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Critical Food Safety Violations in Food Facilities by Regions Across Calgary Communities From 2022 Versus 2023

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Walden University

College of Health Sciences and Public Policy

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Kamorudeen Olayinka Bakare

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Walden University

2025

Abstract

Critical Food Safety Violations in Food Facilities by Regions Across Calgary

Communities From 2022 Versus 2023

by

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MS, University of Lagos, Lagos, Nigeria, 1996

BS, University of Agriculture, Makurdi, Nigeria, 1990

Dissertation Submitted in Partial Fulfilment

of the Requirements for the Degree of

Doctor of Philosophy

Public Health

Walden University

November 2025

Abstract

Critical food safety violations in food facilities are severe infractions that may affect the quality and safety of foods as well as the health and wellbeing of consumers in Canada. In 2023, Alberta Health Services heightened scrutiny on these violations in Calgary. However, no investigation has been undertaken to document its potential effects on types and trend (from the previous year) of food safety violations in food facilities across Calgary regions. The purpose of this quantitative study was to examine the associations between Calgary regions of Canada, Year (2022 versus 2023), and the number of types of critical food safety violations (temperature control deviations, poor sanitation, pest control issues, poor personal hygiene, and unsuitable food conditions). Year and region were the predictor variables and critical food safety violations were the outcome variable. The study was based on the Epidemiology Triangle Theory, which explains that infections are caused by the interactions of the environment, the agent, and the host. Secondary data from inspection reports by Calgary zone of Alberta Health Services between 2022 and 2023 ($N = 877$) were used. Based on chi-square test of independence, there was a statistically significant association between violation type and year [$\chi^2(4, N = 877) = 11.94, p = .018$] as well as between violation type and region [$\chi^2(12, N = 877) = 35.46, p < .001$]. In 2023, there were reduced number of poor sanitation and temperature control deviations compared to 2022, suggesting that recent efforts may have some benefits on food safety in Calgary. Findings, though preliminary, highlight the need for more public health interventions to reduce food safety violations in this region and identify the areas most impacted on which such interventions should be targeted.

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Dedication

To the memory of my mom who lived mostly as a widow and a single mother. She sacrificed all for my education. I pray that Almighty Allah forgive her shortcomings and grant her paradise. Aameen.

Acknowledgments

All praises to the Almighty Allah for His guidance and mercies to complete this journey. Special thanks to my committee members, Dr. Nancy Rea, Dr. Harrison Ndetan and Dr. Kate L. Callahan-Myrick for their mentorship and support. I thank the faculty members and all those who guided me during my study at Walden University. I appreciate the support of my family members - Rasheedat, Abdullah, Ibrahim, Layla, Halima and Aisha. Your encouragement was instrumental to the completion of my study.

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Chapter 1: Introduction to the Study

Introduction

This research was conducted to examine critical food safety violations in food facilities across Calgary regions in 2022 and 2023. I also explored the socioeconomic factors status (age, gender, race, income, and educational level) in communities across Calgary regions. Critical food safety violations in food facilities are severe deviations that may affect the quality and safety of foods as well as the health and well-being of the consumers. According to Reynolds (2022) critical food safety violations include improper food handling, poor sanitation, temperature control deviations, lack of pest control strategies and other deviations in food facilities linked to microbial contamination and occurrence of foodborne illness in consumers.

The city of Calgary is in western Canada at the southern part in the province of Alberta. As the largest city and with the highest population in the province of Alberta, Calgary has hundreds of neighborhoods and communities classified primarily into four regions/quadrants named Northwest (NW), Northeast (NE), Southwest (SW), and Southeast (SE) (Havre, 2024). There are several food service facilities across regions in the city of Calgary ranging from cafeterias, restaurants, canteens, fast food outlets, hotels, ethnic food service providers, and other establishments that serve food for public consumption. The Alberta Food Regulation AR 31/2006 establishes the laws that regulate the activities of food service facilities across the province of Alberta including the city of Calgary. The Alberta Food Regulation AR 31/2006 applies to all categories of food facilities irrespective of establishment size and nature of food served. Food facilities must

adhere to the provisions of the regulations, and failure to comply may result in financial penalties and business closure (Government of Alberta, 2024; FoodSafetyMarket, n.d).

This research will compare critical food safety violations in food facilities across Calgary regions with focus on critical food safety violations reported in Years 2022 and 2023 by public health inspectors (PHIs).

The critical food safety violations that will be examined are temperature control deviations, poor sanitation, pest control issues, poor personal hygiene, and unsuitable food conditions. This study is necessary because of the reported insufficient food safety inspections conducted by PHIs and the subsequent detection of critical food safety violations leading to outbreak of foodborne infections. In terms of positive social change, the research will examine trends and number of types of critical food safety violations in food facilities across Calgary regions to provide detailed understanding of the needed improvement in policy formulation for food facilities inspection. Furthermore, the study will provide insights towards improvements of food safety standards and practices in Calgary through the identification of the frequent types of food safety violations amongst food facilities and thereby limit occurrence of foodborne infections in the communities. The outcome of the study could also provide an indicator on the aspects of food safety training and the regions that required attention.

This chapter will provide preliminary information on background to the study, problem statement, purpose of the study, research questions and hypotheses. The chapter will also highlight theoretical framework for the research, nature of study, definitions, and assumptions. Finally, this chapter will examine the research scope, delimitations,

limitations, an explanation on the significance of the study and a summary of the preceding sections.

Background

Food safety violations in establishments that prepare food for public consumption are one of the major causes of foodborne infections. According to Ehuwa et al. (2021), food contamination in food service facilities is significantly influenced by workers with direct impact on the occurrence of critical food safety violations and its resultant public health consequences. Ehuwa et al. (2021) and Reynolds (2022) identified food safety violations such poor personal hygiene, lack of food safety knowledge, food handlers' attitude, pest infestations, poor equipment design, unapproved food sources, poor sanitation, temperature abuse and other deviations which contributed to food contamination. According to Reynolds (2022), critical food safety violations are described as serious non-compliances in food safety practices with a high probability of causing foodborne illness. The types of critical food safety violations commonly encountered in food facilities include improper food handling, temperature deviations, sanitation issues, pest infestation, and poor personal hygiene which can cause food contamination and growth of disease-causing microorganisms (Reynolds, 2022). In this study, the critical food safety violations in food facilities across Calgary regions in 2022 and 2023 will be examined with focus on temperature control deviations, poor sanitation, pest control issues, poor personal hygiene, and unsuitable food condition.

Geographical location is a factor that influences performance of food facilities including occurrence of critical food safety violations. Based on a study conducted in the

United States between 2010 and 2019 which focused on food safety violations among school system in urban municipalities, Reynolds (2022) noted that lack of food safety knowledge, temperature abuse and inadequate supplies accounted for serious food safety violations. Moritz et al. (2023) reviewed National Environmental Assessment Reporting System (NEARS) in 25 states and local health departments in the United States between 2017 and 2019. It was observed that 800 cases of foodborne infectious diseases were connected to 875 retail food outlets during the period investigated in which salmonella and norovirus accounted for most of the outbreaks of which 40% of the incidents were attributed to a sick or infected food handler (Moritz et al., 2023). In a similar investigation, Lunden et al. (2021) conducted a study on restaurants operations in Finland to determine the reasons for differences in their performance. Results from the investigation revealed regional and local discrepancies in inspection scores. Lunden et al. (2021) attributed the variation in inspection scores from the various regions to inconsistency in the assessment protocol and the economic status of the location of restaurants. In another study conducted across regions in Finland, Kosola et al. (2023) reported that food facilities with low inspection grades were linked with incidence of *Salmonella* and *Campylobacter* infections attributed to critical food safety violations.

The city of Calgary is in western Canada at the southern part in the province of Alberta. Geographically, Calgary is located at the confluence of the Bow and Elbow rivers, and the city has been a gathering point for Indigenous peoples for thousands of years, sharing knowledge and planning for future generations (City of Calgary, n.d.). Calgary is the third largest municipality in Canada with a population of 1.3 million

people and the average age of Calgarians is 37 years, with 41% identified as visible minorities living in the city. The city has the highest personal income per capital of Canada's major cities, the highest GDP per capital of major Canadian cities, and the second lowest cost of living in Canada (City of Calgary, n.d.).

According to Havre (2024), Calgary has hundreds of neighborhoods and communities classified primarily into the city's four geographical quadrants/regions which are named as Northwest (NW), Northeast (NE), Southwest (SW), and Southeast (SE) (See Appendix A). Northwest Calgary consists of 40 primary neighborhoods including Tuscany, Arbour Lake, and Rocky Ridge. Other communities in Northwest Calgary are Park Ridge Estates, Livingston, and Abbeydale. Northeast Calgary comprises 35 residential communities which include Bridgeland, Marlborough, Skyview Ranch, Saddle Ridge and Falconridge (Havre, 2024). On the other hand, 14 distinct neighborhoods such as Shawnee Slopes, Woodbine, and Bridlewood made up the Southwest quadrant, while 28 communities including McKenzie Lake, Sundance, and Fairview neighborhoods made up the Southeast quadrant in the city of Calgary (Havre, 2024).

The COVID-19 pandemic affected the frequency of food facilities inspections conducted by PHIs. This study will examine critical food safety violations in food facilities across Calgary regions for 2022 and 2023 which are periods that borders relieve from the effects of COVID-19 pandemic. According to Charlebois and Music (2021) the pandemic had serious impacts on the meat packing facilities in Alberta with the largest outbreak of COVID-19 of more than 1,500 cases recorded at the Cargill beef packing

plant in High River South of Calgary. In the study of the effect of the COVID-19 pandemic on food safety violations, Young et al. (2023) reported a decrease in the number of food safety inspections conducted on food facilities in the city of Toronto. The combined impact of emergency lockdown and focus of PHIs on contact tracing of COVID-19 cases resulted in lower number of food facilities inspections conducted after the resumption of regular inspections in 2020 compared to prepandemic periods until mid-2022 (Young et al., 2023). A study conducted by Smith and Heacock (2022) on food safety violations and frequency of inspections of food facilities during COVID-19 pandemic in Vancouver Island, British Columbia, Canada, revealed a lower frequency in restaurant inspections and a reduction in the number of food safety violations from 2019 to 2021. The study also confirmed that the number of inspections with critical violations reduced across the regions between 2019 to 2020 with an uptick in 2021 across regions in Vancouver Island (Smith & Heacock, 2022). In another study, Shah and Kambo (2023) examined the effect of COVID-19 pandemic on postpandemic food safety with attention on the restaurants in Fraser East region of British Columbia, Canada. Findings showed a reduction in the number of sanitation related violations in 2022 compared to 2019 among restaurants in the same region. Furthermore, it was observed that the mean overall hazard score for restaurants in 2022 increased compared to 2019 (Shah & Kambo, 2023). The current study will examine critical food safety violations in food facilities across Calgary regions in 2022 and 2023. Alberta Health Services (AHS, n.d.b) reported that temperature abuse, sanitation issues and pest infestations accounted for most critical food safety violations in food facilities across Calgary regions in 2022. The trend of critical food

safety violations in food facilities during 2023 were similar to 2022, however the outbreak of *E.coli* O157 traced to a central kitchen that supplied food to some daycares in Calgary was a notable event. The kitchen had five reported violations, three of which were critical food safety violations which included temperature control deviation, pest infestation, and poor sanitation (Entis, 2023).

The critical food safety violations that will be considered in the present study include temperature control deviations, poor sanitation, pest control issues, poor personal hygiene, and unsuitable food conditions. According to Hartantyo et al. (2023), the danger zone temperature for food is 4°C (40°F) and (140°F) 60°C, and deviation from this range was regarded as a critical food safety infraction and creates a condition that supports the growth of pathogenic microorganisms. Ishak and Rabbania (2022) noted that the lack of proper sanitation practices and hygiene constitutes a critical food safety violation in food facilities, and it is often considered by consumers as condition for patronage. Herniwanti and Jayanti (2022) emphasized the importance of employees, equipment, food, and operating environment as crucial to maintaining good sanitation and hygiene in food facilities. Furthermore, the concept of sanitation includes the availability of portable water for cleaning, provision of hand washing stations, toilets facilities and adequate storage space (Herniwanti & Jayanti, 2022). Poor personal hygiene by food handlers constitutes a critical food safety violation. Alemayehu et al. (2021) reported that effective training of food handlers is important to ensure the understanding of hygiene and sanitation protocol required in food facilities. Inadequately trained food handlers lack the knowledge of correct handwashing procedures, insufficient knowledge of basic food

handling and use of personal protective clothing (Alemayehu et al., 2021). According to Sousa et al. (2022) pest infestation is a critical food safety violation in food facilities. In a study conducted in Vitória City, Espírito Santo State, Brazil to analyze hygienic-sanitary conditions in restaurants, it was observed that cockroaches, flies, and ants were common pests found in food preparation areas (Sousa et al., 2022). Unsuitable food conditions were another type of critical food safety violation observed in food facilities. In May to August 2021 an outbreak of *Salmonella Typhimurium* infections reported across health districts in Ontario Canada was linked to consumption of ready-to-eat seasoned Tofu distributed by a manufacturer to restaurants (Osasah et al., 2023). According to Johnson et al. (2023) factors such as inadequate infrastructure, lack of supplier verification procedure, insufficient training and poor hygiene standards were some of the causes of unsuitable food handling conditions in food establishments.

Food safety inspection and monitoring of food service facilities is a tool used to prevent foodborne diseases and provide oversight on the activities of food businesses. Barnes et al. (2022) reported that food safety inspection was viewed as an essential tool for protection against consumption of unsafe food. The disclosure of the outcome of inspection to consumers was regarded as a means of assurance that food service establishments and facilities complied with food safety standards and consumers view food safety inspection as a statutory responsibility of government towards protection of public health (Barnes et al., 2022).

PHIs are integral part of the public health resources in Canada and in the province of Alberta. According to AHS (n.d.a), the primary objective of a PHI was to identify and

eliminate public health hazards by conducting risk analysis, inspections, and responding to public health complaints. PHIs enforce the provisions of Public Health Act regulations, collect samples, and provide education to operators as a tool to ensure compliance.

This study will provide knowledge on the types of critical food safety violations reported across Calgary regions in 2022 and 2023 and insights on discrepancies between the 2 years across regions. The research is needed because it will provide public health policy makers with tools to understand the variations in food safety violations and to allocate resources for food handlers training and dispatch PHIs to the most required regions.

Problem Statement

The frequent closures of food service facilities by local authorities due to critical food safety violations are connected to poor food safety practices, insufficient food inspections, and failure to comply with food safety regulations among food facilities in Calgary regions. Ashwood et al. (2021) explained that the high numbers and severe nature of food safety violations can pose risks to public health which is an indication of the potential deficiencies in food handling practices within food facilities. Researchers have investigated the issue of critical food safety violations in food service facilities in other Canadian jurisdictions, however, there has not been a comprehensive study to examine critical food safety violations from food establishments across Calgary regions with focus on the number of types of critical food safety violations (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food condition*) during the last 3 years. In addition, this study will explore the

socioeconomic factors of the individual Calgary regions such as age, gender, race, income, and education level. The recent outbreak of *E. coli* in some daycare facilities in Calgary was attributed to inadequate food facilities inspection within the city (Derworiz, 2023; Toy and Swensrude, 2023). The lack of comprehensive understanding and comparison of the trends, patterns, and nature of critical food safety violations in food facilities across Calgary regions for 2022 versus 2023 is a challenge that this study will explore.

Purpose of the Study

The purpose of this study is to examine the association between Calgary regions for 2022 versus 2023 and the number of types of critical food safety violations (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions*) in food facilities.

Research Questions and Hypotheses

The research questions and the hypotheses for the study are stated below.

RQ1: Is there an association between the Year (2022 vs. 2023) and number of types of critical food safety violations (temperature control deviations, poor sanitation, pest control issues, poor personal hygiene sanitation and unsuitable food conditions) in food facilities in Calgary regions?

H_0 1: There is no association between the Year (2022 vs. 2023) and number of types of critical food safety violations (temperature control deviations, poor sanitation, pest control issues, poor personal hygiene, and unsuitable food conditions) in food facilities in Calgary regions.

*H*₁₁: There is an association between the Year (2022 vs. 2023) and number of types of critical food safety violations (temperature control deviations, poor sanitation, pest control issues, poor personal hygiene, and unsuitable food conditions) in food facilities in Calgary regions.

RQ2: Is there an association between the regions of food facility in Calgary and number of types of critical food safety violations (temperature control deviations, poor sanitation, pest control issues, poor personal hygiene, and unsuitable food conditions)?

*H*₀₂: There is no association between the regions of food facility in Calgary and number types of critical food safety violations (temperature control deviations, poor sanitation, pest control issues, poor personal hygiene, and unsuitable food conditions).

*H*₁₂: There is an association between the region of food facility in Calgary and number types of critical food safety violations (temperature control deviations, poor sanitation, pest control issues, poor personal hygiene, and unsuitable food conditions).

Theoretical and/or Conceptual Framework for the Study

The epidemiology triangle theory (ETT) provides a framework for the understanding of disease transmission with the involvement of three important factors - the agent, the host, and the environment (Liu et al., 2023). ETT is relevant to the fundamental knowledge of prevention and control of infectious diseases including foodborne illnesses connected to critical food safety violations such as temperature control deviations, poor sanitation, pest control issues, poor personal hygiene, and

unsuitable food conditions. According to Jannah et al. (2024), the ETT, also known as the epidemiologic triangle or triangle model, is the basic concept in epidemiology that explains the mechanism of interaction among the components require for the development of a disease condition. Described as the fundamental basis of ETT, the *epidemiology triad* explains the epidemiologic concept of the interaction between the three essential components in the development of disease (John & Kompithra, 2023).

The significance of the ETT in foodborne disease is its ability to link the three key factors of the agent (the pathogen causing the disease), the host (the individual affected by the disease) and the environment (the conditions that allow for the disease to spread). The ETT is relevant to the topic of critical food safety violations in food facilities across Calgary communities because it can assist to identify the factors that contribute to food safety violations. According to John and Kompithra (2023), identifying the specific pathogen and conditions responsible for an infection can help direct control measures and provide policy makers with necessary pathways to stem further transmission of foodborne illnesses.

Nature of the Study

This quantitative study will use a cross-sectional comparative analysis design to address the research questions. The study will compare number of types of critical food safety violations in food facilities across Calgary regions over a 2-year period. Information for the study will be obtained from the website of AHS. The publicly available information in the form of PHIs report will provide secondary data sources which include details of food facility names, Calgary regions, type of food safety

violations and reported date of violations. Other information from AHS website is the description of the violations, inspector comments and the relevant section of the regulation violated. The data collected will be analyzed to identify patterns, trends, and determine potential association between number of types of critical food safety violations across Calgary regions in 2022 and 2023.

Definitions

Calgary regions: This consists of hundreds of neighborhoods and communities which are divided into four geographical quadrants/regions which are named as Northwest (NW), Northeast (NE), Southwest (SW) and Southeast (SE) (Havre, 2024).

City of Calgary: The city of Calgary is in western Canada at the southern part in the province of Alberta. Calgary is located at the confluence of the Bow and Elbow rivers, and the city has been a gathering point for Indigenous peoples for thousands of years, sharing knowledge and planning for future generations (City of Calgary, n.d.).

Critical food safety violations: These are severe noncompliances in food safety protocols and procedures which could result in a high likelihood of causing foodborne illness or harm to consumers (Reynolds, 2022)

Northeast Calgary: This comprises of 35 residential communities which include Bridgeland, Marlborough, Skyview Ranch, Saddle Ridge and Falconridge (Havre, 2024).

Northwest Calgary: This consists of 40 primary neighborhoods including Tuscany, Arbour Lake, and Rocky Ridge. Other neighborhoods in Northwest Calgary include Park Ridge Estates, Livingston, and Abbeydale (Havre, 2024).

Pest control issues: Pest control issues are the challenges of eliminating pests that can contaminate food and spread foodborne diseases in food facilities (Liba et al., 2022).

Poor personal hygiene: This refers to the behaviors and activities of food handlers that constitutes a significant factor in food safety practices with serious health risk implications for consumers (Verrill et al., 2021).

Poor sanitation: This refers to the inadequate maintenance of cleanliness and hygiene standards in a food facility which can lead to food contamination and health risks for consumers (Ishak & Rabbania, 2022).

Public health inspectors (PHIs): They are also called environmental health officers (EHOs). These are public servants that play key roles in protecting public health by ensuring food safety and preventing foodborne diseases by supporting food facilities to maintain a high standard of food safety and sanitation Alberta Health Services (AHS, n.d.a).

Southeast Calgary: This consists of 28 communities including McKenzie Lake, Sundance, and Fairview neighborhoods. Other communities in the Southeast are Riverbend, McKenzie Lake, Cranston, Belmont, and Auburn Bay (Havre, 2024).

Southwest Calgary: This consists of 14 distinct neighborhoods including Shawnee Slopes, Woodbine, Bridlewood, Aspen Woods, Shawnessy, Oakridge, and Altadore (Havre, 2024).

Temperature control deviations: Refers to instances where food is not maintained at the correct temperature, either hot or cold, during preparation, cooking, or storage, posing potential food safety risks (Reynolds, 2022)

Unsuitable food conditions: This describes circumstances where food is stored, prepared, or served in a manner that makes it unsafe for consumption, which can lead to foodborne illnesses (Johnson et al. 2023).

Assumptions

The current study on critical food safety violations in Calgary food facilities will be conducted based on certain assumptions. The study assumes accuracy of the information from food facility inspections report compiled by PHIs. The information obtained on the website of AHS used to generate secondary data is assumed to be accurate. The study also assumes that there are minimal variations in inspection protocols between 2022 and 2023. In addition, it was assumed that the provincial food safety regulations used by PHIs remain unchanged for 2022 and 2023. It was also assumed that a uniform reporting standard was used for food facilities to allow for unbiased comparison of data across Calgary regions.

Scope and Delimitations

The study was focused on food facilities within communities across Calgary regions with exclusion of food facilities outside the specified regions. Based on the years with complete food facilities inspection report, only data for 2022 and 2023 were considered for the study. Furthermore, the scope of the study examined only ‘critical’ food safety violations reported by PHIs in food facilities across Calgary regions for the specified years. In terms of delimitations, the study does not consider non-critical violations, and the investigation does not extend to other areas outside of Calgary regions.

Limitations

Limitations and challenges in this study may include potential inaccuracies in health inspection reports, variations in inspection standards across different regions, and the possibility that not all violations were reported. Additionally, the study only considered a 2-year period, which may not be representative of long-term trends. Barriers could include difficulty in accessing or obtaining the necessary data, especially if there are concerns about privacy or if the data are not publicly available.

Significance

This study is significant because of its potential to address meaningful, discipline-specific issues by providing a comparative analysis of the numbers of types of critical food safety violations in food facilities across Calgary regions. This will involve collecting and analyzing data from various food facilities in Calgary regions focusing on 2022 and 2023. The study will identify patterns and trends in critical food safety violations, which can support in understanding the areas that need improvement. The study will contribute to positive social change by providing valuable insights that can be used to improve food safety standards and practices in Calgary regions. By identifying the regions with the highest number of violations, targeted interventions can be implemented to reduce these violations, thereby improving food safety and public health standards in the implicated regions.

Summary

The study of critical food safety violations in food facilities has both public health and economic significance. Calgary is an important city in western Canada with an

increasing and diverse population in communities across the four regions. With focus on food facilities such as restaurants, canteens, cafeterias, hotels and other food establishments, the study examined the number of types of critical food violations (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene, and unsuitable food conditions*) for 2022 and 2023. The ETT provides a relevance theoretical framework for the study because it explains factors necessary for transmission of foodborne illness and their link to critical food safety violations. In addition, this chapter examined the scope, assumptions, delimitations, and significance of the study.

Chapter two of the study explored a comprehensive analysis of related literature. The chapter discussed literature search strategy, theoretical foundation and expanded on literature related to key variables in the study. Additional information was provided on the independent and dependent variables associated with the study. A review of methods and findings in past studies on food safety violations in food facilities were discussed and a summary of the topics covered in chapter two formed the concluding section.

Chapter 2: Literature Review

Introduction

Detecting and investigating food safety violations is one of the objectives of food safety inspections conducted by EHOs or PHIs. Food facilities in many parts of the world are faced with the requirement to meet food safety standards and regulations in one form or the other. The high numbers and severe nature of food safety violations is a direct result of insufficient food inspection and enforcement of food safety standards among food facilities in Calgary communities.

