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Identifying Predictors of Safe Food Handling Practices among Canadian Households with Children Under Eighteen Years

ABSTRACT

Poor food handling practices at home are a common cause of foodborne illness. Children are more susceptible to foodborne illness than adults. Because children's food safety depends on the safe food handling practices of parents and caregivers, this study aims to identify determinants of safe food handling practices among Canadian families with children under 18 years. Data for Canadian households with children (n = 294) were extracted from a larger telephone survey conducted across all Canadian provinces and territories between 2014 and 2015. Four food safety practice outcomes and six demographic variables were examined using multivariable logistics regression. Most survey participants were females (56%) who had less than a bachelor's degree (67%) and were caring for one child (55%). Approximately 90% of caregivers reported proper hand hygiene, and 79% refrigerated leftovers within 2 h of cooking. Only 33% of caregivers reported preventing cross-contamination, and fewer reported using food thermometers for poultry cuts (13%) and hamburgers (11%). Those in the higher income and education categories were less likely to follow safe food handling practices such as hand hygiene and safe refrigeration of leftovers. This research highlights the need for food safety interventions that target Canadian families with children within certain demographic groups.

INTRODUCTION

Children are disproportionately affected by foodborne illnesses and, if infected, have an increased risk of developing severe sequelae, such as kidney disease, reactive arthritis, and bloodstream infection (*25*). The risk of *Salmonella* and *Campylobacter* infections is higher for children than all other age groups (*33*). Children are also three times more likely to be hospitalized once infected with *Salmonella* (*33*). Those under five years of age are at higher risk of hemolytic uremic syndrome than any other age group. For example, according to the 2015 U.S. FoodNet report, of 98 confirmed cases of *E. coli* O157:H7 in children under five, approximately 22% developed hemolytic uremic syndrome (*10*).

Children are more susceptible to foodborne illnesses because their underdeveloped immune system impairs their

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ability to fight infections *(8)*. They have limited control over their meal preparation; and, given their low body weight, a smaller quantity of a foodborne pathogen can cause illness *(27)*. Earlier studies on younger consumers indicated that adolescents, particularly those aged 15 to 16, learn by observing others (i.e., primary food handlers), which could lead to the transfer of safe or unsafe food handling knowledge and practices *(30)*. Bas et al. *(4)* reported that adolescents' understanding of food safety was positively associated with their parents' food safety attitudes, educational level, and age. Many adolescents are not adequately taught essential food safety practices at home, such as hand hygiene after handling raw food *(4, 37)*. Thus, enhanced food safety education in homes is needed.

Using data from FoodNet Canada in 2018, five major food pathogens (*Campylobacter*, *Salmonella*, verotoxigenic *E. coli*, *Giardia*, and *Clostridium*) were identified as primary causes of foodborne illness among children in the home setting *(46)*. Additionally, a study using outbreak data found that cheese, eggs, unpasteurized milk, and undercooked meat were the most common food sources that result in hospitalization and death among children *(5)*.

Unsafe food practices can occur during meal preparation, storage, and handling. Various factors influence consumers' behaviors, including psychosocial factors (e.g., optimistic bias, perceived risk, imbedded habits, social influences, lack of self-efficacy to perform safe food handling practices), and insufficient food safety knowledge *(9, 18, 36)*. Approximately four million Canadians are affected by domestically acquired foodborne illnesses yearly, leading to 11,600 hospitalizations and 238 deaths *(54)*. Most respondents who reported foodborne illness believed that their disease had been caused by food prepared somewhere other than the home *(9)*. Parents or caregivers in households with children should ensure good food safety practices due to the potential risk of foodborne illness in children under their care.

Food safety intervention programs have been shown to reduce the incidence of foodborne illness *(41)*. For instance, the partnership for food safety education (FightBAC!) developed a campaign to promote effective education programs to reduce the risk of foodborne illness among consumers. The campaign focuses on four food safety messages: (i) clean, i.e., wash hands and surfaces often; (ii) separate, i.e., avoid cross-contamination; (iii) cook, i.e., cook to a safe internal temperature; and (iv) chill, i.e., refrigerate promptly *(43)*. These concepts, which represent areas closely related to an increased risk of foodborne illness, were a guiding framework for this study.

In 2014, a database of Canadian food safety knowledge and behavior was established via a nationwide population-based telephone survey called the Foodbook study *(45)*. The study sought to establish possible sources of enteric illness in Canada and set a baseline to determine the effectiveness of public health interventions over time to reduce foodborne illness *(45)*. The report found that, although few (29%) Canadians used food thermometers when they cooked meat and poultry, most (90%) of them adhered to recommended cleaning and separating instructions when they handled raw meat, and most were aware of foodborne illnesses associated with chicken and hamburgers *(39)*. Although data were collected on families with children, results specific to that population have not previously been analyzed for risk factors and trends. The objectives of this study were to measure the prevalence of food safety practices (clean, chill, cook, and separate constructs) among the primary food preparers in Canadian households with children and to assess whether these practices are associated with sociodemographic factors such as gender, number of children, region, income, and educational level. This article will also provide clearly defined recommendations to inform food safety interventions and education for Canadian parents or caregivers of children under 18.

