Food Safety Attitudes and Self-Reported Behaviours of Undergraduate Students at the University of Waterloo (Ontario, Canada)

by

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Author's Declaration

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Statement of Contributions

With the exception of the content noted below, the work of this thesis consists of content that I authored.

Survey

In this thesis, I used existing data from a survey used in a previously conducted study (1).

Chapters 5, 6, and 8

I conducted the data analysis for these chapters, with model guidance and data coding assistance from Dr. Ashok Chaurasia. I wrote the chapters, with input on drafts from Dr. Shannon Majowicz.

Chapter 7

I conducted the data analysis for this chapter, with assistance mapping the attitude and behaviour questions to constructs in behaviour change theories from Dr. Kitty Corbett. I wrote this chapter, with input on drafts from Dr. Shannon Majowicz.

Abstract

Introduction: In Canada, foodborne disease is an important public health issue. Rates of foodborne disease are usually highest among the young and elderly, but an increase in foodborne disease incidence and prevalence is also observed among young adults. Foodborne diseases can be prevented by properly preparing, cooking, and storing food, and the likelihood of individuals using proper food handling and hygiene behaviours varies with their attitude towards food safety. Studies measuring the food safety attitudes and behaviours of young adults, and then exploring the relationship between food safety attitudes and behaviours using relevant behaviour change theories, have yet to be completed in Canada. Therefore, I explored what undergraduate students at the University of Waterloo think about food safety and what they do to prevent foodborne disease by: (i) measuring students' food safety attitudes; (ii) understanding students' self-reported food safety behaviours; (iii) exploring if behaviour change theories can be used to examine the relationship between attitudes and self-reported behaviours, and; (iv) exploring the relationship between students' attitudes and behaviours.

Methods: Existing data collected in February 2015 from 470 undergraduate students from the University were analyzed. The attitudes and self-reported behaviours were analyzed descriptively using frequency calculations, and using multiple linear or ordinal logistic regression to determine the significantly associated demographic and food skills and cooking experience characteristics. In addition, the attitudes and self-reported behaviours were mapped against the constructs in previously applied behaviour change theories, as well as the COM-B Model. The theory with most even distribution of attitude and self-reported behaviour questions across the greatest number of theoretical constructs was selected as the framework to examine the relationship between food safety attitudes and self-reported behaviours. Structural equation

modeling was then used to model the relationship between the collected food safety attitudes and self-reported behaviours, while adjusting for potential confounders.

Results: In general, undergraduate students at the University of Waterloo had positive food safety attitudes and self-reported behaviours. All attitudes, except for "anyone can get sick with food poisoning, even me", and self-reported behaviours, except for "If I have a cut or sore on my hand, I cover it before preparing food" were significantly associated with one or more of the 13 collected demographic and food skills and cooking experience characteristics. In addition, it was determined that behaviour change theory can be used to examine the relationship between the collected food safety attitudes and self-reported behaviours. Even though the Theory of Planned Behaviour and the Health Belief Model had the most even distribution of attitude questions across the greatest number of theoretical constructs, all of the attitude and self-reported behaviour questions mapped to constructs in the COM-B Model, and it has not yet been applied to food safety attitude and behaviour literature, so it was used to explore the relationship between food safety attitudes and behaviours of young adults. Finally, using the COM-B Model, I found that some of the collected food safety attitudes were significantly associated with self-reported food safety behaviours.

Conclusion: Undergraduate students at the University of Waterloo have good food safety attitudes and self-reported behaviours, which, using the COM-B Model, were found to be significantly associated. This is the first study to examine the food safety attitudes and self-reported behaviours of exclusively young adults in Canada, as well as the association between both food safety attitudes and self-reported behaviours, and demographic and cooking skills and experience characteristics other than gender or race. In addition, this is the first study to apply the newly developed COM-B Model to food safety attitudes and self-reported behaviours. Future

research should build on this thesis by examining undergraduate students' observed food safety behaviours to determine what undergraduate students actually do to protect themselves from foodborne disease, as well as use cluster analysis to determine whether undergraduate students can be divided into students that are motivated to improve their food safety behaviours and students who need motivation to improve their food safety behaviours in order to tailor interventions, such as messaging, based on the motivational needs of the students.

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1. Introduction

Foodborne disease is a global public health issue, and is caused by the consumption of food contaminated with pathogens, chemicals, or physical pollutants (2,3). Consumption of contaminated food often leads to acute symptoms such as vomiting and diarrhea, but long term consequences such as renal disease, inflammatory bowel disease, and Guillain-Barré syndrome can also occur (e.g., 1,3).

In Canada, approximately 4 million (90% credible interval [CrI] 3.1 – 5.0 million) cases of domestically acquired foodborne disease occur each year (5), costing between $364 to $455 million (6–8). Norovirus, *C. perfringens*, *Campylobacter* spp., and non-typhoidal *Salmonella* spp. cause the majority of these cases (5). Foodborne pathogens are also responsible for 11,632 (90% CrI 9,249 – 14,158) hospitalizations and 238 (90% CrI 155 – 323) deaths in Canada each year (3). In Ontario, *Campylobacter*, *Salmonella*, verotoxin-producing *Escherichia coli*, *Yersinia*, *Shigella*, hepatitis A, *Listeria*, and *Clostridium botulinum* caused 44,451 reported cases of enteric disease between the years 1997 and 2001, and food was cited as the source of the pathogen in 74.0% of the cases (9). These illnesses also led to a total of 2,488 hospitalizations and 113 deaths over the same time period (9).

Rates of foodborne disease vary with age; foodborne disease is highest among the young and elderly, but an increase in foodborne disease incidence and prevalence is also observed among young adults between 19 and 29 years of age (9–11). The young and elderly become ill because their newly developed or declining immune systems are unable to fight infection to their full capacity (12), but young adults may become ill due to the hypothesized “second weaning” phenomenon, thought to occur when individuals become the primary food preparer while not possessing the necessary skills to protect themselves from illness (13).

There are many opportunities for food to be contaminated along the 'farm-to-fork' continuum (14); however, foodborne diseases can be prevented by properly preparing, cooking, and storing food (15). A few studies have found that the likelihood of individuals employing proper food handling and hygiene practices varies with their attitude towards food safety, such that individuals with a positive attitude towards food safety tend to have better self-reported food safety practices than individuals with a negative attitude towards food safety (16–18). Studies on food safety attitudes and behaviours, either self-reported or observed, have been conducted among various age groups around the world (see literature review). Of the 64 food safety attitude and behaviour studies, only 10 studies used behaviour change theories to understand the relationship between attitudes and behaviours in the food safety context. The other 54 studies measured attitudes and behaviours, and either developed or used pre-existing attitude and behaviour questionnaires, such as the questionnaire developed by Byrd-Bredbenner et al. (see literature review). Of the 54 studies, 3 studies were Canadian, conducted among high school students (19) and the general population (20,21), and none have been conducted among young adults. Therefore, the goal of this thesis is to measure the food safety attitudes and self-reported behaviours of undergraduate students at the University of Waterloo, and then explore the relationship between food safety attitudes and behaviours using relevant behaviour change theories.

2. Literature Review

2.1 Foodborne disease in young adults

Typically, foodborne disease incidence and prevalence is highest among the very young and very old, for biological reasons (12), but an increase in incidence and prevalence, not caused by changes in immune system capabilities, is also observed among young adults between the ages of 19 and 29 years (9–11). For example, the annual incidence rate of *Campylobacter* in the province of Ontario circa 2003 was highest among individuals between the ages of 0 to 4 (88.6 cases per 100,000 people) and steadily declined until the incidence rate increased again to 55.5 cases per 100,000 people for individuals between the ages of 20 and 29 (9). However, in 2013, the incidence rate of *Campylobacter* in Ontario was no longer highest among individuals between the ages of 0 and 4, rather the highest rate was among individuals between the ages of 20 and 29 at 38.6 cases per 100,000 people (22). Similarly, the prevalence of gastrointestinal illness circa 2001 peaked in individuals 20 to 24 years, as well as individuals 0 to 9 years, in Hamilton, Ontario (11). In addition, a report by Toronto Public Health found that average annual rate of sporadic foodborne disease between the years 1998 and 2007 was highest among young adults between the ages of 20 and 29, although the majority of foodborne disease outbreak cases occurred in young children (0-4 years of age) attending childcare centers (10).

The cause of the increase in foodborne disease incidence and prevalence seen among young adults is unknown, but potential influencing factors have been hypothesized. One study hypothesizes that the increase in incidence and prevalence is due to the foodborne disease reporting behaviours of young adults (23), but most studies indicate that it may be due to their risky food handling behaviours (24–28).

Young adults are more likely to engage in risky food handling than adults over the age of 30 (24–28), and the 'second weaning' phenomenon may be the cause (13). Many individuals become the primary food preparer for the first time during young adulthood, and have little to no food preparation skills or food hygiene knowledge (13,29). Parents, especially mothers, are working longer hours outside of the home (30–32), and processed, convenience, and fast foods are purchased instead of basic ingredients (29,33–37), both of which reduce the opportunity for young adults to learn proper food handling through observation at home before they move out on their own (35,38–40). A study examining the food safety knowledge, attitudes, and behaviours of over 4,000 college and university students across the United States hypothesized that many young adults may have also never been exposed to proper food safety procedures in the work place, as the majority of the study participants had never held a job as a food server (60%) or food preparer (76%), and even fewer participants did not hold a food safety certification (94%) (41). The same study also discovered that the majority of the participants had never completed a course in nutrition, food science, or microbiology, in which basic food safety principles would be reviewed (41). In addition, foods-based courses are being eliminated from high schools, so fewer and fewer young adults have the opportunity to learn important food safety skills at school (42).

The majority of studies that have explored the potential reasons why young adults experience an increase in incidence and prevalence of foodborne disease have looked at it from a societal perspective; however, the only study to date that has examined foodborne disease reporting practices by age group found that people less than 35 years of age are significantly more likely to report a suspected food poisoning and have the suspected food poisoning confirmed by a health practitioner than people over the age of 35 (23). It is possible that the increase in foodborne disease incidence and prevalence among young adults may not be because they have poorer food

safety practices than adults, but may be because they are more willing to report suspected food poisonings than adults, creating an artificial increase in incidence and prevalence (23). Participants were asked whether they had their food poisoning positively identified by a doctor or nurse via a telephone interview without confirming the diagnosis by reviewing their medical records (23), and it is possible that the number of young adults who had their diagnosis confirmed by a medical professional was overinflated. The incidence rate of *Campylobacter* determined by Public Health Ontario (22) and the average annual rate of sporadic foodborne disease determined by Arthur et al. (10) were calculated based on laboratory-confirmed cases of foodborne disease (10,22), and so could have also been overinflated if more young adults sought medical attention for foodborne disease than other age groups. The same issue would not apply to the study conducted by Majowicz et al. as the data were collected through a community-based survey, so it would not be subjected to the same reporting bias (11).

2.2 Food safety attitudes and behaviours in the population

Studies aimed at measuring food safety attitudes and behaviours have been conducted in two main populations: food service workers (43), which are beyond the scope of this review; and consumers, who - in the food safety context - are considered anyone who handles or prepares food in the domestic or personal setting (44). Studies investigating the food safety attitudes and behaviours of special populations of consumers, such as young children, pregnant women, the immunocompromised, and the elderly, will not be reviewed here because these groups have unique food safety requirements compared to general consumers (45–57). Studies whose primary objective was to assess the food safety attitudes and behaviours of young adults in particular are reviewed in detail in the following sub-section; this section includes studies that have targeted

the general population regardless of age (which may include young adults as a part of the general population) as well as studies that targeted specific age groups other than young adults.

Consumer food safety attitudes and behaviours have been assessed by 36 studies in both developing and develop countries, including Canada (Tables 1 to 3, which also include all the references). The studies were conducted between the years 1995 to 2016, and the most popular option (40.5%; 15/37) was for authors to create their own food safety questionnaire interested in either attitudes, behaviours, or both attitudes and behaviours (18,28,58–69).

The 15 studies that assessed food safety attitudes, which were conducted in Canada, China, India, Jamaica, Turkey, the United Kingdom, and the United States between the years 2003 to 2015, found that consumers tend to have positive food safety attitudes (Tables 1 and 3) (18,19,62,70–73). Women (18,74,75), consumers between the ages of 30 and 59 (74,75), individuals of races other than Caucasian (74), people with less education (74), people in a higher income group (74), and people employed in the food industry (74) tended to have more positive foods safety attitudes than men, consumers under the age of 30 and 60 years of age or older, Caucasians, people with higher education, people in a lower income group, and people who are not employed in the food industry.

Consumers with positive food safety attitudes believe it is important to take steps to prevent themselves from foodborne disease (73), and that they have the ability to do so (75). However, they also believe they do not need to improve their food safety behaviours (76), as they feel they are more likely to get sick from food prepared outside the home than food prepared inside the home (62,76,77). In Canada, specifically, high school students have positive food safety attitudes (19), but residents of Ontario who have never experienced foodborne disease are significantly more likely to believe that they have a lower risk of acute gastrointestinal illness than the general

population when compared to those who have experienced foodborne disease (20). Consumers who had poor or ambivalent attitudes towards food safety believe that food safety is the responsibility of restaurants (77), meat packers (72), and the government (77). Young adults between the ages of 18 and 29, specifically, have confidence that the government, farmers, meat packers, grocery stores, and restaurants will keep them safe from foodborne disease (74,75), yet they also have a greater perception of the risk of foodborne disease than adults over the age of 30 (75).

Of the 36 studies, 34 examined food safety behaviours among consumers and found that although both observed and self-reported food safety behaviours tended to be poor (59–61,65,67,68,70–73,78–80), youth, however, reported usually or always performing recommended food safety behaviours (Tables 2 and 3) (18,19). Similar to food safety attitudes, women (21,28,69,74) consumers between the ages of 30 and 59 (28,69), individuals of races other than Caucasian (69,74), and people with less education (28,74) tended to have more positive food safety self-reported and observed food safety behaviours than men, consumers under the age of 30 and 60 years of age or older, Caucasians, and people with higher education. However, unlike food safety attitudes, people in a lower income group tended to have better food safety self-reported behaviours than people in a higher income group (21,28). Frequent food preparers also tended to have better food safety self-reported behaviours than those who prepare food infrequently (69).

Cooking behaviours tended to be poor as consumers reported (61,67,76,79,81) and were also observed (60,67,79,80) not using a thermometer to determine the doneness of food, but used taste (60) or appearance to determine doneness instead (60,72). Consumers tended to have good self-reported, but poor observed cleaning behaviours. The majority of consumers reported that

always washing their hands with soap and water before and during food preparation (66,67,69,79,81,82), however observations demonstrate that the majority of consumers actually do not properly wash their hands or wash their hands at all before or during food preparation (59,60,64,67,72,79,80,83). Self-reported hand washing before eating or handling food was found to be more likely among older adults than young adults in a Canadian study (21). Consumers also reported that they frequently clean surfaces, such as countertops, to prevent cross-contamination (76,78), but in other studies that used observations instead of self-reports, consumers did not prevent cross-contamination by properly cleaning kitchen surfaces while under observation (65,83). Cleaning implements, such as sponges and dish cloths, are not changed on a regular basis (68,76), which could unintentionally lead to cross-contamination. A Canadian study found that young adults are more likely to clean their kitchen sink and cutting board after preparing raw meat when compared to older adults (21). The evidence surrounding consumers' cold temperature control behaviours tends to be less straightforward than the evidence surrounding cooking and cleaning behaviours. Consumers both reported (84) and were observed (72) to have their refrigerator set at a temperature at or below 4.4 degrees Celsius (as recommended by the U.S. Department of Agriculture and U.S. Food and Drug Administration), however many consumers also reported that they do not own a refrigerator thermometer, which means they are unable to determine whether their refrigerators are compliant with refrigerator temperature recommendations (70,73,84). Studies on consumer thawing practices have been conflicting; consumers have reported both correct (73) and incorrect (61) thawing behaviours, and have been observed using both correct (80) and incorrect (79) thawing behaviours. Similarly, consumers have been observed properly storing leftovers within two hours of cooking (72), as well as leaving leftovers out on the counter for too long (70,73). In Canada, consumers had

adequate self-reported hand washing and cross-contamination behaviours, but did not have proper food handling or cooking behaviours (21).