The problem to be addressed by this study is the concern on insufficient food inspections and lack of enforcement of food safety standards among food facilities in Calgary communities with the resultant increase in the number and types of critical food safety violations. Ashwood et al. (2021) reported that the increasing occurrence of critical food safety violations pose risk to public health and portray the lack of knowledge of food safety practices by food facilities workers coupled with insufficient inspections conducted by EHO or PHI.

The purpose of this study is to examine the association between Calgary regions for 2022 versus 2023 considering COVID-19 impact and the number of types of critical food safety violations (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene, and unsuitable food conditions*) in food facilities.

The need to meet established food safety standards and regulations by facilities and outlets serving food varies from one country to the other with differences among regional authorities. In Europe, there are notable variations in the food safety regulations

among the EU members states with some commonality in approach (Borraz et al., 2022). Study showed that the United States of America, New Zealand, Australia, Ireland, and the United Kingdom have similar practices in conducting food safety inspections (Barnes et al., 2024). In the United States and Canada, most of the food facilities safety inspections are conducted by states, provincial, and municipal health departments (Shah et al., 2022).

Food safety inspections are conducted by EHO or PHI to ensure adherence to food safety standards and to prevent food safety violations by facility operators. Critical food safety violations when detected in food facilities such as restaurants, cafeterias, institutional food service establishments and facilities where food is served indicate significant risks for patrons and the likelihood of foodborne infections. Critical food safety violations are deviations considered by EHO or PHI as major nonconformity detected as an outcome of food facilities inspections. In this study, the critical food safety violations that will be explored are temperature control deviations, poor personal hygiene, pest control issues, poor sanitation, and unsuitable food conditions.

Furthermore, the study will examine the types of food facilities considered across the regions in Calgary communities. The classification of communities within the city of Calgary will be explained with a focus on demographic and socioeconomic factors that characterized each community. The type of food facilities in an area is often associated with sociocultural, economic, and demographic factors of the community. Additionally, the educational level and knowledge of food safety by food handlers in establishments are related to the socioeconomic status of the community. It is common to find the

occurrence of critical food safety violations in facilities located within communities in which the residents have poor socioeconomic status. Barnes et al. (2022) explained that the concept of food safety inspection is viewed differently by various groups. A sector of society views food safety inspection as a means of assurance, and others view it as a process that lacks fairness and justification. In general, food safety inspection is mostly linked to a process conducted by government officers trained to execute the exercise (Barnes et al., 2022).

Lastly, this chapter will provide insight into the literature search strategy, including search terms and databases used. The chapter will also include an explanation of the theoretical foundation for the study, a literature review of key variables, and a section for summary and conclusion.

Literature Search Strategy

The literature review strategy includes the use of relevant library databases and search engines. Key search and combinations of search terms were utilized for the study. The library databases and search engines include PubMed (searches related to food safety-related research), Google Scholar (provide access to broad range of academic articles), Canadian Journal of Public Health (provides searches related to public health issues in Canada) and BCIT Environmental Public Health Journal (searches for specific issues related to food safety and public health). Other databases and search engines consulted are ProQuest (for dissertations, theses, and academic papers), EBSCOhost (searches on a variety of academic journals and articles), Web of Science (for comprehensive citation data and academic articles), ScienceDirect (provides relevant

searches on scientific and technical research) and Food Safety News (for industry-specific news and updates).

The key search terms and combinations include *food safety violations Calgary 2022*, *food safety violations Calgary 2023*, *food safety inspections Calgary 2022*, *food safety inspections Calgary 2023*, *critical food safety violations Calgary*, *food facility inspections Calgary*, *Calgary communities*, *food safety violations*, *temperature control deviations*, *poor sanitation*, *pest control issues*, *poor personal hygiene*, *unsuitable food conditions*, *food handlers training*, and *food safety enforcement*.

The articles searched were peer-reviewed studies from the last 5 years. This includes articles published focusing on food safety violations, inspection outcomes, and regional analysis. The other articles consulted are comparative studies which compare different regions or time periods to provide context for your findings. In addition, specific focus was on 2022-2023 critical food safety violations in Calgary. Seminal literature includes foundational studies and key reports that have shaped the understanding of food safety violations and public health policies. The literature and sources searched include peer-reviewed journals, government reports, industry reports, dissertations and theses, news articles, and books.

Theoretical Foundation

ETT is relevant to the prevention and control of infectious diseases including occurrence of foodborne illnesses which could result from critical food safety violations such as temperature control deviations, poor sanitation, pest control issues, poor personal hygiene, and unsuitable food conditions. According to Liu et al. (2023) ETT provides a

framework for understanding the process of transmission of diseases by focusing on the relationships between the agent, the host, and the environment. The ETT, also known as the epidemiologic triangle or triangle model, is the basic concept in epidemiology that explains the mechanism of interaction among the components required for the development of a disease condition (Jannah et al., 2024). According to John and Kompithra (2023), the 'Epidemiology Triad' forms the basis of the ETT. It is the basic concept in epidemiology that explains the interaction between the three essential components in the development of disease. This model is important for understanding how diseases spread and how they can be controlled. The account on the origin of the ETT varied. The theory was believed to have been created by Rudolf Virchow with his teaching that microbes are not responsible for pathology but rather invade damaged tissue with a view to explaining the importance of environment in disease development. Claude Bernard was also linked to the ETT. He explained that disease-causing agents were less important compared to the environment and discounted the teaching of Louis Pasteur that microbes caused diseases (John & Kompithra, 2023).

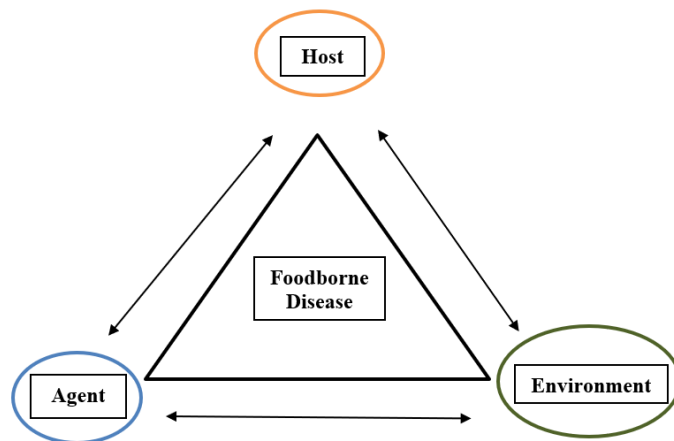
The significance of the ETT in foodborne infections lies in its ability to identify the three key factors involved in the spread of disease. By understanding the agent (the pathogen causing the disease), the host (the individual affected by the disease), and the environment (the conditions that allow for the disease to spread), public health officials can develop strategies to prevent and control foodborne infections. According to Liu et al. (2023), identification of specific pathogens attributed to infections provide an understanding for the appropriate control measures such as cooking food to required

temperature that kill harmful bacteria, thereby reducing the incidence of foodborne infections. Jannah et al. (2024) explained the host as an individual or group exposed to the disease. Related to foodborne infections, various underlying factors such as age and immune status play significant roles in susceptibility to infection. Hence, children, the elderly, and immunocompromised individuals are at higher risk of severe outcomes from foodborne illnesses. According to Foreman (2023), the environment is paramount in disease causation and transmission. Thus, implementing strict hygiene and sanitation practices in food facilities reduces the likelihood of contamination and outbreak of foodborne illnesses. The ETT is relevant to the topic of critical food safety violations in food facilities across Calgary communities because it can help identify the factors that contribute to food safety violations. For example, the agent could be a specific pathogen found in food facilities due to poor sanitation, improper temperature, or poor personal hygiene of food handlers. The host refers to individuals consuming the food, and the environment could be the conditions within the food facilities or in the community that allow for the pathogen to thrive. According to John and Kompithra (2023), identifying the specific pathogen responsible for an infection can help direct control measures. For example, ensuring that food is cooked to the correct temperature can eliminate pathogenic bacteria, thereby reducing the incidence of foodborne infections. Jannah et al. (2024) explained that the unique characteristics of the host assist in identification of high-risk groups and the appropriate measures for interventions. Thus, it is important to provide the necessary food safety education and knowledge to food handlers to reduce the risk of foodborne infections. Violations due to poor sanitation practices could indicate

an inherent problem with environmental factors within the food facility (Liu et al., 2023). In addition, variation in operational environment of the food facility and socioeconomic conditions of the residents of the community could dictate differences in the number and types of food safety violations across communities in Calgary. The ETT and its applicability to the study will be examined with focus on factors that are responsible for development of disease. According to John and Kompithra (2023) the *epidemiology Triad* are agent, host, and environment, and these form the basis of the ETT. These three factors are important to create an infection and in the understanding of measures for intervention (Jannah et al., 2024). The ETT is highly relevant to the study of critical food safety violations in food facilities across Calgary communities in 2022 versus 2023. This model can assist in analyzing how different factors contribute to critical food safety violations and identify areas for improvement. Figure 1 is the diagrammatic representation of the Epidemiologic Triangle.

Figure 1

Epidemiologic Triangle



Literature Review Related to Key Variables and/or Concepts

Regions and Type of Critical Food Safety Violations

Several studies looking at regional and other geographic locations show the importance of critical food safety violations in the food service industry. Reynolds (2022) studied the trend in food safety violations among large urban school system in different regions of the United States between 2010 and 2019. It was noted that critical and serious food safety violations included lack of food safety knowledge, poor temperature control in the food preparation process, and insufficient supplies. Reynolds (2022) observed that noncritical violations occurred more frequently and were linked to cleanliness and hygiene of the premises, issues with facility air exchange system, flooring, walls, ceiling and food contact-surfaces. The author explained that a 10-year period (2010–2019) of data analyzed showed a slightly downward trend in the number of food safety violations per inspection, however, the same kind of critical violations were noted throughout the period across the school system investigated in different regions which underscored the importance of providing food safety education and knowledge to food handlers (Reynolds, 2022). Moritz et al. (2023) investigated outbreaks of foodborne disease in retail food establishments through a review of the NEARS in 25 state and local health departments in the United States between the period of 2017 to 2019. A total of 800 foodborne disease outbreaks were linked to 875 retail food establishments according to reports submitted to NEARS by the participating health departments between 2017 to 2019. *Salmonella* and Norovirus accounted for 18.6% and 47.0% of outbreaks of which 40% of the incidents were connected to a sick or infected food handler (Moritz et al.,

2023). Critical food safety violations are an important public health issue that cannot be overemphasized as causative agents for foodborne diseases. This highlights the significance of following food safety protocols to avoid critical violations by ensuring adequate cooking temperatures, proper food handling to prevent cross-contamination, ensuring good personal hygiene, regular sanitization, and monitoring employees health to prevent spread of foodborne illnesses. Food facility operators should ensure regular internal audit, inspections, and training of food handlers to ensure adherence to standards and regulations (Augustin et al., 2020; Ehuwa et al., 2021).

Lunden et al. (2021) investigated the result of 4989 restaurants inspections conducted in Finland from 2014 to determine reasons for differences in inspection grades. The analyses showed local and regional discrepancies in inspection grades awarded to restaurants in addition to differences in the own check sections' scores and those of the food inspectors. According to Lunden et al. (2021), the large variations in result of restaurant inspections across regions and locality were attributed to inconsistency in the assessment protocol and outcomes. The study did not find adequate explanation from the food inspectors reports to justify the discrepancies in restaurant inspection grades, however noticeable trend showed that the differences in restaurant inspection grades were influenced by region and economic status of the location of restaurants (Lunden et al., 2021). The findings further suggested that the effects of economic status were mild, however the differences in restaurant inspectors' assessment result across locality and regions required intervention through training (Lunden et al., 2021). Kosola et al. (2023) examined regional food safety inspection reports and grades

obtained by food facilities in relation to occurrence of food borne illnesses linked to *Campylobacter* spp., *Salmonella* spp., enterohemorrhagic *Escherichia coli* (EHEC), and *Listeria monocytogenes*. Inspection report of local food establishments and data on foodborne diseases from 2014 to 2019 from Finland were utilized (Kosola et al., 2023). Results showed that across the regions, food establishments with low inspection scores were associated with incidence of *Salmonella* infections linked to violation in sanitation practices. Similarly, food establishments with low scores across regions exhibited an association with incidence of *Campylobacter* infections linked to unsuitable food handling and storage practices.

In the Philippines, Tumaliuan (2022) investigated the level of compliance to food safety standards by restaurants located in selected municipality of region two. Findings showed a significant difference in the standard of sanitation between restaurants. Similarly, results showed significant differences in compliance level to personal hygiene between and among the participating restaurants (Tumaliuan, 2022). Wafukho et al. (2021) studied compliance to personal and environmental hygiene practices to ensure food safety in selected public universities located in different regions in the city of Nairobi. The study enrolled 95 food handlers and 21 departmental managers in three universities across Nairobi which include Cooperative University of Kenya, Technical University of Kenya, and the University of Nairobi. The investigation focused on the food service facilities within the selected institutions with fully operated kitchens that consist of dry and cold storage units (Wafukho et al., 2021). Statistically analyzed data from interviews conducted showed a significant positive result in the observance of

personal hygiene by food handlers across the three institutions; however, onsite behavioral observations were not in agreement with participants responses to interview questions (Wafukho et al., 2021). Similarly, critical food safety violations were observed in all institutions in respect to environmental hygiene practices, contrary to claims of food safety compliance by operational staff (Wafukho et al., 2021). The present study will examine the number of types of critical food safety violations across regions in Calgary.

Year (COVID-19 Impact) and Critical Food Safety Violations

The COVID-19 pandemic started in late 2019 and lasted till 2023 affecting socioeconomic activities across the world. The impact of the global pandemic on all aspects of human life cannot be overemphasized and has significant effects on the food service industry. The years 2022 and 2023 are the main considerations in the present study and they coincide with the period of COVID-19 pandemic, hence the need to review the impacts of the global pandemic on food safety violations in food facilities during the period.

Charlebois and Music (2021) reported a significant impact of the COVID-19 pandemic on both food security and food safety in the province of Alberta and in Canada. The impact of COVID-19 disruptions from 2020 to 2022 in the retail food sector was significant across regions in Canada partly because of the country's low population density and high cost of distribution due to land mass. In the years of COVID-19 pandemic, it was estimated that 10 employees died across meat packing plants in which the Cargill beef packing plant in High River South of Calgary, Alberta recorded the largest outbreak in Canada with more than 1,500 cases. Additionally, three workers died

because of COVID-19 complications at the pork packing plant in Red Deer North of Calgary, Alberta (Charlebois & Music, 2021). In a study conducted by Young et al. (2023) in Toronto, Canada, the effect of the COVID-19 pandemic on food safety violations was examined. The study utilized PHIs' report for food facilities including restaurants from 2017 to 2022. The indices investigated in the study include number of inspections, pass ratings and total number of violations. Compared to the prepandemic period, it was noted that during the pandemic year, there was on average a 0.31 decrease in weekly violation rate and a 2% increased probability of passing inspections.

Furthermore, models estimated lower violation rates and higher pass rates for the period immediately after the COVID-19 pandemic compared to period before the pandemic (Young et al., 2023). The COVID-19 pandemic beginning from March 2020 disrupted food facilities inspection in Toronto due to the emergency lockdown and reassignment of PHIs to management of COVID-19 cases and contact tracing. The situation led to many food facilities and establishments not being inspected for several weeks, and the number of weekly inspections conducted after the resumption of regular inspections in 2020 were reduced compared to prepandemic periods until mid-2022 (Young et al., 2023).

Smith and Heacock (2022) studied food safety violations and frequency of inspections during COVID-19 in Vancouver Island, British Columbia, Canada. The investigation examined the impact of COVID-19 on restaurant infractions in Vancouver Island with its focus on food safety violations, inspection frequency, and hazard ratings. Data obtained from inspection reports from January 2019 to December 2021 were analyzed to ascertain if there was a change in hazard ratings, number of inspections

conducted, and total number of violations recorded (critical and noncritical violations) between 2019, 2020 and 2021 (Smith & Heacock, 2022). The investigation discovered a yearly decrease in restaurants inspection frequency and the total number of food safety violations across the three regions in Vancouver Island (North, South and Central) from 2019 to 2021. It was also established that the number of inspections that resulted in critical violations reduced across the regions between 2019 and 2020 with an uptick in 2021 in all regions (Smith & Heacock, 2022). In a similar study, Shah and Kambo (2023) investigated the impact of COVID-19 pandemic on postpandemic food safety with a focus on the restaurants in Fraser East region of British Columbia, Canada. Prepandemic inspection reports from 2019 and those of postpandemic for 2022 were obtained from the Fraser Health Region. The study findings suggested that food safety violations are connected to hygiene and sanitation, total hazard ratings of restaurants and distribution of food safety violations among restaurants across the region (Shah & Kambo, 2023). The number of sanitation related violations reduced in 2022 following the pandemic compared to same number of violations recorded in 2019 among restaurants across the Frazer region. There was an increase in the mean overall hazard score in 2022 as compared to 2019 for restaurants in the region (Shah & Kambo, 2023). These studies clearly showed there were significant impacts that incidences and events could have on critical food safety violations from year to year. This present study will examine critical food safety violations in food facilities across Calgary regions in 2022 versus 2023.

Year 2022 Versus 2023 and Critical Food Safety Violations

Fekadu et al. (2024) conducted a cross-sectional study from December 2022 to September 2023. The investigators recruited four hundred food handlers from twenty randomly selected food establishments in Lemi Kura, Addis Ababa, Ethiopia. The objective of the study was to assess the impact of knowledge, attitude, and practices of food handlers in commercial public food establishments on food safety violations. According to Fekadu et al. (2024), 65.5% of the food handlers that were examined understood food safety principles, and all food handlers demonstrated adequate knowledge of the importance of hand washing and temperature control in food handling. In terms of positive attitude towards food safety practices, 65.3% of the participants were proficient and 55.3% demonstrated good food handling practice. The study recommended formal training and education of food handlers to positively enhance their knowledge and attitude to reduce food safety violations and handling practices (Fekadu et al., 2024). Based on a report issued by the AHS, the critical food safety violations noted in the City of Calgary in 2022 include improper food storage linked to temperature abuse which is a precursor to growth of pathogenic microorganisms. In addition, many food establishments in Calgary were in contravention due to sanitation issues related to inadequate cleaning of kitchen surfaces and utensils and pest infestations due to poor pest control practices (AHS, n.d.c.). In 2023, the trend of critical food safety violations in Calgary food facilities was a continuation of the previous year. There was an outbreak of *E.coli* O157 traced to the central kitchen that supplies food to some daycares in Calgary. Several children were hospitalized due to the outbreak with severe health consequences.

The outbreak infected at least 264 people and sent thirty-seven of them to hospital in September 2023. Investigation revealed that the implicated kitchen had five food safety violations, three of which were critical. The critical food safety violations included inadequate temperature control, poor pest control practices, and insufficient sanitation (Entis, 2023). In another study, Ze et al. (2024) conducted a systematic review to examine food safety risk factors linked to food business operations from risk-based inspection. The study aimed to analyze and identify associated food safety risk factors that affect food business operators. The review utilized studies published between January 1 and February 1, 2023 and identified 53 relevant studies and 43 risk factors respectively (Ze et al., 2024). The presence of trained personnel in food business operation was identified as the most prominent cited factors that could enhance reduction in food safety risk of critical violations (Ze et al., 2024). Comparison of critical food safety violations in Calgary between 2022 and 2023 indicated that the types of issues were consistent, including improper food storage, poor sanitation, and pest infestations, however the event of the *E. coli* O157 outbreak from the central kitchen made the impact of the violations more severe in 2023 (AHS, n.d.c; Entis, 2023). The present study focused on the number of types of critical food safety violations (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene, and unsuitable food conditions*) in food facilities within communities across regions in Calgary in 2022 and 2023.

Number of Types of Critical Food Safety Violations

Reynolds (2022) explained that Critical food safety violations are severe noncompliances in food safety protocols and procedures which could result in a high likelihood of causing foodborne illness or harm to consumers. In most cases, critical food safety violations are related to improper food handling, storage, cooking, and sanitation practices that can lead to contamination and growth of pathogenic microorganisms. Based on a review conducted in Missouri, the top critical food safety violations are temperature control, improper equipment usage, and inappropriate utilization of poisonous and toxic materials. The three most common noncritical food safety violations include improper equipment usage, inadequate physical facilities, and inadequate equipment for holding food at a given temperature (Reynolds, 2022). Food handlers have direct impact on the occurrence of critical food safety violations and its consequences. Ehuwa et al. (2021) reported that the likelihood of food contamination depends on the personal hygiene, food safety knowledge, and attitude of food handlers. Institutional noncompliance such as pest infestations, poor equipment design, unapproved food sources, and other factors could contribute to critical food safety violations (Ehuwa et al., 2021; Reynolds, 2022). Barros et al. (2020) in a study of the impact of food handler certification on food premises in Ontario Canada, explained that most critical food safety violations observed by EHOs during food establishments inspection include inadequate holding temperature of potentially hazardous foods, improper storage of foods and issues with pest infestations. The types of critical food safety violations that will be examined in this study are

temperature control deviations, poor sanitation, pest control issues, poor personal hygiene, and unsuitable food conditions.

Temperature Control Deviations as a Critical Food Safety Violation

Harris et al. (2023) reported that in the period between 2006 to 2021 there were 50 confirmed cases of outbreaks of foodborne botulism across Canada with seven deaths. Food contaminated with *Clostridium botulinum* spores produce botulinum neurotoxin when stored in conditions with reduced oxygen, low acidity, temperature less than 10°C and a water activity (a_w) of less than 0.93 respectively (Harris et al., 2023). Poor temperature control was attributed to an outbreak linked to ground beef left at room temperature, and Alfredo sauce stored at room temperature by a retailer contrary to label instructions for product to be kept refrigerated (Harris et al., 2023). In another study, poor temperature control of food in restaurants was linked to biological hazards in food served at restaurants. De France et al. (2022) explained that biological hazards in foods prepared at restaurants include bacteria, viruses, parasites, and fungi. Pathogenic microorganisms are responsible for foodborne illness if found in food and consumed. Hartantyo et al. (2023) described danger zone temperature {4°C (40°F) and (140°F) 60°C} violation as a critical food safety infraction in restaurants due to the potential growth of pathogenic microorganisms when foods are kept at this temperature range for an extended time. Foods kept at danger zone temperature provide optimal condition for multiplication of bacteria that leads to outbreaks of diseases related to *Salmonella*, *E. coli*, and *Listeria* (Hartantyo et al., 2023). According to De France et al. (2022) bacterial grow in food at an optimal temperature range of between 4°C (40°F) and (140°F) 60°C. Thus, cold foods

should be stored at temperatures of 4°C or lower, while hot foods should be kept at temperatures of 60°C at minimum. Wittry et al. (2022) identified ineffective cold-holding equipment and lack of knowledge by food handlers on the use of holding equipment as a contributory factor to temperature control deviations and a cause of *Clostridium perfringens* outbreaks in retail food establishments in the United States. Hartantyo et al. (2023) explained that evaluating violations of temperature in food preparation needs a systematic approach including a review of past inspection reports and tracking temperature control issues. Analysis of temperature data from routine inspections provides information on activities that resulted in poor temperature control and critical violations. According to Warmate and Onarinde (2023), temperature abuse in food facilities was linked to several outbreaks of foodborne illnesses in Canada. Recent studies observed that a significant percentage of food establishments in Canada experienced temperature-related violations, often related to improper refrigeration or inadequate cooking. In 1998, consumption of Bear Burger was linked to *Trichinella* outbreak due to temperature abuse in a food facility in Canada. Similarly, in 2012 an outbreak of *E. coli* O157:H7 from consumption of pork roast in a catering event was traced to temperature abuse (Warmate & Onarinde, 2023). This study will evaluate temperature control deviations as a critical food safety violation in food facilities across Calgary communities in 2022 versus 2023.