MATERIALS AND METHODS

Sample data

We analyzed data from the Foodbook study, a national telephone survey conducted between November 2014 and April 2015 in various languages (English, French, Inuktitut, and other languages offered through on-demand verbal translation) across all provinces and territories in Canada *(39, 45)*. The original report included questions on food consumption, water and animal exposures, acute gastrointestinal illness, and consumer food safety knowledge and behaviors. Questions were asked only to those 18 and older (i.e., those most likely responsible for food preparation). However, only participants who reported living with children under 18 years of age were used for this study. The Foodbook study was reviewed and approved by the Public Health Agency of Canada and Health Canada's Research Ethics Board (REB 2013-0025) alongside the Newfoundland and Labrador Health Research Ethics Authority to meet a unique provincial legal requirement (HREB 13.238). The analysis for this study was reviewed and approved by the University of Guelph's Research Ethics Board (REB 20-10-030). Information on study design, participant selection, questionnaire administration, and data collection are detailed in the Foodbook study *(45)* and on the government of Canada Open Data Platform *(47)*.

Questionnaire design

The food safety knowledge and practices questionnaire was developed in consultation with the Canadian Partnership for Consumer Food Safety Education, academia, industry, provincial-territorial, and federal governments. Stakeholders identified five main themes: clean, cook, chill, separate, and risky food awareness (e.g., undercooked chicken and egg). They drafted 12 questions to be included in the Foodbook study. However, for this present study, one question repre-

senting each core food safety practice (clean, cook, chill, and separate) was identified based on prior evidence and relevance to families with children *(11, 34)*. All questionnaires were pilot tested, and survey respondents provided feedback via computer-assisted telephone interviewing programming. Survey weights were provided in the data set to reflect the weights of the proportions, and all analyses were performed using survey weights. The weighting ensured that the sample represented the Canadian population.

Statistical analyses

Data were formatted and analyzed in Stata/BE 17.0 for Windows (StataCorp, College Station, TX) using the weighted survey data. The data were weighted using the census metropolitan area (CMA) nearest to the respondent's residence, household type, age group, number of people living in households, province and territory, gender, and number of landlines and cellphones. Models were fitted using logistic regression to identify predictors of the following food safety practices: (i) clean, i.e., wash hands with soap after handling raw meat or poultry; (ii) cook, i.e., use a food thermometer when cooking whole chicken, whole turkey, chicken or turkey pieces, pork cuts, hamburger, roasts, steak, and fish; (iii) chill, i.e., refrigerate leftovers within 2 h after cooking; (iv) separate, i.e., store meat, poultry, or seafood on the bottom shelf of the refrigerator to prevent cross-contamination. Response outcomes with more than two options, such as hand hygiene (multiple choice) and use of a food thermometer when cooking (yes, sometimes, no, don't know), were dichotomized: correct (or best) versus incorrect practice.

A prespecified number of explanatory variables consisting of demographic characteristics were selected as potential covariates for analysis. These variables included gender, educational level, household income, number of children under 18 living in households, province or territory of residence, and whether participants live in a metropolitan area (i.e., an area with a total population of ≥ 100,000 of which ≥ 50,000 live in the core).

For this analysis, all demographic variables were collapsed into binary categories (except for regions with more than two categories) to have sufficient observations per category for subsequent statistical modeling. Provinces and territories were combined to represent five regions of Canada: West Coast (British Columbia), Prairie Provinces (Alberta, Saskatchewan, Manitoba), Central Canada (Ontario and Quebec), Atlantic Provinces (New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland, and Labrador), the Northern Territories (Yukon, Northwest Territories, Nunavut). The income level was grouped into either less than C$60,000 or C$60,000 or more. Education level was grouped into two categories: less than bachelor's degree and bachelor's degree or above. Finally, the number of children in households was grouped into two categories: one child and two or more children.

Phi correlation coefficients were used to assess whether any predictor variables were highly correlated using a cut-off value of ≥ |0.8|. If highly correlated variables were encountered, the most relevant variable based on epidemiological plausibility was selected to be included in subsequent multivariable models. Next, univariable logistic regression models were fit with appropriate survey weights to examine associations between each predictor and outcome variable using a liberal significance level (i.e., $\alpha = 0.20$) *(51)*. Details of the univariable analysis are available as Supplemental Material *(Tables S1–S10)*. A manual forward stepwise approach was used to fit our multivariable logistics regression models. Predictors remained in the model if they were statistically significant ($\alpha = 0.05$), acted as an explanatory antecedent (i.e., confounder), or were part of a significant interaction term with gender. Confounding was defined as a ≥ 30% change in the coefficient of a statistically significant nonintervening variable with the removal of the confounder *(7)*. Only after a main effects model was fitted did we examine interactions between these variables and gender. Odds ratios, 95% confidence intervals, and *P*-values were reported for each model coefficient. Model fit was assessed using F-adjusted mean residual goodness-of-fit tests *(2)*.

