yi follows a Bernoulli distribution with probability π_i , indicating that each establishment either passes or does not pass the inspection with the specified probability. The logit function, logit(π_i), is used to transform the probability π_i to the log-odds scale. The model includes an intercept term, α, which represents the log-odds of passing the inspection when all predictor variables are zero. The coefficients β_1, β_2, and β_3 correspond to the predictors Establishment Type, Severity of infractions, and Minimum Inspections Per Year, respectively. A prior distribution is assumed for the intercept and coefficients, modelled as normally distributed with a mean of 0 and a standard deviation of 10, which represents the prior belief about their values before seeing the data. The logistic regression model allows people to estimate the impact of each predictor variable on the likelihood of a food establishment passing an inspection, while accounting for the potential correlation between predictors. Unlike linear regression, there is no formula for the estimates of β for logistic regression [12, 13]. By analysing the estimated coefficients, identify the relative importance of each predictor and make informed decisions regarding food safety measures and regulatory interventions.

3. Results and discussion

3.1. Data preprocess

To organize the timeline within the dataset to track the monthly variation in the number of restaurant violations from 2022 to 2024, to validate my hypothesis about the seasonal impact on food safety in Toronto. Figure 1 shows the trend in the number of restaurant violations over time and provides a general overview. There are two noteworthy observations: first, there is a significant increase in violations in 2024 compared to 2022 and 2023. This trend indicates that food safety violations are worsening, which may suggest a need for stricter safety measures or policy intervention. Second, both in 2023 and 2024, there is a pattern of seasonal fluctuations-peaks and troughs-that repeats annually, which could imply that certain times of the year are associated with a higher rate of violations. This may be related to periods of increased food service activity, such as holidays or festivals. Additionally, the most significant peaks occur in the middle of the year and at the beginning of the next year. The mid-year

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peak could be associated with summer activities when food related events and outdoor dining are likely to increase. The early-year peak could be related to the winter holiday season, which traditionally sees an increase in dining out.

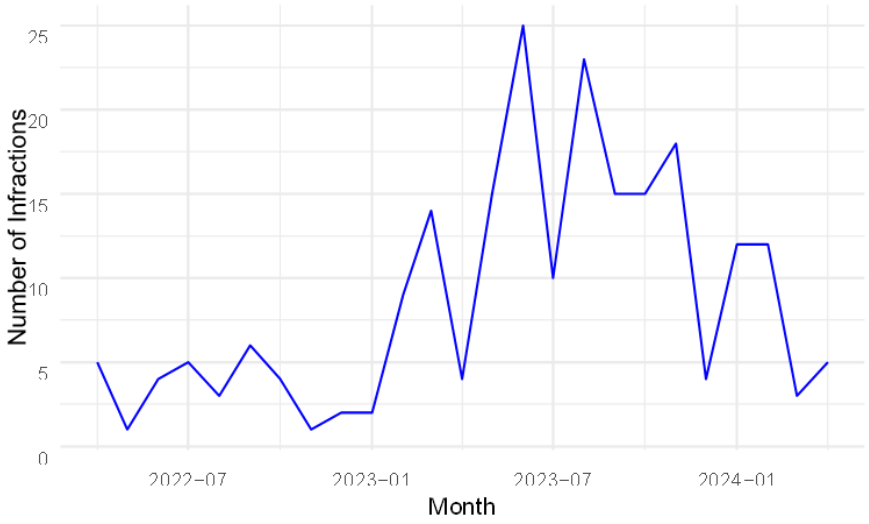

Figure 1. Summarize data by month

Figure 2 focuses on the outcomes of food safety inspections across different types of dining establishments, revealing that the "Restaurant" category has a noticeably higher rate of both passes and conditional passes. This indicates that restaurants are either inspected more frequently or are simply more numerous compared to other types of establishments. Concurrently, there is a considerable number of conditional passes in the categories of "Restaurants," "Food Take Out," and "Private Clubs." A conditional pass typically signifies minor infractions that need to be addressed but are not severe enough to necessitate immediate closure. Other establishment types, such as "Bakeries," "Food Stores," and "Cocktail Bars," have relatively fewer inspections, which might reflect their smaller scale of operation or different inspection frequency policies. It is evident that Toronto's regulatory authorities are concentrating their inspection efforts on restaurants, and there is insufficient scrutiny of other food establishments like mobile food carts and small eateries, which may require additional focus or assistance to meet food safety standards.