Poor Sanitation as a Critical Food Safety Violation

Ishak and Rabbania (2022) emphasized the importance of hygiene and sanitation as a factor considered by customers to ensure they receive food products that are safe and

free from harmful microorganisms. The study conducted by Ishak and Rabbania (2022) concluded that sanitation significantly influences consumer choice at Favela Sunset Cafe Paledang Bogor. Herniwanti and Jayanti (2022) examined factors that affect hygiene and sanitation in restaurants such as employees, equipment, food, and place. The authors explained that the concept of sanitation covers availability of clean water sources, provision of hand washing facilities and toilets, and adequate and appropriate storage facilities. Tokan et al. (2023) explained the relationships between knowledge, sanitation, and food safety in restaurants in Indonesia. It was observed that a significant relationship exists between knowledge and behavior with respect to food handlers' hygiene and food safety. In another study conducted in Wuhu City, Anhui Province, China, Chen et al. (2024) reported that self-reported foodborne diseases among food handlers in the restaurant industry were linked to not using the three-compartment sinks for cleaning raw food materials, poor preprocessing activities with respect to aquatic products, and temperature abuse during food handling. Better supervision for catering and restaurant workers was advocated to reduce incidence of foodborne disease outbreak associated with food handlers (Chen et al., 2024). Agüeria et al. (2021) studied verification procedures for cleaning and disinfection programs in food establishments. It was noted that establishment of an acceptable limit of cleaning and sanitation for food contact surfaces remains a challenge. In another study, Kim et al. (2021) studied assessment of restaurant surfaces' cleanliness in comparison to customers perceptions on cleanliness of dining surfaces. Findings showed that there is a high degree of consistency between the consumers' perceptions of cleanliness and the actual result from validated method of

cleanliness assessment. The study demonstrated the importance of sanitation and cleaning, and the need for improved cleaning techniques by food handlers in the foodservice industry (Kim et al., 2021). This present study will evaluate the number of critical food safety violations related to poor sanitation in food facilities across Calgary communities in 2022 versus 2023.

Pest Control Issues as a Critical Food Safety Violation

According to Sousa et al. (2022) pest infestation represents a significant food safety violation in the food preparation processes of restaurants and other food establishments. In a study conducted to analyze the hygienic-sanitary conditions in commercial restaurants in Vitória City, Espírito Santo State, Brazil, it was noted that pests such as cockroaches, flies, and ants were observed in food preparation areas (Sousa et al., 2022). In another investigation, pest infestations were identified as a concern among restaurants that provide halal foods in Metro Manila in the Philippines. Liba et al. (2022) reported that certification of restaurants for provision of halal food requires establishments to ensure protection against pest infestation and cross contamination. In addition, halal food restaurants are expected to conduct quarterly pest control exercise on their premises. External contractors provide pest control services; however, lack of effort on pest control from nearby premises and ineffectiveness of the chemicals used for pest control allows infiltration of pests and insects into food facilities (Liba et al., 2022). The present study will evaluate the number of food safety violations in food facilities across Calgary communities that were associated with pest control issues in 2022 versus 2023.

Poor Personal Hygiene as a Critical Food Safety Violation

Verrill et al. (2021) stated that proper hand washing by food handlers can reduce the risk of pathogenic microorganisms and transmission of foodborne infections in food service operations. It was noted that most food service workers do not engage in proper hand washing or fail to frequently wash hands as expected. Verrill et al. (2021) assessed hand washing by food handlers in relation to ease of access to hand washing facilities, availability of hand washing supplies, provision of various hand washing stations and having procedure that support and promote compliance with proper hand washing. It was observed that approximately 20% of fast-food establishments and 30% of full-service establishments lack access to hand washing stations. In addition, 11.3% of fast-food restaurants failed to meet standards on hand washing supplies while 21.5% of full-service establishments lack hand washing supplies (Verrill et al., 2021). Insufficient training of food handlers is one of the leading causes of the poor personal hygiene in food establishments. According to Alemayehu et al. (2021), effective food safety training is important to ensure that food handlers understand and follow hygiene standards. Inadequately trained food handlers may lack the awareness of proper handwashing procedures, use of protective equipment and lack understanding of what constitutes direct and indirect contamination of food (Alemayehu et al., 2021). The importance of food handlers training was also highlighted by Barros et al. (2020) in their study of the impact of food handler certification on food premises in Ontario, Canada. It was noted that food establishments without certified food handlers were more likely to have critical food safety violations. The potential of failing food safety inspection was dependent on the

cultural affiliation; however, independently owned food establishments had lower odds of inspection failure compared to chain operations (Barros et al., 2020). Poor personal hygiene of food handlers constitutes a significant factor in food safety with serious health risk implications for consumers. The present study will explore the number of critical food safety violations related to poor personal hygiene of food handlers observed by PHIs in food facilities in communities across Calgary with respect to 2022 versus 2023.

Unsuitable Food Condition as a Critical Food Safety Violation

Osasah et al. (2023) reported an outbreak of *Salmonella Typhimurium* infections across several health districts in Ontario Canada between the months of May to August 2021. Thirty-eight patients were investigated; all cases were linked to consumption of ready-to-eat seasoned Tofu distributed by a manufacturer to restaurants across Ontario. According to Osasah et al. (2023) unsuitable food handling conditions were directly implicated which resulted to cross-contamination of the product. This situation coupled with insufficient heat application during processing could have allowed survival of pathogens. A recall of the Tofu was initiated by the Canadian Food Inspection Agency across food facilities including institutions, restaurants, and hotels as the product was identified as the main vehicle in the transmission of the outbreak (Osasah et al., 2023). In another scenario Smith et al. (2023) reported the first outbreak of *Escherichia coli* O157 associated with Kimchi in Canada. A total of fourteen cases were investigated in Western Canada between December 2021 and January 2022. Unsuitable food handling was identified as the primary cause due to improper heat treatment during manufacturing. The implicated Kimchi contained ingredients such as sweet rice powder, garlic, Napa

cabbage, red pepper powder, sweet rice powder, green onions, anchovy extract, salted shrimp, ginger, radish, onion, salt, sugar and water was traced to a manufacturer in Western⁶ Canada. Investigation revealed failure to apply heat treatment during processing of the product (Smith et al., 2023). Inadequate infrastructure, inadequate training, and poor hygiene standards among food handlers are some of the causes of improper food handling conditions in restaurants and food service industries (Johnson et al. 2023). In the present study, the number of unsuitable food conditions will be enumerated from food facilities inspection reports across Calgary communities in 2022 versus 2023.

Summary on Types of Food Safety Violations

Reynolds (2022) explained that critical food safety violations are severe noncompliances in food safety protocols and procedures which could result in a high likelihood of causing foodborne illness or harm to consumers. In most cases, critical food safety violations are related to improper food handling, storage, cooking, and sanitation practices that can lead to contamination and growth of pathogenic microorganisms. Based on a review conducted in Missouri, the top critical food safety violations are food temperature control, improper equipment usage, and inappropriate utilization of poisonous and toxic materials. The three most common noncritical food safety violations include improper equipment usage, inadequate physical facilities, and inadequate equipment for holding food at a given temperature (Reynolds, 2022). Food handlers have direct impact on the occurrence of critical food safety violations and its consequences. Ehuwa et al. (2021) reported that the likelihood of food contamination depends on the

personal hygiene, food safety knowledge, and attitude of food handlers. Institutional noncompliance such as pest infestations, poor equipment design, unapproved food sources and other factors could contribute to critical food safety violations (Ehuwa et al., 2021; Reynolds, 2022).

The most important critical food safety violations that occur in food facilities and establishments include improper food storage, cross-contamination, inadequate temperatures control, poor personal hygiene, pest infestation, improper use of chemicals, and presence of sick employees (Augustin et al., 2020). According to U.S. Food and Drug Administration (2023) storing food at incorrect temperatures allows bacteria to grow. Thus, hot foods must be kept above 135°F and cold foods below 41°F to prevent bacterial growth. Another cause of critical food safety violations is poor sanitation. Improper cleaning and sanitation of food preparation areas, utensils, and equipment can have serious consequences. Cleaning ensures removal of visible dirt, food particles, and grease from surfaces using soap and water, whereas sanitizing ensures elimination of pathogenic bacteria (Canadian Institute of Food Safety, n.d.a). Poor personal hygiene of food handlers constitutes a critical food safety violation. According to (Canadian Institute of Food Safety, n.d.b), failure of food handlers to properly wash hands after handling raw foods, using the restroom, or touching their face or hair and not wearing the appropriate protective gear could lead to direct contamination of food. Observance of pest infestation or traces of pest dropping during inspection could constitute a critical food safety violation. The presence of pests like rodents and insects in food establishments, especially in food preparation and storage areas, is a serious violation. Pests can

contaminate food and spread pathogens (Augustin et al., 2020; Government of Canada, 2021). Obtaining food from an unapproved supplier and sources constitutes a critical food safety violation. Receiving food from unapproved sources could impact on the safety of the food. Food facilities must source their food from an approved supplier to ensure the input is from an accredited source (Government of Alberta, 2020). Improper storage and use of chemicals is another critical food safety violation. According to Hutchings (n.d.), improper storage and use of unapproved chemicals near food and on food contact surfaces can cause contamination resulting from mishandling and misuse of cleaning agents and other chemicals. The presence of ill workers at site with food handling duties is a typical critical food safety violation. Hutchings (n.d.) reported that foodborne disease could break out with ill employees performing normal duties including touching food. It is important to restrict sick workers with obvious symptoms from engaging in normal duties in a food facility.

Critical food safety violations are an important public health issue that cannot be overemphasized as causative agents for foodborne diseases. This underscores the significance of following food safety protocols to avoid critical violations by ensuring adequate cooking temperatures, proper food storage, prevention of cross-contamination, maintain personal hygiene, regular sanitization, health monitoring of employees, and proper use of chemicals are necessary to prevent foodborne illnesses. Food facility operators should ensure regular internal audit, inspections, and training of food handlers to ensure adherence to standards and regulations (Augustin et al., 2020; Ehuwa et al., 2021).

Demographics and Food Safety Violations

Buczowska et al. (2023) linked the occurrence of infectious intestinal diseases to the socioeconomic condition of the affected persons and communities. In a study conducted in the United Kingdom, infections related to *Salmonella* and *Shigella* bacteria were prominent among low socioeconomic populations due to poor personal hygiene. Buczowska et al. (2023) suggested that frequent consumption of food from restaurants and other foods that are not properly processed could have accounted for the prevalence of foodborne infections in communities with higher income levels. Amin et al. (2024) investigated the association between food safety risk in retail food outlets and mean incomes in surrounding communities in the United States. The investigation focused on deli procured from grocery stores due to its direct implication with *Listeria monocytogenes* contamination. Findings showed that retail food establishments located in neighborhoods with high population density and lower income have greater *Listeria monocytogenes* prevalence. In addition, the study revealed that American Indian and Alaskan Native residents are strongly associated with food safety risks (Amin et al., 2024). The high rate of foodborne diseases in low-income communities was attributed to air pollution linked to poor sanitation. Thus, the prevalence of infectious diseases is connected to income distribution, wealth and education (Amin et al., 2024). Another study conducted in Northeast Thailand, Wang et al. (2023) noted that foodborne infection transmissions are related to locations and the complexities of human-environment. Transmission of human liver fluke through consumption of raw freshwater fish in Northeast Thailand was attributed to poor socioeconomic condition at the individual,

community, and society level. Policy implementation in Thailand failed to properly control foodborne infections and other diseases and how people's behavior and interaction with their environment influences overall socioeconomic conditions and exposure to health risks (Wang et al., 2023). In the present study, the socioeconomic factors of age, gender, race, income and educational level of communities in Calgary were examined and their differences across regions were related to the number of types of food safety violations among food facilities.

Age and Food Safety Violations

Ahmed et al. (2021) investigated the association between demographic characteristics and food safety knowledge, attitudes, and practices (KAP) of food handlers employed in restaurants, eateries and hotels in Lahore, Pakistan. The authors used a structured questionnaire to collect interview responses from two hundred and two randomly selected food handlers with an age range of between less than 18 years to above 50 years of age (Ahmed et al., 2021). Findings from the investigation showed that there was no significant relationship between food handlers' age and food safety knowledge. In addition, there was no significant correlation established between the food safety attitude of food handlers and their ages. However, it was established that a significant relationship exists between food safety practice and the age of the participants with 79.2% of the food handlers in the range of 19 to 35 years of age. The relationships between food safety practices and ages of food handlers could be significant in predicting food safety violations in restaurants, hotels and eateries because of the high number of workers in the age brackets (Ahmed et al., 2021). Lotfy et al. (2022) studied the

relationships between restaurant workers demographics and counterproductive work behaviors in Cairo, Egypt. The variations between restaurant workers demographics such as age, gender, and marital status were examined in relations to counterproductive work behaviors which are linked to food safety violations. Twenty restaurants in Cairo were used for the investigation with 12 to 15 workers from each restaurant and a total of 255 participants. Results from the study revealed that young workers are more likely to engage in counterproductive behaviors linked to food safety violations compared to older employees (Lotfy et al., 2022). Silva et al. (2021) investigated the association between food service workers burnout and food safety violations. The investigation examined two hundred and two food service workers in twenty establishments to evaluate job satisfaction, motivation, burnout and occurrence of food safety violations. Findings showed that food establishments with varieties of menu exhibited high rates of workers burnout and significant number of food safety violations. Worker's burnouts were linked to factors such as age, experience and training which influences number of types of food safety violations in the investigated food establishments (Silva et al., 2021). Ehuwa et al. (2021) reported the potential of food handlers in the transmission of foodborne diseases through violations of food safety rules in the food service sector. The responsibility of the food handlers for direct contact with food and their potential contamination of the food could lead to severe consequences for the consumers. Ehuwa et al. (2021) explained that *Salmonella* contamination by food handlers could result in serious infection and hospitalization in children less than 5 years of age, the elderly and people with comprised immune system.

Gender and Food Safety Violations

According to Ahmed et al. (2021) gender of food handlers who works in restaurants, eateries and hotels in Lahore, Pakistan was examined as one of the demographic characteristics that influences food safety violations because of its impact on food safety knowledge, attitude and practices (KAP). In a total of 202 food handlers investigated, 96.5% were male and 3.5% were female. Ahmed et al. (2021) reported a significant association between gender of food handlers and their food safety knowledge. However, gender and age of food handlers were found to be insignificantly correlated with food safety knowledge. Gender of food handlers was also not significantly associated with food safety practices of food handlers (Ahmed et al., 2021). Lotfy et al. (2022) examined two hundred and fifty-five workers from food establishments in Cairo, Egypt. It was revealed that female employees compared to their male counterparts are less likely to engage in counterproductive behaviors that could directly lead to food safety violations. Alsultan et al. (2023) examined food safety awareness and practices among handlers in the food service sector at Riyadh City hospitals. The study was conducted using a questionnaire administered to three hundred and fifteen food handlers from five hospitals in Riyadh City between December 2020 and February 2021 during COVID-19 (Alsultan et al., 2023). Two hundred and sixty-five (84.1%) of the food service workers were male and 50 (15.9%) were female. Most of the respondents (90%) knew the importance of proper sanitation in food handling with more than 60% of participants aware of food handlers as a source of pathogenic microbes, however 39% of respondents lack same awareness (Alsultan et al., 2023). Zanetta et al. (2022) conducted

a scoping review to examine factors that motivate consumers food safety perceptions and beliefs in BRICS (Brazil, Russia, India, China, and South Africa) countries. Gender was identified as one of the motivating factors that influence the understanding of food safety practices. According to Zanetta et al. (2022), gender is among the socioeconomic characteristics of age, education level, income and cognitive factors that impact the consumer reaction to past food safety violations. Gender was associated with the perception of food safety of street foods in South Africa while there was negative correlation to the source of food safety risk in China (Zanetta et al., 2022).

Race and Food Safety Violations

Food safety violations which are sometimes influenced by food handlers are linked to contamination and foodborne illnesses. The ethnic background and knowledge of food safety practices of restaurants owners and food handlers are important considerations. Study conducted by Mbombo-Dweba et al. (2022) investigated hygiene practices among operators of ethnic food facilities in Gauteng Province (GP) of South Africa. The cross-sectional study sampled 40 unregistered food facilities including those owned by immigrants with a questionnaire to obtain information on hygiene practices. Mbombo-Dweba et al. (2022) reported that 65% of the participants lack freezers, 55% of the participants owned microwave ovens and most respondents have access to pipe borne and water toilet facilities. The study further revealed that 5% of the informal ethnic food facility operators in Gauteng Province bring water from home and make use of washroom facilities located at nearby shopping malls. Finding shows that 72.5% of respondents lack knowledge of proper holding temperature for hot foods, while 55% do not reheat food

prior to serving and 10% of respondents followed the protocol for reheating of food (Mbombo-Dweba et al., 2022). The operators of ethnic and immigrants' food facilities in Gauteng Province are major sources of food safety violations because of poor food handling practices, lack of knowledge of protocol for holding food above temperature of 65°C and poor knowledge of reheating food prior to serving. Mbombo-Dweba et al. (2022) attributed the food safety violations observed at the informal ethnic and immigrant operated food establishments as the source of food contamination that often result in the spread of pathogenic microorganisms. In another study, Yusoff et al. (2022) assessed the knowledge of migrant food handlers employed in the Malaysia food service industry as well as their skill and attitude in respect of food safety and quality. Data were obtained from 198 participants who are managers and supervisors of food service establishments in Malaysia. Result showed immigrant food handlers have moderate knowledge, attitude and skills in food safety practices (Yusoff et al., 2022). Furthermore, findings revealed that perceived knowledge and attitude of migrant food handlers significantly impacted food safety practice, however the impact of skills on food safety practices was insignificant but skill affected food quality in the sampled food facilities (Yusoff et al., 2022). According to Yusoff et al. (2022) the study provides an opportunity for food facilities operators in Malaysia to enhance the knowledge and attitude of migrant food handlers to limit the occurrence of food safety violations and outbreak of foodborne diseases. Boutros and Roberts (2023) conducted a comparative study that involved 106 participating restaurants to assess the food safety culture between independent and chain Chinese and Mexican restaurants with focus on food handlers' demographics and

approach to work. Boutros and Roberts (2023) used stratified random sampling method to collect data from 300 hundred food handlers with a self-administered questionnaire focused on 75 food handlers from each category of chain and independent Chinese and Mexican restaurant operators. Result indicated significant difference in perceptions of food handlers to workplace support and leadership, and between the food handlers trained in food safety practices and their untrained counterparts when the Mexican restaurants were compared to the Chinese restaurants (Boutros & Roberts, 2023). The investigation concluded that leadership perception among food handlers was significantly different and varies with the types of service provided, additionally the perception of food handlers commitment to food safety practices was significantly different among food handlers from different ethnic backgrounds (Boutros & Roberts, 2023). The present study will discuss the potential impact of race on food safety violations by food facilities in communities across Calgary regions in 2022 and 2023.

Income Level and Food Safety Violations

According to a study conducted Al Banna et al. (2021) on three hundred meat handlers in Bangladesh, it revealed that participants with higher income and who had worked for more than 10 years possessed higher food safety knowledge because of their ability to afford and attend training which translate to less food safety violations. Huynh-Van et al. (2022) reported that the amount of capital invested in a food service business and total space occupied were significantly associated with food safety compliance. Huynh-Van et al. (2022) conducted a cross-sectional study with the aid of a questionnaire and a checklist to evaluate the food safety practices based on ten criteria set for

Vietnamese food vendors in Can Tho city. Four hundred street food vendors were randomly selected including fixed and mobile operators in the city. The amount of money invested in the business by the operators, their level of education, total space occupied by the business, and food safety training received were significant factors that affected compliance with food safety rules and regulations (Huynh-Van et al., 2022). In their review on improving food safety culture in Nigeria, Onyeaka et al. (2021), addressed the practical issues associated with consumption of street foods. Consumers patronize street food vendors who lack knowledge of food safety practices and operate in an unhygienic environment. Onyeaka et al. (2021) reported that patronage and consumption of foods from street vendors in Nigeria thrives because of the low-cost of the products and the target consumers are people with low income. The safety of foods sold by street vendors are subject to contamination due to unwholesome practices, poor sanitation, lack of proper temperature for cooking and storage, and the use of nonportable water sources (Onyeaka et al., 2021). In a systematic review conducted by Desye et al. (2023), focused was on street food vendors in low-and middle-income countries with respect to their food safety knowledge, attitude, and practice. Results from the review showed that street food vendors with higher income are more likely to follow food safety practices compared to those with low income. This finding was justified by the possibility that vendors with high income will readily provide needed hygienic materials and utensils to prevent contamination (Desye et al., 2023). Zanetta et al. (2022) examined the factors that motivates consumer food safety perception in BRICS (Brazil, Russia, India, China, and South Africa) countries. Results showed that the level of income and education of

consumers were among the highest sociodemographic considerations that affect food safety perception. Consumers with higher income are aware of the importance of food safety while low-income consumers are often misled with misinformation on food safety. Hence, patronage from higher income consumers makes restaurants adhere to high food safety standards (Zanetta et al., 2022). The present study will consider the effect of level income as a possible controlling factor and its impact on food safety violations in food facilities across Calgary communities in 2022 and 2023.

Education and Food Safety Violations

Abdelhakeem et al. (2021) investigated food safety knowledge among two hundred and forty-five food handlers who worked in the food service sections of six selected private and public hospitals in Jordan. According to Abdelhakeem et al. (2021), results from the study revealed that many of the food handlers in food service sections in private and public hospitals had less than high school education with a mean experience of 12.55 ± 8.1 years. In addition, it was revealed that 72% of the food handlers had moderate overall safety knowledge, 80.87% had highest knowledge in the aspects of hand washing and personal hygiene, 86.10% in the understanding of health challenges associated with food safety and 75.96% in the understanding of sanitation and control of contamination. The result also showed that food handlers with higher educational qualifications possessed a better understanding and had a higher food safety knowledge (Abdelhakeem et al., 2021). In another study, Gebru et al. (2023) conducted a cross-sectional investigation in food facilities to evaluate knowledge, attitude, and food safety practice among three hundred and forty-three randomly selected food handlers in Mohoni

District, Southern Tigray, Ethiopia from January to May 2020. Gebru et al. (2023) linked the occurrence of foodborne illnesses to food safety violations occasioned by contamination from workers due to poor attitude, a lack of knowledge of food safety, and improper food handling in many food establishments. Analysis of participants responses showed that 73.8% had overall good level of food safety knowledge, 64.4% showed a positive attitude and 57.7% showed poor hygienic practices (Gebru et al., 2023). In addition, it was revealed that food handlers with a secondary, a diploma and higher education showed a sound knowledge of food safety linked to a reduction in critical violations. Participants with a minimum of 4 years' work experience also showed a positive attitude towards food safety. The study concluded that the attainment of good food safety practices in food establishments will require effective supervision in addition to food safety knowledge and positive attitude from food handlers (Gebru et al., 2023).

Al Banna et al. (2021) investigated the factors connected with knowledge and practices of food safety among meat handlers in Bangladesh. In a cross-sectional study, three hundred meat handlers were interviewed from January to March 2021 to evaluate their food safety knowledge and practices. Twenty percent of the participants showed acceptable food safety knowledge and practices. The possession of higher education and more than 10 years of experience in the job was linked to a good knowledge of and practice of food safety by the participants. The study recommended improved food safety education among meat handlers in Bangladesh to reduce incidence of food safety violations and outbreaks of food borne illnesses (Al Banna et al., 2021). The present study will examine

level of income as a potential controlling factor and its impact on food safety violations in food facilities in Calgary communities in 2022 and 2023.

Application of Epidemiologic Triangle Theory to Food Safety Violations

According to John and Kompithra (2023), three factors were identified as necessary to start an infectious disease including foodborne illnesses. These factors are essential to sustain disease prevalence and to commence an epidemic. John and Kompithra (2023) explained that epidemiology triad or the epidemiologic triangle theory (ETT) focuses on the interaction of the three key factors which are the *agent*, the *host*, and the *environment* required to cause an infection. The theory further explained that the environment is the factor that can prevent the interaction of the agent and host to avoid an infection or promotes their interaction and lead to an infection (John & Kompithra, 2023). Lee and Yoon (2021) reported that foodborne disease is prevalent worldwide because of food contamination with an annual death of 420,000 people worldwide. The most implicated microorganisms as agents in foodborne illnesses include *Campylobacter*, *Listeria monocytogenes*, *Salmonella*, and *E. coli*. Viruses that are etiological agents of foodborne illness include Norovirus and Hepatitis 'A' while *Trichinella* and *Toxoplasma gondii* are mostly implicated parasites as etiological agents of animal origin in foodborne illnesses (Lee & Yoon, 2021). De France et al. (2022) examined the significance of microorganisms as biological food hazards found in food service establishments and an agent of transmission of foodborne illness. Microorganisms were identified as the main agent responsible for severe gastrointestinal sickness and associated symptoms of foodborne diseases. De France et al. (2022) reported that the main biological agents

responsible for foodborne illness in food facilities include pathogenic bacteria such as *Clostridium perfringens*, *Listeria monocytogenes*, *Staphylococcus aureus*, *Escherichia coli*, *Campylobacter jejuni* and *Salmonella* spp. Parasites were also identified as biological agents linked to food borne illness, prominent among the parasites linked to outbreaks in food facilities include *Trichinella spiralis*, *Cryptosporidium parvum*, *Toxoplasma gondii*, *Giardia intestinalis*, *Taenia solium*, and *Taenia saginata* (De France et al., 2022). The implicated viruses known as agents of foodborne infections connected to food service facilities include norovirus, rotavirus, Hepatitis A and Hepatitis E virus. In addition, fungi were identified as a biological hazard of concern in food service facilities and an agent of disease transmission. The common fungi implicated in restaurant foodborne disease outbreaks include *Penicillium* spp. and *Aspergillus* spp. Measures advocated to control biological food hazards in food service facilities include strict personal hygiene protocol, establishment of standard sanitation procedures and pest control (De France et al., 2022).