RESULTS

Study participant characteristics

In total, 2,401 households participated in the Foodbook study's food safety questionnaire. Of this number, 294 respondents reported having children (< 18 years old) in their household and were used for data analyses in this study. *Table 1* shows the demographic characteristics of the 294 survey respondents. Most participants were females (56.1%, *n* = 165), and the majority (67.5%, n = 137) had less than a bachelor's degree. A little more than half reported having a total household income of C$60,000 or more (53.1%, *n* = 130), and 54.8% of respondents had only one child at home (versus two or more). Fewer than half of the respondents (47.3%, *n* = 139) reported living in a CMA. Central Canada had the highest number of study participants (30.3%, *n* = 89), followed by the Prairie Provinces (27.2%, *n* = 80). The fewest participants resided on the West Coast (10.9%, *n* = 32).

Food safety behavior frequencies are presented in *Table 2*. One-third of the respondents indicated that they made efforts to separate raw meats, poultry, and seafood from other ready-to-eat foods in the refrigerator to avoid cross-contamination (32.7%, *n* = 96). Most participants reported that they washed hands with soap after handling raw meat or poultry (89.8%, *n* = 264), and most refrigerated leftovers within 2 h of cooking (78.6%, *n* = 231). Food thermometer usage was most often reported for whole poultry (chicken, 35.7%, *n* = 105; turkey, 45.2%, *n* = 133) and less commonly for poultry cuts (12.6%, *n* = 37). Thermometer use was rarely reported for ground meat such as hamburgers (10.5%, *n* = 31) and for fish (4.4%, *n* = 13).

TABLE 1. Demographic characteristics of Canadian households with children below 18 years (*N* = 294) that responded to the Foodbook study

Variables	*n*	Total respondents (%)
Gender		
Male	129	43.9
Female	165	56.1
Education level		
Less than bachelor's degree	137	67.5
Bachelor's degree and above	66	32.5
Income category[a]		
<$60,000	115	46.9
≥ $60,000	130	53.1
No. of children in household		
1	161	54.8
≥2	133	45.2
Province or territory of residence[b]		
West Coast	32	10.9
Prairie Provinces	80	27.2
Central Canada	89	30.3
Atlantic Provinces	44	15.0
Northern Territories	49	16.7
Residence in census metropolitan area		
Yes	139	47.3
No	155	52.7

[a]Money values are in Canadian dollars.

[b]West Coast, British Columbia; Prairie Provinces, Alberta, Saskatchewan, Manitoba; Central Canada, Ontario, Quebec; Atlantic Provinces, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland, and Labrador; Northern Territories, Yukon, Northwest Territories, Nunavut.

Predictors of food safety behavior

Clean. Income level and residence in CMAs are significantly associated with hand washing with soap after handling raw meat and poultry *(Table 3)*. Participants with a higher income level (C$60,000 or higher) were significantly less likely to practice hand washing with soap after handling raw meat and poultry than those in lower-income groups *(Table 3)*. Individuals who lived in CMAs were significantly less likely to wash hands with soap following meat handling than were non-CMA residents *(Table 3)*.

Separate. Gender and the number of children in households are significantly associated with storing meat, poultry, or seafood on the bottom shelf of the refrigerator to prevent cross-contamination. Education, income, and region were retained in this model because they acted as confounders *(Table 4)*. Female caregivers were significantly more likely to practice proper food storage to prevent cross-contamination than were male participants. Households with two or more children were less likely to report this practice than households with one child *(Table 4)*.

Chill. Education level and residence in the CMAs were significantly associated with refrigerating leftovers after 2 h of cooking. Respondents with a bachelor's degree or higher had significantly lower odds of reporting that they refrigerated leftovers after 2 h of cooking than those without a bachelor's degree *(Table 5)*. Similarly, individuals who lived in CMAs were significantly less likely to refrigerate leftovers within 2 h after cooking than those who lived outside CMAs *(Table 5)*.

Cook. Individuals who lived in CMAs were significantly more likely to use a food thermometer when cooking pork cuts than those in non-CMAs *(Table 6)*. In contrast, those with a bachelor's degree or higher were significantly less likely to use thermometers for small cuts of poultry (chicken or turkey) than those without a bachelor's degree *(Table 7)*.