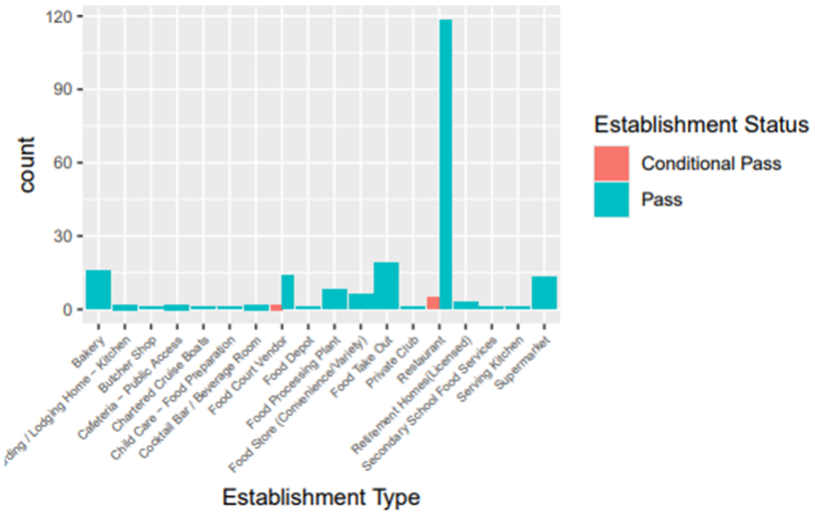

Figure 2. Relationship between Establishment Type and Establishment Status

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Figure 3 illustrates the relationship between the status of establishments following inspections—either 'Pass' or 'Conditional Pass'-and the minimum number of inspections per year. A 'Conditional Pass' suggests that violations were identified during the inspection, which were rectified before final approval was granted. It is observable that there are more points for the 'Pass' status, indicating that most establishments comply with food safety standards during inspections. There are outliers with a higher frequency of inspections, possibly reflecting a targeted approach towards establishments that had prior violations or are considered high-risk. Notably, the 'Conditional Pass' status, marked in red, is less common and appears after a higher threshold of inspections, specifically after 2.5 inspections per year. Establishments with fewer than 2.5 inspections per year show no 'Conditional Pass' outcomes, suggesting that an increase in the minimum number of inspections could lead to the identification of more violations.

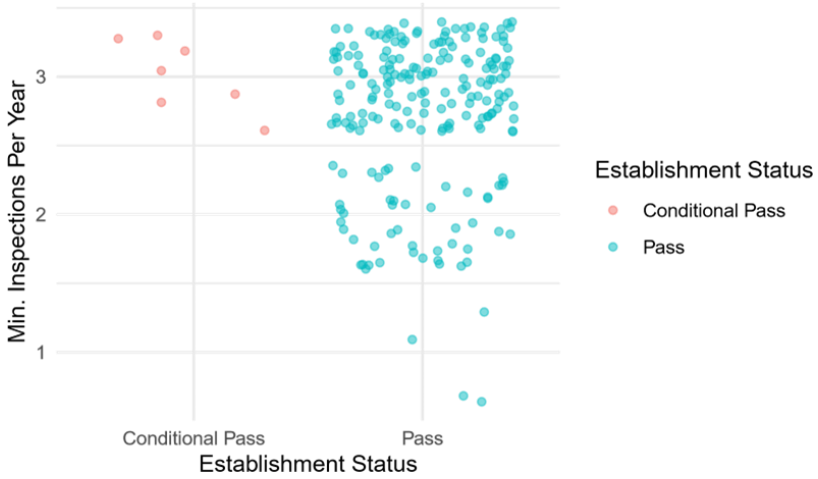

Figure 3. Relationship between wing Min. Inspections Per Year and Establishment Status