In discussing the environmental as it relates to food safety violations and occurrence of foodborne illness, Lu et al. (2023) conducted a study between 2010 to 2020 in China to evaluate the nature, and related environmental factors connected to foodborne illness outbreaks in catering establishments. Lu et al. (2023) explained that unsuitable food handling associated with raw materials, challenges with storage and transportation practices provide the required condition for outbreaks of foodborne illness resulting from critical violations. In addition, prevalence of outbreaks linked to catering service facilities was rampant in the second and third quarter of the year due to increased temperature and

humidity and the subsequent high incidence of foodborne illness related to bacteria contamination (Lu et al., 2023). Furthermore, Lu et al. (2023) reported that during the summer and autumn periods with increased outdoor activities, there is a high number of cases linked to *Staphylococcus aureus*, *Vibrio parahaemolyticus*, and *Salmonella* spp., as the dominant pathogens in outbreaks involving food service establishments. In places like eastern and the coastal regions of China, higher number of foodborne illness cases were attributed to increase in economic activities including consumption of food from outside the homes. Dietrich et al. (2023) examined environmental factors that impact the occurrence of foodborne infections and intoxications. It was explained that factors such as precipitation, humidity and temperature influenced the growth and multiplication of foodborne pathogen in the environment. According to Dietrich et al. (2023) the environmental factors resulting from the effects of climate change provide suitable conditions for microbial growth. In Germany, the impact of the environmental factors resulted in significant prevalence of foodborne pathogens such as *Salmonella*, *Campylobacter* and *Vibrio*, and parasites (Dietrich et al., 2023).

John and Kompithra (2023) explained that in ETT the host provides a site for lodging of agent which could be a pathogenic microorganism. According to Ehuwa et al. (2021), the host is exposed to consumption of contaminated food and poor personal hygiene practices while handling food. Factors such as genetics, level of immunity, age, amount of exposure and overall health status of an individual determine opportunity for exposure (Ehuwa et al., 2021). Elbehiry et al. (2023) emphasized the importance of food products as a medium of spread of communicable diseases among people and advocated

for measures that ensure consumer protection. In addition to improved food safety standards in food handling, consumers and food safety experts must focus attention on factors that can prevent exposure to foodborne pathogens (Elbehiry et al., 2023). The present study will attempt to examine the number of types of food safety violations in food facilities in communities across regions in Calgary with focus on 2022 and 2023.

Methods and Findings in Past Studies on Food Safety Violations in Food Facilities

Tumaliuan (2022) examined the importance of food safety compliance among restaurants in a selected municipality of Region II in the Philippines. The study adopted the quantitative methodology with ANOVA as a statistical tool to evaluate difference in food safety practices and standard of sanitation between restaurants. According to Tumaliuan (2022) significant differences were established in compliance level in respect to kitchen and personal hygiene among the participating restaurants. The need to improve the implementation of food handling and sanitation practices were recommended. In addition, the findings emphasized the necessity to increase food safety education through the Local Health Unit by organizing regular seminars and workshops for owners of restaurants and food handlers (Tumaliuan, 2022). In a different study, Smith and Heacock (2022) used quantitative methodology to investigate the impact of the COVID-19 pandemic on frequency of restaurant inspections, food safety violations and hazard gradings among restaurants on Vancouver Island, British Columbia in Canada. Smith and Heacock (2022) analyzed inspection data obtained from Vancouver Island Health Authority (VIHA) with NCSS 2022 Statistical Software. Electronic reports of routine food premises inspections conducted from January 2019 to December 2021 across the

regions were utilized for the study. Results showed a decrease in the number of food premises inspections from 2019 to 2021 and a decrease in the total number of food safety violations across the regions during the period. However, the frequency of food premises inspections that yielded critical food safety violations reduced from 2019 to 2020, then increased in 2021 for all regions within VIHA (Smith & Heacock, 2022). Olajubutu et al. (2021) investigated compliance to food safety regulations by urban and rural food vendors in Oyo State, Nigeria. The study examined five areas in the municipality of Afijio local government area of the state. Eighty-six participants were sampled among restaurants, canteens, hotels and food hawkers for interviews and data generations. Olajubutu et al. (2021) utilized quantitative methods to analyze data with statistical tools such as T-test, Chi-square, percentages and Pearson's Product-Moment Correlation (PPMC). Findings showed that 53.5% of participants complied with food safety regulations and a significant difference was obtained between the level of compliance of urban and rural food establishments to food safety regulations. In addition, the study inferred that the level of compliance with food safety regulations was lower among food establishments in rural areas (Olajubutu et al., 2021). Bulochova et al. (2024) conducted systematic review on the existing research conducted on food safety and food handlers in the food service industry to identify future approaches. A total of 118 published research articles focused on food safety practices between 2001 and 2021 were reviewed to identify methods used in the studies. In a review conducted to highlight the previous research on food safety practices by food handlers in the food service industry and a proposal for the future, Bulochova et al. (2024) reported that most studies were

conducted in United Kingdom (7%), Brazil (17%) and in the United States (29%).

Additionally, findings showed that 12% of the reviewed articles evaluated behavioral and cognitive attributes, observational methods were used in 29% of the studies and mixed method used in 28% of the articles reviewed and thus recommended mixed method approach in food safety research (Bulochova et al., 2024). The present study will utilize quantitative methodology to examine the number of types of food safety violations in food facilities in communities across Calgary regions in 2022 and 2023.

Summary and Conclusions

The increasing occurrence of critical food safety violations in food facilities is a cause of concern for the public and is mounting pressure on PHIs to ensure a reduction in violations by providing knowledge to food handlers while enforcing standards and regulations (Ashwood et al., 2021). The objective of the present study will be achieved by examining the number of types of critical food safety violations with specific focus on *temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions* by comparing the results obtained in 2022 and 2023 in communities across Calgary regions (see Appendix A). In addition, the study will fill a gap in literature by providing insights into the numbers of types of critical food safety violations for the period mentioned in Calgary communities. In terms of theoretical foundation, the ETT aligns with the objective of the study because of the theory's focus on the mechanism of disease transmission which, because of food safety violations, leads to foodborne illness. Liu et al. (2023) reported that ETT provides a basis for understanding the process of diseases transmission by analyzing the interconnectivity

among the agent, the host, and the environment. This was corroborated by Jannah et al. (2024) who explained that the Epidemiologic Triangle or Triangle Model is the basic concept in epidemiology that explains the mechanism of interaction among the components require for the development of a disease condition. The present study will examine the number of types of critical food safety violations (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions*) in food facilities in communities across in Calgary regions by comparing 2022 versus 2023 including the impact of COVID-19 while controlling for the community's socioeconomic status (age, gender, race, income and educational level).

The independent (predictor) variables in the study are Calgary regions and 2022 and 2023, respectively. The impact of the COVID-19 pandemic during 2022 and 2023 on food safety violations in food facilities in communities across Calgary regions will also be examined. According to Reynolds (2022) there were variations in food safety violations observed across schools' systems located in different regions of the United States for a period of 10 years. A slight decrease was noted in the number of violations during the study period, but it was noted that the same types of food safety violations were observed during the study period across the school system (Reynolds, 2022). In another study that involved twenty-five state and local health departments in the United States between the period of 2017 to 2019, Moritz et al. (2023) examined the incidence of foodborne diseases in retail food outlets through a review of the NEARS. The study highlighted Norovirus and *Salmonella* ssp. as main contributors to foodborne illnesses linked to infected food handlers (Moritz et al., 2023). In a study conducted in Finland,

Lunden et al. (2021) attributed variation in restaurants inspection results across regions to inconsistency in inspection protocols. In addition, the variation in restaurants inspection grades was linked to regional variations and economic status of the location (Lunden et al., 2021). The years 2022 and 2023 being the primary focus of the present study coincided with the period of global pandemic which had a great impact on socioeconomic activities including restaurant operations and inspection.

The dependent (outcome) variables in the present study are number of types of critical food safety violations (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions*). According to Reynolds (2022), critical food safety violations were described as severe noncompliances which deviate from established food safety practices and could lead to foodborne illness. Most critical food safety violations are related to poor temperature control, improper equipment usage, and inappropriate utilization of poisonous and toxic materials (Reynolds, 2022). The present study will attempt to evaluate the number of types of critical food safety violations (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions*) as the dependent (outcome) variable by examining their numbers in food facilities in communities across Calgary regions for 2022 and 2023.

The study will also explore existing data on socioeconomic and demographic differences in Calgary communities. Buczkowska et al. (2023) linked occurrence of infectious disease to socioeconomic condition of the affected persons and communities in a study conducted in the United Kingdom. In another study conducted in the United

States, (Amin et al., 2024) reported that retail food outlets in areas of high population density and lower income are exposed to *Listeria monocytogenes*, with the American Indian and Alaskan Native residents strongly associated with food safety risks. Similarly, Wang et al. (2023) reported that infectious disease transmission in humans is prevalent in certain locations and environment. In a study carried out in Thailand, consumption of contaminated raw freshwater fish in Northeast Thailand was linked to poor socioeconomic condition (Wang et al., 2023).

Several studies were conducted on critical food safety violations from restaurant operations by exploring data from public health inspection results. However, literature research showed gaps in respect of studies to examine critical food safety violations in food establishments across regions in Calgary communities with focus on the number of types of critical food safety violations (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions*) in the last 3 years. According to Smith and Heacock (2022), the effect of COVID-19 pandemic on food safety violations and hazard ratings among restaurants in Vancouver Island, British Columbia in Canada was examined with a quantitative methodology approach. Similarly, Tumaliuan (2022) used quantitative methodology to study food safety compliance among restaurants in a selected municipality of region II in the Philippines. The investigation conducted by Tumaliuan (2022) used ANOVA as a statistical tool to assess differences in food safety practices and standard of sanitation in restaurants. The present study will use a quantitative research approach to examine the number of types of critical food safety violations in food establishments across regions in Calgary communities. In addition, the

investigation will examine demographics and foods safety violations with respect to existing data on age, gender, level of education, level of income and race as it relates to food safety violations in food establishments located in communities across Calgary regions in 2022 and 2023.

In Chapter 3, a detailed explanation will be provided on research design, rationale, and methodology for the study. The chapter will highlight the study population, samples, sampling procedure and data collection method. In addition, Chapter three will address the use of archival data, instrumentation and operationalization of constructs, and data analysis plan. Threats to validity of result and ethical procedures will also be examined in Chapter three.

Chapter 3: Research Method

Introduction

Critical food safety violations are serious noncompliances in food safety protocols that could result in the outbreak of foodborne illness when the implicated food is consumed (Reynolds, 2022). The purpose of this study is to examine the association between Calgary regions for 2022 versus 2023 and the number of types of critical food safety violations (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions*) in food facilities. The City of Calgary is divided into four regions with many communities in each region. The diversity within each region is reflected in the age, gender, race, income and educational level of the population within the communities. The demographic factors affect the outcome of the various activities including food safety violations among the food establishments in the communities across Calgary regions. The study based on ETT involves an analysis of data generated by PHIs through inspections of food facilities across Calgary regions with focus on 2022 and 2023.

This chapter will describe the research design and provide rationale for its selection. Furthermore, the research methodology will be discussed with a focus on population, sampling method, data collection protocol and a description of data analysis and the associated challenges and summary.

Research Design and Rationale

In the present study, the dependent (outcome) variables are the number of types of critical food safety violations (*temperature control deviations, poor sanitation, pest*

control issues, poor personal hygiene and unsuitable food conditions) established through inspection data generated by PHIs in the Environmental Health Department of AHS. The independent (predictor) variables are Calgary regions and Years 2022 and 2023. The regions of Calgary are Northwest, Northeast, Southwest and Southeast. The controlling variables (covariates) are the demographic factors within the communities located across Calgary regions. The study will explore socioeconomic factors within the communities across Calgary regions. The socioeconomic factors are age, gender, race, income and educational level.

In this study, a comparative cross-sectional design will be utilized to address the research questions (Ahmed et al., 2021; Al Banna et al., 2021). This research design will allow for the analysis of data collected from food facilities inspection reports across Calgary regions in 2022 and 2023. The comparative cross-sectional design is appropriate for the study and suitable to address the research questions because it allows for the identification of number of types of critical food safety violations in 2022 and 2023 across Calgary regions (Tumaliuan, 2022; Mbombo-Dweba et al., 2022). Furthermore, the research design allows for the utilization of the information generated by PHIs from food facilities inspections report which are converted to secondary data to explore relationships with minimal variables manipulations. Thus, the comparative cross-sectional design addresses the trend of critical food safety violations across regions in 2022 and 2023 in the research questions. Comparative cross-sectional design has inherent challenges due to time and resources constraints. The study relies on secondary data generated from the information provided by PHIs reports which may require time to

collect and analyze for different regions of Calgary. According to Chirico (2023), common limitations of cross-sectional study include the inability to account for the effect of confounding variables linked to the predictor and outcome variables, and subjective interpretation of outcomes. The secondary data required for the study may be challenged with inaccuracies and incomplete information from the main source. In addition, considerable time may be needed by the local health authority for approval to access and use data for research purposes. These challenges are further exacerbated by the limited time available for the completion of the research project.

The comparative cross-sectional design is used in environmental public health research to track and compare outcomes overtime and across geographical areas. In the context of the present study, the chosen design allows for comparison of secondary data collected for 2022 and 2023 in Calgary regions and thus provides insights into trends of food safety violations in food establishments. The use of existing inspection reports from the local health authority can help inform and guide policy formulation on food safety inspection, regulation enforcement and public health intervention. The chosen design will contribute to identifying areas for improvement and potential gaps in food handling practices and contribute to advancement of knowledge in food safety management.

Methodology

Quantitative research methodology was the most appropriate for studying critical food safety violations in food service establishments across Calgary regions for 2022 and 2023. Thandi et al. (2022) used quantitative research methodology to conduct a comparative study on the food safety violations by restaurants in the cities of Toronto and

Vancouver. In another study, Lundén et al. (2021) utilized quantitative research methodology to investigate the variations in inspection grades among restaurants in Finland. The use of quantitative research methodology in this study allowed for the analysis of trends, patterns and differences in number of types of food safety violations in food service establishments across Calgary regions between 2022 and 2023.

Population

In this study, the population of interest were the food facilities inspected across Calgary regions which had critical food safety violations based on the inspectors' report in 2022 and 2023. Food facilities across regions were inspected by PHIs under the mandate of the AHS. The population consists of all food facilities inspected in Calgary Northwest, Northeast, Southwest and Southeast during 2022 and 2023. The food facilities included restaurants, canteens, grocery stores, and other establishments involved in food preparation and service for public consumption.

Sampling and Sampling Procedures

Samples for the study included a selection of representative food facilities from the four regions in Calgary (Northwest, Northeast, Southwest and Southeast) which had critical food safety violations based on PHIs reports in 2022 and 2023. Thandi et al. (2022) studied food violations by comparing restaurants in the cities of Toronto and Vancouver. The authors utilized online data from a total of two hundred restaurant inspection reports, with one hundred sampled from each region (Thandi et al., 2022). A stratified random sampling was used to ensure that the food facilities inspected during 2022 and 2023 in Calgary regions were sampled (Hartantyo et al., 2023).

Samples were selected from food facilities across Calgary regions with documented inspection reports and critical violations in 2022 and 2023. Hartantyo et al. (2023) used stratified random samples to study the effect of food poisoning resulting from catering operations related to hygiene violations, food safety practices and processing environment. Ten food catering operators were randomly selected with at least one operator challenged with hygiene-related violation (Hartantyo et al., 2023). In the present study, random samples of food facilities were selected from each region to ensure diversity and representation. Only critical food safety violations reported for 2022 and 2023 were considered for selection across Calgary regions.

Sampling Frame

Sampling frame refers to the food facilities across Calgary regions that were inspected for critical food safety violations in 2022 and 2023, respectively. The food facilities included in the sampling frame are restaurants, cafés, canteens, hotels, bars, and other food service establishments. The information on food safety inspections for this study was obtained from AHS. The inclusion criteria focused on food facilities inspected in 2022 and 2023 which had critical food safety violations within Calgary regions. The exclusion criteria were food facilities without inspection records in 2022 and 2023, food facilities outside Calgary regions, and facilities with noncritical violations during 2022 and 2023, respectively.

Power Analysis: Effect Size, Alpha Level, and Power Level

In this study, power analysis was used to determine the minimum sample size to detect an effect of a given magnitude with the appropriate degree of confidence. An

insufficient sample size may produce an inconclusive result, while too large sample size needs enormous resources. The components of a power analysis and determinants of sample size are effect size, alpha level and power level (Giner-Sorolla et al., 2024; Haile, 2023).

According to López-Martín and Ardura-Martínez (2022), effect size measures the strength of the relationship between two variables. Effect size was also referred to as Cohen's d or proportions. In this study, the effect size was the magnitude of the difference between two groups which were the proportions of critical food safety violations in 2022 and 2023. It was expected that a small to medium effect size was appropriate to compare critical food safety violations for 2022 and 2023. Unless previous research provides a specific value, a medium effect size is typically used in social sciences (Cohen's $d = 0.5$), and this was appropriate choice for this study. A medium effect size (Cohen's $d = 0.5$) was justifiable based on conventional choice for social and health science research and practical considerations (Panjeh et al., 2023). In addition, medium changes in critical food safety violations were expected due to minimal variation in inspection protocol and food safety regulations between 2022 and 2023. In terms of proportions, an assumption of a baseline critical food safety violation rate of 25% in 2022 and an increase to 35% in 2023 were used for the study. This gave a difference of 0.10 (or Cohen's $h \approx 0.2-0.3$, medium). Thus, the medium-size effects were appropriate in public health research, balancing sensitivity to detect changes without overestimating real-world effects (López-Martín & Ardura-Martínez, 2022; Panjeh et al., 2023).

Wulff and Taylor (2024) reported that alpha level represents the probability of rejecting the null hypothesis when it is true (Type I error). A value of 0.05 is a common alpha level which denotes a 5% risk of concluding that a difference exists when it does not. The choice of $\alpha = 0.05$ was related to the standard procedure used in most social and health sciences research as it balances the risk of Type I error with the need for statistical significance. Justification for the use of $\alpha = 0.05$ was because of its wide acceptability in testing hypothesis, and for providing a reasonable cutoff for significance without being overly conservative (Wulff & Taylor, 2024).

Power level ($1-\beta$) refers to the probability of correctly rejecting the null hypothesis when it is false. It is the probability of detecting a true effect when it exists (avoiding Type II error; Haile, 2023). Typically, power level is 0.80 which connotes that there is an 80% chance of detecting an effect if it exists. This reduces the risk of a Type II error and thus balances the risk of Type I and Type II errors (Haile, 2023). Justification for use of a power level ($1-\beta$) of 0.80 (80%) was because of its use in standard research, and it ensured an 80% probability to detect a significant difference if one exists and gave a balance between sensitivity and resource constraints. Justification for the use of power level ($1-\beta$) = 0.80 was due to its practicability and wide acceptance in research. The use of a higher power level such as 0.90 increased sensitivity but required a larger sample size.

The parameters selected for the power analysis were justified because the smaller effect size ensured larger sample size and choosing a higher alpha or power level increase

statistical accuracy but needed additional resources (López-Martín & Ardura-Martínez, 2022; Panjeh et al., 2023; Wulff & Taylor, 2024).

Sample Size Calculations

For this study, the sample size was calculated with the statistical tool of G*Power with consideration for two-proportion variables of critical food safety violations for 2022 and 2023 with the following parameters:

$$\text{Alpha } (\alpha) = 0.05$$

$$\text{Power level } (1-\beta) = 0.80$$

$$\text{Effect size } (h) = 0.2-0.3 \text{ (medium).}$$

Components of the formula:

1. $Z_{\alpha/2}$: Critical value for a two-tailed test at $\alpha = 0.05$ is 1.96
2. Z_{β} : Critical value for $\beta = 0.2$ (power of 0.8) is 0.84
3. $p_1 = 0.25$: Proportion of critical food safety violations in 2022
4. $p_2 = 0.35$: Proportion of critical food safety violations in 2023
5. Effect size (h): $h = 2 \cdot \arcsin(\sqrt{p_2}) - 2 \cdot \arcsin(\sqrt{p_1})$
6. Sample size (n) was computed with the above formula in (5 above) for $h = 0.2$
7. To calculate the Effect size, the arcsine transformation was used, thus.

$$h = 2 \cdot \arcsin(\sqrt{p_2}) - 2 \cdot \arcsin(\sqrt{p_1})$$

For $p_1 = 0.25$ and $p_2 = 0.35$

$$\arcsin(\sqrt{0.25}) = \arcsin(0.5) = 0.5236 \text{ radians}$$

$$\arcsin(\sqrt{0.35}) = \arcsin(0.5916) = 0.6324 \text{ radians}$$

$$h = 2 (0.6324 - 0.5236) = 2 (0.1088) = 0.2176$$

This gave an effect size of 0.22 which was in the medium range.

8. The formula for sample size for proportion given as

$$n = (Z_{\alpha/2} + Z_{\beta})^2 \cdot \{ p_1(1 - p_1) + p_2(1 - p_2) / (p_2 - p_1)^2 \}$$

Substituting the values:

$$Z_{\alpha/2} = 1.96, Z_{\beta} = 0.84, p_1 = 0.25, p_2 = 0.35$$

Compute the numerator.

$$Z_{\alpha/2} + Z_{\beta} = 1.96 + 0.84 = 2.8$$

$$p_1(1 - p_1) = 0.25 (0.75) = 0.1875$$

$$p_2(1 - p_2) = 0.35 (0.65) = 0.2275$$

$$p_1(1 - p_1) + p_2(1 - p_2) = 0.1875 + 0.2275 = 0.415$$

$$(2.8)^2 (0.415) = 7.84 (0.415) = 3.254$$

Compute the denominator.

$$(p_2 - p_1)^2 = (0.35 - 0.25)^2 = (0.1)^2 = 0.01$$

$$n = 3.254 / 0.01 = 325.4$$

The number of samples of critical food safety violations (participants) required for each Year 2022 and 2023 was 325. For the effect size $h = 0.22$, $n = 325$ (Ausaf, 2024; Fosgate, 2009). The number of samples for each 2022 and 2023 was 325.

Data Collection

Secondary data for the study was generated from food facilities inspection reports which contained food safety violations recorded in 2022 and 2023 in Calgary regions (Northwest, Northeast, Southwest, and Southeast). Access to the data for the study was obtained from the information publicly available on the website of AHS. The available

information included names of food facility, physical address, and the community in which the food facility was located. Other information from AHS website were types of critical food safety violation, date of the violation, status of the violation, inspector description of the violation and a remark based on food safety regulations violated (AHS, n.d.c). Only food facilities that had critical food safety violations (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions*) were extracted from the databases.

Archival Data Use

Information for the study was obtained in the form of secondary data from public databases of AHS. The archival data were made up of depository records of food safety violations in 2022 and 2023 specific to Calgary regions (Northwest, Northeast, Southwest, and Southeast). The records of food safety violations were collected by PHIs through routine food facilities inspections conducted by the use of standardized and consistent protocol (AHS, n.d.c). Permission for access to the information needed for the secondary data for the study was through adherence to the standard protocol established by the Internal Review Board (IRB) at Walden University.

Instrumentation and Operationalization of Constructs

The independent variables for the study were Year (2022 and 2023) and Calgary regions of Northwest, Northeast, Southwest, and Southeast (NW, NE, SW, SE). Years 2022 and 2023 were the calendar years during which data on critical food safety violations for the study were collected. Regions of Calgary (NW, NE, SW, SE) represented the geographical divisions within Calgary used to categorize and assess

variations in critical food safety violations across the regions. Years 2022 and 2023 were measured as categorical variables which indicates the time period of data collection. The regions of Calgary (NW, NE, SW, SE) were measured as categorical variables to denote specific regions of Calgary where the food facilities corresponding to the reported critical food safety violations were located.