TABLE 2. Frequencies and percentages of food safety practices among Canadian households with children (*N* = 294)

Behavior variable	n[a]	Total participants (%)
Clean		
After handling raw meat or poultry, do you wash your hands with soap and water? (correct answer: yes)		
Yes	264	89.8
No	30	10.2
Chill		
Typically, how long after cooking food do you refrigerate the leftovers? (correct answer: within 2 h after cooking)		
Correct	231	78.6
Incorrect	63	21.4
Separate		
When storing raw meat, poultry, or seafood in your refrigerator, what steps do you take to prevent contamination of other foods from the meat or poultry juices? (correct answer: put meat, poultry, or seafood on the bottom shelf of the refrigerator)		
Yes	96	32.7
No	198	67.4
Cook		
Do you use a food thermometer when cooking the following? (correct answer for all: yes)		
Pork cuts		
Yes	41	14.0
No	253	86.1
Ground meat or meat mixtures, e.g., meatballs, sausages, and hamburger		
Yes	31	10.5
No	263	89.5
Whole chicken		
Yes	105	35.7
No	189	64.3
Whole turkey		
Yes	133	45.2
No	161	54.8
Chicken or turkey pieces		
Yes	37	12.6
No	257	87.4
Fish		
Yes	13	4.4
No	281	95.6
Roasts		
Yes	105	35.7
No	189	64.3
Steak		
Yes	29	9.9
No	265	90.1

[a]Number may not add up to 294 because of missing responses.

TABLE 3. Results of the multivariable logistic regression model examining the associations between Foodbook study respondents' demographic characteristics and the clean construct[a]

Variable	OR (95% CI)	*P*-value
Income		
<$60,000	(Referent)	
≥$60,000	0.06 (0.01, 0.27)	0.001
Census metropolitan area		
No	(Referent)	
Yes	0.15 (0.04, 0.55)	0.004

[a]*N* = 245; OR, odds ratio; CI, confidence interval.

TABLE 4. Results of the multivariable logistic regression model examining the associations between Foodbook study respondents' demographic characteristics and the separate construct[a]

Variable	OR (95% CI)	*P*-value
Gender		
Male	(Referent)	
Female	3.52 (1.34, 9.25)	0.011
No. of children in household		
1	(Referent)	
≥2	0.38 (0.15, 0.96)	0.040
Education		
Less than bachelor's degree	(Referent)	
Bachelor's degree and above	1.61 (0.60, 4.29)	0.343
Regions		
West Coast	(Referent)	
Prairie Provinces	0.95 (0.29, 3.15)	0.938
Central Canada	0.59 (0.18, 1.91)	0.376
Atlantic Provinces	1.70 (0.36, 7.93)	0.497
Northern Territories	0.92 (0.22, 4.29)	0.903

[a]*N* = 203; OR, odds ratio; CI, confidence interval.

For the other meat types, none of our explanatory variables has a significant association with the use of a food thermometer *(Table S1 – S10)*.

DISCUSSION

This study presents findings about the food safety practices of Canadian households with children under 18, highlighting demographic differences and gaps in food safety behaviors. The COVID-19 pandemic restrictions imposed by governments worldwide, including Canada, have resulted in more cooking at home and increased household food handling *(35)*. This was further heightened by physical distancing, restaurant closures, and restrictions in movement, thus leading to a change in demographics that favored those working from home. Reports indicated that urban households with children under 15 years of age, in which members worked from home, were more likely to cook at home during the pandemic than during the prepandemic period *(13)*. The preference for household food consumption has continued to increase since the pandemic began

TABLE 5. Results of the multivariable logistic regression model examining the associations between Foodbook study respondents' demographic characteristics and the chill construct[a]

Variable	OR (95% CI)	*P*-value
Education		
Less than bachelor's degree	(Referent)	
Bachelor's degree and above	0.20 (0.07, 0.56)	0.003
Census metropolitan area		
No	(Referent)	
Yes	0.30 (0.10, 0.88)	0.029

[a]*N* = 203; OR, odds ratio; CI, confidence interval.

TABLE 6. Results of the multivariable logistic regression model examining the associations between Foodbook study respondents' demographic characteristics and the cook construct (pork cuts)[a]

Variable	OR (95% CI)	*P*-value
Income		
< $60,000	(Referent)	
≥ $60,000	2.44 (0.54, 11.01)	0.245
Education		
Less than bachelor's degree	(Referent)	
Bachelor's degree and above	0.31 (0.07, 1.45)	0.136
Gender		
Male	(Referent)	
Female	1.76 (0.46, 6.83)	0.409
Census metropolitan area		
No	(Referent)	
Yes	4.47 (1.33, 14.98)	0.016

[a]*N* = 185; OR, odds ratio; CI, confidence interval.

TABLE 7. Results of the multivariable logistic regression model examining the associations between Foodbook study respondents' demographic characteristics and the cook construct (chicken or turkey pieces)[a]

Variable	OR (95% CI)	*P*-value
Income		
< $60,000	(Referent)	
≥ $60,000	1.24 (0.23, 6.63)	0.802
Education		
Less than bachelor's degree	(Referent)	
Bachelor's degree or higher	0.16 (0.04, 0.54)	0.003

[a]*N* = 185; OR, odds ratio; CI, confidence interval.

in 2020 *(58)*. In this study, most households with children reported following recommended food safety practices for clean (90%) and chill (79%) constructs. In contrast, primary food preparers with children need to improve in practices involving the cook and separate themes. Although the survey analyzed in this study was conducted before the pandemic, the insights gained from it are important to help inform public health intervention and messaging on safe food handling at home, given these recent trends.