The studies that examined the risky food consumption behaviours of consumers found that the risky foods most frequently consumed are raw egg or foods containing raw egg (18,61,78), undercooked ground beef (74), and ethnic delicacies such as raw meatballs, stuffed mussels, and roasted sheep intestines (85). In addition, many consumers report tasting food to determine if it is still safe to eat (18,78). Males and younger adults (28,85) tend to consume a significantly greater number of risky foods than females and older adults. However, a Canadian study found that high risk food consumption practices were more frequently reported among the elderly, children, and residents of rural communities (21).

Of the 36 studies, 13 assessed both food safety attitudes and behaviours in the same study (Table 3). The majority of studies (71.4%; 5/7) that assessed both food safety attitudes and behaviours, and compared the two found that consumers had more positive attitudes than self-reported and observed behaviours (16,18,72,73,85). Two of the five studies were completed by general consumers in the United States (63, 66), one was completed by middle school students in the United States (18), one was completed by general consumers in Turkey (85), and one was completed by primary school students in China (16). The source of the questionnaires for three of the five studies was not reported (72,73,85), and the questionnaires for the other two of the five studies were developed by the authors (18) or experts in the field (16). The studies that found self-reported and observed behaviours to be more positive than attitudes were completed among adults in the United States (76) and Jamaica (77), and used previously developed questionnaires interested in food safety attitudes and self-reported behaviours (76,77). Two studies examined the relationship between food safety attitudes and self-reported behaviours, and

found that attitude scores were significantly positively correlated with self-reported behaviour scores (16,18). Both studies were interested in the food safety attitudes and self-reported behaviours of children, but they used different analytic methods as the study by Haapala et al. used Pearson's correlation (18) to look at the relationship between attitudes and behaviours, whereas the study by Shen et al. used Item Response Theory (16).

Four out of the thirty-six studies conducted education-based interventions with the goal of improving food safety attitudes and behaviours among consumers (16,86–88). The first study used radio, television, newspaper, posters, stickers, brochures, and colouring books to promote safe handling and preparation of food among the Puerto Rican community in Connecticut (88). The results of the study showed that the number of participants who reported performing two out of the nine behaviours, which were related to washing hands with soap and water before cooking and defrosting meat in the refrigerator, significantly increased after the intervention (88). The second study, which was conducted in a community in the United Kingdom, created promotional materials similar to the first study (88), such as leaflets, posters, and fridge magnets, but the second study also created a television documentary and a newspaper article, to try to improve community member's observed handwashing and cross-contamination prevention behaviours (87). Immediately after the intervention, the number of participants who performed at least one appropriate handwashing and drying behaviour in a test kitchen increased from 0% to 21%, but decreased to 13% four to six weeks after the intervention (87). The intervention did not appear to improve participants' cross-contamination prevention behaviours, such as the washing of cutting boards and knives after preparing chicken and before preparing ready-to-eat foods (87). The third study randomly assigned immigrants and refugees to a cooking class, 2-hour food safety discussion map class, or no education to determine the effects of the interventions on self-

reported food safety behaviours (86). Participants in the discussion map and cooking classes achieved significantly higher self-reported behaviour scores than the control group, but the participants in the cooking class reported using a thermometer significantly more frequently when cooking large pieces of meat than the participants in the discussion map class (86). In the fourth study, Chinese students in grades four to six were randomized to receive health education on nutrition and food safety for one hour every two weeks, for two school semesters (16). The study found that health education significantly improved students' attitude and self-reported behaviour scores (16). The students who did not receive health education also experienced a significant increase in their self-reported behaviour scores, but the improvement seen by the students who received the health education was greater than the improvement seen by the students who did not receive the education (16).

Table 1: Details of the two studies examining only food safety attitudes in the general population

Study	**Year**	**Location**	**Sample size and characteristics**	**Questionnaire source**	**Mean attitude score**
Redmond et al., 2004 (75)	NR*	United Kingdom	100 adults over 16 years of age	NR	NR
Sargeant et al., 2010 (20)	2005 to 2006	Canada	2,057 English-speaking residents of Ontario	Majowicz et al., 2004 (11)	NR

*Not reported

Table 2: Details of the 21 studies examining only food safety behaviours in the general population

Study	**Year**	**Location**	**Sample size and characteristics**	**Questionnaire source**	**Observed versus self-reported behaviour measurement**	**Mean behaviour score**
Transtheoretical Model						
Kang et al., 2010 (82)	2009	South Korea	342 4th to 6th grade elementary school students	Byrd-Bredbenner et al., 2007 (89); Rollnick et al., 1992 (90)	Self-reported	NR*
Theoretical underpinning not reported						
Altekruse et al., 1995 (69)	1992 to 1993	United States of America	1,620 participants from across the United States	Developed by the authors	Self-reported	NR
Altekruse et al., 1999 (28)	1995, 1996	United States of America	19,356 adults from Colorado, Florida, Indiana, Missouri, New	Behavioural Risk Factor Surveillance System (91)	Self-reported	NR

			Jersey, New York, South Dakota, Tennessee			
Jay et al., 1999 (83)	1997 to 1998	Australia	40 homeowners from Melborne	NR	Observed	NR
Anderson et al., 2004 (80)	NR	United States of America	99 residents of a county in the western United States	NR	Observed	NR
Bermudez-Millan et al., 2004 (67)	1999 to 2000	United States of America	100 Puerto Rican women from Hartford, Connecticut	Developed and pilot-tested by the authors	Self-reported and observed	NR
Mitakakis et al., 2004 (68)	1999	Australia	524 households from Melbourne	Developed by the authors based on	Self-reported	NR

				the recommendations of the Australian Food Safety Information Council and Victorian Department of Human Services		
Gauci et al., 2005 (66)	NR	Malta	90 participants	Developed and pilot-tested by the authors	Self-reported	62.0%
Redmond et al., 2006 (87)	NR	United Kingdom	38 consumers	NR	Observed	NR

Dharod et al., 2007 (79)	2003 to 2004	United States of America	60 Puerto Rican women from Hartford, Connecticut	NR	Self-reported and observed	NR
Fischer et al., 2007 (64)	2004	Netherlands	25 participants from Wageningen and Utrecht, Netherlands	Developed by the authors	Observed	NR
Gilbert et al., 2007 (65)	2005	New Zealand	316 New Zealand residents	Developed and pilot-tested by the authors	Self-reported	NR
Kosa et al., 2007 (84)	2002	United States of America	2,428 adults from across the United States	NR	Self-reported	NR

Hudson et al., 2009 (63)	NR	United Kingdom	110 students from a junior school	Developed and pilot-tested by the authors	Self-reported and observed	NR
Nesbitt et al., 2009 (21)	2005 to 2006	Canada	2,332 residents from the Waterloo region	NR	Self-reported	NR
Sanlier, 2009 (78)	2006	Tukey	1,461 participants between the ages of 14 to 66	Unusan, 2007 (92); Duffy, 1998 (93); Sammarco et al., 1997 (94)	Self-reported	NR
Henley et al., 2012 (61)	2011	United States of America	56 consumers from Philadelphia	Developed by the authors	Self-reported	NR
Hoelzl et al., 2013 (60)	2011	Austria	40 participants from Vienna	Developed and pilot-tested by the authors	Self-reported and observed	NR

Gold et al., 2014 (86)	NR	United States of America	78 international students, refugees, or immigrants	Developed and pilot-tested by the authors	Self-reported	NR
Kosa et al., 2015 (59)	2013	United States of America	1,054 adult grocery shoppers	Developed by the authors	Self-reported	NR
Donelan et al., 2016 (58)	NR	United States of America	102 consumers from Manhattan, Kansas; Kansas City, Missouri; Nashville, Tennessee	Developed by the authors	Observed	NR

*Not reported

Table 3: Details of the 13 studies examining both food safety attitudes and behaviours in the general population

Study	Year	Location	Sample size and characteristics	Questionnaire source	Observed versus self-reported behaviour measurement	Mean attitude score	Mean behaviour score
Cody et al., 2003 (76)	2002	United States of America	1,006 participants between the ages of 20 and 75 from across the United States	Home Food Safety… It's in Your Hands, developed and implemented by the American Dietetic Association and the ConAgra Foods Foundation (can no longer be found)	Self-reported	NR*	NR

Knight et al., 2003 (77)	1999	Jamaica	110 adults from North Central St. Andrew	Altekruse et al., 1996 (95); Fein et al., 1995 (96); Schafer et al., 1993 (97)	Self-reported	NR	NR
Dharod et al., 2004 (88)	2000	United States of America	500 Latinos from Connecticut and Southwestern Massachusetts	NR	Self-reported	NR	NR
Haapala et al., 2004 (18)	2000	United States of America	178 middle school students from central Pennsylvania	Developed and pilot-tested by the authors	Self-reported	76.9%	97.5%
Roseman et al., 2006 (74)	1999	United States of America	728 consumers from Kentucky	U.S. FDA Survey of Consumer Food Handling Practices and Awareness of	Self-reported	NR	NR

				Microbiological Hazards (can no longer be found)			
Towns et al., 2006 (73)	2005	United States of America	81 consumers in Peoria County, Illinois	NR	Self-reported	71.5%	44.1%
Gavaravarapu et al., 2009 (62)	NR	India	Unreported number of adolescent females from south India	Developed by the authors	Self-reported	NR	NR
Fein et al., 2011 (71)	1988, 1993, 1998, 2001,	United States of America	Unreported number residents at least 18 years of age from the United States	Food Safety Surveys from the U.S. Food and Drug Administration in collaboration with the	Self-reported	NR	NR

	2006, 2010			U.S. Department of Agriculture (no reference)			
Phang et al., 2011 (72)	NR	United States of America	199 volunteers from Northern California	NR	Observed	NR	NR
Zorba et al., 2011 (85)	2006	Turkey	2,000 consumers from Canakkale	NR	Self-reported	NR	NR
Evans et al., 2014 (70)	1993 to 2014	29 countries	9 to 4,343 consumers	NR	Self-reported and observed	NR	NR
Kosa et al., 2015 (81)	2013	United States of America	1,504 participants from across the United States	Developed by the authors based on the Be Food Safe Campaign developed by the U.S. Department of	Self-reported	NR	NR

				Agriculture and the Partnership for Food Safety Education (98)			
Shen et al., 2015 (16)	2010, 2012	China	478 primary school students	Designed by nutritionists and experts of school health in Central South University	Self-reported	NR	NR

*Not reported

2.3 Food safety attitudes and behaviours specifically in young adults

Of the 36 studies discussed in the preceding section, 22 examined food safety attitudes and behaviours of the general population, and of these, 6 provided details specific to young adults. The studies that discussed the differences in food safety attitudes and behaviours between young adults and adults, found that young adults tend to have poorer attitudes (74,75), and both self-reported and observed behaviours (21,28,69,85) than adults over the age of 30.

Only 17 studies looking at the food safety attitudes, behaviours, or both in just young adults have been published, (17,41,99–112). These 17 studies were conducted in both developed and developing countries (Tables 4 to 6) including Greece, Japan, Turkey, and the United States; however, the food safety attitudes and behaviours (17,41,99–113) of just young adults in Canada have not been explored. Before the development of the food safety attitudes and behaviours questionnaire by Byrd-Bredbenner et al. (89), studies interested in the food safety attitudes and behaviours of young adults either created their own survey (112) or used food safety attitudes and behaviours surveys that had been conducted among the general population (110,111). After Byrd-Bredbenner et al. developed the food safety attitudes and behaviours questionnaire, it was used by the majority (57.1%; 8/14) of subsequent studies interested in food safety attitudes and behaviours of young adults (41,99,104,105,107–109,113).

Of the 17 studies, 10 discussed food safety attitudes of young adults and found that, in general, college and university students' attitudes towards food safety were positive (Tables 4 and 6) (41,78,100,102–107,112). Women, students in health and nutrition-related programs (41,78,102,103,106,107,112), vegetarians (100), and those belonging to races other than Caucasian (100,107) tended to have more positive foods safety attitudes than men, students in non-health related programs, omnivores, and Caucasians.

Young adults in the United States strongly believe that they are at risk for foodborne disease (105), that cleanliness and sanitation are important for preventing foodborne disease (41,107), and that they have the knowledge and skills to prevent foodborne disease (104). But, young adults also strongly believe that restaurant managers, the health department, and the government should be responsible for food safety (112). They are most unsure whether they should responsible for protecting themselves from foodborne disease (41,105), and whether they are at greater risk for foodborne disease when they eat at restaurants than when they eat at home (112). It appears as though young adults are concerned about foodborne disease, but are unsure about whether they should be responsible for preventing the development foodborne disease (41,105,107). Contrary to young adults in the United States, a single study found that many young adults in Saudi Arabia do not believe they are at risk for food poisoning from the foods they eat (103). They believe that consumption of risky foods such as raw milk and eggs will not make them sick, and also believe that these risky foods are more nutritious than their less-risky counterparts, which may be due to differences in cultural practices (103).

Regardless of cultural background, several studies found that the most positive attitudes among young adults were towards handwashing practices (41,103,104). One study found that young adults strongly believed that cleanliness and sanitation are important (41) and two studies found that young adults believe that hand washing before eating or preparing food is very important (103,104). The studies found similar results even though each study used a different questionnaire, corroborating each other's findings (41,103,104).

Food safety self-reported and observed behaviours of young adults were discussed in all but one of the studies (16/17) (17,41,99,101–113). Although three studies reported mean behaviour scores over 80 percent (99,103,105), most studies (81.3%; 13/16) reported that young

adults had poor food safety self-reported and observed behaviours, with mean behaviour scores ranging between 10 and 65 percent (Tables 5 and 6) (17,41,101,102,104–106,108–113). Similar to food safety attitudes, females and students in health-related programs tended to have better self-reported and observed food safety behaviours than males and students in non-health-related programs (17,41,99,102–104,106–113).

Young adults reported that they tend to follow food safety guidelines related to hygiene behaviours most often (41,99,103,104) and food safety guidelines related to refrigeration behaviours least often (41,104,105). Studies observed that young adults tended to follow the food safety guidelines related to cross-contamination prevention behaviours most often (105,108) and the food safety guidelines related to cooking behaviours least often (105,108). When the home kitchens of young adults were observed, it was found that young adults appropriately stored dry foods and poisons, had cleaning supplies readily available and kept their kitchens fairly clean, but did not keep their appliances as clean, did not have appropriate cold food storage, and had poor access to a thermometer or temperature control (88, 90). The one study that looked at the relationship between self-reported and observed food safety behaviours discovered that cross-contamination prevention self-reported behaviours were predictors for all food preparation observed behaviours (105).

Of the 17 studies, 5 also examined the risky food consumption behaviours of young adults, and found that although young adults do not consume a wide range of risky foods (41,105,107,111,112), the risky foods they do eat, such as eggs with soft or runny yolks, undercooked hamburgers, and raw cookie dough, put them at risk for foodborne diseases such as *Salmonella* and *Escherichia coli* (41,105,107,111,112). Males and Caucasians tend to eat significantly more risky foods than females and individuals of other races (41,107,111).

Most of the studies (66.7%; 6/9) that examined both the food safety attitudes and behaviours of young adults found that young adults had better attitudes than self-reported and observed behaviours (41,104–107,112). This may suggest that young adults are ready to learn about food safety, and apply what they are taught to their behaviours in the kitchen (41). The other three studies, that found that young adults had better self-reported food safety behaviours than attitudes, may have done so because they were conducted in locations with cultures that may be more accepting of risky food safety attitudes than Western cultures (17,102,103). To-date, only one study has explored the relationship between food safety attitudes and behaviours in young adults; this study used correlation to measure the strength of the linear relationship, and discovered that there is a strong positive linear relationship between food safety attitudes and self-reported behaviours (17).