The dependent variables were the number of types of critical food safety violations (*temperature control deviations, poor sanitation, pest control, poor personal hygiene and unsuitable food condition*). Each type of critical food safety violation was counted as categorized in the inspection report and recorded as occurrences for the food facilities. The number of types of critical food safety violations in each category were totaled for a given year and region. For example, the number of incidents of sanitation violations will be denoted by a score. A score of 20, for example, showed that there were twenty violations related to poor sanitation. For unsuitable food conditions, a score of 10 denoted ten instances of poor food handling related critical food safety violations. The scores representation denoted the frequency of each type of violation in a given year per region such as 15 instances of temperature control deviations in NE Calgary during 2023.

Data for socioeconomic factors of the populations in each Calgary regions were obtained from the government of Alberta website based on Alberta Provincial Electoral Division compiled from the 2021 census conducted in Canada (Government of Alberta, 2023a, 2023b, 2023c, 2023d).

Classification of data to independent variables (years and regions) and dependent variables of number of types of critical food safety violations (*temperature control*

deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions) ensured proper definition and assessment for statistical analysis. The socioeconomic factors that were explored include age, gender, race, income, and education. Table 1 shows study variables, variables names and measurement scales.

Table 1*Study Variables, Variable Name, and Measurement Scale*

Research question	Variable name	Level of measurement	Variable type	Response options
*RQ 1	Year (2022 vs. 2023).	Categorical/Nominal	Independent	1. 2022 2. 2023
	Calgary regions	Categorical/Nominal	Independent	1. Northwest (NW) 2. Northeast (NE) 3. Southwest (SW) 4. Southeast (SE)
	Number of types of critical food safety violations (5 categories)	Numeric/Discrete	Dependent	1. No of types of critical food safety violations. Temperature control deviation. Poor sanitation. Pest control issues Poor personal hygiene. Unsuitable food conditions.
**RQ 2	Year (2022 vs. 2023).	Categorical/Nominal	Independent	1. 2022 2. 2023
	Calgary regions	Categorical/Nominal	Independent	1. Northwest (NW) 2. Northeast (NE) 3. Southwest (SW) 4. Southeast (SE)
	Number of types of critical food safety violations (5 categories)	Numeric/Discrete	Dependent	1. No of types of critical food safety violations. Temperature control deviation. Poor sanitation. Pest control issues Poor personal hygiene. Unsuitable food conditions.
	Age	Numerical/Continuous	Not applicable	1. 0-4 years 2. 5-17 years 3. 18-24 years 4. 25-44 years 5. 45-64 years 6. 65 years and over 7. Average age (years)
	Gender	Categorical/Nominal	Not applicable	1. Male 2. Female
	Race	Categorical/Nominal	Not applicable	1. Total population by visible minorities. 2. Not a visible minority 3. Visible minority population

Research question	Variable name	Level of measurement	Variable type	Response options
	Income	Numerical/Continuous	Not applicable	1. Under \$5,000 2. \$5,000 to \$9,999 3. \$10,000 to \$14,999 4. \$15,000 to \$19,999 5. \$20,000 to \$24,999 6. \$25,000 to \$29,999 7. \$30,000 to \$34,999 8. \$35,000 to \$39,999 9. \$40,000 to \$44,999 10. \$45,000 to \$49,999 11. \$50,000 to \$59,999 12. \$60,000 to \$69,999 13. \$70,000 to \$79,999 14. \$80,000 to \$89,999 15. \$90,000 to \$99,999 16. \$100,000 and over 17. \$100,000 to \$124,999 18. \$125,000 to \$149,999 19. \$150,000 to \$199,999 20. \$200,000 and over
	Educational level	Ordinal	Not applicable	1. No certificate, diploma or degree. 2. Secondary (high) school diploma or equivalency certificate. 3. Post-secondary certificate, diploma or degree

Note. *RQ1: Is there an association between the Year (2022 vs. 2023) and number of types of critical food safety violations (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene & unsuitable food conditions*) in food facilities in Calgary regions?

**RQ2: Is there an association between the regions of food facility in Calgary and number of types of critical food safety violations (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions*)?

Data Analysis Plan

SPSS statistical software Version 29, owned by IBM corporation, was used to classify and quantify the types of critical food safety violations from the food facilities inspected across Calgary regions for 2022 and 2023. Information on types of food safety violations were coded for ease of interpretation with SPSS software for statistical analysis. The critical food safety violations were counted for 2022 and 2023 which were coded as 0 and 1, respectively. Types of critical food safety violations were coded as 1 for poor sanitation, 2 for temperature control deviation, 3 for poor personnel hygiene, 4 for pest control issues and 5 for unsuitable food condition.

Important constructs such as “critical food safety violations” were consistently defined across regions for 2022 and 2023. The variables for the study were the numerical count of types of critical food safety violations from each region for 2022 and 2023, respectively.

Data cleaning was done to remove duplicates entries to ensure consistency and standardization across variables. In addition, accuracy was confirmed to ensure that the original information obtained from the inspection report was not distorted. The research questions and the hypothesis for the study are stated below.

RQ1: Is there an association between the Year (2022 vs. 2023) and number of types of critical food safety violations (temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions) in food facilities in Calgary regions?

*H*₀₁: There is no association between the Year (2022 vs. 2023) and number of types of critical food safety violations (temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions) in food facilities in Calgary regions.

*H*₁₁: There is an association between the Year (2022 vs. 2023) and number of types of critical food safety violations (temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions) in food facilities in Calgary regions.

RQ2: Is there an association between the regions of food facility in Calgary and number of types of critical food safety violations (temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions)?

*H*₀₂: There is no association between the regions of food facility in Calgary and number types of critical food safety violations (temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions).

*H*₁₂: There is an association between the region of food facility in Calgary and number types of critical food safety violations (temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions).

Hypothesis testing for the study was based on comparison of level of significance obtained from Pearson Chi-Square and Measures of Phi and Cramer's V with the conventional p-value ($p= 0.05$). Socioeconomic data obtained from 2021 Canada

population census result for factors of age, gender, race, income and educational level were explored for their potential impact on the independent variable of Calgary regions. The result of the socioeconomic factors for each region was compared with the number of types of critical food safety violations from the respective regions (Kotronoulas et al., 2023). Table 2 shows the independent variables, dependent variables, measurements and statistical analysis.

Table 2

Description of Research Questions, Variables and Statistical Analysis Plan

Research question	Independent variables and measurement	Dependent variables and measurement	Statistical analysis
RQ1: Is there an association between the Year (2022 vs. 2023) and number of types of critical food safety violations (temperature control deviations, poor sanitation, pest control issues, poor personal hygiene & unsuitable food conditions) in food facilities in Calgary regions?	Year: Categorical variable measured as binary (2022 vs. 2023).	Number of Types of Critical Food Safety Violations: Count/discrete variable measuring types of violations such as temperature control deviations, poor personal hygiene, pest control issues, poor sanitation, and unsuitable food conditions	<p>Descriptive statistics determined frequencies distribution of variables and crosstabulation to perform a Chi-square analysis.</p> <p>Chi-Square Test of Independence: This will be used to determine if there is an association between the year and number of critical food safety violations.</p> <p>Test for significant with the application of Pearson Chi-square and Measures of Phi and Cramer's V.</p> <p>Correspondence Analysis (CA):</p> <p>CA was used to visualize and summarize associations between dependent categorical variables : (a) Violation Type (five categories: Poor Sanitation, Temperature Control Deviation, Poor Personal Hygiene, Pest Control Issue, Unsuitable Food Condition) by Year (2022 vs. 2023), and (b) Violation Type by Region (Northeast—NE, Northwest—NW, Southeast—SE, Southwest—SW).</p> <p>Hierarchical Cluster Analysis</p> <p>Hierarchical Cluster Analysis (HCA) was used to group objects variables into clusters based on their similarities. The result is represented in a hierarchical structure, depicted as a dendrogram. In the agglomerative, the bottom-up approach was used where each object starts in its own cluster, and pairs of clusters were combined as one moves up the hierarchy. The dendrogram showed how clusters were formed at different levels of similarity. The height of the branches showed the distance or dissimilarity between clusters.</p> <p>Binary Logistic Regression</p> <p>Binary Logistic Regression is a statistical tool for modeling and interpreting binary outcomes. The method was used to model the relationship between one or more independent variables (predictors) and a dependent variable that is binary (i.e., it can take on two outcomes, typically coded as 0 and 1). The model estimated the probability that a given input point belongs to a particular category. The logistic function (or sigmoid function) was used to ensure that the output remains between 0 and 1, suitable for a probability measure.</p> <p>Multinomial Logistic Regression</p> <p>Multinomial Logistic Regression was used for modeling the relationship between dependent categorical variables (critical food safety violations) with more than two levels (or categories) and one or more independent variables (year and region). Multinomial logistic regression was used to predict the probabilities of each class or category</p>

Research question	Independent variables and measurement	Dependent variables and measurement	Statistical analysis
RQ2: Is there an association between the region of food facility in Calgary and Year (2022 vs. 2023) and number of types of critical food safety violations, temperature control deviations, poor sanitation, pest control issues, poor personal hygiene & unsuitable food conditions)?	Regions: Categorical variable representing different regions in Calgary (NW, NE, SW & SE). Year: Categorical variable (2022 vs. 2023).	Number of Types of Critical Food Safety Violations: Count/discrete variable.	<p>of the dependent variable, given the values of the independent variables.</p> <p>Descriptive statistics to determine frequencies distribution of variables and crosstabulation to perform a Chi-square analysis.</p> <p>Chi-Square Test of Independence: This will be used to determine if there is an association between the regions and number of critical food safety violations.</p> <p>Test for significant with the application of Pearson Chi-square and Measures of Phi and Cramer's V.</p> <p>Correspondence Analysis (CA): CA was used to visualize and summarize associations between dependent categorical variables : (a) Violation Type (five categories: Poor Sanitation, Temperature Control Deviation, Poor Personal Hygiene, Pest Control Issue, Unsuitable Food Condition) by Year (2022 vs. 2023), and (b) Violation Type by Region (Northeast—NE, Northwest—NW, Southeast—SE, Southwest—SW).</p> <p>Hierarchical Cluster Analysis Hierarchical Cluster Analysis (HCA) is used to group objects variables into clusters based on their similarities. The result is represented in a hierarchical structure, depicted as a dendrogram. In the agglomerative, the bottom-up approach was used where each object starts in its own cluster, and pairs of clusters were combined as one moves up the hierarchy. The dendrogram showed how clusters were formed at different levels of similarity. The height of the branches showed the distance or dissimilarity between clusters.</p> <p>Binary Logistic Regression Binary Logistic Regression is a statistical tool for modeling and interpreting binary outcomes. The method was used to model the relationship between one or more independent variables (predictors) and a dependent variable that is binary (i.e., it can take on two outcomes, typically coded as 0 and 1). The model estimated the probability that a given input point belongs to a particular category. The logistic function (or sigmoid function) was used to ensure that the output remains between 0 and 1, suitable for a probability measure.</p> <p>Multinomial Logistic Regression Multinomial Logistic Regression was used for modeling the relationship between dependent categorical variables (critical food safety violations) with more than two levels (or categories) and one or more independent variables (year and region). Multinomial logistic regression was used to predict the probabilities of each class or category of the dependent variable, given the values of the independent variables.</p> <p>Measure as percentage to compare regions.</p>
	Community's Socioeconomic Status: Measured using numerical or categorical scales for age, gender, race, income, and education level.		

Threats to Validity

It is important to address various validity threats that can affect the reliability of findings from the study. External validity in the study showed the extent to which the

findings could be generalized to similar research arrangements. In terms of external validity, COVID-19 pandemic could have influenced the regular inspections of food facilities in 2022 with an impact on the frequency of data collection on food facilities inspection because of the deployment of resources to other pandemic related activities. On the other hand, internal validity focused on the relationships among variables in the study. Food facilities inspection methodology was a possible internal validity threat to the study and interpretation of findings. For example, data collection tools and criteria utilized by PHIs must be standardized between the years and across regions to ensure consistency (Trafimow, 2023). The accurate measurement of the variables in the study addressed the threats to construct validity, while the correct interpretation of analytical result and inference ensured statistical conclusion validity. According to Trafimow (2023), careful consideration of the mentioned validity threats and the use of mitigating measures ensured a reliable study outcome and result interpretations.

Ethical Procedures

Data required for the study was obtained from report on food facilities inspection across Calgary regions which were publicly available on the official website of AHS (n.d.c). However, the required procedure was followed to access the information on the website of AHS for research purposes. Data was generated after approval from Walden University Institutional Review Board (IRB). The process ensured compliance with data request procedures and adherence to IRB standards. The study was devoid of human participants, ethical concerns on recruitment and intervention activities were not a concern. Anonymity and confidentiality of food facilities inspection reports were ensured

by strict data coding and not referring to names, locations and identifying labels of individual food establishments in the study report. Data storage was secured by the use of encryption protection, and only coded data were used for statistical analysis and reports to ensure anonymity and compliance with ethical standards. In addition, there was no conflict of interest resulting from the conduct of the study and there was no undue advantage to any of the facilities and regions studied. Adherence to ethical guidelines and data handling ethics was ensured and the study conducted in a responsible manner to yield a reliable and consistent result.

Summary

The study utilized comparative cross-sectional design to examine the association between Calgary regions in 2022 versus 2023 considering COVID-19 impact and the number of types of critical food safety violations (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions*). The study also explored socioeconomic data from the 2021 Canada population census result for communities within Calgary regions. The socioeconomic status factors that were explored were age, gender, race, income and educational level.

Information on food facilities inspection reports was obtained from AHS and converted to secondary data to generate variables for the study. Quantitative methodology was used for the study with Calgary regions (Northwest, Northeast, Southwest and Southeast) and 2022 and 2023 as independent variables and critical food safety violations (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions*) as independent variables. The study populations

were food facilities with critical food safety violations inspected across Calgary regions in 2022 and 2023 and stratified random sampling was utilized to select the food facilities for the study. The SPSS statistical software version 29 developed by IBM was used for data analyses and hypothesis testing conducted by crosstabulation with Pearson Chi-square and Measures of Phi and Cramer's V coefficients used to determine association between the number of types of critical food safety violations during a year (2022 vs. 2023) and across Calgary regions. Threats to external and internal validity in the study were addressed to ensure result reliability, and ethical principles followed to comply with data privacy and prevent conflict of interest.

The next chapter outlines results of statistical analyses based on the secondary data generated from the information on food facilities inspection reports across Calgary regions in 2022 and 2023. In chapter four a brief review of the purpose, research questions, and hypotheses was discussed and a concise report of the result presented. In addition, changes in instrumentation, data analysis strategies and other aspects of the methodology were discussed. The time frame for data collection, the ease to access of data and discrepancies in data collection from the plan presented in chapter 3 was enumerated. Furthermore, in chapter four, baseline descriptive and demographic characteristics were presented and the relationship between the sample and the population used to justify external validity. Appropriate descriptive statistics related to the samples were reported and statistical assumptions related to the study evaluated. Report of statistical analysis hypothesis testing and relevant statistical tables were also presented.

Chapter 4: Results

Introduction

The purpose of this quantitative research was to examine the association between Calgary regions for 2022 versus 2023 and the number of types of critical food safety violations (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions*) in food facilities.

Secondary data collected from the website of AHS was analyzed to address two research questions in the study and the associated hypotheses as stated below.

RQ1: Is there an association between the Year (2022 vs. 2023) and number of types of critical food safety violations (temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions) in food facilities in Calgary regions?

H_0 1: There is no association between the Year (2022 vs. 2023) and number of types of critical food safety violations (temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions) in food facilities in Calgary regions.

H_1 1: There is an association between the Year (2022 vs. 2023) and number of types of critical food safety violations (temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions) in food facilities in Calgary regions.

RQ2: Is there an association between the regions of food facility in Calgary and number of types of critical food safety violations (temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions)?

H₀₂: There is no association between the regions of food facility in Calgary and number types of critical food safety violations (temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions).

H₁₂: There is an association between the region of food facility in Calgary and number types of critical food safety violations (temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions).

This chapter focuses on data collection procedures, data cleaning, and explanation of the key variables and demographic characteristics of the population across Calgary regions. The chapter presents details on descriptive statistics for the sample and result summary in tables. The result of each research question, their statistical interpretations and implications were explained based on the assumptions and hypotheses for the study.

Sample Description

Samples for the study were selected representative food facilities from the four regions in Calgary (Northwest, Northeast, Southwest and Southeast) which had critical food safety violations based on PHIs reports in 2022 and 2023.

Selected food facilities across Calgary regions have documented inspection reports with critical food safety violations in 2022 and 2023. The food facilities sampled

for the study include restaurants, cafés, canteens, hotels, bars, and other food service establishments. Each sample was described with the names of food facility, physical address, the region in which the food facility was located and types of critical food safety violations associated with the facility. Other details of the sampled food facilities were the date in which violation occurred, inspector description of the violation, status of the violation and a remark based on food safety regulations violated.

The study also explored the socioeconomic factors in communities across Calgary regions with focus on age, gender, race, income and educational level of communities within Calgary regions.

Data Collection

Secondary data for the study were generated from food facilities inspection reports which contain critical food safety violations recorded in 2022 and 2023 in Calgary regions (Northwest, Northeast, Southwest and Southeast). The food facilities inspection reports were accessed on the website of AHS (n.d.c). Based on the description of food safety violations on the inspection reports, critical food safety violations were categorized into temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions.

Data Cleaning

To provide clarity, the information on food facilities inspection reports obtained from AHS website were tabulated in a spreadsheet. Summarized spreadsheets contained information in which the names of the food facilities were coded from 1 to 877. Other information on the consolidated spreadsheets were Calgary regions, types of critical food

safety violations and respective years that correspond to the extracted details. Data was cleaned by removing duplicated information, spellings were checked, numbering accuracy and spaces between words were verified to avoid misinterpretation in SPSS.

The cleaned and consolidated spreadsheets used for statistical analysis in SPSS consisted of four columns which were food facilities identification code (1 to 877), regions of Calgary (NE, NW, SE and SW), year (2022 and 2023) and the number of types of critical food safety violations (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions*).

Study Variables

The independent variables in the study were years of food safety violations (2022 versus 2023) and Calgary regions (Northwest, Northeast, Southwest and Southeast). The independent variables were categorical and applicable to both research questions. The dependent variable in the study was the number of types of critical food safety violations which were discrete and applicable to research questions 1 and 2. The types of critical food safety violations identified in the study were temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions.

Results

Descriptive Statistics

Table 3 showed variation in the number of types of critical food safety violations by Year (2022 versus 2023) and regions. The critical food safety violations were counted for 2022 and 2023 which were coded as 0 and 1, respectively. Types of critical food safety violations were coded as 1 for poor sanitation, 2 for temperature control deviation,

3 for poor personnel hygiene, 4 for pest control issues and 5 for unsuitable food condition.

The total count of the number of types of critical food safety violations for 2022 was 98, which accounted for 11.17% for both years combined. In 2023, the total count for the number of types of critical food safety violations was 779 equivalent to 88.83% for both years combined. There were 54 cases of poor sanitation in 2022 equivalent to 55.10% of total number of types of critical food safety violations for the year. On the other hand, cases of poor sanitation in 2023 were 450 equivalent to 57.77% of total number of types of critical food safety violations reported during the year. In 2022, eighteen cases an equivalent of 18.37% of temperature control deviations were reported compared to 195 cases which translated to 25.03% of reported cases of total number of types of critical food safety violations in 2023. The number of types of critical food safety violations in respect of poor personnel hygiene were zero (0) and 20 cases in 2022 and 2023 both represented 0% and 2.57%, respectively. Only one case of pest control issue was reported in 2022 equivalent of 1.02% for the year, in contrast to four cases an equivalent of 0.52% reported in 2023. Critical food safety violations connected to unsuitable food conditions were 25 (25.51%) in 2022 and 110 (14.12%) in 2023, respectively. With a p-value of 0.018, there was an association between number of types of critical food safety violations and year (2022 versus 2023).

The variation between the number of types of critical food safety violations, year regions were also displayed in Table 3. The critical food safety violations for the four regions in Calgary which are Northeast (NE) coded as 1, Northwest (NW) coded as 2,

Southeast (SE) coded as 3 and Southwest (SW) coded as 4. Types of critical food safety violations were coded as poor sanitation (1), temperature control deviation (2), poor personnel hygiene (3), pest control issues (4) and unsuitable food condition (5) respectively. The Northeast region had a count of three hundred and fifty (350) critical food safety deviations followed by the Northwest region with a count of two hundred and twenty-five (225) critical food safety deviations. The Southeast and Southwest regions recorded 100 and 202 counts of critical food safety deviations, respectively. The highest counts of critical food safety violations were poor sanitation with 504 cases reported across regions. Temperature control deviation had 213 cases and poor personnel hygiene cases were 20 across regions. The counts for pest control issues and unsuitable food condition were 5 and 125, respectively. With a p-value of < 0.001 , there was an association between number of types of critical food safety violations and region. Appendix B (B1 to B5) showed graphical representations of the descriptive statistics.

Table 3

Number of Types of Critical Food Safety Violations by Year and Region

Critical food safety violations		Poor sanitation (1)	Temperature control violations (2)	Pest control issue (3)	Poor personal hygiene (4)	Unsuitable food condition (5)	n (%)	p-value
Year	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)		
2022 (0)	54 (55.10)	18 (18.37)	0 (0)	1 (1.02)	25 (25.51)	98 (11.17)	0.018	
2023 (1)	450 (57.77)	195 (25.03)	20 (2.57)	4 (0.51)	110 (14.12)	779 (88.83)		
Total	503 (57.35)	213 (24.29)	20 (2.28)	5 (0.57)	135 (15.39)	877		
Region								
NE (1)	193 (55.14)	69 (19.71)	9 (2.57)	29 (0.57)	77 (22)	350	< 0.001	
NW (2)	123 (54.67)	68 (30.22)	8 (3.56)	0 (0)	26 (11.56)	225		
SE (3)	63 (63)	22 (22)	0 (0)	2 (2)	13 (13)	100		
SW (4)	125 (61.88)	54 (26.73)	3 (1.49)	1 (0.50)	19 (9.41)	202		
Total	504	213	20	5	125	877		

Statistical Analysis

Chi-Square Test and Symmetric Measures

Table 4 showed summary of statistical analysis results of Chi-square test of independence and measures of Phi and Cramer's V tests to evaluate the association between the number of critical food safety violations and Year (2022 Versus 2023), and the number of critical food safety violations and regions.

For association between the number of critical food safety violations and year, result showed a statistically significant link, $\chi^2(4, N = 877) = 11.944, p = .018$ which indicated that different number of types of critical food safety violations distribution emerged between 2022 and 2023. The p-value obtained for Pearson Chi-square was 0.018 which was less than 0.05 which indicated a statistically significant association. Thus, the null hypothesis (**H₀**) was rejected which postulated that there was no association between the number of critical food safety violations and year. The result was supported by the alternative hypothesis (**H₁**) which postulated that an association between the number of types of critical food safety violations were different for year of critical food safety violations (2022 versus 2023). In terms of measures symmetry denoted by Phi and Cramer's V tests, a p-value of less than a significance level of alpha of 0.05 threshold was obtained. The p-values for both Phi and Cramer's V coefficients were 0.018, this suggested that the results were statistically significant for both coefficients. This was interpreted as statistically significant evidence, an indication of an association between the year of critical food safety violations (2022 versus 2023) and the number of types of critical food safety violations. In other words, evidence indicated that the occurrences of

food safety violations were related to the year of the violations. With the p-values of 0.018 for Pearson Chi-square as well as Phi and Cramer's V coefficients, the null hypothesis (**H₀**) was rejected. This was interpreted as a statistically significant association between the year of critical food safety violations (2022 versus 2023) and the number of types of critical food safety violations.