Food thermometer usage (cook)

Our findings reveal that food thermometer usage varies with different meat types. The low-reported use of a food thermometer for small cuts of chicken, turkey, and pork and for hamburgers is consistent with previous studies, which found that food thermometers were used less often with smaller cuts of meat than with whole poultry or roasts *(16, 29, 40, 59)*. One possible reason is that thermometers are difficult to use, especially for small cuts; for these, consumers may assess cooking using other cues, such as color, taste, and texture *(29)*. Other studies have also found that families with young children report visual inspection *(34)* or cutting through the meat *(28)* as primary methods for determining when meat is cooked. But these sensory approaches to checking doneness are unreliable in ensuring food has reached a safe internal cooking temperature *(55)*. A 2018 Canadian national survey found that the percentage of consumers who frequently use food thermometers to check cooking doneness increased from 28% in 2010 to 49% in 2018 *(24)*. A majority of seniors used food thermometers (55%), including those with a compromised immune system (49%), but usage was lower among parents of young children (43%) *(24)*. The low thermometer usage for ground meat (11%) is concerning because the risk of acquiring a verotoxigenic *E. coli* infection is higher, especially among children, when undercooked meat or hamburger is consumed *(21)*. Food safety interventions that encourage using food thermometers are required among parents and caregivers of children.

We found significant demographic differences in food thermometer usage. Respondents who lived in CMAs were more likely to use a food thermometer for pork cuts than were non-CMA residents. Participants with a bachelor's degree or higher were less likely to use a thermometer for small cuts (chicken or turkey) than those without a bachelor's degree. A similar national survey in the United States also showed regional differences. In the Northeast, the largest metropolitan area of the United States, residents were more likely to use food thermometers for roasts than were those who lived in the midwestern United States *(29)*. In another study, residence in rural areas was positively associated with undercooked meat consumption and *E. coli* O157 infection *(21)*. Previous research has found that consumers with more education are less likely to use food thermometers *(16, 29, 44)*. This may be intentional, probably due to preferences for undercooked foods such as medium steak and raw oysters *(17)*. Therefore, food safety interventions to promote food thermometer usage and to draw attention to the risk associated with consuming undercooked meat should target Canadian households living in nonurban areas and those with higher educational attainment.

Safe food storage to prevent cross-contamination (separate)

Most households with children under 18 did not report keeping raw meat, poultry, and seafood separate from other foods in the refrigerator. In contrast, in a prior 2010 national survey, Canadians commonly reported separating raw meat and juice from other foods *(15)*. Note that some studies have found that parents of young children do not report proper storage of raw meat or poultry in the refrigerator *(1, 9, 57)*, whereas other studies have shown that parents of young children practice this more effectively than seniors *(3, 28)*. The low practice level seen in the current study is a source of concern due to the possible risk of cross-contamination and foodborne illness among young children *(22)*. Awareness and strategies aimed at enhancing this food safety practice are recommended.

Families with two or more children were less likely to safely store meat, poultry, and seafood in the refrigerator than were families with one child. Several factors could be responsible for this finding: multitasking, other house chores, and childcare duties *(12, 50)*. Increased efforts may be required to promote safe storage practices and to educate Canadian families with two or more children about the risk of eating contaminated food. Female caregivers were more likely to avoid cross-contamination by properly storing meats in the refrigerator than were their male counterparts. The Foodbook study also indicated that fewer males than females reported taking measures to prevent cross-contamination (87 versus 95%) *(45)*. This finding also corresponds with previous research that found that females tend to have better attitudes and practices toward food safety than males *(42, 48)*. Women tend to be more concerned about food hygiene because they are the main food preparers at home *(19, 53)*. However, due to societal changes (e.g., more women entering the workforce, urbanization, changing gender roles in household tasks, and the COVID-19 pandemic), men are also increasingly involved in home food preparation *(58)*. Gender-specific messaging may be needed to promote safe practice. One possible way to improve safe food handling practices among men is to appeal to their subjective norms by outlining expectations for their behavior and educating them on the impact of their actions on the health of other family members *(38, 52)*.

Hand washing with soap after handling raw meat products (clean)

Most respondents reported washing their hands with soap after handling raw meat or poultry. This result corresponds

with previous national surveys, in which many Canadians reported practicing hand washing with soap after handling raw meat *(15, 24)*. Previous research conducted in the United States, Canada, and Austria also found that parents of young children regard hand washing with soap as a clear and essential practice in food preparation *(31, 40)*. In addition, because parents touch their kids frequently to pick them up, wipe their faces, and change diapers, they are motivated to take precautions to keep their hands clean. A recent study found that intentions, self-efficacy, and self-control significantly predicted hand hygiene among parents with young children *(11)*, which indicates that parents rely on conscious processes more than on automatic or usual tasks for this behavior. For this reason, a conscious-based intervention (e.g., one based on theories such as the Theory of Planned Behavior) may help parents handle food safely more frequently and consistently for their children *(11)*.