Of the 17 studies examining food safety attitudes and behaviours within young adult populations specifically, three attempted to improve food safety attitudes and behaviours among college and university students through the use of education interventions (104–106). Two of the three used informative refrigerator magnets, posters, table tents, brief cartoon videos, recorded radio skits, and advertisements in student newspapers over a four-week period to try to improve food safety attitudes and self-reported behaviours (104,105). One study, which specifically looked at improving self-reported handwashing behaviours, found that the number of participants that reported washing their hands with soap before cooking and washing their hands after going to the bathroom increased, moving the average scores from “some of the time” closer to “most of the time” (105). The other study found two of the nine attitude statements, which were related to handwashing before preparing food and checking refrigerator temperatures, significantly improved from the pre-campaign survey to the post-campaign survey, but also found that more

students reported washing their hands before preparing food on the pre-campaign survey than the post-campaign survey (104). The third study developed three 30- to 60-minute web-based interactive instructional modules to improve food safety attitudes and self-reported behaviours, which included food safety instruction with clip art, animated graphics, flash card activities, quizzes, word seek activities, word seek puzzles, drag-and-drop activities, audio clips, and links to exterior websites (106). Overall, the intervention significantly improved students' food safety attitude and self-reported behaviour scores, but the improvement was due to students in health majors, as they experienced a significantly greater increase in scores on all food safety attitude and self-reported behaviour indices, except high risk food intake, than non-health majors (106).

Table 4: Details of the one study examining only food safety attitudes in young adults

Study	**Year**	**Location**	**Sample size and characteristics**	**Questionnaire source**	**Mean attitude score**
Booth et al., 2013 (100)	2011	United States of America	499 undergraduate students from Andrews University	Yarrow, 2006 (114)	NR*

*Not reported

Table 5: Details of the seven studies examining only food safety behaviours in young adults

Study	**Year**	**Location**	**Sample size and characteristics**	**Questionnaire source**	**Observed versus self-reported behaviour measurement**	**Mean behaviour score**
Theory of Reasoned Action and Theory of Planned Behaviour						
Abbot et al., 2012 (101)	NR*	United States of America	607 university students from 5 geographically diverse universities	Source of the behaviour questions was not disclosed	Self-reported	NR
Theoretical underpinning not reported						
Morrone et al., 2003 (111)	NR	United States of America	354 university students from Ohio University	Behavioural Risk Factor Surveliance Survey, the Center for Disease Control, 1984 (115)	Self-reported	NR

Garayoa et al., 2005 (110)	2004	Spain	562 university students from the University of Navarra	Anglillo et al., 2001 (116); Jay et al., 1999 (83); Alterkuse et al., 1995 (69)	Self-reported	NR
Byrd-Bredbenner et al., 2007 (109)	2005	United States of America	154 university students from Rutgers University	Developed and validated by the authors	Observed	NR
Byrd-Bredbenner et al., 2007 (108)	2005	United States of America	154 university students from Rutgers University	Developed and validated by the authors	Observed	50.1%
Lazou et al., 2012 (113)	2010	Greece	750 undergraduate students from Aristotle University of Thessaloniki	Byrd-Bredbenner et al., 2007 (89)	Self-reported	37.5%

Hassan et al., 2014 (99)	2013	Lebanon	1,172 undergraduate students from Lebanese American University	Byrd-Bredbenner et al., 2007 (89)	Self-reported	44.7%

*Not reported

Table 6: Details of the nine studies examining both food safety attitudes and behaviours in young adults

Study	**Year**	**Location**	**Sample size and characteristics**	**Questionnaire source**	**Observed versus self-reported behaviour measurement**	**Mean attitude score**	**Mean behaviour score**
Transtheoretical Model							
Byrd-Bredbenner et al., 2007 (41)	2005	United States of America	4,343 university students from 21 colleges and universities	Developed and validated by the authors	Self-reported	NR*	NR
Byrd-Bredbenner et al., 2008 (107)	2005	United States of America	4,343 university students from 21 colleges and universities	Developed and validated by the authors	Self-reported	62.0%	18.9%

Abbot et al., 2009 (105)	NR	United States of America	153 university students from a major university	Byrd-Bredbenner et al., 2007 (89)	Self-reported and observed	NR	NR
Takeda et al., 2011 (102)	2008	Japan	658 undergraduate students from 6 universities	Behaviour questions developed by the Food Safety Commission of Japan and belief questions were from Haapala et al., 2004 (18)	Self-reported	NR	NR
Theoretical underpinning not reported							
Unklesbay et al., 1998 (112)	NR	United States of America	824 university students from 3 universities	Developed and pilot tested by the authors	Self-reported	NR	NR

Yarrow et al., 2009 (106)	NR	United States of America	59 university students from Kansas State University	Medeiros et al., 2001 (117)	Self-reported	Pretest: 77.9% Posttest: 83.1%	Prerest: 70.4% Posttest: 77.8%
Sharif et al., 2010 (103)	NR	Saudi Arabia	1,020 university students from Taif University	Structured questionnaire designed by the authors, pilot tested before distribution	Self-reported	67.3%	80.3%
Stein et al., 2010 (104)	NR	United States of America	1122 undergraduate students from Drexel University	Byrd-Bredbenner et al., 2007 (89)	Self-reported	NR	NR

Sanlier et al., 2012 (17)	NR	Turkey	1340 university students from Gazi University	Developed and pilot tested by the authors	Self-reported	60.3%	73.9%

*Not reported

2.4 Application of behaviour change theories to understanding food safety attitudes and behaviours

Studies of food safety attitudes and behaviours appear to be in two separate bodies of literature. In the first body of literature are the studies aimed at measuring food safety attitudes and behaviours of a population, reviewed in detail in the preceding sections; in these studies, behaviour change theory appears to have been rarely used to inform the development of questionnaires and never to guide the analysis. In the second body of literature are the studies aimed at using behaviour change theory to determine how well the theory explains the variation seen in food safety behavior; in these studies, behaviour change theory is used to develop questionnaires and analyze the data. These studies will be included in this section of the literature review.

There are 10 studies in which behaviour change theories were applied to understanding food safety attitudes and behaviours of consumers (118–127). Of these 10 studies, one study used both the Theory of Planned Behaviour and Temporal Self-Regulation Theory (122), one study used the Health Action Process Approach (124), one study used the Health Belief Model (127), one study used the Transtheoretical Model (126), and six studies used the Theory of Planned Behaviour (118–121,123,125).

The seven studies that used the Theory of Planned Behaviour attempted to determine how food safety attitudes, social norms related to food safety, and perceived behaviour control over the prevention of foodborne disease predict food safety intentions and ultimately, behaviours (118–123,125). All of the studies used the Theory of Planned Behaviour to inform the development of their questionnaires and they also conducted exploratory analyses of the relationships between the Theory of Planned Behaviour components using a series of regressions

(118–123,125). Over half (57.1%; 4/7) of the studies were conducted among young adults (118,121,122,125), and the rest were either conducted among the general population (119,123) or adolescents (120).

The Theory of Planned Behaviour explained between 26.3% and 74% of the variation in food safety intentions (118–121,123,125), and between 8.9% and 39% of the variation in self-reported food safety behaviours (118–121,123,125). The studies that specifically applied the Theory of Planned Behaviour to young adults found that the theory explained between 26.3% and 69% of the variation in food safety intentions (118,121,125), and between 8.9% and 39% of the variation in self-reported food safety behaviours (118,121,122,125).

Attitudes, subjective norms, and perceived behavioural control tended to significantly explain the variation in food safety intentions (118–121,123,125), and intention and perceived behavioural control tended to significantly explain the variation in self-reported behaviour (118–121,123,125). The studies conducted among young adults also found that attitudes, subjective norms, and perceived behavioural control tended to significantly explain the variation in food safety intentions (118,121,125), and intention and perceived behavioural control tended to significantly explain the variation in self-reported behaviour (118,121,122,125).

The Temporal Self-Regulation Theory is based on the assumption that the intention-behaviour relationship is not stable and consistent (128). The theory was only used in one study, which was interested in food safety behaviours among young adults (122). Before applying the variables from the Temporal Self-Regulation Theory to the structural equation model, the variables from the Theory of Planned Behaviour were applied (122). The study found that the Theory of Planned Behaviour explained 16.3% of the variation in food safety behaviour, but the addition of behavioural prepotency from the Temporal Self-Regulation theory increased the

explained variation in food safety behaviour to 25.7% (122). Behavioural prepotency was the only variable from the Temporal Self-Regulation Theory that significantly explained the variation in self-reported behaviour (122).

The Health Action Process Approach is a staged model with two phases: a motivational phase and a volitional phase (129). The motivational phase suggests that intentions to implement behaviour are affected by risk awareness, outcome expectancy, and action self-efficacy, and the volitional phase highlights action planning as the bridge between intention and behaviour (129). The only study that used the Health Action Process Approach conducted the study among young adults and found that the theory explained 54.3% of the variation in intention to prepare food safely, however only outcome expectancies, as well as subjective norms and past behaviours, which were also included in the model, significantly explained the variation (124). Intention and maintenance self-efficacy explained 17.2% of the variation in planning to prepare food safely, and both variables significantly explained the variation (124). All of the variables in the Health Action Process Approach theory, as well as past behaviour, explained 36.8% of the variation in self-reported food safety behaviour, but only maintenance self-efficacy and past behaviour significantly explained the variation (124).

The Health Belief Model was only used in one study, conducted among older adults (127). The Health Belief Model suggests that individuals will engage in healthy behaviours when they see themselves as susceptible to the illness of interest, perceive the illness as a serious threat, and believe that the benefits of the healthy behaviours outweigh the cost (130). The study found that perceived threat of foodborne disease and safe food handling behaviours were positively correlated to cues to action concerning safe food handling (127). The amount of variation in safe food handling explained by the Health Belief Model was not calculated (127).

The study that applied the Transtheoretical Model developed an intervention with the aim of advancing the general populations' stage of change towards thermometer use (126). The Transtheoretical Model proposes that behaviour change is a process that occurs over five stages: precontemplation, contemplation, preparation, action, and maintenance (131). Participants received an educational package about thermometer use, which contained a brochure, a 15-minute video, five illustrated recipe cards featuring preparation of small cuts of meat, and a refrigerator magnet (126). The intervention resulted in a significant decrease in the number of participants in the pre-contemplation stage and a significant increase in the number of participants in the preparation, action, and maintenance stage (126). The study also found that as participants progressed along the stages of change, their attitudes towards thermometer use became more positive (126).

In all of the above 10 papers, behaviour change theory was used during analysis to determine how well the variation in self-reported behaviour was explained by the constructs within each of the theories (118–127). Behaviour change theory was also used to inform the development of the questionnaire used, so all of the variables in the selected theory were reflected, making the application of that theory to the collected data easier (118–127). In contrast, the majority (90.6%; 48/53) of studies whose goal was to quantify food safety attitudes and behaviours did not use behaviour change theory (16–18,21,28,58–81,83–88,99,100,103,104,106,108–113), and if they did, it was to inform their questionnaire design (41,82,101,102,105,107). This results in studies that can only examine the relationship between food safety attitudes and behaviours using correlation; the relationship cannot be explored in-depth.

3. Thesis Goal and Objectives

The goal of my thesis was to explore what undergraduate students at the University of Waterloo think about food safety and what they do to prevent foodborne disease. Specifically, the objectives of my thesis were to:

1. measure students' personal interest in learning about avoiding food poisoning, perceived personal susceptibility to food poisoning, perceived personal threat of food poisoning (89), and other food safety attitudes (Chapter 5);
2. understand students' self-reported food safety behaviours (Chapter 6);
3. explore if behaviour change theories can be used to examine the relationship between attitudes and behaviours for typically collected attitude and behaviour measurements (generated using commonly applied questionnaires (19,89,114,117); Chapter 7), and;
4. explore the relationship between students' attitudes and behaviours, in light of the findings from objective 3 (Chapter 8).

4. Description of the Existing Data Analyzed for this Thesis

For this thesis, I analyzed data from an electronic, cross-sectional survey that I had previously administered to undergraduate students at the University of Waterloo in February 2015. Details about the methods used to collect the data have been published (1). The survey measured food safety attitudes, including students' personal interest in learning about food safety, perceived personal susceptibility to food poisoning, and perceived personal threat of food poisoning, using the questionnaire developed by Byrd-Bredbenner et al. (89), and used previously in eight studies (41,99,104,105,107–109,113). Additional food safety attitude questions were selected from another food safety questionnaire (19). The survey also measured self-reported food safety behaviours, and personal hygiene behaviours, using questions selected from existing, validated questionnaires (114,117). A behaviour question asking about eating food past the 'Best Before' date was also added.

The survey (Appendix A) was completed by 470 undergraduate students, with a 9.4% response rate (470/5,000), which was close to the expected response rate of 10%. The data that were analyzed for this thesis were those collected via the 5 demographic questions, the 5 food skills and cooking experience questions, the 20 attitude questions, and the 19 behaviour questions (Table 7).

Table 7: Food safety attitude and behaviour questions analyzed in this thesis, which were completed by undergraduate students at the University of Waterloo in February 2015

Category of questions or construct	**Survey questions***	**Format of question**	**Question source**	**Percent missing data**
Independent/predictor variables				
Demographics	How old are you?	Multiple choice	Majowicz et al., 2015 (19)	1.3%
	Please select your gender.		Majowicz et al., 2015 (19)	1.7%
	Which faculty do you belong to?		Newly created	1.1%
	Which system of study do you belong to?		Newly created	1.7%
	Where do you currently live?		Newly created	1.1%
Food skills and cooking experience	Do you currently work or volunteer in any of the following? A restaurant, deli, or other food service location; a hospital; a daycare or other place where you interact with	Multiple choice	Majowicz et al., 2015 (19)	0.0%

	children; a retirement home, nursing home, or long-term care facility; not applicable			
	Do you handle or prepare food in those places?	Yes/no		0.9%
	Have you ever taken a course where are you taught to prepare food or meals?	Yes/no		4.7%
	How would you describe your ability to cook from basic ingredients? I don't know how to cook; I can only cook food when the instructions are on the box; I can do the basics from scratch; I can prepare simple meals if I have a recipe to follow; I can cook almost anything	Multiple choice		1.1%
	How often do you cook meals from basic ingredients? At least once a day; a few times a week; a few times a	Multiple choice		1.3%

	month; a few times a year; never			
Food safety attitudes				
Interest in learning about avoiding food poisoning	I am interested in finding out how to avoid food poisoning.	5-point Likert scale ranging from strongly disagree to strongly agree	Byrd-Bredbenner et al., 2007 (89)	0.4%
	It is not worth my time to learn about preventing food poisoning.			0.6%
	I like learning about how to keep my foods safe to eat.			0.4%
	It is of little use to me to learn about how to prevent food poisoning.			1.1%
	I would like to learn about how to prevent food poisoning.			0.6%
Perceived personal susceptibility to food poisoning	I believe that I could get food poisoning.	5-point Likert scale ranging from strongly disagree to strongly agree	Byrd-Bredbenner et al., 2007 (89)	2.1%
	I have a chance of getting food poisoning.			2.3%
	It is possible that I could get food poisoning this year.			1.5%

Perceived personal threat of food poisoning	Food poisoning is not currently a big threat to my health	5-point Likert scale ranging from strongly disagree to strongly agree	Byrd-Bredbenner et al., 2007 (89)	1.3%
	I do not worry about getting food poisoning from the food I eat.			1.5%
	I am not concerned about getting food poisoning.			1.3%
	Getting food poisoning is not a problem I worry about.			1.7%
	I am concerned about getting food poisoning.			2.3%
	I worry about getting food poisoning.			2.8%
Other food safety attitudes	I'm not someone who will get food poisoning.	5-point Likert-type scale ranging from strongly disagree to strongly agree	Majowicz et al., 2015 (19)	1.7%
	Anyone can get sick with food poisoning, even me.			2.6%
	There is little I can do to change my food preparation habits.			3.0%