Table 4 displayed results of tests to detect association between the number of types of critical food safety violations and regions. Result revealed a significant association with $\chi^2 (12, N = 877) = 35.460$, and $p < 0.001$ which showed variations in number of types of critical violations across regions. A statistically significant p-value of less than 0.001 was obtained which was less than 0.05. Hence, the null hypothesis (**H₀**) which postulated that there was no association between the number of types of critical food safety violations and region was rejected. The p-value thus supported the alternative hypothesis (**H₁**) which established that the number of types of critical food safety violations were different between regions. The result showed that it was highly unlikely that the observed association across Calgary regions and the number of types of critical food safety violations were due to random chance. In addition, a low p-value (< 0.001) for Phi and Cramer's V measures indicated a statistically significant association which implied a meaningful relationship between the Calgary regions and the number of types of critical food safety violations. With the p-values less than 0.001, the null hypothesis (**H₀**) was rejected. This was interpreted as a statistically significant association between the Calgary regions and the number of types of critical food safety violations.

Table 4

Result of Statistical Analysis for Chi-Square Test of Independence

Variables	Statistics	Values	df	p-values
Number of critical food safety violations by Year (2022 versus 2023)	Pearson Chi-square	11.994a		0.018
	Phi coefficient	.117		0.018
	Cramer V coefficient	.117	4	0.018
	Valid cases	877		
Variables	Statistics	Values	df	p-values
Number of critical food safety violations by regions	Pearson Chi-square	35.460a		< 0.001
	Phi coefficient	.201		< 0.001
	Cramer V coefficient	.116		< 0.001
	Valid cases	877	12	

Interpretation of the Findings in the Context of the Research Questions/Hypotheses

For research question 1, the objective was to determine if there was an association between Year (2022 versus 2023) and number of types of critical food safety violations. Thus, RQ1 along with the null and alternative hypotheses are stated below:

RQ1: Is there an association between the Year (2022 vs. 2023) and number of types of critical food safety violations (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions*) in food facilities in Calgary regions?

H_0 1: There is no association between the Year (2022 vs. 2023) and number of types of critical food safety violations (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions*) in food facilities in Calgary regions.

H₁₁: There is an association between the Year (2022 vs. 2023) and number of types of critical food safety violations (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions*) in food facilities in Calgary regions.

The result in Table 4 from the Pearson Chi-square and Symmetric Measures (Measures of Phi and Cramer's V) showed $p = .018 (< 0.05)$ and interpreted as a statistical significance between Year (2022 versus 2023) and number of types of critical food safety violations, hence the null hypothesis (H₀) was rejected.

Research question 2 aimed to determine if there was an association between Calgary regions and number of types of critical food safety violations. Thus, RQ2 along with the null and alternative hypotheses are stated below:

RQ2: Is there an association between the regions of food facility in Calgary and number of types of critical food safety violations (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions*)?

H₀₂: There is no association between the regions of food facility in Calgary and number of types of critical food safety violations (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions*)?

H₁₂: There is an association between the regions of food facility in Calgary and number types of critical food safety violations, (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions*)?

Similarly in Table 4, a statistically significant p-value, $p = .000$ was obtained for Pearson Chi-square and symmetric measures (Measures of Phi and Cramer's V), hence

the null hypothesis (H_0) which postulated that there was no association between the number of types of critical food safety violations and regions was rejected. The alternative hypothesis (H_1) which suggested an association between the number of types of critical food safety violations and region was accepted. The result was interpreted as a statistical significance between Calgary regions and the number of types of critical food safety violations; hence the null hypothesis (H_0) was rejected.

Correspondence Analysis

Correspondence Analysis (CA) visualized and summarized associations between dependent variables: number of types of critical food safety violations which are poor sanitation, temperature control deviation, poor personal hygiene, pest control issue and unsuitable food condition by Year (2022 vs. 2023), and by region (Northeast—NE, Northwest—NW, Southeast—SE, Southwest—SW). Analyses were conducted on SPSS with χ^2 distances and symmetrical normalization. For year by critical food safety violations, only one dimension was available (2-year table) with interpretation focused on a single axis.

CA for Critical Food Safety Violations by Year

In Table 5, only one dimension was considered. The model revealed a single dimension with singular value = 0.117 and total inertia = 0.014 (equivalent $\chi^2 = 11.944$, $p = .018$), which showed a small but statistically detectable association between number of types of critical food safety violations and year. Year 2022 had a positive column score on the axis with a high contribution (column score ≈ 0.963 ; high contribution), whereas 2023 had a negative column score (≈ -0.121). Unsuitable food condition appeared on the

most positive side (row score ≈ 0.682 ; largest contribution), while temperature control deviation had a negative value of negative 0.253 and poor personal hygiene was strongly negative with a value of negative 1.038.

The result aligned with the chi-square residuals which showed that unsuitable food condition was over-represented in 2022 and under-represented in 2023.

Table 5

Critical Food Safety Violations by Year (2022 and 2023) - CA Scores and Contributions

Category	Type	Score (Dimension 1)	Contribution (Dimension 1)
Violation 1	Row	-0.043	0.009
Violation 2	Row	-0.253	0.133
Violation 3	Row	-1.038	0.211
Violation 4	Row	0.820	0.033
Violation 5	Row	0.682	0.614
Year 2022	Column	0.963	0.888
Year 2023	Column	-0.121	0.112

CA for Number of Types Critical Food Safety Violations by Region

Table 6 showed result of a model with two dimensions. These dimensions were interpreted as singular values = 0.163 and 0.114; total inertia = 0.040; $\chi^2 = 35.460$ and $p < .001$. This indicated a small but meaningful association between the number of types of critical food safety violations by regions. In dimension (Dim) 1, the critical food safety violations with the largest positive weight were unsuitable food condition (row score ≈ 0.873 ; highest contribution) and pest control issue (≈ 0.539). On the other hand, a negative value was obtained for temperature control deviation (≈ -0.412). By region, NE was positive (column score ≈ 0.480 ; highest contribution), while SW was negative (\approx

-0.407) which was consistent with earlier residuals that showed unsuitable food condition was higher in NE and lower in SW, respectively.

The secondary contrast in dimension (Dim) 2 showed the axis was shaped by poor personal hygiene (row score ≈ -1.404 ; high contribution) and pest control issue (≈ 2.739). On the region side, SE had a strong influence (column score ≈ 0.768) and the contribution from NW was negative 0.385. The result showed that NE aligned with unsuitable food condition, while SW was positioned away from it and NW leaned more toward temperature control deviation. On the second dimension, SE was influenced by personal hygiene and pest control issue, a secondary profile features distinct from other regions.

The findings from CA corroborated the chi-square findings. Year 2022 and NE region were associated with unsuitable food condition, whereas SW region did not align with unsuitable food condition. The NW showed a relative emphasis on temperature control deviation. The effects for both year and region were small in magnitude (total inertia ≈ 0.014 for Year; ≈ 0.040 for Region) but statistically significant, thus they described shifts in composition rather than large absolute differences.

Table 6

Critical Food Safety Violations by Region CA Scores (Dim1, Dim2) and Contributions

Category	Type	Score (Dim1, Dim2)	Contribution Dim1	Contribution Dim2
Violation 1	Row	(-0.068, 0.153)	0.016	0.118
Violation 2	Row	(-0.412, -0.200)	0.253	0.085
Violation 3	Row	(0.076, -1.404)	0.001	0.393
Violation 4	Row	(0.539, 2.739)	0.010	0.374
Violation 5	Row	(0.873, -0.149)	0.720	0.030
Region 1	Column	(0.480, -0.073)	0.564	0.018
Region 2	Column	(-0.357, -0.385)	0.200	0.332
Region 3	Column	(-0.057, 0.768)	0.002	0.588
Region 4	Column	(-0.407, 0.174)	0.234	0.061

Hierarchical Cluster Analysis of Region–Year

Ward’s method with squared Euclidean distance in SPSS was used to cluster region and year profiles for Northeast (NE), Northwest (NW), Southeast (SE), Southwest (SW) along with 2022 and 2023. Variables were the five critical food safety violation types which are poor sanitation, temperature control deviation, poor personal hygiene, pest control issue, and unsuitable food condition. These were summarized as profile vectors for each region and year. The total counts for the critical food safety violations differed by year, hence emphasis was on relative composition (profiles), not raw counts. Inspection of the agglomeration schedule and the dendrogram indicated a pronounced elbow at the final merge point. Hence, a two-cluster solution was selected as in Table 7 (cut immediately before the last fusion).

Cluster 1 termed as “2022-like profiles” comprised NE-2022, NW-2022, SE-2022, SW-2022, and SE-2023. This cluster represented a more balanced mix overall with a larger share of unsuitable food conditions relative to 2023. On the other hand,

cluster 2 comprised of NE-2023, NW-2023, SW-2023 region and year interaction. The pattern in cluster 2 was characterized by more temperature control deviation and less unsuitable food condition overall. Within cluster 2, NW-2023 showed the clearest emphasis on temperature control deviation; SW-2023 was low on unsuitable food condition; NE-2023 was comparatively higher on unsuitable food condition than other members in the cluster which explained its pairing order in the dendrogram shown in Figure 2.

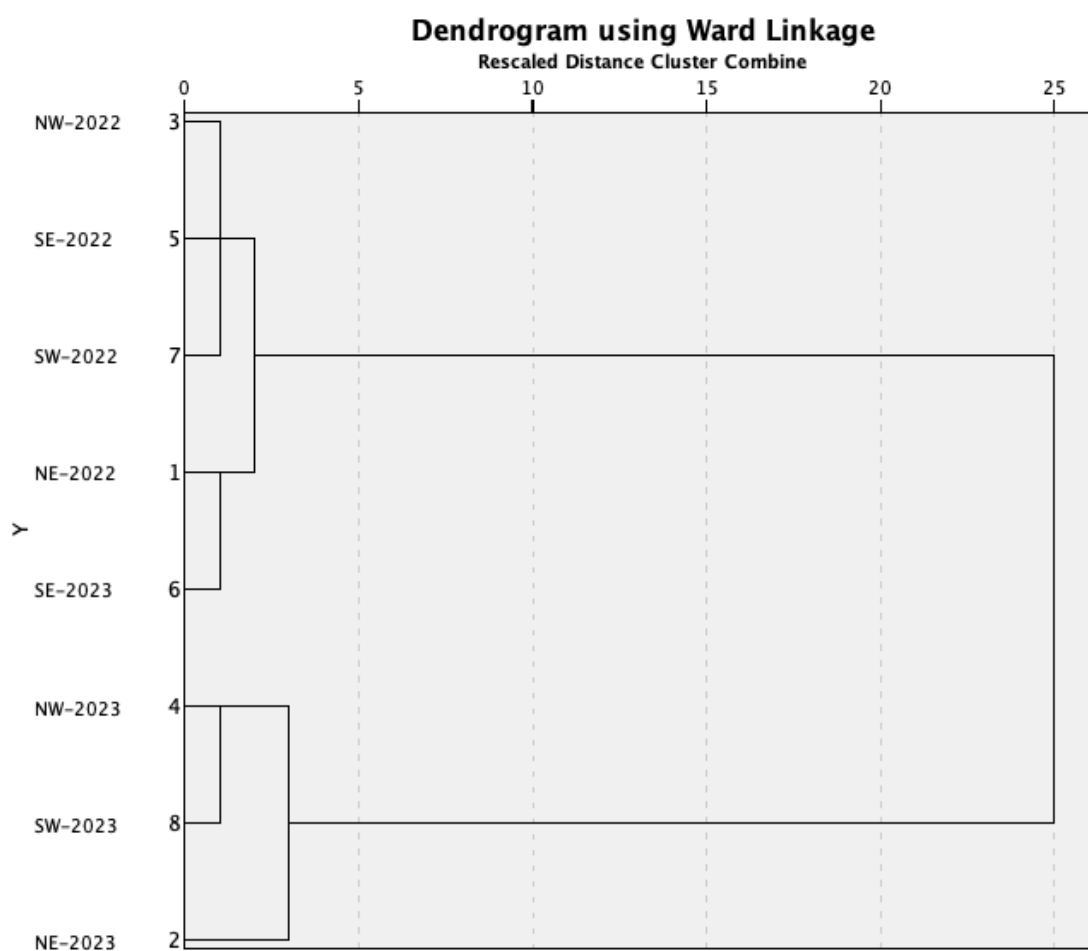
Table 7

Region–Year Membership by Cluster

Cluster	Region–Year members
Cluster 1	NE-2022; NW-2022; SE-2022; SW-2022; SE-2023
Cluster 2	NE-2023; NW-2023; SW-2023

Figure 2

Dendrogram (Ward Linkage) With Cut Indicated Just Before the Final Fusion



Note. Labels show region–year (e.g., NW-2023)

Table 8 displayed interaction between members in the profiles of cluster 1 and cluster 2 with corresponding coefficients with an agglomeration schedule (ward linkage). As descriptive clustering, given $n = 8$ profiles and ward linkage groups cases by overall profile similarity, there were relative emphases in violation mix rather than large absolute differences. Table 8 revealed that the largest increase occurred at Stage 7 (coefficient \approx

34,404.625) which suggested a 2-cluster solution if a cut was made just before the final merger. The result was exploratory given the descriptive nature of the clustering and $n=8$.

Table 8

Agglomeration Schedule (Ward Linkage)

Stage	Cluster 1	Cluster 2	Coeff.	First Appears (Cluster 1)	First Appears (Cluster 2)	Next Stage
1	3	5	1.500	0	0	2
2	3	7	40.667	1	0	5
3	4	8	162.167	0	0	6
4	1	6	557.167	0	0	5
5	1	3	1915.900	4	2	7
6	2	4	4688.400	0	3	7
7	1	2	34404.625	5	6	0

The clusters mirrored the chi-square residuals and correspondence-analysis maps in which unsuitable food condition was higher in 2022 and in NE region, whereas NW region showed a relative emphasis on temperature control deviation and SW region was lower on unsuitable food condition.

Binary Logistic Regression

A binary logistic regression (SPSS *LOGISTIC REGRESSION*) predicted the odds of a serious violation (*Serious Flag* = 1), where serious = codes 3–5 (*Poor Personal Hygiene, Pest Control Issue, Unsuitable Food Condition*) and not-serious = codes 1–2 (*Poor Sanitation, Temperature Control Deviation*). Predictors were Year (2023 vs. 2022) and region (NW, SE, SW vs. NE as the reference). The default probability cutoff of 0.50 was used for the classification table.

The model was statistically significant (Omnibus $\chi^2(4) = 22.483$, $p = < .001$); -2 Log Likelihood = 810.796; pseudo- R^2 were small (Cox & Snell = 0.025, Nagelkerke =

0.041). With a rare positive class, the default 0.50 cutoff produced 81.8% accuracy with 100% specificity but 0% sensitivity (the model predicted all cases as not-serious at the default threshold). Table 9 summarized model fit and classification with a default cutoff of 0.50.

Table 9

Model Fit and Classification

Metric	Value
Omnibus χ^2 (df=4), p	22.483, < .001
-2 Log Likelihood	810.796
Cox & Snell R ²	0.025
Nagelkerke R ²	0.041
Cutoff	0.50
Overall accuracy	81.8%
Specificity	100%
Sensitivity	0%

The NE region was used as a reference for the regions and 2023 vs. 2022 for year. Odds ratios (OR) < 1 indicated lower odds relative to the reference, while OR > 1 showed higher odds. Table 10 showed a summary of the odd ratios, the p-values and interpretation based on NE region as a reference.

Table 10

Odds Ratios and p-Values

Predictor	Odds Ratio (OR)	p-value
2023 vs. 2022	0.648	.088
NW vs. NE	0.545	.007
SE vs. NE	0.511	.029
SW vs. NE	0.403	< .001

Holding region constant, 2023 showed a decrease in serious critical food safety violations relative to 2022, but the effect was not significant level (p = .088). Holding

year constant, the NE region had the highest odds of serious critical food safety violations, thus NW, SE, and SW regions each had significantly lower odds than NE. With Year (2023 versus 2022) as predictor variable, result displayed in table 10 indicated fewer serious violations in 2023 with an odd ratio and p-value of 0.648 and 0.088, respectively. Northwest (NW) region compared to Northeast (NE) region showed significantly lower odds in NW than NE region with an odd ratio and p-value of 0.545 and 0.007, respectively. Significantly lower odds were recorded in Southeast (SE) compared to the Northeast (NE) region. The odd ratio and p-value were 0.511 and 0.029. Similarly, the odd ratio and p-value were 0.403 and $< .001$ when Southwest (SW) and Northeast (NE) regions were compared. Table 11 displayed the values of logistic regression coefficients.

Table 11

Logistic Regression Coefficients

Predictor	B	SE	OR (Exp(B))	df	95% CI	p-value
Year=2023	-0.434	0.254	0.648	1	[0.394, 1.066]	.088
Region=1(NW)	-0.607	0.224	0.545	1	[0.351, 0.845]	.007
Region=2 (SE)	-0.671	0.307	0.511	1	[0.280, 0.933]	.029
Region=3 (SW)	-0.908	0.256	0.403	1	[0.244, 0.666]	$< .001$
Intercept	-0.728	0.243	0.483	1		.003

Multinomial Logistic Regression

A multinomial (nominal) logistic regression was estimated in SPSS (NOMREG) with unsuitable food condition (code 5) as the reference outcome, 2023 (code 1) as the reference year, and Southwest—SW (code 4) as the reference region. SPSS reported sparse cells and Hessian singularities; therefore, parameter estimates for rare categories

should be read with caution. Table 12 showed summary of analysis results for global model tests and fit indices.

The model improved over the intercept-only baseline ($-2LL: 134.041 \rightarrow 86.971$), $\Delta\chi^2(16) = 47.071$, $p < .001$. Goodness-of-fit was acceptable (Pearson $\chi^2(12) = 3.727$, $p = .988$; Deviance $\chi^2(12) = 5.165$, $p = .952$), though pseudo- R^2 values indicate small explanatory power (Nagelkerke = .059). Likelihood-ratio tests indicated that Year ($\chi^2(4) = 9.878$, $p = .043$) and Region ($\chi^2(12) = 33.902$, $p < .001$) contributed to differences in violation type.

Table 12

Global Model Tests and Fit Indices

Metric	Value
Baseline $-2LL$	134.041
Final $-2LL$	86.971
Model $\Delta\chi^2$ (df=16), p	47.071, < .001
Pearson χ^2 (df=12), p	3.727, .988
Deviance χ^2 (df=12), p	5.165, .952
Nagelkerke R^2	.059
LR Test — Year (df=4), p	9.878, .043
LR Test — Region (df=12), p	33.902, < .001

Given sparse categories of the dependent variables, results focused on the two well-populated outcomes (poor sanitation and temperature control deviation). Estimates for poor personal hygiene and pest control issue were unstable and not interpreted. Though both year and region had significant impact, the effects were small, however, relative to unsuitable food conditions, 2023 shifted toward temperature control deviation compared with 2022. There were also noticeable differences in regional effects. Both SW and NE regions showed lower odds of poor sanitation and temperature control deviation

consistent with NE region which had a higher share of unsuitable food condition reported in preceding analyses. Estimates for poor personal hygiene and pest control issues were not emphasized due to sparse cells and instability.

Table 13 displayed the statistical analysis result of selected parameter estimates with focus on poor sanitation and temperature control deviation for 2022 and NE region.

Table 13

Selected Parameter Estimates with Unsuitable Food Condition as Reference

Outcome	Predictor	B	SE	Wald	df	p	OR	95% CI (LB-UB)
1	Year=0	-0.527	0.271	3.786	1	.052	0.591	—
1	Region=1	-0.896	0.284	9.995	1	.002	0.408	0.234–0.711
2	Year=0	-0.732	0.339	4.662	1	.031	0.481	0.247–0.935
2	Region=1	-1.066	0.317	11.297	1	<.001	0.344	0.185–0.641

Table 14 displayed the result of multinomial logistic regression for the interaction of poor sanitation and temperature control deviation relative to unsuitable food condition. Additionally, Table 14 showed interaction of predictor variables which correspond to the outcome variables of poor sanitation and temperature control deviation. In comparison to unsuitable food condition, Table 14 showed 2022 had lower odds of poor sanitation than 2023, and the Northeast (NE) region leaned towards unsuitable food condition relative to Southwest (SW) region when contrasted with poor sanitation. Similarly, 2023 had higher relative odds of temperature control deviation compared to unsuitable food condition than 2022. Thus, the Northeast (NE) region had more occurrences of unsuitable food condition relative to Southwest (SW) region when contrasted with temperature control deviation.

Table 14*Selected Parameter Estimates*

Outcome (vs. Unsuitable Food Condition)	Predictor	B	OR	95% CI	p -value
Poor sanitation (code 1)	2022 vs. 2023	-0.527	0.591	[0.348, 1.004]	.052
Poor sanitation (code 1)	NE vs. SW	-0.896	0.408	[0.234, 0.711]	.002
Temperature control deviation (code 2)	2022 vs. 2023	-0.732	0.481	[0.247, 0.935]	.031
Temperature control deviation (code 2)	NE vs. SW	-1.066	0.344	[0.185, 0.641]	< .001

Exploration of Socioeconomic Indices by Region

Table 15 displayed summary of numbers, proportions and percentages of key socioeconomic indices compiled for Northeast (NE), Northwest (NW), Southeast (SE) and Southwest (SW) regions of Calgary from Canada 2012 population census result.

Table 15 summarized information from Appendix C which comprised of Tables C1, C2, C3 and C4, respectively. Each of Tables C1 to C4 in Appendix C represented data of socioeconomic indices for the Northeast (NE), Northwest (NW), Southeast (SE) and Southwest (SW) regions of Calgary obtained from Canada 2012 population census result.

The total population for NE region was 65,530 while NW had a population of 48,010. The reported population for SE and SW regions were 56,755 and 45,975, respectively. Across regions, percentage of women in the population was slightly higher than those of men. Southwest region had the highest population of women at 51.4% and Northeast with the lowest percentage of women population at 50.5%. The percentages of women population in the Northwest and Southeast were 51.1 and 50.9, respectively. The

percentages of men in the population for NE were 49.5%, NW was 48.9%, SE was 49.1% and SW was 48.6%, respectively.

The percentage of population in each age group was within same range across the regions as shown in Table 15. The age group of 25-44 years had the highest percentages across regions with highest values of 36.6% in the Northeast and Southeast regions. The percentage of populations in the age group of 25-44 years for Northwest and Southwest were 24.6% and 21.3%, respectively.

In terms of level of schooling, the northeast region had the highest percentage of population (9.5%) in the 25-64 years old age group with no certificate, diploma or degree followed by the Southeast (3.9%), the Southwest (2.4%) and the Northwest (2.1%) which had the least percentage of population with no certificate, diploma or degree. Similarly, the Northeast region recorded the highest percentage (22.9%) of population in the 25-64 years of age with a secondary (high) school diploma or equivalency certificate. This was followed by other regions in decreasing order with the Southeast (20.2%), Northwest (14.9%) and Southwest (12.3%) of population within same age group with a secondary (high) school diploma or equivalency certificate. The Southwest region had the highest percentage of population (85.3%) in the age group 25-64 years old with a postsecondary certificate, diploma, or degree. This was followed closely by the Northwest region (83.0%), the Southeast region (75.9%) and the least percentage of population in same age group with a postsecondary certificate, diploma or degree was Northeast region which had as 67.6%.

The highest median household income of \$142,000 was recorded in the Southwest region, and the lowest median household income of \$102,000 which was the value for the Northeast region. The median household income for the Northwest and Southeast regions was \$132,000 and \$125,000, respectively. The percentage of population of visible minorities was highest in the Northeast region (78%) followed by Southwest region with 38.8% of visible minorities. The percentage of visible minorities in Northwest and Southeast regions were 33.4% and 32.4%, respectively.