We found significant demographic differences in hand washing. Participants in the high-income category were less likely to report practicing hand washing than those in the lower-income category. Similarly, households in non-CMAs were more likely to report good hand hygiene practices than those in CMAs. Consistent with previous studies, high-income earners have been associated with less cooking at home, risky food consumption (e.g., undercooked meat, runny eggs), and poor food handling practices *(40, 44)*, possibly because food is prepared less frequently in those households. Low-income families prepare meals more frequently than high-income households *(30)*. Consumers who cook meals at home more regularly may be better informed because their routine helps strengthen their recall of food safety behaviors *(30)*. Nesbitt et al. *(40)* and colleagues also found that rural residents are much more likely than urban residents to practice hand washing with soap after handling raw meat. Our findings suggest that primary food preparers for children in urban and high-income households require more targeted outreach on hand washing.

Refrigerating leftovers within 2 h of cooking (chill)

Most of the study participants refrigerated leftovers within 2 h of cooking. This is consistent with a Canadian national survey that found that the majority of Canadians routinely refrigerate leftovers within 2 h of cooking *(15)*. Among the population subgroups, parents of young children reported the lowest level of practicing this behavior (60%) *(15)*. Previous research has found that some participants incorrectly believe cooked food should be cooled to room temperature before it is refrigerated *(6)*. It is vital to emphasize that leftovers must be refrigerated within 2 h of cooking and to discourage letting food sit out for more than 2 h in the "danger zone" *(9)*, which may allow pathogen growth and toxin production.

Participants with more education and those living in CMAs were less likely to refrigerate leftovers within 2 h of cooking. Numerous studies have shown that those with higher education and income levels are less likely to engage in positive food safety practices at home *(9, 39, 49)*. A study conducted during the COVID-19 pandemic also found that participants with a bachelor's degree or higher tend to have poorer food safety practices than those with high school degrees or below *(32)*, which indicates that food safety education would benefit higher-educated residents of CMAs. The barriers that consumers face in adopting good food safety practices need to be further explored and addressed.

LIMITATIONS

One key limitation of this study is the small sample size of the subpopulation (parents and caregivers). We could only investigate binary categories of demographic predictors, which lost some potentially important information. Second, the survey excluded individuals without a landline or cellular phone, including those living in remote areas of Canada without telephone access. It has been widely reported that most households with children only have cell phones and have opted out of traditional landlines *(14)*. Technologies such as caller identification (call screening), answering machines, and call blocking have contributed to sampling bias *(26)*; many homes with young children may be excluded from the sampling frame when survey interviews involve landlines. Third, this study used a self-report questionnaire, which can be biased toward socially desirable responses and overestimation of good food safety practices. For example, a systematic review found that most people overestimate hand washing with soap in self-reported responses compared to direct observation *(20)*. Fourth, this study examined food safety practices among Canadian households with children < 18 years. But we also recognize that safe food handling practices can differ when caring for children in different age groups (e.g., those < 5 years old versus adolescents). It is unclear whether misclassification bias would be present in the results because this study examined only food handling practices; however, caution is advised when interpreting these findings. Fifth, this study assessed only self-reported practices limited to the four food safety constructs and did not assess knowledge or other psychosocial constructs. The section on storing raw meat on the bottom shelf of the refrigerator may not provide a comprehensive picture of safe storage. Some government agencies recommend that raw meats be placed in a sealed plastic bag or be wrapped securely to prevent cross-contamination in the refrigerator *(23, 56)*.

CONCLUSIONS

This study found gaps in food safety practices among Canadian households with children under 18, particularly in the cook and separate constructs. These findings should be considered in the development of food safety education programs. However, in designing food safety education for a vulnerable population, such as parents and caregivers of young children, all food safety constructs need to be emphasized because foodborne illness can be particularly

severe in this population. Families with two or more children, men who are caregivers of children, and those who live in urban areas are key groups that need to be targeted for safe food handling interventions. Because families with high income and education levels demonstrated poor hand hygiene and unsafe food storage practices, tailored food safety messaging and interventions for these households may be warranted.

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SUPPLEMENTAL MATERIAL

Summary of univariable analysis
Note: Money values are in Canadian Dollars

TABLE S1. Summary of clean construct univariable analysis

Variable	OR (95% CI)[a]	*P*-value
Gender		
Male	(Referent)	
Female	1.84 (0.38, 8.95)	0.452
No. of children in household		
1	(Referent)	
≥ 2	0.26 (0.07, 0.96)	0.043
Education		
Less than bachelor's degree	(Referent)	
Bachelor's degree and above	0.44 (0.09, 2.23)	0.324
Income		
< $60,000	(Referent)	
≥ $60,000	0.06 (0.01, 0.27)	0.001
Region		
West Coast	(Referent)	
Prairie Provinces	1.64 (0.27, 10.08)	0.591
Central Canada	1.42 (0.21, 9.56)	0.721
Atlantic Provinces	2.66 (0.35, 20.10)	0.342
Northern Territories	5.25 (0.70, 39.45)	0.107
Census metropolitan area		
No	(Referent)	
Yes	0.32 (0.10, 1.05)	0.060

[a]OR, odds ratio; CI, confidence interval.