	I am worried that I may get sick if I eat a lunch that has sat out all day.			3.2%
	I have no real control over the food I eat.			2.8%
	I am confident that I can cook safe, healthy meals for myself and my family.			2.8%
Food safety behaviours				
	I plan, or help plan, the meals in my household.	5-point Likert-type scale ranging from strongly disagree to strongly agree	Yarrow et al., 2009 (105)	3.4%
	Before preparing or handling food, I wash my hands with soap and warm running water.	5-point Likert-type scale ranging from strongly disagree to strongly agree	Medeiros et al., 2001 (116)	2.6%

	If I have a cut or sore on my hand, I cover it before preparing food.	5-point Likert-type scale ranging from strongly disagree to strongly agree	Medeiros et al., 2001 (116)	3.6%
	I wash the plate that used to hold raw meat or chicken with hot soapy water before using it for anything else.	5-point Likert-type scale ranging from strongly disagree to strongly agree	Yarrow et al., 2009 (105)	4.5%
	I wash my hands with soap and warm running water after working with raw meat or chicken.	5-point Likert-type scale ranging from strongly disagree to strongly agree	Medeiros et al., 2001 (116)	3.8%

	I clean countertops with hot soapy water after preparing food.	5-point Likert-type scale ranging from strongly disagree to strongly agree	Yarrow et al., 2009 (105)	3.4%
	I refrigerate hot food within two hours of preparing and eating.	5-point Likert-type scale ranging from strongly disagree to strongly agree	Yarrow et al., 2009 (105)	2.8%
	I keep raw meat and chicken away from ready-to-eat foods like raw vegetables.	5-point Likert-type scale ranging from strongly disagree to strongly agree	Yarrow et al., 2009 (105)	4.5%

	I use a thermometer to check if meat or chicken has been cooked enough.	5-point Likert-type scale ranging from strongly disagree to strongly agree	Yarrow et al., 2009 (105)	5.1%
	I used a thermometer to check if leftovers have been reheated enough.	5-point Likert-type scale ranging from strongly disagree to strongly agree	Yarrow et al., 2009 (105)	3.8%
	I read nutrition labels to make decisions about the foods I choose.	5-point Likert-type scale ranging from strongly disagree to strongly agree	Majowicz et al., 2015 (18)	4.0%

	I read ingredient lists to make decisions about the foods I choose.	5-point Likert-type scale ranging from strongly disagree to strongly agree	Majowicz et al., 2015 (18)	3.6%
	I use an ice pack when I take my lunch to school.	5-point Likert-type scale ranging from strongly disagree to strongly agree	Yarrow et al., 2009 (105)	7.2%
	I use an ice pack when I take my lunch with me for day trips (like a trip to the beach).	5-point Likert-type scale ranging from strongly disagree to strongly agree	Yarrow et al., 2009 (105)	5.5%
	After playing with a pet and before getting a snack, I wash	5-point Likert-type	Medeiros et al., 2001 (116)	6.4%

	my hands with soap and warm running water.	scale ranging from strongly disagree to strongly agree		
	I use the Canada Food Guide to help me choose what to eat.	5-point Likert-type scale ranging from strongly disagree to strongly agree	Majowicz et al., 2015 (18)	3.8%
	When I cook or reheat meals, I use a microwave.	5-point Likert-type scale ranging from strongly disagree to strongly agree	Yarrow et al., 2009 (105)	4.0%
	When I cook or reheat meals, I use a regular oven.	5-point Likert-type scale ranging from strongly	Yarrow et al., 2009 (105)	3.6%

		disagree to strongly agree		
	I eat food that has passed the "Best Before" date.	5-point Likert-type scale ranging from strongly disagree to strongly agree	Newly created	2.6%

*Survey responses can be found in Appendix A

5. Food Safety Attitudes in Undergraduate Students at the University of Waterloo

The objective of this analysis was to measure students' personal interest in learning about avoiding food poisoning, perceived personal susceptibility to food poisoning, perceived personal threat of food poisoning (89), and other food safety attitudes.

5.1 Methods

Text responses were coded into numerical responses for analysis. For positively worded attitude questions, a value of one was assigned to 'strongly disagree' and a value of five was assigned to 'strongly agree'. Scoring was reversed for negatively worded attitude questions. Missing data were imputed using non-parametric methods of predictive means matching (132). Other parametric methods of imputation (133) were attempted, but due to the large number of nominal and ordinals variables, the imputation algorithm failed to converge. The imputation was performed using Multivariate Imputation by Chained Equations (MICE) in R (version 3.3.2) (134).

Measures of students' personal interest in learning about avoiding food poisoning, perceived personal susceptibility to food poisoning, and perceived personal threat of food poisoning were created by averaging the scores from the five attitude questions within the personal interest in learning about food safety construct, the three questions within the personal susceptibility to food poisoning construct, and the six questions within the personal threat of food poisoning construct, respectively, as per Byrd-Bredbenner et al. (89). The six attitude questions that did not fall into the 'personal interest in learning about avoiding food poisoning', 'personal susceptibility to food poisoning', and 'personal threat of food poisoning' constructs, developed by Byrd-Bredbenner et al. (89), were analyzed independently, resulting in a total of nine attitude outcome variables. The

three averaged outcome variables were continuous variables and the six independently analyzed outcome variables were ordinal variables.

All nine attitude outcome variables were analyzed descriptively using frequency calculations. Differences in participation in a food preparation-based course between respondents who handled food for the public and respondents who did not were tested using Pearson's chi-square. For each of the three continuous outcome variables, personal interest in learning about avoiding food poisoning, perceived personal susceptibility to food poisoning, and perceived personal threat of food poisoning, a multivariate analysis that contained all the demographic and cooking experience and frequency variables was performed to determine which demographic, and food skills and cooking experience variables were significantly associated with the three attitude variables.

5.2 Results

The demographic and food skills and cooking experience characteristics of the survey respondents, unadjusted for missing data, are found in Table 8, with the imputed demographic food skills and cooking experience characteristics also given for comparison; note that the imputed values were close to the unadjusted values because the inherent characteristics of the survey participants were used during multiple imputation to produce plausible values for the missing data (134–136). The majority of participants were female (65.5%; 303/462), 20 (20.9%; 97/464) and 21 (21.1%; 98/464) years of age, and from the faculty of Science (23.4%; 109/465). Almost two-thirds (64.3%; 299/465) lived off campus, followed by at home (17.8%; 83/465), in a traditional-style residence (10.8%; 50/465), and in a suite-style residence (7.1%; 33/465).

Approximately one-quarter of respondents (23.0%; 108/470) worked or volunteered in at least one of the following locations; a restaurant, deli, or other food service location (44.4%;

48/108), a daycare or other place where they interact with children (38.0%; 41/108), a hospital (26.9%; 29/108), or a retirement home, nursing home, or long-term care facility (8.3%; 9/108). Fifteen of the one hundred and eight respondents worked or volunteered in more than one establishment that handles food for the public; one respondent worked or volunteered at all four locations (6.7%; 1/15), two respondents worked or volunteered in three of the four locations (a restaurant, deli, or other food service location; a daycare or other place where they interact with children; and a retirement home, nursing home, or long-term care facility; 13.3%; 2/15), and the remaining twelve respondents worked or volunteered in two of the four locations (80.0%; 12/15). Half (58.3%; 7/12) of the remaining twelve respondents worked or volunteered in at a restaurant, deli, or other food service location, and a: hospital (57.1%; 4/7); daycare or other place where they interact with children (28.6%; 2/7); or retirement home, nursing home, or long-term care facility (14.3%; 1/7). Four of the remaining twelve respondents (33.3%) worked or volunteered in a hospital, and a: daycare or other place where they interact with children (50.0%; 2/4); or retirement home, nursing home, or long-term care facility (50.0; 2/4). The remaining one of the twelve respondents (8.3%; 1/12) that worked or volunteered in two locations did so in a daycare or other place where they interact with children, as well as a retirement home, nursing home, or long-term care facility. Less than half of the 108 participants handled food in these locations (47.2%; 51/108). Of the 51 respondents that handled food for the public, most did so in a restaurant, deli, or other food service location (84.3%; 43/51), however food handling also occurred while working or volunteering in a day care or other location for children (23.5%; 12/51), a hospital (13.7%; 7/51), or in a retirement home or long-term care facility (7.8%; 4/51).

Approximately 40% of respondents (41.3%; 185/448) reported ever having taken a course where they were taught how to prepare food or meals, such as a high school class, or food

handler certification. There was no significant difference in having taken a food preparation-based course between respondents who handled food for the public (44.0%; 22/50) and respondents who did not (40.9%; 161/394; p=0.6712).

Participants reported that they frequently cook from basic ingredients, with most reporting doing so at least once a day (34.7%; 161/464) or a few times a week (40.7%; 189/464). Relatively few participants reported that they cook from basic ingredients a few times a month (16.4%; 76/464), a few times a year (4.3%; 20/464), or never (3.9%; 18/464). Participants also reported that they are capable home cooks, with most stating that they can "prepare simple meals if I have a recipe to follow" (50.5%; 235/465), or "cook almost anything" (40.0%; 186/465), followed by reporting they "can do the basics from scratch (like boil an egg or make a grilled cheese sandwich) but nothing more complicated" (6.9%; 32/465), "can only cook food when the instructions are on the box" (1.9%; 9/465), and "don't know how to cook" (0.7%; 3/465).

The unadjusted values of the average interest in learning about avoiding food poisoning, perceived personal susceptibility to food poisoning, and perceived personal threat of food poisoning, with the imputed values given for comparison, are found in Table 9. The unadjusted values of the other food safety attitudes, with the imputed values given for comparison, are found in Table 10. The imputed food safety attitude values were close to the unadjusted values because the inherent characteristics of the survey participants were used during multiple imputation to produce plausible values for the missing data (134–136). Overall, participants had positive food safety attitudes. On average, participants agreed that they were interested in learning about avoiding food poisoning (mean 4.0; s.d. 0.7; on a scale of 1 – strongly disagree to 5 – strongly agree), somewhat agreed that they were susceptible to food poisoning (mean 3.6; s.d. 0.8; 1 – strongly disagree to 5 – strongly agree), and somewhat disagreed that food poisoning is a

personal threat (mean 2.6; s.d. 0.9; 1 – strongly disagree to 5 – strongly agree; Table 9). The majority of respondents agreed or strongly agreed that they could cook safe, healthy meals for themselves and their families (81.4%; 372/457), that they have control over the food they eat (81.2%; 371/457), and that they can change their food preparation habits (73.0%; 333/456; Table 10). Most participants (92.6%; 428/462) also agreed or strongly agreed that anyone can get sick from food poisoning, but just under half (45.5%; 207/455) were unsure, disagreed, or strongly disagreed that they could get sick if they ate a lunch that sat out. Greater than one-third of participants (39.2%; 181/462) agreed that they were someone who will get food poisoning, but approximately one-third of participants (32.9%; 152/462) were unsure.

Using the imputed data, it was found that all three of the continuous attitude outcome variables were significantly associated with one or more of the demographic and food skills and cooking experience characteristics (Table 11). Only cooking frequency was significantly associated with interest in learning about avoiding food poisoning. Respondents who cooked a few times a week had a significantly higher interest in learning about avoiding food poisoning than respondents who never cooked (0.46; 95% Confidence Interval [CI] 0.001, 0.93). Cooking frequency was also the only demographic and food skills and cooking experience characteristic that was significantly associated with perceived personal threat of food poisoning. Respondents who cooked at least once a day had significantly higher perceived personal threat of food poisoning than respondents who never cooked (0.59; 95% CI 0.01, 1.17). Three demographic and food skills and cooking experience characteristics, age, faculty, and system of study, were significantly associated with perceived personal susceptibility to food poisoning. Respondents who were 21 years of age had significantly higher perceived personal susceptibility than respondents who were 18 years or younger (0.33; 95% CI 0.001, 0.66), respondents in the

Faculty of Arts had significantly higher perceived personal susceptibility than respondents in the Faculty of Applied Health Sciences (0.38; 95% CI 0.09, 0.68), and respondents in the co-op system of study had higher perceived personal susceptibility to food poisoning than respondents in the regular system of study (0.20; 95% CI 0.01, 0.38). These findings are all adjusted for the other variables in the model.

Again, using the imputed data, it was found that five of the six ordinal attitude outcome variables were significantly associated with at least one of the demographic and food skills and cooking experience characteristics (Table 12); none of the demographic and food skills and cooking experience characteristics were significantly associated with the attitude outcome variable "anyone can get sick with food poisoning, even me" (results not shown). Respondents in the faculties of Arts (-0.82; 95% CI -1.56, -0.08), Engineering (-1.15; 95% CI -1.92, -0.38), Environment (-1.01; 95% CI -1.88, -0.14), Mathematics (-0.93; 95% CI -1.74, -0.12), or Science (-1.38; 95% CI -2.12, -0.65) were significantly less likely to believe that there is little they can do to change their food preparation habits, respondents in the faculty of Environment (-0.82; 95% CI -1.63, -0.01) were significantly less worried that they may get sick if they eat a lunch that has sat out all day, and respondents in the faculty of Environment (-1.12; 95% CI -1.99, -0.26) or Mathematics (-0.97; 95% CI -1.76, -0.17) were significantly less likely to believe that they have no real control over the food they eat, when compared with students in the faculty of Applied Health Sciences. Respondents who reported they could cook the basics from scratch (3.67; 95% CI 1.13, 6.22), simple meals with a recipe (3.94; 95% CI 1.43, 6.45), or almost anything (4.24; 95% CI 1.70, 6.77) were significantly more likely to believe they have control over the food they eat, and respondents who reported they could cook simple meals with a recipe (3.53; 95% CI 1.04, 6.03), or almost anything (4.94; 95% CI 2.40, 7.47) were significantly more

confident they could cook safe and healthy meals for themselves and their families, when compared to respondents who reported that they do not know how to cook. Respondents who lived in a suite-style residence (0.94; 95% CI 0.05, 1.82) were significantly more likely to believe they are someone who will get food poisoning, respondents who lived in a suite-style residence (-0.97; 95% CI -0.87, -0.07) and off campus (-0.92; 95% CI -1.72, -0.12) were significantly less worried that they may get sick if they eat a lunch that has sat out all day, and respondents who lived in a suite-style residence (1.34; 95% CI 0.40, 2.28), off campus (1.53; 95% CI 0.69, 2.37), or at home (1.41; 95% CI 0.53, 2.30) were significantly more likely to believe they have control over the food they eat, when compared to respondents who lived in a traditional-style residence.

5.3 Discussion

In this chapter I measured the personal interest in learning about avoiding food poisoning, perceived personal susceptibility to food poisoning, perceived personal threat of food poisoning, and other food safety attitudes of undergraduate students at the University of Waterloo. In general, food safety attitudes were positive, and all but one ("anyone can get sick with food poisoning, even me") were significantly associated with one or more of the demographic and food skills and cooking experience characteristics I measured in this thesis.