Table 15*Summary of Socioeconomic Indices by Region*

Indices	NE	NW	SE	SW
Population	n (%)	n (%)	n (%)	n (%)
Total Population	65,530	48,010	56,755	45,975
Men	32,437.35 (49.5)	23,476.89 (48.9)	27,866.71 (49.1)	22,343.85 (48.6)
Women	33,092.65 (50.5)	24,533.11 (51.1)	28,888.29 (50.9)	23,631.15 (51.4)
Age Groups				
0-4 years	473.88 (8.5)	110.64 (4.8)	408.85 (8.5)	92.48 (4.5)
5-17 years	1,980.12 (17.4)	1,842.4 (19.6)	2,477.70 (20.9)	1,611.94 (18.7)
18-24 years	449.03 (8.3)	329.51 (8.3)	185.25 (5.7)	331.93 (8.5)
25-44 years	8,780.34 (36.6)	2,902.8 (24.6)	7,610.97 (36.6)	2,084.21 (21.3)
45-64 years	2,889.6 (21.0)	4,184.58 (29.5)	2,386.2 (20.5)	4,451.97 (31.1)
65 years and over	449.86 (8.3)	836.88 (13.2)	343.2 (7.8)	1,149.45 (15.8)
Highest Level of Schooling				
Total population 25 to 64 years	37,735	25,870	32,420	23,865
No certificate, diploma, or degree (%)	9.5	2.1	3.9	2.4
Secondary (high) school diploma or equivalency certificate (%)	22.9	14.9	20.2	12.3
Postsecondary certificate, diploma, or degree (%)	67.6	83.0	75.9	85.3
Household Income (2020)				
Total private households (n)	21,035	16,650	19,920	16,105
Median household income (\$)	102,000	132,000	125,000	142,000
Visible Minorities				
Total population by visible minority	64,755	47,600	56,455	45,335
Not a visible minority (%)	18,908.46 (29.2)	31,701.6 (66.6)	38,163.58 (67.6)	27,745.02 (61.2)
Visible minority population (%)	45,846.54 (70.8)	15,898.4 (33.4)	18,291.42 (32.4)	17,589.98 (38.8)

Summary

The intent of the study was to determine associations between the number of types of critical food safety violations and years (2022 versus 2023) on one hand, and the association between the number of types of critical food safety violations and regions in Calgary (Northeast, Northwest, Southeast and Southwest) on the other hand. The study also explored the socioeconomic factors across Calgary.

For research question 1, statistical analysis results from Pearson Chi-Square and Measures of Phi and Cramer's V showed a significant difference ($p = .018$). This implied different distributions and patterns in the number of types of critical food safety violations for 2022 versus 2023 across Calgary regions. Thus, the null hypothesis (H_0) which stated that there was no association between the number of types of critical food safety violations and Year (2022 versus 2023) was rejected. The number of food facilities across Calgary regions and Years (2022 versus 2023) was 877. In 2022, 11.2% of food facilities had critical food safety violations and 88.8% of the food facilities had critical food safety violations in 2023. With respect to research question 2, statistical analysis results from Pearson Chi-Square and Measures of Phi and Cramer's V showed a significant difference ($p = .000$). This implied that the number of types of critical food safety violations differed and varied significantly across Calgary regions. The statistical results did not support the null hypothesis (H_0) which stated that there was no association between the number of types of critical food safety violations and Calgary regions. Number of types of critical food safety violations differed from regions, and this was

corroborated by result of Pearson Chi-Square and Measures of Phi and Cramer's V statistical analysis result.

The result of correspondence analysis aligned with the chi-square test of independence with a statistically detectable association between number of types of critical food safety violations and year ($p = 0.018$). Similarly, their correspondence analysis revealed a small but meaningful association between the number of types of critical food safety violations by region ($p < .001$). Result from hierarchical cluster analysis followed a similar with the chi-square residuals and correspondence-analysis maps. Cluster analysis showed that unsuitable food condition was higher in 2022 and in NE region, however, the NW region showed a relative emphasis on temperature control deviation and SW region was lower on unsuitable food condition.

A binary logistic regression model predicted the odds of a serious violation with serious violation represented as serious = codes 3–5 (Poor Personal Hygiene, Pest Control Issue, Unsuitable Food Condition) and not-serious = codes 1–2 (Poor Sanitation, Temperature Control Deviation). With Year (2023 vs. 2022) as predictors and region as the reference, a statistically significant ($p = < .001$) was obtained. Results of multinomial logistic regression revealed differences in regional effects in which both SW and NE regions showed lower odds of poor sanitation and temperature control deviation consistent with NE region with higher share of unsuitable food condition reported in other statistical analyses.

The socioeconomic factors of the communities across Calgary regions were explored. Compared to other regions, Northeast region of Calgary had the highest number

of types of critical food safety violations, as shown in Table 4. The region had the highest population of individuals who had no educational certificate, diploma, or degree. The NE region also had the least percentage (67.7%) of individuals with postsecondary certificate, diploma, or degree. In comparison to other regions, the percentages of individuals with postsecondary certificate, diploma, or degree were 83.0% for the NW, 75.9% for the SE and 85.3% for the SW region.

It was probable to link percentages of educated individuals with the number of critical food safety violations across regions with the highest number of types of critical violations recorded in the NE region which had the least percentage of individuals with postsecondary education and the highest number of individuals with no educational certificate, diploma, or degree.

With respect to the population of visible minorities across Calgary regions, NE region had the highest population (64,755), followed by SE (56,455), then NW (47,600) and SW (45,335) respectively.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

Food safety is a fundamental public health principle and lack of its understanding in food facilities often lead to significant violations (Augustin et al., 2020; Ehuwa et al., 2021). The present study evaluated regional variations of food safety violations and analyzed the number of types of critical food safety violations in food facilities across Calgary regions for 2022 versus 2023. According to Reynolds (2022), critical food safety violations are serious noncompliance in food safety protocols and handling procedures which could result in a high likelihood of foodborne illness or harm to consumers. The critical food safety violations considered in the study were temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions. Calgary regions for the study were Northeast (NE), Northwest (NW), Southeast (SE) and Southwest (SW) with focus on food facilities such as cafeterias, hotels, canteen, fast food outlets, restaurants, ethnic food service providers and other institutions that prepare and serve food for public consumption. The number of types of food safety violations were analyzed for regions and for 2022 and 2023 to detect association. The purpose of this study was to examine the association between Calgary regions for 2022 versus 2023 and the number of types of critical food safety violations (*temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions*) in food facilities.

Findings revealed that there was variation in the number of types of critical food safety violations across regions and between 2022 and 2023, respectively. The Northeast

(NE) region had the highest of number of types of critical food safety violations with a count of 350 critical violations followed by the Northwest (NW) region which had a count of 225 for the number of types of critical food safety violations. Findings showed counts of 100 in the number of types of critical food safety violations for the Southeast (SE) region and 202 counts in the number of types of critical food safety violations for the Southwest (SW) region. Lunden et al. (2021) reported regional variations in the result of restaurant inspections across regions in Finland. The counts for the number of types of critical food safety violations for 2022 and 2023 were analyzed to detect association. The total count of the number of types of critical food safety violations in 2022 was 98 while the count of the number of types of critical food safety violations for 2023 was 779. Thus, significant variation exists in the number of types of critical food safety variations across Calgary regions and between 2022 and 2023.

The socioeconomic factors in communities across Calgary regions were also explored through the result of Canada population census conducted in 2021. Factors of age, gender, race, income and educational level of populations were examined and their differences in communities across Calgary regions examined and compared to the variations of number of types of critical food safety violations among food facilities. According to Wang et al. (2023), transmission of foodborne diseases was dependent on location and human-environmental factors. Thus, Wang et al. (2023) identified that socioeconomic conditions of communities in Northeast Thailand influenced the prevalence of foodborne disease in the region. Based on the 2021 Canada population census result, the Northeast region of Calgary had a total population of 65,530 while the

total population of Northwest region of Calgary was 48,010. The Southeast and Southwest regions had a total population of 56,755 and 45,975, respectively. The Northeast region of Calgary had the highest percentage of men at 49.5% followed by Southeast region with 49.1% of men population. The percentages of men population in the Northwest and Southwest regions of Calgary were 48.9 and 48.6, respectively. The Northeast and the Southeast regions had 50.5 and 50.9 percentages of women while the Northwest and Southwest regions had 51.1% and 51.4% of women populations.

The age groups of 18-24 years made up of 17.4% in the Northeast region, 19.6% in the Northwest, 20.9% in the Southeast and 18.7% in the Southwest region. The age groups 25-44 years and 45-64 years had the most percentages of the population in communities across regions. Study conducted in Lahore Pakistan concluded that age of food handlers in food facilities could predict food safety practices when participants within age range of 19 to 35 years were examined (Ahmed et al., 2021). Similarly, Lotfy et al. (2022), reported that young workers studied in Egypt were linked to food safety violations compared to older employees. Ahmed et al. (2021) observed that gender and age of food handlers were insignificantly correlated with food safety knowledge. However, it noted that female employees are less likely to contribute to food safety violations compared to their male counterparts (Lotfy et al., 2022).

Abdelhakeem et al. (2021), reported that food handlers with higher educational qualifications possessed a better understanding and had a higher food safety knowledge. The level of education in Calgary regions was explored for the age group of 25-64 years. The proportions of the population who had no certificate or diploma was 9.55% in the

Northeast region of Calgary, 2.1% in the Northwest, 3.9% in the Southeast and 2.4% in the Southwest region. The proportion of the population in same group with a high school diploma in Calgary regions was 22.9% for the Northeast, 14.9% for the Northwest region, 20.2% for the Southeast and 12.3% for the Southwest region. Furthermore, the proportion of population with postsecondary education was 67.6% in Calgary Northeast region, 83.0% in the Northwest, 75.9% in the Southeast and 85.3% in the Southwest region of Calgary. The study also examined the median household income across Calgary regions. Northeast region had a median household income of \$102,000; the Northwest had a median household income of \$132,000, Southeast and Southwest had median household incomes of \$125,000 and \$142,000, respectively. Studies have linked higher level of income by operators of food facilities to improved food safety practices and reduction in food safety violations (Al Banna et al., 2021 and Huynh-Van et al., 2022). The present study also explored data from the 2021 Canada population census result on proportion of visible minorities in communities across Calgary regions. The Northeast region of Calgary had the highest proportion of visible minority population at 70.8%, followed by Southwest region at 38.8%, Northwest region had 33.4% of visible minority population and 32.4% was the proportion of visible minority population in the Southeast region. Studies have linked poor food safety practices and food safety violations to ethnic and immigrant food facilities operators (Dweba et al., 2022; Yusoff et al., 2022).

Interpretation of the Findings

The study of critical food safety violations in food facilities within communities across Calgary regions for 2022 and 2023 provided opportunities to evaluate associations

among the variables of interest. Additionally, the study examined data from Canada 2021 population census result in relation to critical food safety violations in food facilities across Calgary regions with focus on socioeconomic indices.

Findings in Respect of Year (2022 and 2023) and the Number of Types of Critical Food Safety Violations

Findings revealed a statistically significant difference between 2022 and 2023 and the number of types of critical food safety violations in food facilities across Calgary regions. The Pearson Chi-square and for Phi and Cramer's V coefficients produced a *p*-value of .018 which is less than 0.05, which showed an association between the number of types of critical food safety violations and years of violations which were 2022 and 2023. Thus, there were differences in the number of types of critical food safety violations in 2022 versus 2023. The count of types of critical food safety violations in 2022 was 98 while a count of 779 was obtained for the number of critical food safety violations in 2023. Results of correspondence analysis for critical food safety violations by year showed a statistically detectable association between number of types of critical food safety violations and year with a *p*-value of 0.018. Hierarchical clusters analysis revealed similar pattern as it was shown in Chi-square residuals and correspondence analysis maps in which unsuitable food condition was higher in 2022 compared to 2023. Result of binary logistic regression with Year (2023 vs. 2022) as predictor and region was the reference, 2023 revealed a decrease in serious critical food safety violations relative to 2022, but the effect was not significant level ($p = .088$). The serious violations were poor personal hygiene, pest control issue, unsuitable food condition and not-serious

were poor sanitation and temperature control deviation. Multinomial logistic regression for year and number of critical food safety violations showed significant impact with small effects, however with respect to unsuitable food condition, 2023 had more influence from temperature control deviation compared with 2022.

According to AHS (n.d.c.), the contributory factors to critical food safety violations in the city of Calgary during 2022 include temperature control deviations, issues with sanitation and pest infestation in food facilities. An outbreak of *E.coli* O157 Calgary in 2023 was traced to the central kitchen that supplied food to some daycare facilities in the city. According to Entis (2023), at least 264 people were infected by the outbreak of which thirty-seven were hospitalized in September 2023. Investigation revealed that critical food safety violations in the central kitchen operations included inadequate temperature control, poor pest control practices and insufficient sanitation.

Smith and Heacock (2022) reported a yearly decrease in restaurants inspection frequency and the total number of food safety violations across the three regions in Vancouver Island (North, South and Central) from 2019 to 2021. Shah and Kambo (2023) studied the influence of COVID-19 pandemic on postpandemic food safety with attention on restaurants in Fraser East region of British Columbia, Canada. Findings showed that the number of sanitation related violations reduced in 2022 after the pandemic compared to same number of violations recorded in 2019 among restaurants across the Frazer region. Furthermore, an increase in the mean overall hazard score was recorded in 2022 compared to 2019 for restaurants in the region (Shah & Kambo, 2023).

The studies conducted by both Smith and Heacock (2022) and (Shah & Kambo, 2023) showed an impact of events on critical food safety violations from year to year.

Findings in Respect of Regions and the Number of Types of Critical Food Safety Violations

The present study revealed an association between the number of types of critical food safety violations and Calgary regions. With a *p*-value of < 0.001 obtained for Pearson Chi-square and for Phi and Cramer's V coefficients which was less than the conventional threshold of 0.05. The findings revealed a statistically significant association that connotes a meaningful relationship between the Calgary regions and the number of types of critical food safety violations. The result showed that the Northeast and Northwest regions had 350 and 225 counts of number of types of critical food safety violations. On the other hand, Southeast and Southwest regions had 100 and 202 counts of number of types of food safety violations, respectively.

Findings showed that there were 193 and 123 counts of temperature control deviations in the Northeast and Northwest regions. The Southeast and Southwest regions had 63 and 125 counts of temperature control deviations. Counts of poor sanitation were 69 and 68 for Northeast and Northwest regions, while the Southeast and Southwest regions had 22 and 54 counts of poor sanitation, respectively. Counts for poor personal hygiene were 9 for the Northeast region and 8 for Northwest region of Calgary. The Southeast and Southwest region had zero and three counts of poor personal hygiene. The count for pest control issue was two and zero for the Northeast and Northwest regions while Southeast and Southwest regions had two and one counts of pest control issue. The

counts of unsuitable food condition were 77 and 26 for the Northeast and Northwest regions while Southeast and Southwest regions recorded 13 and 19 counts of unsuitable food condition. Correspondence analysis revealed a meaningful association between the number of types of critical food safety violations by region with a p-value of $< .001$ which aligned with the result of Chi-square test of independence. In line the result from Chi-square test of independence and correspondence analysis, hierarchical cluster analysis confirmed that the NE region had a relatively higher number of unsuitable food condition as a critical food safety violation, however, the NW region showed a relative emphasis on temperature control deviation and SW region was lower on unsuitable food condition. Result of binary logistic regression showed that NE region had the highest odds of serious critical food safety violations, thus NW, SE, and SW regions each had significantly lower odds than NE with year held constant. Multinomial logistic regression analysis indicated that SW and NE regions had lower odds of poor sanitation and temperature control deviation consistent with NE region which had a higher share of unsuitable food condition.

Lunden et al. (2021) attributed variation in restaurants inspection results across regions in Finland to differences in the application of assessment protocols in addition to the economic status of the location of restaurants. Study conducted on food safety compliance of local restaurants in the two regions in the Philippines showed a significant difference in the sanitation and personal hygiene compliance among the restaurants (Tumaliuan, 2022). Furthermore, findings from studies conducted by Wafukho et al.

(2021) revealed that food service facilities within three tertiary institutions in different locations of Nairobi had varied levels of compliance with food safety protocols.

Findings in Respect of Socioeconomic Factors in Communities Across Calgary

Regions

Findings revealed differences in socioeconomic factors relative to the count of number of critical food safety violations in food facilities within communities across Calgary regions. The Northeast region had the highest population of 65,530 people and same region (NE) recorded 350 as the highest count of the number of types of critical food safety violations compared to the Northwest region with a count 225 and a population of 48,010. The Southeast region had a count of one hundred and a population of 56,755 and the Southwest region with a total population of 45,975 and a corresponding count of 202 of the number of types of critical food safety violations.

Socioeconomic data revealed that the proportion of population in the age group 25 to 64 years, the Northeast region had the 9.5% of people with no certificate, diploma or degree. In comparison to other regions, the proportion of population in the age group 25 to 64 years without certificate, diploma or degree were 2.1% for the Northwest region, 3.9% for the Southeast and 2.4% for the Southwest regions, respectively. Furthermore, the proportion of the population in the age group 25 to 64 years with a postsecondary education in the Northeast region was 67.6%, which was the lowest among Calgary regions. The proportions of the population with postsecondary education in other Calgary regions were 83.0% for the Northwest region, 75.9 % for the Southeast and 85.3% for the Southwest region, respectively. In terms of secondary school education, the Northeast

region had the highest population of individuals with a secondary school education compared to other regions. The proportion of the population in the age group 25 to 64 years with a secondary school education was 22.9% for the Northeast region, 14.9% for the Northwest region, 20.2% for the Southeast region and 12.3% for the Southwest region, respectively. According to Abdelhakeem et al. (2021) food handlers with higher educational qualifications had a better understanding and knowledge of food safety practices and mostly contribute to reduced food safety violations. Gebru et al. (2023) reported that food handlers with either a high school diploma or postsecondary education exhibited a sound knowledge of food safety protocol with a corresponding reduction in critical violations. Similarly, Al Banna et al. (2021) reported that possession of higher education qualifications and more than 10 years of work experience amongst meat handlers in Bangladesh was linked to a good food safety practice and reduction in the incidence of food safety violations and outbreaks of food borne illnesses.

Findings showed that the Northeast region had a median household income of \$102,000 which was the lowest compared to the median household income of other regions. The Northwest region had a median household income of \$132,000, the median household income for the Southeast and Southwest region were \$125,000 and \$142,000, respectively. Al Banna et al. (2021) observed that meat handlers with higher income and more than 10 years in the trade had access to funds for training which translate to higher food safety knowledge and less food safety violations. Huynh-Van et al. (2022) reported that the level of capital invested in the business by the operators, their educational qualifications, food safety training received, and total space occupied by the business

influenced compliance with food safety rules and regulations. In another study, Onyeaka et al. (2021) linked low income to the sales and patronage of food from street vendors in Nigeria. The street food operators were associated with critical food safety violations due to poor personal hygiene, poor sanitation, lack of proper temperature control and storage, and the use of nonportable water sources (Onyeaka et al., 2021). However, the result of studies conducted by Desye et al. (2023), concluded that street food vendors with higher income are more likely to follow food safety practices compared to those with low income because of the possibility that vendors with high income complied with the food safety protocols to prevent contamination.

The proportion of visible minority population in the Northeast region was 70.8%, the highest across Calgary regions. The proportion of visible minority population in the Northwest region was 33.4%, the Southeast and the Southwest regions had proportions of visible minority population as 32.4% and 38.8%, respectively. Findings of study conducted by Mbombo-Dweba et al. (2022) in South Africa Gauteng Province showed that food facilities operated by informal ethnic and immigrants are a major source of food contamination due to critical food safety violations. The study conducted by Yusoff et al. (2022) in Malaysia revealed that immigrant food handlers have moderate knowledge, attitude and skills in food safety practices, and thus emphasized the need for food safety training among the operators to reduce incidence of food safety violations.

Findings in Respect of the Concept of Epidemiological Triangle Theory

According to John and Kompithra (2023), the Epidemiologic Triangle Theory (ETT) conceptualized the interaction of the three key elements required for an infection

to occur. The key elements are the “Agent,” the “Host” and the “Environment.” John and Kompithra (2023) explained that the “Environment” is the requirement that can eliminate the possible interaction of the agent and host to avoid an infection or promotes their interaction and lead to an infection.

The occurrence of foodborne infections was possible due to incidents of critical food safety violations in a food facility. The critical food safety violations analyzed in this study provided the ‘agent’ (microorganisms) with the required environment which served as vehicle for transmission of foodborne infections. Lee and Yoon (2021) listed the causative agent of foodborne diseases as microorganisms which include bacteria, viruses, fungi, and parasites. The critical food safety violations of temperature control deviations, poor sanitation, pest control issues, poor personal hygiene and unsuitable food conditions considered in the present study were related to the factor of “environment” which provided the favorable condition for the occurrence of foodborne infections as conceptualized in the Epidemiologic Triangle Theory (ETT). According to Lu et al. (2023) foodborne illness often results from poor food handling practices connected with raw materials, challenges, compromised storage, poor temperature control and unsuitable transportation practices.

The ‘host’ factor in Epidemiologic Triangle Theory (ETT) according to John and Kompithra (2023) provided a conducive site for the agent to thrive. In the context of the present study, the people in the communities across Calgary regions region who consumed contaminated food from food facilities with critical food safety violations made up the host. Ehuwa et al. (2021), explained further that genetics, individual level of

immunity, age, amount of contaminants, and health status determines opportunity for exposure. Ehuwa et al. (2021), mentioned that the host could be exposed to consumption of contaminated food and poor personal hygiene practices while handling food. Factors such as genetics, level of immunity, age, amount of exposure and overall health status of an individual determine opportunity for exposure (Ehuwa et al., 2021).

Limitations of the Study

The use of secondary data in the study based on inspection reports was a potential limitation. The possible inaccuracies in health inspection reports, variations in inspection standards across different regions, and the possibility that not all violations were reported. The potential inaccuracy from the use of secondary data and the quality of data when they were collected by the PHIs were potential factors that could have impacted findings from the study. The study considered a 2-year period (2022 and 2023), which may not be a broad representative of long-term trends. For example, years prior to 2022 were not accounted for in the study. The diversity of populations in various communities across Calgary regions was not fully explored because many factors could have been considered in the study. The study examined socioeconomic data obtained from the Canada population census conducted in 2021 with respect to result for communities across Calgary regions. However, the study did not directly perform statistical analysis to link the secondary data on critical food safety violations directly with the socioeconomic data from Canada 2021 population census.

The possible lack of uniformity in the interpretation and categorization of data on critical food safety violations was another limitation in the study. Different PHIs could

have had different approaches in classifying food safety violations as either critical or non-critical. The inability of the study to investigate the root causes of the critical food safety violations was a potential limitation. Factors such as inadequate training, poor supervision, cultural influence and economic pressure could have influenced the critical food safety violations in food facilities across Calgary regions.

Recommendations

Future research studies should endeavor to utilize primary data collection methods via interviews and surveys to obtain direct information from food handlers, food facilities operators and PHIs. This approach could provide more in-depth understanding of critical food safety violations and the underlying causes. Furthermore, an extended analysis over a long period of time should be conducted to reveal trends and systemic variations across regions and thus enable appropriate measures to be prescribed. The study showed that critical food safety violations cut across food facilities in Calgary regions. Thus, providing training on food handling protocols and food safety for food handlers and facilities operators will be appropriate to reduce the occurrence of critical food safety violations.

Community engagement and creating awareness on the causes and signs of foodborne illness couple with educating the public on food safety standards for food facility operators will generate interest and encourage public accountability towards reporting observed violations. Calgary Northeast region had the highest count of number of types of critical food safety violations. Thus, public health agencies should direct

attention to the Northeast region with increased inspections frequency, food safety training and public awareness program.

Implications

The findings from the study may contribute to positive social change by providing valuable insights that can be used to improve food safety standards and practices in food facilities in communities across Calgary regions. By identifying the communities with the highest number of violations, targeted interventions can be implemented to reduce these violations, thereby improving food safety and public health in these communities.

Furthermore, by addressing the identified critical food safety violations based on regions, the study has the potential to improve health outcomes for residents in Calgary, reducing foodborne illnesses and increasing overall community health. The findings on the number of types of critical food safety violations can foster a culture of food safety awareness among food handlers, facility operators and consumers.

The influence of the findings on policy development is an important positive social change. The insights provided on the count of the number of types of critical food safety violations, and their regional variations can influence local health policies and regulations, promoting stricter enforcement or new standards that might lead to long-term benefits in food handling and preparation practices. In addition, a proper food safety policy implementation can enhance the reputation of local food businesses, potentially attract more customers, and foster economic growth within Calgary communities through higher compliance and trust.

Conclusion

The study on “Critical Food Safety Violations in Food Facilities by Regions Across Calgary Communities From 2022 Versus 2023” highlighted essential insights into food safety practices and compliance levels in Calgary regions. While the findings exposed significant limitations, such as data dependence and potential inconsistencies in reporting, they also opened avenues for actionable recommendations aimed at improving food safety standards. The implications of the study underscored the potential for positive social change, not only enhancing public health and community awareness but also influencing policy development and economic stability for local businesses. Future research must build on these findings, ensuring that Calgary continues to prioritize food safety and public well-being through ongoing education and improved regulatory frameworks.