TABLE S2. Summary of chill construct univariable analysis

Variable	OR (95% CI)[a]	*P*-value
Gender		
Male	(Referent)	
Female	1.92 (0.64, 5.81)	0.248
No. of children in household		
1	(Referent)	
≥ 2	1.35 (0.44, 4.19)	0.599
Education		
Less than bachelor's degree	(Referent)	
Bachelor's degree and above	0.17 (0.06, 0.50)	0.001

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TABLE S2. Summary of chill construct univariable analysis (cont.)

Variable	OR (95% CI)[a]	*P*-value
Income		
< $60,000	(Referent)	
≥ $60,000	0.06 (0.20, 3.78)	0.859
Region		
West Coast	Referent)	
Prairie Provinces	0.36 (0.07, 1.86)	0.222
Central Canada	0.27 (0.05, 1.36)	0.111
Atlantic Provinces	1.00 (0.15, 6.82)	0.999
Northern Territories	0.23 (0.04, 1.24)	0.086
Census metropolitan area		
No	(Referent)	
Yes	0.29 (0.11, 0.76)	0.011

[a]OR, odds ratio; CI, confidence interval.

TABLE S3. Summary of separate construct univariable analysis

Variable	OR (95% CI)[a]	*P*-value
Gender		
Male	(Referent)	
Female	3.40 (1.37, 8.45)	0.008
No. of children in household		
1	(Referent)	
≥ 2	0.39 (0.17, 0.88)	0.024
Education		
Less than bachelor's degree	(Referent)	
Bachelor's degree and above	1.00 (0.38, 2.62)	1.000
Income		
< $30,000–$59,000	(Referent)	
$60,000 or more	1.82 (0.67, 4.93)	0.241
Region		
West Coast	(Referent)	
Prairie Provinces	1.00 (0.32, 3.14)	0.999
Central Canada	0.89 (0.28, 2.77)	0.837
Atlantic Provinces	1.41 (0.39, 5.12)	0.600
Northern Territories	0.94 (0.27, 3.32)	0.926
Census metropolitan area		
No	(Referent)	
Yes	0.65 (0.30, 1.45)	0.294

[a]OR, odds ratio; CI, confidence interval.

TABLE S4. Summary of cook construct (pork cuts) univariable analysis

Variable	OR (95% CI)[a]	*P*-value
Gender		
Male	(Referent)	
Female	2.38 (0.81, 7.04)	0.116
No. of children in household		
1	(Referent)	
≥ 2	0.62 (0.20, 1.94)	0.414
Education		
Less than bachelor's degree	(Referent)	
Bachelor's degree and above	0.37 (0.09, 1.53)	0.170
Income		
< $30,000–$59,000	(Referent)	
$60,000 or more	1.97 (0.43, 8.93)	0.381
Region		
West Coast	(Referent)	
Prairie Provinces	1.64 (0.32, 8.43)	0.552
Central Canada	1.63 (0.32, 8.39)	0.558
Atlantic Provinces	0.77 (0.13, 4.56)	0.770
Northern Territories	0.60 (0.10, 3.73)	0.581
Census metropolitan area		
No	(Referent)	
Yes	1.92 (0.11, 0.76)	0.190

[a]OR, odds ratio; CI, confidence interval.

TABLE S5. Summary of cook construct (ground meat, e.g., hamburger) univariable analysis

Variable	OR (95% CI)[a]	*P*-value
Gender		
Male	(Referent)	
Female	1.38 (0.21, 9.35)	0.730
No. of children in household		
1	(Referent)	
≥ 2	0.49 (0.09, 2.72)	0.417
Education		
Less than bachelor's degree	(Referent)	
Bachelor's degree and above	0.56 (0.06, 5.12)	0.610
Income		
< $60,000	(Referent)	
≥ $60,000	2.88 (0.47, 17.88)	0.253

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TABLE S5. Summary of cook construct (ground meat, e.g., hamburger) univariable analysis (cont.)

Variable	OR (95% CI)[a]	*P*-value
Region		
West Coast	(Referent)	
Prairie Provinces	0.59 (0.09, 3.73)	0.575
Central Canada	0.67 (0.32, 8.39)	0.704
Atlantic Provinces	1.30 (0.13, 4.56)	0.803
Northern Territories	1.21 (0.10, 3.73)	0.860
Census metropolitan area		
No	(Referent)	
Yes	1.48 (0.27, 8.08)	0.648

[a]OR, odds ratio; CI, confidence interval.