The generally positive food safety attitudes of undergraduate students at the University of Waterloo found here were similar to the ten other studies that examined food safety attitudes in young adults (17,41,100,102–107,112). These studies found that students' strongly believe that clean hands and cooking spaces are important for preventing foodborne disease (41,103,104,112), and that they believe they are susceptible to food poisoning (41,105). The survey I used included questions on food poisoning susceptibility used by previously conducted

studies which found that students agreed (mean 3.9 out of 5) (41) or strongly agreed (mean 4.5 out of 5) (105) that they are susceptible to food poisoning, whereas I found that students somewhat agreed (mean 3.6 out of 5) that they are susceptible to food poisoning. The slight difference in findings between my study and the study that found that students agreed that they are susceptible to food poisoning may be due to differences in sample size or study location, however, the greater difference in findings between my study and the study that found that students strongly agreed that they are susceptible to food poisoning may be because of the requirements for participation in the study. Only students that lived in an apartment or house with access to a kitchen were eligible to participate in the study, which means students who do not cook for themselves, like students who live in a traditional-style residence, were unable to participate. This may have over-inflated the estimate of students' perceived personal susceptibility to food poisoning, because these students may cook for themselves more frequently than the actual student population and as a result, may be more aware of some of the risks associated with incorrect preparation and food storage of food.

Here, students' least positive food safety attitude was their perceived personal threat of food poisoning; students somewhat disagreed that food poisoning is a personal threat. Studies that measured perceived personal threat of food poisoning using the same measurement tool (89) found that students' least positive food safety attitude was also perceived personal threat of food poisoning, however, students neither agreed nor disagreed that food poisoning is a personal threat (41,105). Other studies that did not use the same measurement tool as the one used here found that students were unsure they could use a thermometer to check for proper cooking temperature when preparing ground beef (104), believe there is no risk of disease from consuming risky foods (103), and unsure of whether they are at greater risk for foodborne illness

when they eat at restaurants then when they eat at home (112), which supports the finding that college and university students do not believe that food poisoning is a personal threat.

This study examined the association between 13 demographic and food skills and cooking experience characteristics and the food safety attitudes "interest in learning about avoiding food poisoning", "perceived personal susceptibility to food poisoning", and "perceived personal threat of food poisoning"(89). Studies that measured the same attitudes using the same tool examined only the association between gender, and race (not examined here), and the three food safety attitudes, and found that female respondents had significantly higher interest in learning about avoiding food poisoning, perceived personal susceptibility of food poisoning, and perceived personal threat of food poisoning than male respondents (41,107). In contrast, here gender was not significantly associated with any of the three food safety attitudes, but found that students who reported that they frequently cook had a greater interest in learning about avoiding food poisoning and higher perceived personal threat of food poisoning than students who reported that they never cook, and older students, students in the Faculty of Arts, and students in the co-op system of study had higher perceived personal susceptibility to food poisoning than students 18 years of age or younger, students in the Faculty of Applied Health Sciences, and students in the regular system of study. Gender may be a proxy for some of the significantly associated demographic and food skills and cooking experience variables, particularly cooking frequency and faculty, so the significant association seen between gender and the three food safety attitudes in the previously conducted studies may be due to demographic characteristics that were not collected. Future studies should collect information on as many demographic characteristics as possible, so that they can be controlled for in order to find true significant associations.

This chapter is subject to several limitations common to food safety attitude surveys, the most notable being the limited number of validated food safety attitude measurement tools available for use. The results of this chapter may not be comparable to the results of other food safety attitude studies that developed their own surveys, especially if the surveys were not validated, and so the results may not be supported by these previously conducted studies. This study also had a relatively small sample size of 470 students, such that some true differences in food safety attitudes by demographic or food skills and cooking experience characteristics may not have been detected. In addition, this study may have been subject to response bias; students who care about food safety may have been more likely to participate in the study, which may have led to results that show that undergraduate students at the University of Waterloo have food safety attitudes that are generally more positive than they actually are.

Improving food safety attitudes can improve self-reported food safety behaviours due to the strong positive linear relationship between food safety attitudes and self-reported behaviours (17), and so despite these limitations, I identified several important areas for targeted food safety messages aimed at improving food safety attitudes. First, because they do not believe that food poisoning is a personal threat, all undergraduate students may benefit from food safety education, either through courses or extra-curricular activities, on the threat of food poisoning. It may also be beneficial to target students in faculties other than the Faculty of Applied Health Sciences, those who live in traditional-style residences, students who reported that they do not know how to cook, and students who do not cook very often. Students in faculties other than students in the Faculty of Applied Health Sciences should be targeted with messaging about how they can change their food preparation habits, how they can take control over the food they eat, and the dangers of eating food that has sat out all day. Although students who live in traditional-

style residences do not have as much control over the food they eat as students who are able to cook their own food, students who live in a traditional-style residence should be targeted with messaging about how to take control over the food they eat, by making sure that common room fridges and the mini fridges in their rooms are set at the correct temperature, for example. Students who live in a traditional style residence should be targeted with messaging on the risks food poisoning to university students as well. Students who do not know how to cook and students who do not do so very frequently should also be targeted with messaging about how to take control over the food they eat by reminding them to store takeout leftovers in the fridge for only three to four days, for example. Students who do not know how to cook should be targeted with messaging about how to cook safe and healthy meals for themselves and their families, and students who do not cook very often should be targeted with messaging about why it is important to learn about how to avoid food poisoning as well.

Table 8: The demographic, food skills, and cooking experience characteristics (showing the unadjusted values, and the imputed values for comparison) of undergraduate student survey respondents at the University of Waterloo (n=470; February, 2015)

Question	**Response options**	**Unadjusted values**		**Imputed values**	
		Number	**Percent**	**Frequency**	**Percent**
How old are you?	18 years or younger	65	14.0	65.5	13.9
	19 years	75	16.2	75.8	16.1
	20 years	97	20.9	98.1	20.9
	21 years	98	21.1	99.0	21.1
	22 years	77	16.6	78.1	16.6
	23 years or older	52	11.2	53.5	11.4
Please select your gender.	Female	303	65.6	308.9	65.7
	Male	159	34.4	161.1	34.3
Which faculty do you belong to?	Applied Health Sciences	49	10.5	49.8	10.6
	Arts	94	20.2	95.1	20.2
	Engineering	104	22.4	105.3	22.4
	Environment	42	9.1	42.6	9.1
	Mathematics	67	14.4	67.5	14.4
	Science	109	23.4	109.8	23.3
	Co-op	290	62.8	293.1	62.4

Which system of study do you belong to?	Regular	172	37.2	176.9	37.6
Do you currently work or volunteer in any of the following?	A restaurant, deli, or other food service	48	10.2	48.0	10.2
	A hospital	29	6.2	29.0	6.2
	A daycare or other place where you interact with children	41	8.7	41.0	8.7
	A retirement home, nursing home, or long-term care facility	9	1.9	9.0	1.9
Do you handle or prepare food in those places?	Yes	51	10.9	51.3	10.9
	No	415	89.1	418.7	89.1
Have you ever taken a course where you were taught how to	Yes	185	41.3	195.2	41.5
	No	263	58.7	274.8	58.5

prepare food or meals?					
How would you describe your ability to cook from basic ingredients?	I don't know how to cook	3	0.7	3.0	0.6
	I can only cook food when the instructions are on the box	9	1.9	9.1	1.9
	I can do the basics from scratch, but nothing more complicated	32	6.9	32.6	7.0
	I can prepare simple meals if I have a recipe to follow	235	50.5	237.7	50.6
	I can cook almost anything	186	40.0	187.6	39.9
Where do you currently live?	Traditional-style residence	50	10.8	50.6	10.8
	Suite-style residence	33	7.1	33.4	7.1
	Off campus	299	64.3	301.6	64.2

	At home	83	17.8	84.4	17.9
How often do you cook food or meals from basic ingredients?	At least once a day	161	34.7	162.9	34.7
	A few times a week	189	40.7	190.8	40.6
	A few times a month	76	16.4	76.9	16.4
	A few times a year	20	4.3	20.3	4.3
	Never	18	3.9	19.0	4.0

Table 9: The interest in learning about avoiding food poisoning, perceived personal susceptibility to food poisoning, and perceived personal threat of food poisoning (showing the imputed values, and the unadjusted values for comparison) of undergraduate student survey respondents at the University of Waterloo (n=470; February, 2015)

Food safety attitudes	**Unadjusted values**		**Imputed values**	
	Mean	**Standard deviation**	**Mean**	**Standard deviation**
Interest in learning about avoiding food poisoning [a]	4	0.7	4.0	0.7
Perceived personal susceptibility to food poisoning [a]	3.6	0.8	3.6	0.8
Perceived personal threat of food poisoning [a]	2.6	0.9	2.6	0.9

[a] 1=strongly disagree to 5=strongly agree

Table 10: Food safety attitudes (showing the imputed values, and the unadjusted values for comparison) of undergraduate student survey respondents at the University of Waterloo (n=470; February, 2015); the most frequent response for each food safety attitude is shown in bold

Food safety attitudes	**Response options**	**Unadjusted values**		**Imputed values**	
		Frequency	**Percent**	**Number**	**Percent**
I'm not someone who will get food poisoning. [b]	Strongly agree	18	3.9	18.4	3.9
	Agree	49	10.6	50.1	10.7
	Neither agree or disagree	152	32.9	154.2	32.8
	Disagree	181	**39.2**	183.8	39.1
	Strongly disagree	62	13.4	63.6	13.5
Anyone can get sick with food poisoning, even me. [a]	Strongly agree	185	40.0	187.3	39.9
	Agree	243	**52.6**	247.3	52.6
	Neither agree or disagree	26	5.6	27.0	5.7
	Disagree	8	1.8	8.3	1.8
	Strongly disagree	0	0.0	0.0	0.0
There is little I can do to change my	Strongly agree	5	1.1	5.3	1.1
	Agree	32	7	33.7	7.2

food preparation habits. [b]	Neither agree or disagree	86	18.9	88.6	18.8
	Disagree	269	**59**	276.3	58.8
	Strongly disagree	64	14	66.1	14.1
I am worried that I may get sick if I eat a lunch that has sat out all day. [a]	Strongly agree	59	13	61.2	13.0
	Agree	189	**41.5**	195.1	41.5
	Neither agree or disagree	81	17.8	83.4	17.8
	Disagree	101	22.2	104.3	22.2
	Strongly disagree	25	5.5	26.0	5.5
I have no real control over the food I eat. [b]	Strongly agree	7	1.5	7.4	1.5
	Agree	21	4.6	22.0	4.7
	Neither agree or disagree	58	12.7	59.7	12.7
	Disagree	235	**51.4**	241.0	51.3
	Strongly disagree	136	29.8	139.9	29.8
I am confident that I can cook safe, healthy meals for myself and my family. [a]	Strongly agree	163	35.7	168.0	35.8
	Agree	209	**45.7**	214.4	45.6
	Neither agree or disagree	63	13.8	64.8	13.8
	Disagree	16	3.5	16.5	3.5
	Strongly disagree	6	1.3	6.3	1.3

[a]1=strongly disagree to 5=strongly agree; [b]1=strongly agree to 5=strongly disagree

Table 11: The demographic and food skills and cooking experience variables significantly associated with the interest in learning about avoiding food poisoning, perceived personal susceptibility to food poisoning, and perceived personal threat of food poisoning, with 95% confidence intervals; the statistically significant associations are shown in bold

Variable		**Interest in learning about avoiding food poisoning**	**Perceived personal susceptibility to food poisoning**	**Perceived personal threat of food poisoning**
Intercept		3.40 (2.49, 4.32)	2.43 (1.40, 3.47)	2.76 (1.65, 3.87)
Age (Referent = 18 years or younger)	19 years	-0.17 (-0.45, 0.11)	0.15 (-0.16, 0.47)	-0.02 (-0.35, 0.32)
	20 years	-0.15 (-0.44, 0.14)	0.19 (-0.14, 0.52)	0.03 (-0.31, 0.38)
	21 years	-0.21 (-0.51, 0.08)	**0.33 (0.001, 0.66)**	-0.07 (-0.42, 0.28)
	22 years	-0.27 (-0.57, 0.04)	0.17 (-0.18, 0.51)	0.03 (-0.33, 0.39)
	23 years or older	-0.10 (-0.42, 0.23)	0.23 (-0.14, 0.60)	0.08 (-0.31, 0.47)
Sex (Referent = Female)	Male	-0.03 (-0.18, 0.13)	0.05 (-0.13, 0.22)	-0.02 (-0.21, 0.17)
Faculty (Referent = Applied Health Sciences)	Arts	0.18 (-0.08, 0.44)	**0.38 (0.09, 0.68)**	0.24, (-0.07, 0.55)
	Engineering	0.04 (-0.23, 0.31)	0.17 (-0.14, 0.47)	0.28 (-0.05, 0.61)
	Environment	0.03 (-0.28, 0.33)	0.13 (-0.22, 0.48)	0.17 (-0.21, 0.54)
	Mathematics	-0.01 (-0.30, 0.27)	0.29 (-0.03, 0.61)	0.26 (-0.19, 0.14)

	Science	-0.03 (-0.28, 0.22)	0.29 (-0.001, 0.58)	0.04 (-0.26, 0.35)
System of study (Referent = Regular)	Co-op	-0.04 (-0.20, 0.12)	**0.20 (0.01, 0.38)**	-0.15 (-0.34, 0.05)
Work or volunteer location (Referent = No)	Restaurant	-0.21 (-0.66, 0.23)	-0.29 (-0.79, 0.22)	-0.03 (-0.75, 0.33)
	Hospital	0.16 (-0.13, 0.45)	0.09 (-0.23, 0.42)	0.18 (-0.17, 0.53)
	Daycare	0.15 (-0.11, 0.41)	0.24 (-0.05, 0.54)	0.22 (-0.10, 0.53)
	Retirement home	-0.15 (-0.65, 0.35)	-0.34 (-0.91, 0.22)	-0.24 (-0.84, 0.36)
Food handler (Referent = No)	Yes	0.37 (-0.07, 0.82)	0.42 (-0.9, 0.92)	0.26 (-0.28, 0.80)
Previous training (Referent = No)	Yes	-0.05 (-0.19, 0.09)	0.09 (-0.07, 0.25)	-0.03 (-0.19, 0.14)
Cooking ability (Referent = Don't know how)	Instructions on the box	0.27 (-0.69, 1.23)	0.27 (-0.81, 1.36)	-0.36 (-1.52, 0.81)
	Basics from scratch	-0.02 (-0.98, 0.94)	0.22 (-0.87, 1.32)	-0.71 (-1.88, 0.46)
	Simple meals with recipe	0.12 (-0.83, 1.06)	0.29 (-0.79, 1.37)	-0.74 (-1.90, 0.41)
	Almost anything	0.09 (-0.87, 1.04)	0.13 (-0.96, 1.22)	-0.92 (-2.08, 0.24)

Living arrangement (Referent = Traditional-style residence	Suite-style residence	0.28 (-0.06, 0.62)	0.17 (-0.21, 0.55)	0.13 (-0.28, 0.54)
	Off campus	0.22 (-0.08, 0.52)	0.12 (-0.22, 0.46)	0.05 (-0.31, 0.41)
	At home	0.25 (-0.07, 0.56)	0.30 (-0.06, 0.66)	0.13 (-0.25, 0.52)
Cooking frequency (Referent = Never)	At least once a day	0.38 (-0.10, 0.85)	0.32 (-0.23, 0.87)	**0.59 (0.01, 1.17)**
	A few times a week	**0.46 (0.001, 0.93)**	0.10 (-0.44, 0.64)	0.53 (-0.04, 1.10)
	A few times a month	0.36 (-0.11, 0.82)	0.01 (-0.53, 0.56)	0.41 (-0.17, 0.99)
	A few times a year	0.24 (-0.31, 0.78)	0.41 (-0.23, 1.06)	0.21 (-0.46, 0.89)

Table 12: The demographic and food skills and cooking experience variables significantly associated with food safety attitudes; the statistically significant associations at a 95% confidence interval are shown in bold