Figure 4 depicts the frequency of food safety violations across different types of establishments, organized by the severity of the infractions, which are color-coded: 'Crucial' [red], 'Minor' [green], 'Not Applicable' [blue], and 'Significant' [purple]. The chart demonstrates that most violations are minor, as indicated by the predominance of green. However, attention is drawn to the categories featuring red and purple bars, signifying more severe infractions. Notably, establishments such as supermarkets, take-outs, restaurants, mobile food carts, and bakeries are prominent, suggesting that these categories have more complex issues that require additional investigative support.

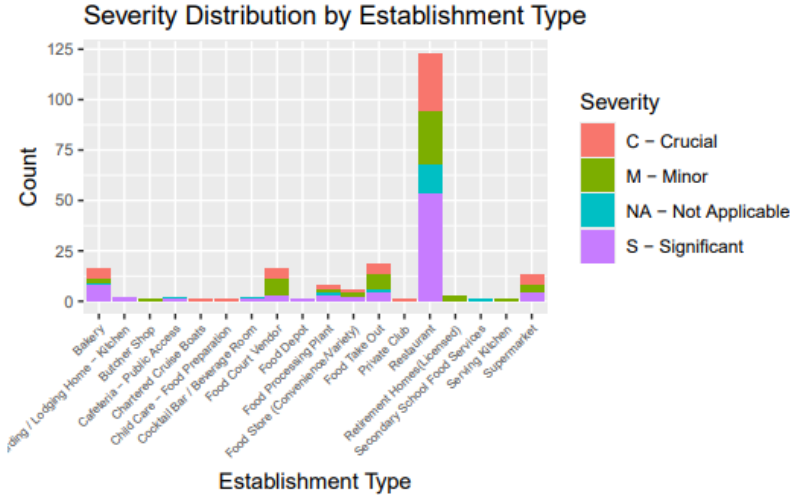

Figure 4. Relationship between Establishment Type and Severity

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3.2. Model results

The analysis of the Bayesian logistic regression model reveals several key insights into the factors affecting compliance rates across various food service establishments. Notably, Food Court Vendors and Restaurants exhibit significant negative coefficients, -3.087 and -2.070, respectively, suggesting that these types of establishments generally have lower compliance rates, likely due to challenges in maintaining food safety standards. Conversely, Food Take Out services show a positive coefficient 0.771, indicating higher compliance, possibly due to simpler operational processes. Severity levels also play a crucial role, with Minor and Significant severities showing negative impacts on compliance rates, as coefficients for Severity Minor and Severity Significant are -1.264 and -1.781, respectively. This indicates that more severe violations are associated with lower compliance rates. Additionally, interaction terms further underscore the challenges faced by these establishments under strict inspection conditions, with coefficients of -1.532 and -1.595. These findings highlight the importance of targeted regulatory strategies to improve food safety practices across differing service types and severity levels.

The visualization of the top 7 effect sizes and their 95% confidence intervals from the logistic regression model reveals several impactful predictors (Figure 5). According to figure,the intercept stands out with a substantial positive value, suggesting a high baseline likelihood of passing food safety inspections when other variables are at zero. Notably, food court vendors are significantly less likely to pass an inspection, as indicated by a large negative coefficient. Moreover, an increased frequency of inspections per year correlates with a lower probability of passing, possibly reflecting stricter scrutiny or insufficient time for establishments to address issues. Moreover, an increased frequency of inspections per year correlates with a lower probability of passing, possibly reflecting stricter scrutiny or insufficient time for establishments to address issues. The interaction terms, especially for restaurants and food court vendors when coupled with significant severity violations, suggest a compounded negative impact on passing inspections. Restaurants also display a negative coefficient independently, further emphasizing the challenges they face. Lastly, the presence of significant severity violations markedly decreases the likelihood of passing, underscoring the stringent penalties for severe.