TABLE S6. Summary of cook construct (whole chicken) univariable analysis

Variable	OR (95% CI)[a]	*P*-value
Gender		
Male	(Referent)	
Female	0.63 (0.23, 1.76)	0.379
No. of children in household		
1	(Referent)	
≥ 2	0.60 (0.19, 1.89)	0.382
Education		
Less than bachelor's degree	(Referent)	
Bachelor's degree and above	1.33 (0.42, 4.23)	0.631
Income		
< $60,000	(Referent)	
≥ $60,000	0.95 (0.27, 3.34)	0.931
Region		
West Coast	(Referent)	
Prairie Provinces	0.55 (0.15, 1.99)	0.364
Central Canada	0.49 (0.32, 1.81)	0.281
Atlantic Provinces	0.78 (0.16, 3.69)	0.749
Northern Territories	0.56 (0.11, 2.90)	0.489
Census metropolitan area		
No	(Referent)	
Yes	0.57 (0.20, 1.68)	0.309

[a]OR, odds ratio; CI, confidence interval.

TABLE S7. Summary of cook construct (whole turkey) univariable analysis

Variable	OR (95% CI)[a]	*P*-value
Gender		
Male	(Referent)	
Female	0.53 (0.21, 1.40)	0.203
No. of children in household		
1	(Referent)	
≥ 2	0.43 (0.14, 1.26)	0.123
Education		
Less than bachelor's degree	(Referent)	
Bachelor's degree and above	1.84 (0.64, 5.28)	0.252
Income		
< $60,000	(Referent)	
≥ $60,000	1.07 (0.34, 3.32)	0.910
Region		
West Coast	(Referent)	
Prairie Provinces	0.61 (0.15, 2.53)	0.497
Central Canada	0.38 (0.09, 1.52)	0.169
Atlantic Provinces	0.68 (0.13, 3.47)	0.643
Northern Territories	0.83 (0.14, 4.75)	0.832
Census metropolitan area		
No	(Referent)	
Yes	0.85 (0.30, 2.38)	0.753

[a]OR, odds ratio; CI, confidence interval.

TABLE S8. Summary of cook construct (roasts) univariable analysis

Variable	OR (95% CI)[a]	*P*-value
Gender		
Male	(Referent)	
Female	0.73 (0.27, 1.99)	0.537
No. of children in household		
1	(Referent)	
≥ 2	0.65 (0.22, 1.91)	0.430
Education		
Less than bachelor's degree	(Referent)	
Bachelor's degree and above	0.94 (0.30, 2.88)	0.907
Income		
< $60,000	(Referent)	
≥ $60,000	1.71 (0.46, 6.37)	0.419

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TABLE S8. Summary of cook construct (roasts) univariable analysis (cont.)

Variable	OR (95% CI)[a]	*P*-value
Region		
West Coast	(Referent)	
Prairie Provinces	0.98 (0.28, 3.39)	0.969
Central Canada	1.26 (0.37, 4.27)	0.706
Atlantic Provinces	1.31 (0.27, 6.31)	0.732
Northern Territories	1.21 (0.30, 6.51)	0.673
Census metropolitan area		
No	(Referent)	
Yes	0.74 (0.27, 2.00)	0.547

[a]OR, odds ratio; CI, confidence interval.

TABLE S9. Summary of cook construct (steak) univariable analysis

Variable	OR (95% CI)[a]	*P*-value
Gender		
Male	(Referent)	
Female	1.43 (0.26, 7.78)	0.679
No. of children in household		
1	(Referent)	
≥ 2	1.26 (0.22, 7.28)	0.799
Education		
Less than bachelor's degree	(Referent)	
Bachelor's degree and above	0.38 (0.06, 5.12)	0.349
Income		
< $60,000	(Referent)	
≥ $60,000	1.80 (0.26, 12.45)	0.551
Region		
West Coast	(Referent)	
Prairie Provinces	0.61 (0.09, 4.12)	0.614
Central Canada	1.05 (0.15, 7.26)	0.960
Atlantic Provinces	0.95 (0.12, 7.30)	0.963
Northern Territories	0.96 (0.09, 10.25)	0.970
Census metropolitan area		
No	(Referent)	
Yes	2.36 (0.60, 9.22)	0.216

[a]OR, odds ratio; CI, confidence interval.

TABLE S10. Summary of cook construct (fish) univariable analysis

Variable	OR (95% CI)[a]	*P*-value
Gender		
Male	(Referent)	
Female	0.36 (0.21, 2.45)	0.730
No. of children in household		
1	(Referent)	
≥ 2	2.70 (0.30, 24.64)	0.376
Education		
Less than bachelor's degree	(Referent)	
Bachelor's degree and above	0.08 (0.003, 2.34)	0.142
Income		
< $60,000	(Referent)	
≥ $60,000	1.82 (0.16, 20.71)	0.626
Region		
West Coast	(Referent)	
Prairie Provinces	0.28 (0.007, 10.82)	0.489
Central Canada	0.47 (0.03, 7.16)	0.583
Atlantic Provinces	1.92 (0.05, 17.13)	0.957
Northern Territories	1.73 (0.03, 15.38)	0.837
Census metropolitan area		
No	(Referent)	
Yes	2.21 (0.18, 26.64)	0.530

[a]OR, odds ratio; CI, confidence interval.