Variable		**I'm not someone who will get food poisoning**	**There is little I can do to change my food preparation habits**	**I am worried that I may get sick if I eat a lunch that has sat out all day**	**I have no real control over the food I eat**	**I am confident that I can cook safe, healthy meals for myself and my family**
Intercept	Strongly disagree	-2.74 (-5.13, -0.34)	-2.14 (-4.58, 0.30)	Referent	-4.16 (-6.58, -1.75)	Referent
	Disagree	-0.66 (-3.05, 1.72)	0.83 (-1.60, 3.27)	4.45 (2.04, 6.86)	-1.52 (-3.92, 0.87)	1.13 (-1.34, 3.60)
	Neither agree or disagree	1.10 (-1.29, 3.48)	2.29 (-0.15, 4.73)	2.51 (0.14, 4.88)	-0.10 (-2.48, 2.28)	-0.28 (-2.68, 2.13)
	Agree	2.58 (0.16, 4.99)	4.38 (1.81, 6.95)	1.68 (-0.69, 4.05)	1.42 (-1.03, 3.86)	-2.00 (-4.42, 0.42)
	Strongly agree	Referent	Referent	-0.53 (-2.90, 1.84)	Referent	-4.51 (-6.96, -2.07)

Age (Referent = 18 years or younger)	19 years	0.11 (-0.62, 0.83)	-0.11 (-0.90, 0.67)	0.07 (-0.67, 0.81)	-0.15 (-0.92, 0.62)	-0.32 (-1.11, 0.47)
	20 years	-0.06 (-0.81, 0.69)	-0.46 (-1.28, 0.35)	0.31 (-0.45, 1.08)	-0.46 (-1.26, 0.34)	-0.01 (-0.84, 0.81)
	21 years	0.07 (-0.68, 0.83)	0.26 (-0.57, 1.08)	0.06 (-0.71, 0.83)	-0.57 (-1.37, 0.24)	-0.59 (-1.43, 0.25)
	22 years	0.04 (-0.74, 0.82)	0.30 (-0.56, 1.15)	-0.26 (-1.05, 0.54)	-0.02 (-0.85, 0.80)	-0.10 (-0.96, 0.76)
	23 years or older	0.03 (-0.82, 0.87)	0.25 (-0.68, 1.18)	0.63 (-0.24, 1.49)	0.17 (-0.74, 1.08)	0.24 (-0.69, 1.16)
Sex (Referent = Female)	Male	**-0.52 (-0.93, -0.11)**	0.20 (-0.23, 0.64)	-0.002 (-0.41, 0.40)	-0.28 (-0.71, 0.15)	-0.19 (-0.62, 0.24)
Faculty (Referent =	Arts	0.65 (-0.03, 1.34)	**-0.82 (-1.56, -0.08)**	-0.53 (-1.22, 0.17)	-0.72 (-1.46, 0.02)	0.03 (-0.70, 0.77)

Applied Health Sciences)	Engineering	0.61 (-0.11, 1.32)	**-1.15 (-1.92, -0.38)**	-0.01 (-0.74, 0.71)	-0.37 (-1.13, 0.40)	-0.02 (-0.79, 0.74)
	Environment	0.05 (-0.76, 0.85)	**-1.01 (-1.88, -0.14)**	**-0.82 (-1.63, -0.01)**	**-1.12 (-1.99, -0.26)**	-0.32 (-1.18, 0.53)
	Mathematics	0.55 (-0.19, 1.30)	**-0.93 (-1.74, -0.12)**	-0.49 (-1.24, 0.26)	**-0.97 (-1.76, -0.17)**	-0.15 (-0.94, 0.63)
	Science	0.28 (-0.40, 0.95)	**-1.38 (-2.12, -0.65)**	-0.51 (-1.20, 0.18)	-0.65 (-1.37, 0.08)	0.15 (-0.58, 0.87)
System of study (Referent = Regular)	Co-op	0.29 (-0.13, 0.71)	-0.24 (-0.70, 0.21)	-0.28 (-0.70, 0.14)	-0.12 (-0.56, 0.32)	0.30 (-0.15, 0.74)
Work or volunteer location	Restaurant	-0.13 (-1.30, 1.05)	0.28 (-0.99, 1.55)	-0.73 (-1.91, 0.45)	**1.26 (0.006, 2.52)**	1.11 (-0.15, 2.37)
	Hospital	0.55 (-0.22, 1.31)	-0.37 (-1.16, 0.41)	-0.16 (-0.92, 0.60)	-0.23 (-1.02, 0.56)	**1.06 (0.19, 1.92)**

(Referent = No)	Daycare	0.39 (-0.31, 1.08)	0.16 (-0.60, 0.91)	-0.26 (-0.95, 0.43)	0.56 (-0.18, 1.29)	-0.03 (-0.78, 0.71)
	Retirement home	**-1.63 (-2.93, -0.34)**	-0.37 (-1.76, 1.01)	0.18 (-1.12, 1.49)	-1.31 (-2.79, 0.16)	-0.42 (-1.79, 0.95)
Food handler (Referent = No)	Yes	0.75 (-0.41, 1.92)	-0.004 (-1.26, 1.26)	1.06 (-0.11, 2.24)	-0.18 (-1.41, 1.06)	-0.74 (-1.99, 0.52)
Previous training (Referent = No)	Yes	-0.02 (-0.38, 0.35)	0.17 (-0.22, 0.56)	-0.32 (-0.68, 0.04)	-0.06 (-0.44, 0.32)	0.14 (-0.25, 0.52)
Cooking ability (Referent =	Instructions on the box	-1.10 (-3.60, 1.40)	0.68 (-1.88, 3.23)	0.82 (-1.67, 3.30)	1.77 (-0.72, 4.26)	1.15 (-1.34, 3.63)
	Basics from scratch	-1.05 (-3.56, 1.45)	0.58 (-1.98, 3.13)	0.22 (-2.26, 2.70)	**3.67 (1.13, 6.22)**	2.06 (-0.45, 4.58)

Don't know how)	Simple meals with recipe	-0.66 (-3.13. 1.81)	0.63 (-1.89, 3.14)	-0.21 (-2.64, 2.23)	**3.94 (1.43, 6.45)**	**3.53 (1.04, 6.03)**
	Almost anything	-0.71 (-3.19, 1.78)	0.64 (-1.89, 3.18)	-0.51 (-2.97, 1.95)	**4.24 (1.70, 6.77)**	**4.94 (2.40, 7.47)**
Living arrangement (Referent = Traditional-style residence	Suite-style residence	**0.94 (0.05, 1.82)**	0.89 (-0.06, 1.85)	**-0.97 (-0.87, -0.07)**	**1.34 (0.40, 2.28)**	0.09 (-0.84, 1.01)
	Off campus	0.70 (-0.08, 1.49)	0.29 (-0.54, 1.13)	**-0.92 (-1.72, -0.12)**	**1.53 (0.69, 2.37)**	-0.15 (-0.99, 0.69)
	At home	0.57 (-0.26, 1.40)	0.25 (-0.63, 1.14)	-0.74 (-1.59, 0.10)	**1.41 (0.53, 2.30)**	0.34 (-0.55, 1.23)
Cooking frequency (Referent = Never)	At least once a day	0.39 (-0.84, 1.63)	0.21 (-1.10, 1.52)	0.11 (-1.12, 1.35)	-0.96 (-2.29, 0.37)	-0.26 (-1.54, 1.03)
	A few times a week	0.28 (-0.93, 1.49)	0.29 (-1.00, 1.57)	0.29 (-0.91, 1.50)	**-1.43 (-2.74, -0.12)**	-0.11 (-1.37, 1.14)
	A few times a month	0.18 (-1.04, 1.40)	0.34 (-0.96, 1.63)	0.03 (-1.19, 1.24)	**-1.45 (-2.77, -0.13)**	-0.26 (-1.52, 1.00)

	A few times a year	0.96 (-0.48, 2.40)	0.59 (-0.94, 2.11)	-0.73 (-2.15, 0.69)	**-1.70 (-3.24, -0.17)**	-0.35 (-1.83, 1.13)

6. Food Safety Self-Reported Behaviours among Undergraduate Students at the University of Waterloo

The objective of this analysis was to understand students' self-reported food safety behaviours.

6.1 Methods

Text responses were coded into numerical responses for analysis. For each of the behaviour questions, a value of one was assigned to 'strongly disagree' and a value of five was assigned to 'strongly agree'. Missing data were imputed using non-parametric methods of predictive means matching (132). Other parametric methods of imputation (133) were attempted, but due to the large number of nominal and ordinals variables, the imputation algorithm failed to converge. The imputation was performed using Multivariate Imputation by Chained Equations (MICE) in R (version 3.3.2) (134).

All 19 behaviour outcome variables were analyzed descriptively using frequency calculations. For each of the behaviour outcome variables, a multivariate analysis that contained all the demographic and cooking experience and frequency variables was performed to determine which demographic, and food skills and cooking experience variables were significantly associated with the 19 behaviour outcomes, controlling for the other variables.

6.2 Results

The unadjusted values of the food safety behaviours, with the imputed values given for comparison, are found in Table 13. The imputed self-reported food safety behaviour results were close to the unadjusted results, which is expected since multiple imputation tries to preserve the inherent characteristics observed in the original incomplete data (134–136). Overall, participants

reported positive food safety behaviours. The majority of participants' agreed or strongly agreed that they wash their hands with soap and warm running water before preparing or handling food (75.5%; 346/458), cover a cut or sore on their hands before preparing food (69.5%; 315/453), wash their hands with soap and warm running water after working with raw meat or chicken (92.0%; 416/452), and wash their hands with soap and warm running water after playing with a pet and before getting a snack (71.1%; 313/440; Table 13). Most of the participants also agreed or strongly agreed that they wash a plate that used to hold raw meat or chicken with hot, soapy water before using it for anything else (90.6%; 407/449), and clean countertops with hot, soapy water after preparing food (53.3%; 242/454). Participants also agreed or strongly agreed that they refrigerate hot food within two hours of preparing and eating (77.7%; 355/457), as well as keep raw meat and chicken away from ready-to-eat foods like raw vegetables (86.6%; 389/449). However, over half of the participants disagreed or strongly disagreed that they use a thermometer to check if meat or chicken has been cooked enough (65.2%; 291/446) and if leftovers have been reheated enough (82.5%; 373/452). The majority of participants also disagreed or strongly disagreed that they use an ice pack when they take their lunch to school (59.6%; 260/436), but agreed or strongly agreed that they use an ice pack when they take their lunch with them for day trips, like a trip to the beach (56.3%; 250/444). Approximately one-third of participants agreed that they eat food that has passed the "Best Before" date (32.3%; 148/458), and a similar number of participants disagreed (24.7%; 113/458).

Most participants agreed or strongly agreed that they plan, or help plan, the meals in their household (73.7%; 335/454; Table 13). Participants also agreed or strongly agreed that they use both a regular oven (59.2%; 267/451) and microwave (83.6%; 377/451) when they cook or reheat meals. The majority of participants disagreed or strongly disagreed that they use the

Canada Food Guide to help them choose what to eat (58.6%; 265/452), but agreed or strongly agreed that they read nutrition labels (63.4%; 287/451) and ingredient lists (64.5%; 292/453) to make decisions about the foods they choose.

Six of the nineteen self-reported behaviour outcomes were behaviours that do not have a "correct" associated food safety behaviour (i.e., I plan, or help plan, the meals in my household). Using the imputed data, it was found that all six of these self-reported behaviour outcomes were significantly associated with one or more of the demographic and food skills and cooking experiences variables (Table 14).

Again, using the imputed data, it was found that 12 of the 13 behaviour self-reported behaviour outcomes that do have a "correct" associated food safety behaviour were significantly associated with at least one of the demographic and food skills and cooking experience characteristics (Tables 15 and 16). The self-reported food safety behaviour outcome "If I have a cut or sore on my hand, I cover it before preparing food" was not significantly associated with any of the demographic or food skills and cooking experience variables (results not shown). Respondents in the faculties of Environment (-0.99; 95% Confidence Interval [CI] -1.96, -0.01), Mathematics (-1.05; 95% CI -1.96, -0.14), and Science (-0.87; 95% CI -1.73, -0.01) were significantly less likely to report that they wash their hands with soap and warm running water after working with raw meat or chicken, respondents in the faculties of Engineering (0.72; 95% CI 0.001, 1.44), Environment (1.17; 95% CI 0.35, 1.99), Mathematics (0.85; 95% CI 0.10, 1.60), and Science (0.69; 95% CI 0.01, 1.37) were significantly more likely to report that they use a thermometer to check if meat or chicken has been cooked enough, respondents in the faculties of Arts (0.80; 95% CI 0.08, 1.52), Engineering (0.98; 95% CI 0.23, 1.74), Mathematics (1.06; 95% CI -0.06, 1.63), and Science (0.90; 95% CI 0.19, 1.61) were significantly more likely to report

that they use a thermometer to check if leftovers have been reheated enough, and respondents in the Faculty of Environment (-0.86; 95% CI -1.70, -0.03) were significantly less likely to report that they wash their hands with soap and warm running water after playing with a pet and before getting a snack, when compared to respondents in the Faculty of Applied Health Sciences. Respondents in the co-op system of study were significantly less likely to report that they clean countertops with hot soapy water after preparing food (-0.43; 95% CI -0.84, -0.01), use a thermometer to check if meat or chicken has been cooked enough (-0.43; 95% CI -0.85, -0.01), use an ice pack when they take their lunch to school (-0.66; 95% CI -1.08, -0.23), use an ice pack when they take their lunch with them on day trips (-0.45; -0.87, -0.03), wash their hands with soap and warm running water after playing with a pet and before getting a snack (-0.47; 95% CI -0.90, -0.04), and significantly more likely to report that they eat food that has passed the "Best Before" date (0.66; 95% CI 0.25, 1.07), than respondents in the regular system of study. Respondents who live in a suite-style residence and off-campus were significantly less likely to report that they clean countertops with hot soapy water after preparing food (-1.06, 95% CI -1.94, -0.18; -0.94, 95% CI -1.73, -0.14), use a thermometer to check if meat or chicken has been cooked enough (-1.08, 95% CI -1.98, -0.18; -1.02, 95% CI -1.83, -0.22), use a thermometer to check if leftovers have been reheated enough (-1.75, 95% CI -2.69, -0.80; -0.96, 95% CI -1.80, -0.11), use an ice pack when they take their lunch to school (-1.27, 95% CI -2.19, -0.36; -1.24, 95% CI -2.06, -0.42), and use an ice pack when they take their lunch with them on day trips (-1.04, 95% CI -1.94, -0.13; -0.90, 95% CI -1.69, -0.11), respondents who live at home were significantly more likely to report that they wash the plate that used to hold raw meat or chicken with hot soapy water before using it for anything else (0.94; 95% CI 0.01, 1.86), and respondents who live off campus were significantly more likely to report that they wash their hands with soap

and warm running water after playing with a pet and before getting a snack (0.93; 95% CI 0.11, 1.74), than respondents who lived in a traditional-style residence.

6.3 Discussion

In this chapter I measured the self-reported food safety behaviours of undergraduate students at the University of Waterloo. In general, self-reported food safety behaviours were good, and all but one ("If I have a cut or sore on my hand, I cover it before preparing food") were significantly associated with one or more of the demographic and food skills and cooking experience characteristics I measured in this thesis.

The overall good self-reported food safety behaviours found in this chapter is the opposite of findings from almost all previously conducted studies; the majority of studies interested in the food safety behaviours of college and university students found that students had generally poor self-reported and observed food safety behaviours (17,41,99,101,102,104–106,108–113). The difference in findings could be because of differences in sample size, study location, or time, as the majority of the studies were conducted over ten years ago. The only study that also found that university students had good overall self-reported food safety behaviours was conducted in Saudi Arabia (103), where they have different food safety needs than Canada.

In this thesis, students tended to agree or strongly agree that they perform cross-contamination prevention behaviours such as washing the plate that used to hold raw meat or chicken with hot and soapy water before using it for anything else. Students from previously conducted studies reported that they tend to follow guidelines related to handwashing most often (41,99,103,104), which can be a niche of cross-contamination prevention behaviours depending on the types of questions asked, and were observed following guidelines related to cross-

contamination prevention most often (105,108), which supports the finding that undergraduate students tended to perform cross-contamination prevention behaviours.