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[18dfa401960d/download/health-food-retail-and-foodservices-code-2020.pdf](https://open.alberta.ca/dataset/0ea69179-2f90-4776-a64d-c903299b2ca6/resource/3354d461-6834-4744-b185-18dfa401960d/download/health-food-retail-and-foodservices-code-2020.pdf)

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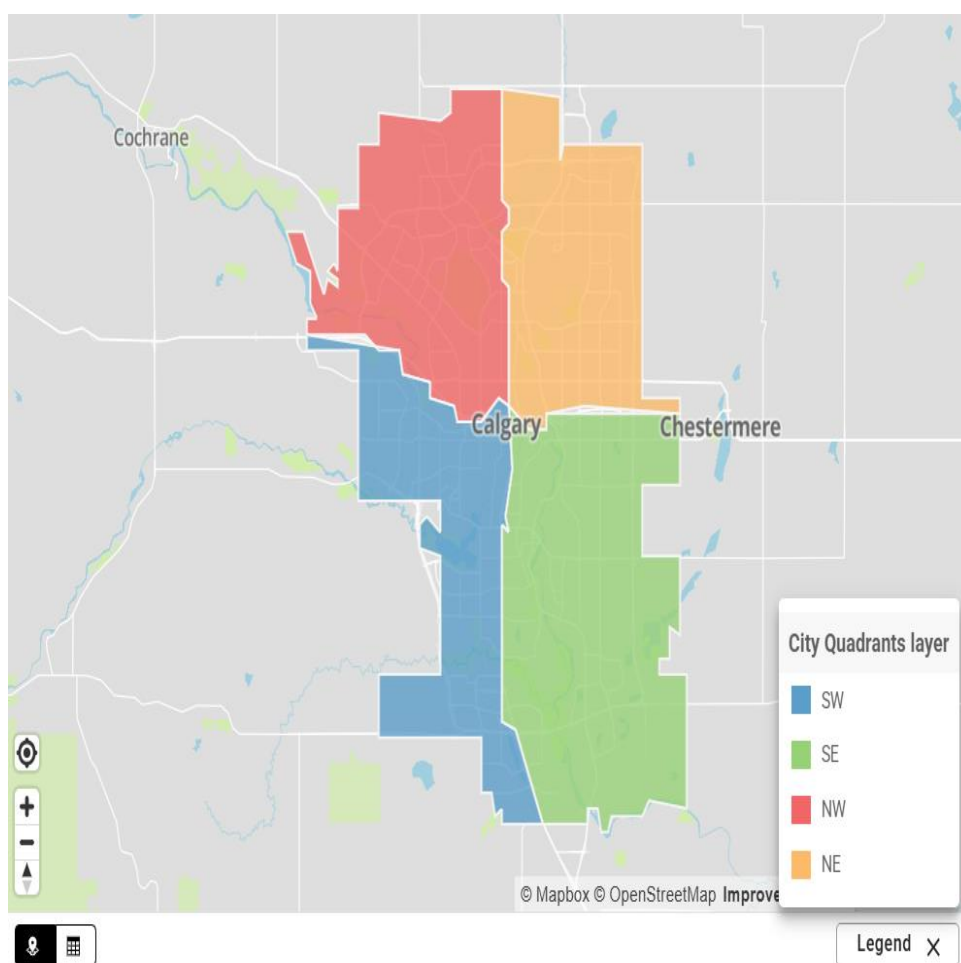
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Appendix A: Map of the City of Calgary Showing the Four Quadrants (Regions)



Source: The City of Calgary (February 1, 2023). Quadrant boundaries for the City of Calgary. <https://data.calgary.ca/Base-Maps/City-Quadrants/g8ma-sywr>

Appendix B: Critical Food Safety Violations

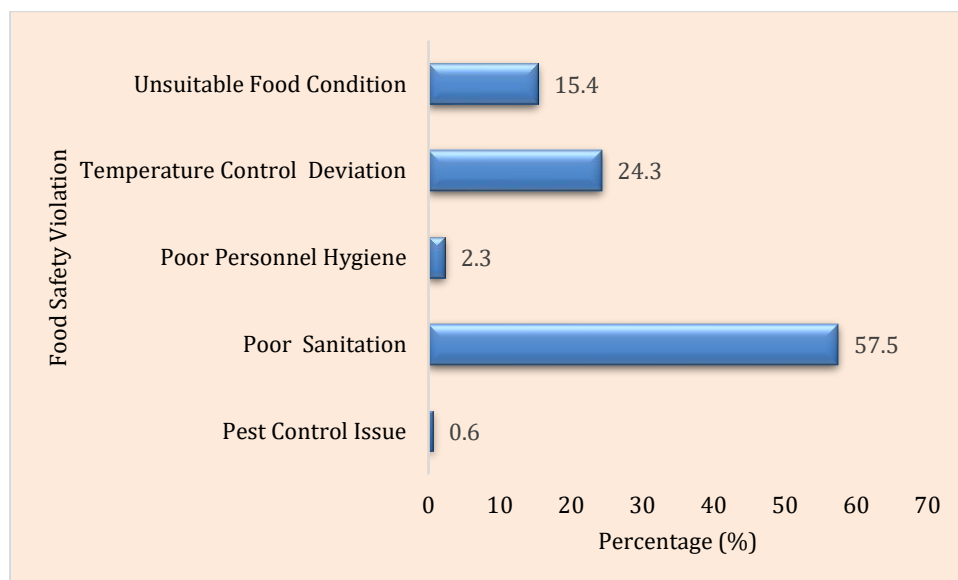
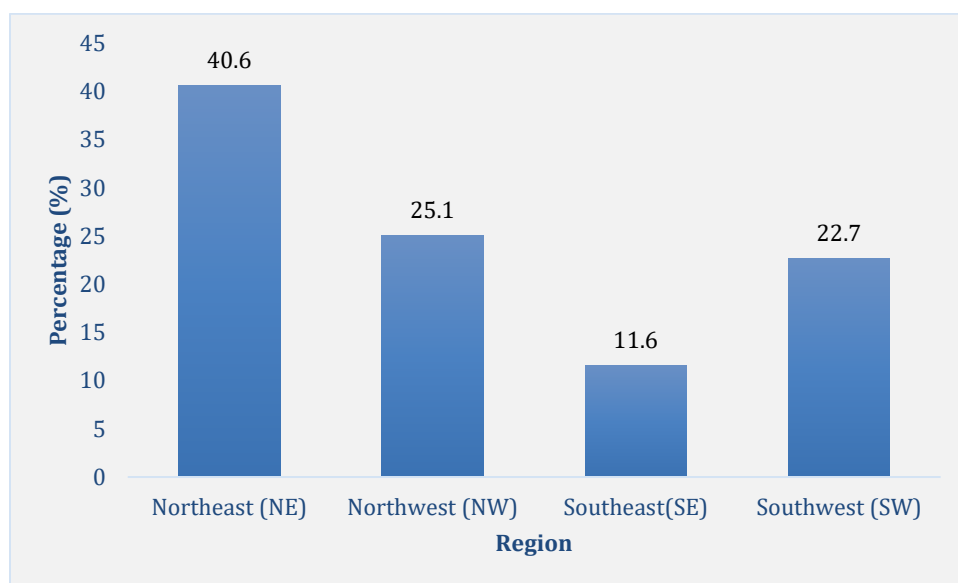
Table B1*Number of Types of Critical Food Safety Violations***Table B2***Number of Types of Critical Food Safety Violations by Regions*

Table B3

Number of Types of Critical Food Safety Violations by Year

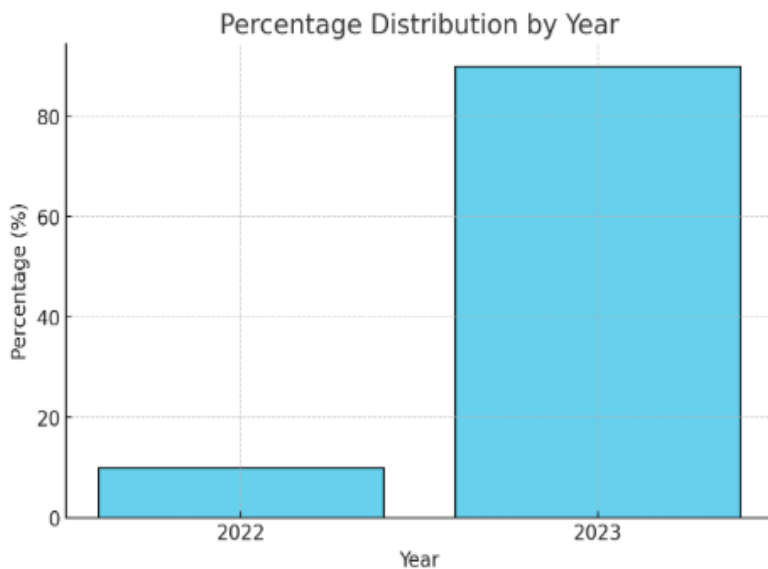


Table B4

Number of Types of Critical Food Safety Violations and Year (2022 versus 2023)

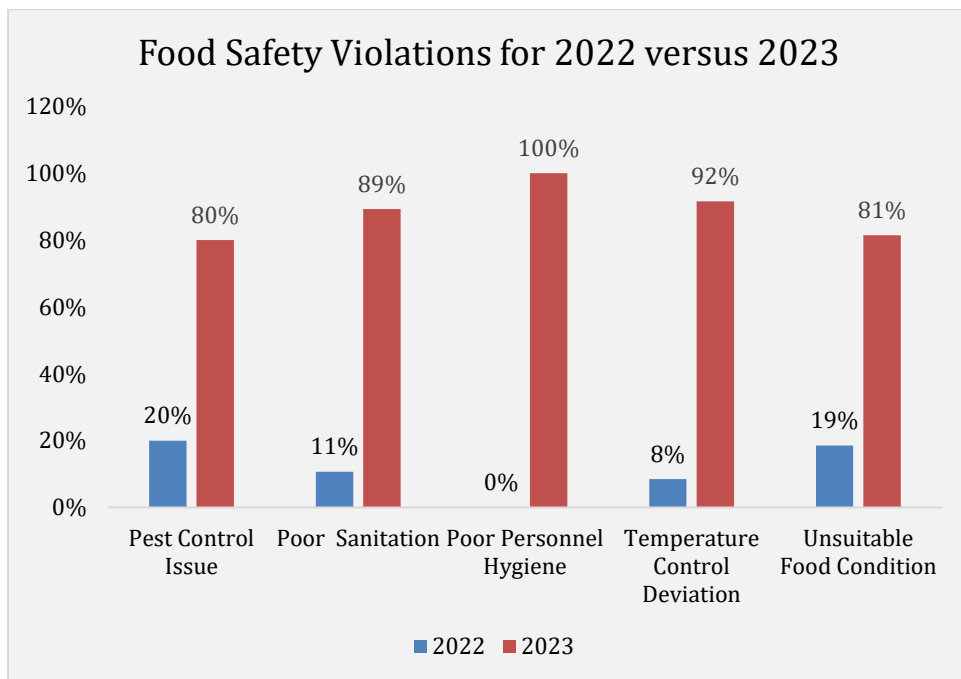
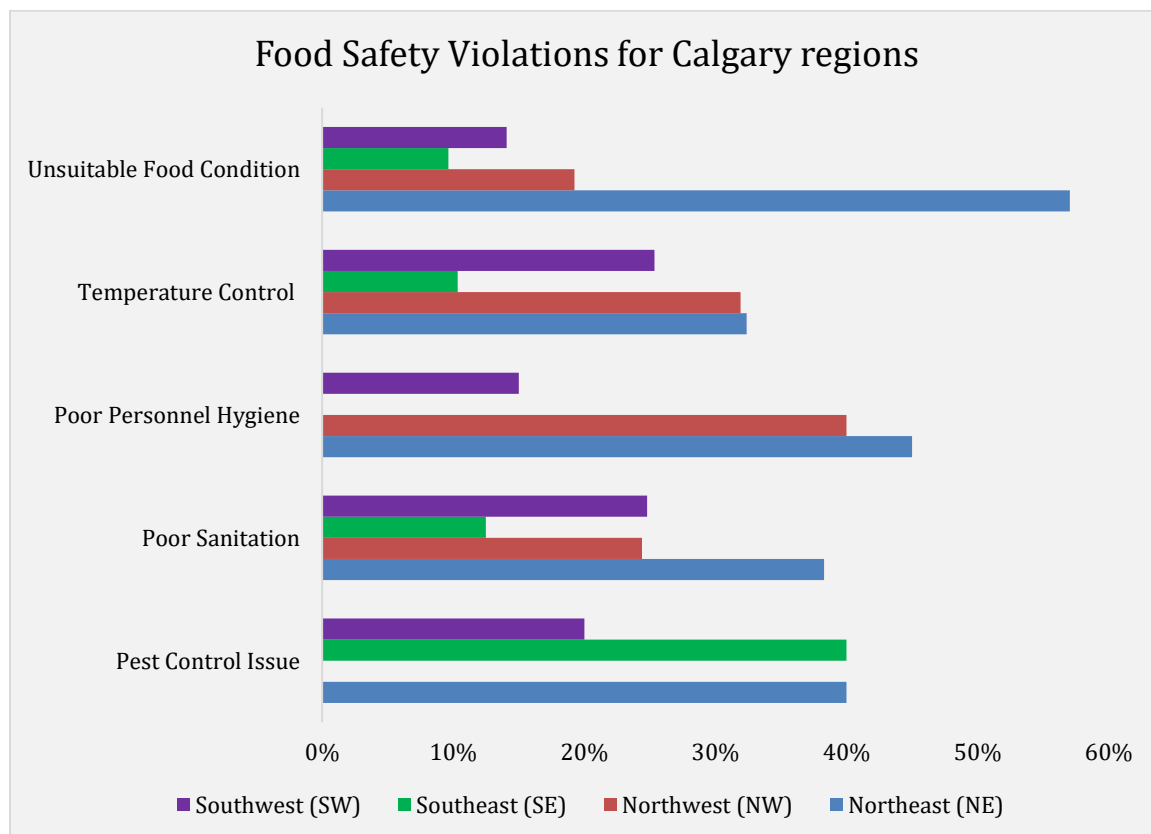


Table B5

Number of Types of Critical Food Safety Violations by Region



Appendix C: Socioeconomic Status of Calgary Communities Across Regions

Table C1*Provincial Electoral Division of Calgary-Northeast (2021)*

Indices	Number	Percentages
Population		
Total Population	65,530	-----
Men	32,460	49.5%
Women	33,070	50.5%
Age Groups		
0-4 years	5,575	8.5%
5-17 years	11,380	17.4%
18-24 years	5,410	8.3%
25-44 years	23,990	36.6%
45-64 years	13,760	21.0%
65 years and over	5,420	8.3%
Average age (years)	34.2	
Highest Level of Schooling		
Total population 25 to 64 years	37,735	-----
No certificate, diploma, or degree	3,570	9.5%
Secondary (high) school diploma or equivalency certificate	8,635	22.9%
Postsecondary certificate, diploma, or degree	25,525	67.6%
Household Income (2020)		
Total private households	21,035	-----
Under \$5,000	130	0.6%
\$5,000 to \$9,999	70	0.3%
\$10,000 to \$14,999	60	0.3%
\$15,000 to \$19,999	150	0.7%
\$20,000 to \$24,999	250	1.2%
\$25,000 to \$29,999	290	1.4%
\$30,000 to \$34,999	315	1.5%
\$35,000 to \$39,999	470	2.2%
\$40,000 to \$44,999	560	2.7%
\$45,000 to \$49,999	460	2.2%
\$50,000 to \$59,999	1,185	5.6%
\$60,000 to \$69,999	1,475	7.0%
\$70,000 to \$79,999	1,445	6.9%
\$80,000 to \$89,999	1,700	8.1%
\$90,000 to \$99,999	1,610	7.7%
\$100,000 and over	10,875	51.7%
\$100,000 to \$124,999	3,595	17.1%
\$125,000 to \$149,999	2,715	12.9%
\$150,000 to \$199,999	2,985	14.2%
\$200,000 and over	1,585	7.5%
Median household income (\$)	\$102,000	
Visible Minorities		
Total population by visible minority	64,755	-----
Not a visible minority	18,910	29.2
Visible minority population	45,845	70.8

Indices	Number	Percentages
South Asian	20,505	44.7
Chinese	4,190	9.1
Black	5,930	12.9
Filipino	7,340	16.0
Arab	1,060	2.3
Latin American	1,765	3.8
Southeast Asian	1,535	3.3
West Asian	1,355	3.0
Korean	255	0.6
Japanese	200	0.4
Visible minority,	450	1.0
Multiple visible minorities	1,260	2.7

Source: Government of Alberta (2023b). Alberta Provincial Electoral Division: compiled

from the 2021 Census of Canada, Calgary-Northeast. *Government of Alberta*.

<https://open.alberta.ca/publications/ped-2021-calgary-north-east>

Table C2

Provincial Electoral Division of Calgary-Northwest (2021)

Indices	Number	Percentages
Population		
Total Population	48,010	-----
Men	23,485	48.9%
Women	24,530	51.1%
Age Groups		
0-4 years	2,305	4.8%
5-17 years	9,400	19.6%
18-24 years	3,970	8.3%
25-44 years	11,800	24.6%
45-64 years	14,185	29.5%
65 years and over	6,340	13.2%
Average age (years)	38.9	
Highest Level of Schooling		
Total population 25 to 64 years	25,870	-----
No certificate, diploma, or degree	550	2.1%
Secondary (high) school diploma or equivalency certificate	3,860	14.9%
Postsecondary certificate, diploma, or degree	21,460	83.0%
Household Income (2020)		

Indices	Number	Percentages
Total private households	16,650	-----
Under \$5,000	120	0.7%
\$5,000 to \$9,999	65	0.4%
\$10,000 to \$14,999	110	0.7%
\$15,000 to \$19,999	120	0.7%
\$20,000 to \$24,999	225	1.4%
\$25,000 to \$29,999	280	1.7%
\$30,000 to \$34,999	250	1.5%
\$35,000 to \$39,999	260	1.6%
\$40,000 to \$44,999	295	1.8%
\$45,000 to \$49,999	285	1.7%
\$50,000 to \$59,999	670	4.0%
\$60,000 to \$69,999	775	4.7%
\$70,000 to \$79,999	815	4.9%
\$80,000 to \$89,999	800	4.8%
\$90,000 to \$99,999	920	5.5%
\$100,000 and over	10,650	64.0%
\$100,000 to \$124,999	1,865	11.2%
\$125,000 to \$149,999	1,725	10.4%
\$150,000 to \$199,999	2,690	16.2%
\$200,000 and over	4,370	26.2%
Median household income (\$)	\$132,000	
Visible Minorities		
Total population by visible minority	47,600	-----
Not a visible minority	31,690	66.6%
Visible minority population	15,910	33.4%
South Asian	4,180	26.3%
Chinese	4,130	26.0%
Black	1,180	7.4%
Filipino	1,165	7.3%
Arab	665	4.2%
Latin American	1,220	7.7%
Southeast Asian	490	3.1%
West Asian	735	4.6%
Korean	1,015	6.4%
Japanese	230	1.4%
Visible minority,	260	1.6%
Multiple visible minorities	650	4.1%

Source: Government of Alberta (2023a). Alberta Provincial Electoral Division: compiled

from the 2021 Census of Canada, Calgary-Northwest. *Government of Alberta*.

<https://open.alberta.ca/publications/ped-2021-calgary-north-west>

Table C3*Provincial Electoral Division of Calgary-Southeast (2021)*

Indices	Number	Percentages
Population		
Total Population	56,755	-----
Men	27,875	49.1%
Women	28,880	50.9%
Age Groups		
0-4 years	4,810	8.5%
5-17 years	11,855	20.9%
18-24 years	3,250	5.7%
25-44 years	20,795	36.6%
45-64 years	11,640	20.5%
65 years and over	4,400	7.8%
Average age (years)	33.6	
Highest Level of Schooling		
Total population 25 to 64 years	32,420	-----
No certificate, diploma, or degree	1,270	3.9%
Secondary (high) school diploma or equivalency certificate	6,535	20.2%
Postsecondary certificate, diploma, or degree	24,615	75.9%
Household Income (2020)		
Total private households	19,920	-----
Under \$5,000	170	0.9%
\$5,000 to \$9,999	50	0.3%
\$10,000 to \$14,999	85	0.4%
\$15,000 to \$19,999	120	0.6%
\$20,000 to \$24,999	215	1.1%
\$25,000 to \$29,999	290	1.5%
\$30,000 to \$34,999	245	1.2%
\$35,000 to \$39,999	320	1.6%
\$40,000 to \$44,999	370	1.9%
\$45,000 to \$49,999	415	2.1%
\$50,000 to \$59,999	845	4.2%
\$60,000 to \$69,999	985	4.9%
\$70,000 to \$79,999	1,030	5.2%
\$80,000 to \$89,999	1,060	5.3%
\$90,000 to \$99,999	1,025	5.1%
\$100,000 and over	12,695	63.7%
\$100,000 to \$124,999	2,690	13.5%
\$125,000 to \$149,999	2,345	11.8%
\$150,000 to \$199,999	3,625	18.2%
\$200,000 and over	4,030	20.2%
Median household income (\$)	\$125,000	
Visible Minorities		

Indices	Number	Percentages
Total population by visible minority	56,455	-----
Not a visible minority	38,150	67.6%
Visible minority population	18,305	32.4%
South Asian	3,925	21.4%
Chinese	2,245	12.3%
Black	1,835	10.0%
Filipino	4,075	22.3%
Arab	980	5.4%
Latin American	2,080	11.4%
Southeast Asian	900	4.9%
West Asian	365	2.0%
Korean	620	3.4%
Japanese	210	1.1%
Visible minority, n.i.e.	185	1.0%
Multiple visible minorities	900	4.9%

Source: Government of Alberta (2023d). Alberta Provincial Electoral Division: compiled

from the 2021 Census of Canada, Calgary-Southeast. *Government of Alberta.*

<https://open.alberta.ca/publications/ped-2021-calgary-south-east>

Table C4*Provincial Electoral Division of Calgary-Southeast (2021)*

Indices	Number	Percentages
Population		
Total Population	45,975	-----
Men	22,350	48.6%
Women	23,625	51.4%
Age Groups		
0-4 years	2,055	4.5%
5-17 years	8,620	18.7%
18-24 years	3,905	8.5%
25-44 years	9,785	21.3%
45-64 years	14,315	31.1%
65 years and over	7,275	15.8%
Average age (years)	40.8	
Highest Level of Schooling		
Total population 25 to 64 years	23,865	-----
No certificate, diploma, or degree	570	2.4%
Secondary (high) school diploma or equivalency certificate	2,930	12.3%
Postsecondary certificate, diploma, or degree	20,365	85.3%
Household Income (2020)		
Total private households	16,105	-----
Under \$5,000	155	1.0%
\$5,000 to \$9,999	70	0.4%
\$10,000 to \$14,999	105	0.7%
\$15,000 to \$19,999	160	1.0%
\$20,000 to \$24,999	215	1.3%
\$25,000 to \$29,999	230	1.4%
\$30,000 to \$34,999	270	1.7%
\$35,000 to \$39,999	310	1.9%
\$40,000 to \$44,999	395	2.5%
\$45,000 to \$49,999	330	2.0%
\$50,000 to \$59,999	600	3.7%
\$60,000 to \$69,999	725	4.5%
\$70,000 to \$79,999	700	4.3%
\$80,000 to \$89,999	665	4.1%
\$90,000 to \$99,999	675	4.2%
\$100,000 and over	10,480	65.1%
\$100,000 to \$124,999	1,550	9.6%
\$125,000 to \$149,999	1,305	8.1%
\$150,000 to \$199,999	2,165	3.4%
\$200,000 and over	5,460	33.9%
Median household income (\$)	\$142,000	
Visible Minorities		

Indices	Number	Percentages
Total population by visible minority	45,335	61.2%
Not a visible minority	27,760	38.8%
Visible minority population	17,570	17.0%
South Asian	2,990	32.2%
Chinese	5,665	6.8%
Black	1,190	6.6%
Filipino	1,165	8.0%
Arab	1,400	4.1%
Latin American	725	3.2%
Southeast Asian	570	7.0%
West Asian	1,230	8.5%
Korean	1,490	1.9%
Japanese	335	1.6%
Visible minority, n.i.e.	275	3.1%
Multiple visible minorities	540	

Source: Government of Alberta (2023c). Alberta Provincial Electoral Division: compiled

from the 2021 Census of Canada, Calgary-West. *Government of Alberta.*

<https://open.alberta.ca/publications/ped-2021-calgary-west>