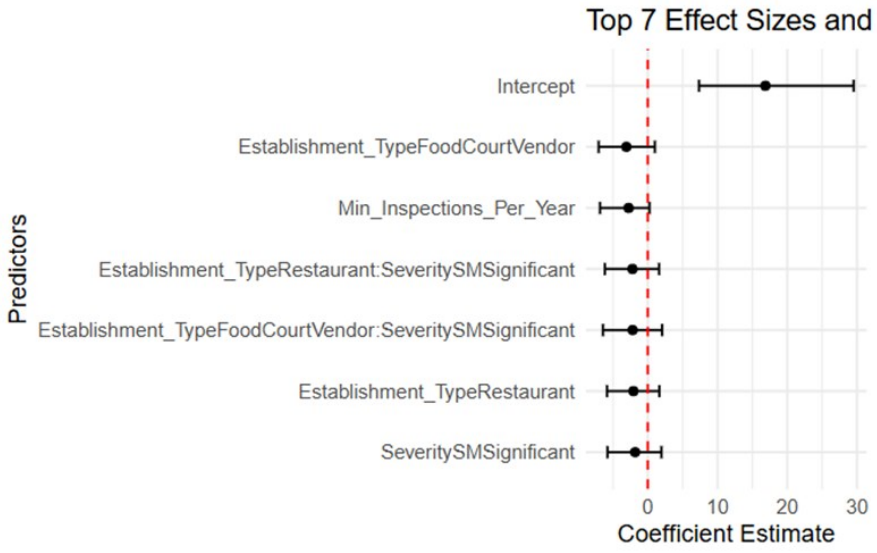

Figure 5. Summarize Top 7 effect data.

4. Conclusion

The correlation between food safety and the operational modes of providers in Toronto is significant. For instance, restaurants, being fixed establishments with permanent structures, face challenges in ensuring food safety due to the large number of establishments and limited inspection personnel. On the other hand, mobile food vendors, often found on the streets, predominantly serve fast food like hot dogs

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and hamburgers. The affordability and simplicity of their production environments often lead to hygiene issues. It's noteworthy that supermarkets also pose significant food safety risks. In some Toronto supermarkets, it's not uncommon to find products like milk that have expired by a day, possibly due to negligence on the part of store managers. Conversely, suppliers such as food warehouses demonstrate commendable pass rates and favourable inspection results, indicating that Toronto's food storage and transportation processes are reliable.

It is recommended that relevant authorities increase regulatory oversight on enterprises with frequent food safety issues, including restaurants, mobile food vendors, and supermarkets. This proactive approach can help mitigate risks and enhance overall food safety standards in Toronto.

Based on the research analysis, a significant number of food-related enterprises reveal issues only after more than 2.5 inspections, while the probability of passing on the first inspection is very high, close to one hundred percent. This underscores the importance of inspection frequency, as more frequent inspections of food establishments are conducive to improving the overall safety standards of Toronto's restaurant industry and food supply. According to the results depicted in the charts, given the considerable number of enterprises found to engage in non-compliant behaviour, the author recommends that relevant authorities increase the minimum number of inspections to at least three times. This measure will effectively address food safety concerns in Toronto.

According to the research findings, the Toronto government should adjust its inspection system based on seasons. For example, during periods of high temperatures when food safety issues are more common, or during holidays when there is increased customer traffic, temporarily increasing the frequency of random inspections could effectively alert some businesses to hygiene issues. As the number of violations detected increases over time, indicating worsening food safety problems in Toronto, it is necessary to increase the severity of penalties and inspection frequency to warn food companies. Food safety concerns affect the health of every Toronto citizen.

The importance of food safety is not fully appreciated by many public health authorities despite a constant increase in the prevalence of foodborne illness. The next step could involve exploring how different categories of restaurants are penalized for violations to assess the efficiency of the penalty mechanism in reducing violations, along with analysing the final review results. Additionally, refining the logistic regression model and incorporating information on the horizontal and vertical coordinates of each restaurant could facilitate the creation of a violation map. This map would allow for the analysis of areas with a high incidence of food safety issues.

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