Undergraduate students at the University of Waterloo tended to disagree or strongly disagree that they use a thermometer to check whether meat or chicken has been cooked enough or to check if leftovers have been reheated enough. Previous studies reported that students tend to follow guidelines related to refrigeration, such as checking the temperature of their refrigerator, least often (41,104,105), but were observed following cooking practices, which include thermometer use, least often (105,108). A similar number of students reported that they agree or strongly agree that they use a thermometer to check the doneness of leftovers as were observed using a thermometer during the previously conducted cooking observations (105,108), which supports the finding that undergraduate students do not tend to use a thermometer while cooking or reheating leftovers.

This chapter is subject to several limitations common to food safety self-reported behaviour surveys, the most notable being that the results of the survey may been influenced by the social desirability bias. Students may have reported that they agree or strongly agree that they use some of all of the food safety behaviours included in the survey because they know they should use them in order to protect themselves from foodborne disease, even though they actually do not use them while preparing or storing food. In addition, similar to the results of the food safety attitudes chapter, the results of this chapter may not be comparable to and supported by the results of other self-reported food safety behaviour studies as there are a limited number validated self-reported food safety behaviours measurement tools available for use, so many authors developed their own surveys.

Despite these limitations, I identified several important areas for targeted food safety messages aimed at improving the food safety behaviours, via the attitudes of undergraduate students at the University of Waterloo (17). All students may benefit from food safety education on why it is important to use a thermometer while cooking and an ice pack to keep packed lunches cold because the majority of students reported that they do not use a thermometer to check if meat or chicken has been cooked enough or if leftovers have been reheated enough, and do not use an ice pack when they bring their lunch to school. It may also be beneficial to target students in the co-op system of study, students who have never worked or volunteered in a hospital, and those who live off campus and in a suite-style residence. Students in co-op should be targeted with messaging on why it is important to refrigerate hot food two hours after cooking and eating, wash their hands after playing with a pet and before getting a snack, and not eat canned and prepackaged foods that have passed the "Best Before" date. Students who have never work or volunteered in a hospital should be targeted with messaging on why it is important to wash a plate that used to hold raw meat or chicken before using it for anything else, wash their hands after working with raw meat or chicken, and keep raw meat or chicken from separated from ready-to-eat foods like raw vegetables. Finally, students who live off campus or in a suite-style residence should be targeted with messaging on why countertops should be cleaned after cooking.

Table 13: Self-reported food safety behaviours (showing the imputed values, and the unadjusted values for comparison) of undergraduate student survey respondents at the University of Waterloo (n=470; February, 2015); the most frequent response for each food safety behaviour is shown in bold

Food safety behaviours [a]	**Response options**	**Unadjusted values**		**Imputed values**	
		Frequency	**Percent**	**Number**	**Percent**
I plan, or help plan, the meals in my household	Strongly agree	139	30.6	143.1	30.4
	Agree	196	**43.2**	202.6	43.1
	Neither agree or disagree	55	12.1	56.9	12.1
	Disagree	54	11.9	56.7	12.1
	Strongly disagree	10	2.2	10.6	2.3
Before preparing or handling food, I wash my hands with soap and warm running water	Strongly agree	138	30.1	142.7	30.4
	Agree	208	**45.4**	212.7	45.2
	Neither agree or disagree	70	15.3	71.5	15.2
	Disagree	37	8.1	37.9	8.1
	Strongly disagree	5	1.1	5.1	1.1
	Strongly agree	101	22.3	105.8	22.5
	Agree	214	**47.2**	221.1	47.0

If I have a cut or sore on my hand, I cover it before preparing food	Neither agree or disagree	71	15.7	73.4	15.6
	Disagree	64	14.1	66.7	14.2
	Strongly disagree	3	0.7	3.1	0.7
I wash the plate used to hold raw meat or chicken with hot soapy water before using it for anything else	Strongly agree	247	**55.0**	261.5	55.6
	Agree	160	35.6	164.9	35.1
	Neither agree or disagree	26	5.8	26.9	5.7
	Disagree	15	3.4	15.6	3.4
	Strongly disagree	1	0.2	1.0	0.2
I wash my hands with soap and warm running water after working with raw meat or chicken	Strongly agree	262	**58.0**	273.8	58.3
	Agree	154	34.1	159.0	33.8
	Neither agree or disagree	21	4.6	21.7	4.6
	Disagree	15	3.3	15.6	3.3
	Strongly disagree	0	0.0	0.0	0.0
I clean countertops with hot soapy water after preparing food	Strongly agree	98	21.6	103.3	22.0
	Agree	144	**31.7**	148.9	31.7
	Neither agree or disagree	94	20.7	96.7	20.6
	Disagree	101	22.3	103.5	22.0
	Strongly disagree	17	3.7	17.6	3.7

I refrigerate hot food within 2 hours of preparing and eating	Strongly agree	132	28.9	136.3	29.0
	Agree	223	**48.8**	228.6	48.6
	Neither agree or disagree	54	11.8	55.6	11.8
	Disagree	45	9.8	46.4	9.9
	Strongly disagree	3	0.7	3.1	0.7
I keep raw meat and chicken away from ready-to-eat foods like raw vegetables	Strongly agree	198	**44.1**	207.5	44.1
	Agree	191	42.5	199.1	42.4
	Neither agree or disagree	39	8.7	40.8	8.7
	Disagree	17	3.8	18.1	3.8
	Strongly disagree	4	0.9	4.5	1.0
I use a thermometer to check if meat or chicken has been cooked enough	Strongly agree	36	8.1	39.0	8.3
	Agree	58	13	61.8	13.1
	Neither agree or disagree	61	13.7	63.8	13.6
	Disagree	183	**41.0**	191.2	40.7
	Strongly disagree	108	24.2	114.3	24.3
I use a thermometer to check if leftovers have been reheated enough	Strongly agree	14	3.1	15.3	3.3
	Agree	16	3.6	17.5	3.7
	Neither agree or disagree	49	10.8	51.4	10.9

	Disagree	227	**50.2**	234.1	49.8
	Strongly disagree	146	32.3	151.7	32.3
I read nutrition labels to make decisions about the foods I choose	Strongly agree	115	25.5	119.7	25.5
	Agree	172	**38.1**	178.2	37.9
	Neither agree or disagree	77	17.1	80.5	17.1
	Disagree	69	15.3	72.3	15.4
	Strongly disagree	18	4	19.3	4.1
I read ingredient lists to make decisions about the foods I choose	Strongly agree	108	23.8	110.7	23.5
	Agree	184	**40.6**	190.4	40.5
	Neither agree or disagree	72	15.9	75.1	16.0
	Disagree	71	15.7	74.1	15.8
	Strongly disagree	18	4	19.8	4.2
I use an ice pack when I take my lunch to school	Strongly agree	40	9.2	43.8	9.3
	Agree	63	14.4	68.6	14.6
	Neither agree or disagree	73	16.7	77.9	16.6
	Disagree	156	**35.8**	166.6	35.4
	Strongly disagree	104	23.9	113.1	24.1
I use an ice pack when I take my lunch with me	Strongly agree	86	19.4	93.1	19.8
	Agree	164	**36.9**	171.4	36.5

for day trips (like a trip to the beach)	Neither agree or disagree	63	14.2	66.2	14.1
	Disagree	81	18.2	85.1	18.1
	Strongly disagree	50	11.3	54.2	11.5
After playing with a pet and before getting a snack, I wash my hands with soap and warm running water	Strongly agree	158	**35.9**	169.5	36.1
	Agree	155	35.2	164.3	35.0
	Neither agree or disagree	59	13.4	62.8	13.3
	Disagree	53	12.1	57.0	12.1
	Strongly disagree	15	3.4	16.4	3.5
I use the Canada Food Guide to help me choose what to eat	Strongly agree	14	3.1	14.7	3.1
	Agree	67	14.8	69.1	14.7
	Neither agree or disagree	106	23.5	110.2	23.4
	Disagree	146	**32.3**	151.2	32.2
	Strongly disagree	119	26.3	124.9	26.6
When I cook or reheat meals, I use a microwave	Strongly agree	135	29.9	141.2	30.0
	Agree	242	**53.7**	251.0	53.4
	Neither agree or disagree	44	9.8	45.9	9.8
	Disagree	20	4.4	21.0	4.5
	Strongly disagree	10	2.2	10.8	2.3

When I cook or reheat meals, I use a regular oven	Strongly agree	43	9.5	44.8	9.5
	Agree	224	**49.4**	232.0	49.4
	Neither agree or disagree	57	12.6	59.0	12.5
	Disagree	96	21.2	99.6	21.2
	Strongly disagree	33	7.3	34.6	7.4
I eat food that has passed the "Best Before" date	Strongly agree	34	7.4	34.9	7.4
	Agree	148	**32.3**	151.6	32.3
	Neither agree or disagree	91	19.9	93.1	19.8
	Disagree	113	24.7	116.2	24.7
	Strongly disagree	72	15.7	74.2	15.8

[a]1=strongly disagree and 5=strongly agree

Table 14: The demographic and food skills and cooking experience variables significantly associated with those self-reported food safety for which there is not a correct behaviour; the statistically significant associations at a 95% confidence interval are shown in bold

		I plan, or help plan, the meals in my household	**I read nutrition labels to make decisions about the foods I choose**	**I read ingredient lists to make decisions about the foods I choose**	**I use the Canada Food Guide to help me choose what to eat**	**When I cook or reheat meals, I use a microwave**	**When I cook or reheat meals, I use a regular oven**
Intercept (Referent = Strongly disagree)	Disagree	1.55 (-0.88, 3.98)	3.37 (1.00, 5.75)	2.74 (0.36, 5.11)	2.13 (-0.22, 4.47)	4.16 (1.57, 6.75)	2.86 (0.40, 5.31)
	Neither agree or disagree	-0.62 (-3.00, 1.76)	1.58 (-0.76, 3.92)	0.90 (-1.44, 3.25)	0.70 (-1.64, 3.03)	3.01 (0.48, 5.55)	1.18 (-1.25, 3.61)
	Agree	-1.53 (-3.91, 0.86)	0.66 (-1.68, 3.00)	0.03 (-2.31, 2.38)	-0.53 (-2.86, 1.80)	1.98 (-0.54, 4.50)	0.59 (-1.84, 3.02)

	Strongly agree	-3.81 (-6.22, -1.41)	-1.06 (-3.39, 1.28)	-1.87 (-4.22, 0.48)	-2.48 (-4.86, -0.10)	-0.65 (-3.16, 1.87)	-2.18 (-4.62, 0.26)
Age (Referent = 18 years or younger)	19 years	0.23 (-0.51, 0.98)	-0.36 (-1.09, 0.37)	-0.59 (-1.34, 0.17)	-0.07 (-0.80, 0.66)	0.67 (-0.11, 1.45)	-0.20 (-0.96, 0.55)
	20 years	0.30 (-0.48, 1.09)	-0.31 (-1.06, 0.44)	**-0.89 (-1.67, -0.12)**	-0.21 (-0.99, 0.56)	0.24 (-0.57, 1.05)	-0.01 (-0.79, 0.77)
	21 years	0.09 (-0.70, 0.88)	-0.40 (-1.16, 0.36)	**-1.30 (-2.09, -0.51)**	-0.33 (-1.11, 0.44)	0.76 (-0.05, 1.58)	-0.40 (-1.19, 0.38)
	22 years	0.24 (-0.57, 1.06)	-0.35 (-1.14, 0.44)	**-1.05 (-1.86, -0.23)**	-0.41 (-1.20, 0.39)	0.54 (-0.31, 1.38)	0.36 (-0.46, 1.18)
	23 years or older	0.36 (-0.53, 1.26)	-0.22 (-1.07, 0.64)	-0.64 (-1.52, 0.24)	-0.57 (-1.43, 0.28)	**1.12 (0.20, 2.04)**	0.20 (-0.70, 1.09)
Sex (Referent = Female)	Male	-0.33 (-0.75, 0.08)	-0.02 (-0.43, 0.40)	-0.23 (-0.64, 0.17)	0.02 (-0.39, 0.42)	-0.02 (-0.45, 0.42)	0.15 (-0.27, 0.56)
Faculty (Referent =	Arts	0.05 (-0.66, 0.76)	-0.40 (-1.08, 0.28)	-0.27 (-0.95, 0.41)	-0.52 (-1.19, 0.15)	-0.71 (-1.45, 0.02)	-0.43 (-1.14, 0.27)

Applied Health Sciences)	Engineering	0.13 (-0.61, 0.87)	-0.49 (-1.20, 0.22)	-0.12 (-0.83, 0.58)	0.02 (-0.68, 0.72)	**-1.16 (-1.93, -0.39)**	-0.28 (-1.01, 0.45)
	Environment	0.51 (-0.33, 1.35)	-0.08 (-0.89, 0.72)	0.26 (-0.55, 1.06)	-0.26 (-1.06, 0.53)	-0.79 (-1.65, 0.06)	-0.76 (-1.58, 0.06)
	Mathematics	-0.08 (-0.85, 0.68)	-0.12 (-0.86, 0.62)	0.31 (-0.43, 1.05)	-0.21 (-0.94, 0.52)	-0.67 (-1.47, 0.12)	-0.59 (-1.35, 0.17)
	Science	0.08 (-0.62, 0.77)	-0.51 (-1.19, 0.16)	-0.29 (-0.95, 0.38)	-0.33 (-0.99, 0.33)	-0.30 (-1.02, 0.42)	-0.39 (-1.08, 0.30)
System of study (Referent = Regular)	Co-op	0.22 (-0.22, 0.65)	-0.11 (-0.53, 0.32)	-0.15 (-0.57, 0.27)	**-0.52 (-0.93, -0.10)**	**0.47 (0.01, 0.92)**	**-0.48 (-0.92, -0.05)**
Work or volunteer location (Referent = No)	Restaurant	-0.39 (-1.65, 0.86)	0.002 (-1.16, 1.16)	0.10 (-1.06, 1.26)	1.08 (-0.09, 2.25)	-0.35 (-1.58, 0.88)	-0.05 (-1.26, 1.17)
	Hospital	0.51 (-0.31, 1.32)	**0.82 (0.03, 1.60)**	0.63 (-0.14, 1.40)	0.53 (-0.21, 1.28)	0.35 (-0.46, 1.15)	0.49 (-0.31, 1.29)

	Daycare	0.08 (-0.63, 0.79)	-0.33 (-1.02, 0.37)	**-0.73 (-1.42, -0.04)**	0.38 (-0.29, 1.05)	0.15 (-0.57, 0.88)	0.35 (-0.38, 1.07)
	Retirement home	0.19 (-1.18, 1.56)	0.43 (-0.89, 1.75)	0.22 (-1.09, 1.53)	-1.25 (-0.22, 0.06)	-0.33 (-1.70, 1.04)	-1.30 (-2.61, 0.002)
Food handler (Referent = No)	Yes	0.97 (-0.29, 2.24)	-0.07 (-1.23, 1.09)	0.50 (-0.65, 1.65)	-0.99 (-2.15, 0.18)	0.34 (-0.88, 1.56)	0.29 (-0.92, 1.50)
Previous training (Referent = No)	Yes	0.21 (-0.17, 0.59)	0.11 (-0.25, 0.48)	0.08 (-0.28, 0.45)	0.14 (-0.22, 0.50)	-0.18 (-0.57, 0.21)	0.01 (-0.36, 0.38)
Cooking ability (Referent = Don't know how)	Instructions on the box	0.16 (-2.31, 2.64)	-0.40 (-2.83, 2.04)	1.01 (-1.44, 3.46)	-0.58 (-3.06, 1.91)	0.40 (-2.26, 3.05)	-0.69 (-3.22, 1.83)
	Basics from scratch	-0.48 (-3.01, 2.05)	1.05 (-1.40, 3.50)	0.51 (-1.96. 2.98)	-1.10 (-3.57, 1.37)	-0.30 (-2.95, 2.35)	-0.18 (-2.72, 2.36)
	Simple meals with recipe	0.25 (-2.24, 2.75)	1.50 (-0.92, 3.92)	1.43 (-1.01, 3.86)	-1.05 (-3.48, 1.38)	-0.49 (-3.10, 2.12)	0.28 (-2.23, 2.79)

	Almost anything	1.29 (-1.23, 3.80)	1.70 (-0.74, 4.14)	1.75 (-0.70, 4.21)	-1.07 (-3.52, 1.38)	-0.51 (-3.14, 2.12)	0.54 (-1.99, 3.07)
Living arrangement (Referent = Traditional-style residence	Suite-style residence	0.06 (-0.84, 0.96)	**-0.91 (-1.79, -0.02)**	-0.77 (-1.66, 0.11)	-0.04 (-0.92, 0.84)	0.92 (-0.02, 1.86)	0.47 (-0.43, 1.37)
	Off campus	0.15 (-0.67, 0.96)	-0.51 (-1.30, 0.29)	0.17 (-0.63, 0.97)	-0.28 (-1.08, 0.52)	0.23 (-0.61, 1.06)	0.33 (-0.47, 1.13)
	At home	0.18 (-0.67, 1.03)	-0.26 (-1.11, 0.59)	0.56 (-0.29, 1.42)	-0.01 (-0.84, 0.83)	-0.06 (-0.94, 0.82)	0.29 (-0.55, 1.14)
Cooking frequency (Referent = Never)	At least once a day	**1.98 (0.65, 3.32)**	-0.35 (-1.59, 0.89)	0.17 (-1.08, 1.42)	1.10 (-0.14, 2.34)	-0.35 (-1.67, 0.98)	-0.29 (-1.55, 0.97)
	A few times a week	**1.67 (0.36, 2.98)**	-0.66 (-1.87, 0.56)	-0.11 (-1.32, 1.11)	0.78 (-0.43, 1.99)	-0.18 (-1.48, 1.12)	-0.17 (-1.40, 1.07)
	A few times a month	0.77 (-0.55, 2.08)	-0.49 (-1.71, 0.74)	-0.35 (-1.58, 0.88)	1.06 (-0.16, 2.29)	0.17 (-1.14, 1.48)	-0.06 (-1.30, 1.18)
	A few times a year	0.71 (-0.81, 2.23)	-1.14 (-2.59, 0.31)	-0.50 (-1.94, 0.94)	0.23 (-1.20, 1.66)	0.66 (-0.88, 2.21)	-0.77 (-2.21, 0.68)

Table 15: The demographic and food skills and cooking experience variables significantly associated with those self-reported food safety for which there is a correct behaviour (Table 1 of 2; see Table 16); the statistically significant associations at a 95% confidence interval are shown in bold

		Before preparing or handling food, I wash my hands with soap and warm running water	**I wash the plate that used to hold raw meat or chicken with hot soapy water before using it for anything else**	**I wash my hands with soap and warm running water after working with raw meat or chicken**	**I clean countertops with hot soapy water after preparing food**	**I refrigerate hot food within two hours of preparing and eating**	**I keep raw meat and chicken away from ready-to-eat foods like raw vegetables**
Intercept (Referent = Strongly disagree,	Disagree	5.56 (2.96, 8.15)	5.37 (2.20, 8.54)	Referent*	4.76 (2.34, 7.18)	4.44 (1.74, 7.13)	5.40 (2.71, 8.09)
	Neither agree or disagree	3.30 (0.85, 5.75)	2.52 (-0.02, 5.05)	2.89 (0.32, 5.45)	2.48 (0.10, 4.85)	1.52 (-0.93, 3.98)	3.71 (1.18, 6.25)

except where noted)	Agree	2.07 (-0.37, 4.51)	1.45 (-1.06, 3.96)	1.93 (-0.61, 4.47)	1.48 (-0.88, 3.85)	0.59 (-1.86, 3.03)	2.54 (0.03, 5.05)
	Strongly agree	-0.09 (-2.52, 2.34)	-0.82 (-3.33, 1.68)	-0.39 (-2.93, 2.14)	-0.07 (-2.43, 2.30)	-1.74 (-4.20, 0.71)	0.22 (-2.27, 2.72)
Age (Referent = 18 years or younger)	19 years	-0.61 (-1.36, 0.13)	-0.64 (-1.46, 0.18)	-0.55 (-1.37, 0.27)	-0.30 (-1.03, 0.43)	0.34 (-0.43, 1.11)	-0.64 (-1.43, 0.15)
	20 years	0.18 (-0.59, 0.96)	-0.56 (-1.42, 0.30)	-0.14 (-1.00, 0.71)	0.07 (-0.68, 0.82)	-0.13 (-0.93, 0.67)	-0.41 (-1.22, 0.39)
	21 years	-0.16 (-0.94, 0.62)	-0.82 (-1.69, 0.05)	-0.57 (-1.43, 0.29)	-0.06 (-0.82, 0.70)	0.03 (-0.78, 0.84)	-0.47 (-1.29, 0.35)
	22 years	-0.32 (-1.12, 0.49)	**-0.97 (-1.86, -0.08)**	-0.45 (-1.34, 0.44)	-0.19 (-0.97, 0.59)	-0.33 (-1.16, 0.50)	-0.34 (-1.19, 0.50)
	23 years or older	0.86 (-0.03, 1.75)	-0.59 (-1.56, 0.38)	-0.27 (-1.25, 0.70)	0.28 (-0.58, 1.14)	0.18 (-0.71, 1.08)	-0.07 (-0.99, 0.86)
Sex (Referent = Female)	Male	**-0.58 (-1.00, -0.16)**	-0.05 (-0.51, 0.41)	-0.40 (-0.85, 0.06)	-0.17 (-0.57, 0.24)	0.24 (-0.18, 0.67)	-0.20 (-0.64, 0.23)

Faculty (Referent = Applied Health Sciences)	Arts	-0.35 (-1.05, 0.36)	-0.28 (-1.12, 0.55)	-0.44 (-1.31, 0.44)	0.47 (-0.21, 1.14)	0.09 (-0.61, 0.79)	0.18 (-0.55, 0.91)
	Engineering	0.28 (-0.46, 1.01)	-0.36 (-1.22, 0.49)	-0.43 (-1.33, 0.47)	0.51 (-0.19, 1.22)	-0.02 (-0.74, 0.71)	0.31 (-0.45, 1.06)
	Environment	0.09 (-0.74, 0.92)	-0.81 (-1.74, 0.12)	**-0.99 (-1.96, -0.01)**	0.20 (-0.59, 0.99)	0.06 (-0.76, 0.89)	0.31 (-0.56, 1.17)
	Mathematics	-0.05 (-0.81, 0.71)	-0.66 (-1.53, 0.22)	**-1.05 (-1.96, -0.14**	0.23 (-0.51, 0.97)	-0.07 (-0.83, 0.69)	0.13 (-0.66, 0.92)
	Science	-0.39 (-1.08, 0.30)	-0.40 (-1.22, 0.43)	**-0.87 (-1.73, -0.01)**	0.58 (-0.10, 1.25)	0.11 (-0.58, 0.80)	-0.21 (-0.92, 0.51)
System of study (Referent = Regular)	Co-op	-0.26 (-0.69, 0.17)	0.17 (-0.30, 0.64)	0.08 (-0.39, 0.56)	**-0.43 (-0.84, -0.01)**	0.27 (-0.16, 0.71)	-0.33 (-0.79, 0.12)
Work or volunteer	Restaurant	0.48 (-0.73, 1.70)	0.72 (-1.22, 3.23)	0.32 (-1.15, 1.79)	0.55 (-1.01, 1.60)	-0.75 (-1.96, 0.47)	0.46 (-0.83, 1.75)

location (Referent = No)	Hospital	0.29 (-0.50, 1.08)	**2.15 (0.67, 3.64)**	**1.54 (0.28, 2.81)**	0.63 (-0.13, 1.39)	0.15 (-0.64, 0.94)	**0.94 (0.05, 1.83)**
	Daycare	0.41 (-0.30, 1.12)	0.34 (-0.47, 1.15)	0.35 (-0.49, 1.18)	0.21 (-0.48, 0.89)	0.53 (-0.19, 1.25)	0.04 (-0.70, 0.78)
	Retirement home	-0.06 (-1.41, 1.29)	1.00 (-1.22, 3.23)	-0.34 (-2.02, 1.34)	0.30 (-1.01, 1.60)	-0.33 (-1.67, 1.00)	-0.17 (-1.59, 1.24)
Food handler (Referent = No)	Yes	-0.24 (-1.45, 0.97)	-0.58 (-1.94, 0.79)	0.26 (-1.25, 1.76)	0.05 (-1.11, 1.22)	0.77 (-0.45, 1.99)	-0.10 (-1.39, 1.19)
Previous training (Referent = No)	Yes	-0.16 (-0.53, 0.22)	-0.30 (-0.70, 0.10)	**-0.49 (-0.90, -0.07)**	0.01 (-0.35, 0.37)	-0.08 (-0.45, 0.30)	**-0.41 (-0.80, -0.02)**
Cooking ability	Instructions on the box	-0.88 (-3.41, 1.65)	0.76 (-1.82, 3.34)	0.29 (-2.28, 2.87)	-1.69 (-4.17, 0.79)	-1.08 (-3.64, 1.48)	-1.98 (-4.57, 0.61)

(Referent = Don't know how)	Basics from scratch	-0.40 (-2.95, 2.15)	-0.37 (-2.95, 2.22)	1.06 (-1.56, 3.68)	-1.58 (-4.05, 0.90)	-1.62 (-4.19, 0.95)	-1.07 (-3.68, 1.54)
	Simple meals with recipe	0.15 (-2.37, 2.67)	0.39 (-2.15, 2.94)	0.96 (-1.61, 3.54)	-1.08 (-3.52, 1.35)	-1.25 (-3.77, 1.28)	-1.09 (-3.65, 1.47)
	Almost anything	0.57 (-1.97, 3.11)	1.19 (-1.38, 3.77)	1.70 (-0.91, 4.31)	-0.67 (-3.13, 1.78)	-0.66 (-3.20, 1.89)	-0.16 (-2.74, 2.42)
Living arrangement (Referent = Traditional-style residence	Suite-style residence	0.03 (-0.88, 0.93)	0.53 (-0.43, 1.49)	0.39 (-0.59, 1.37)	**-1.06 (-1.94, -0.18)**	-0.02 (-0.92, 0.87)	0.17 (-0.77, 1.11)
	Off campus	-0.23 (-1.04, 0.57)	0.83 (-0.03, 1.69)	0.63 (-0.24, 1.49)	**-0.94 (-1.73, -0.14)**	0.33 (-0.48, 1.14)	0.36 (-0.48, 1.20)
	At home	0.08 (-0.78, 0.93)	**0.94 (0.01, 1.86)**	0.65 (-0.27, 1.58)	-0.58 (-1.43, 0.26)	0.29 (-0.57, 1.14)	0.39 (-0.51, 1.28)
Cooking frequency (Referent = Never)	At least once a day	-0.61 (-1.89, 0.68)	0.70 (-0.61, 2.02)	0.14 (-1.21, 1.49)	0.36 (-0.84, 1.57)	**1.54 (0.29, 2.79)**	0.64 (-0.63, 1.92)
	A few times a week	-0.39 (-1.64, 0.87)	0.65 (-0.63, 1.93)	0.004 (-1.31, 1.32)	0.22 (-0.95, 1.40)	1.21 (-0.01, 2.43)	0.46 (-0.78, 1.71)

	A few times a month	-0.34 (-1.61, 0.93)	0.31 (-0.97, 1.60)	0.18 (-1.15, 1.50)	0.33 (-0.86, 1.52)	0.96 (-0.27, 2.20)	0.64 (-0.61, 1.90)
	A few times a year	-0.53 (-2.01, 0.96)	0.68 (-0.83, 2.19)	0.19 (-1.37, 1.75)	0.15 (-1.26, 1.55)	**1.47 (0.01, 2.92)**	0.64 (-0.87, 2.14)

*"Disagree" used as the referent as none of the respondents selected "strongly disagree"

Table 16: The demographic and food skills and cooking experience variables significantly associated with those self-reported food safety for which there is a correct behaviour (Table 2 of 2; see Table 15); the statistically significant associations at a 95% confidence interval are shown in bold

		I use a thermometer to check if meat or chicken has been cooked enough	**I use a thermometer to check if leftovers have been reheated enough**	**I use an ice pack when I take my lunch to school**	**I use an ice pack when I take when I take my lunch with me for day trips (like a trip to the beach)**	**After playing with a pet and before getting a snack, I wash my hands with soap and warm running water**	**I eat food that has passed the "Best Before" date**
Intercept (Referent = Strongly disagree)	Disagree	4.54 (2.10, 6.99)	1.39 (-1.09, 3.88)	2.08 (-0.32, 4.47)	3.62 (1.24, 5.99)	3.80 (1.39, 6.20)	1.20 (-1.21, 3.61)
	Neither agree or disagree	2.65 (0.22, 5.08)	-1.05 (-3.53, 1.43)	0.41 (-1.98, 2.80)	2.39 (0.03, 4.75)	2.12 (-0.25, 4.48)	-0.19 (-2.60, 2.23)

	Agree	1.89 (-0.53, 4.32)	-2.18 (-4.67, 0.31)	-0.44 (-2.83, 1.95)	1.73 (-0.63, 4.09)	1.28 (-1.08, 3.64)	-1.06 (-3.48, 1.35)
	Strongly agree	0.68 (-1.73, 3.10)	-3.01 (-5.53, -0.49)	-1.64 (-4.04, 0.76)	-0.07 (-2.42, 2.28)	-0.32 (-2.67, 2.04)	-3.28 (-5.70, -0.85)
Age (Referent = 18 years or younger)	19 years	-0.05 (-0.79, 0.69)	-0.27 (-1.06, 0.53)	-0.61 (-1.38, 0.17)	-0.02 (-0.76, 0.72)	**-1.25 (-2.02, -0.48)**	0.54 (-0.18, 1.26)
	20 years	0.01 (-0.76, 0.78)	-0.30 (-1.11, 0.51)	-0.45 (-1.27, 0.36)	0.06 (-0.70, 0.83)	**-0.87 (-1.66, -0.08)**	-0.10 (-0.84, 0.64)
	21 years	-0.07 (-0.84, 0.70)	-0.12 (-0.93, 0.69)	-0.58 (-1.41, 0.26)	-0.23 (-1.00, 0.54)	-0.76 (-1.57, 0.04)	0.47 (-0.29, 1.22)
	22 years	-0.47 (-1.26, 0.33)	-0.34 (-1.18, 0.50)	-0.78 (-1.62, 0.06)	-0.24 (-1.03, 0.55)	**-1.24 (-2.07, -0.41)**	0.74 (-0.03, 1.52)
	23 years or older	0.21 (-0.66, 1.07)	-0.68 (-1.59, 0.22)	-0.46 (-1.36, 0.44)	0.05 (-0.81, 0.90)	-0.49 (-1.39, 0.42)	0.38 (-0.46, 1.22)
Sex (Referent = Female)	Male	0.09 (-0.32, 0.50)	0.13 (-0.30, 0.55)	0.25 (-0.18, 0.67)	0.07 (-0.34, 0.47)	-0.07 (-0.49, 0.34)	0.18 (-0.22, 0.58)

Faculty (Referent = Applied Health Sciences)	Arts	0.44 (-0.25, 1.13)	**0.80 (0.08, 1.52)**	0.60 (-0.10, 1.29)	-0.54 (-1.22, 0.13)	-0.46 (-1.17, 0.24)	0.48 (-0.19, 1.15)
	Engineering	**0.72 (0.001, 1.44)**	**0.98 (0.23, 1.74)**	0.65 (-0.09, 1.39)	-0.40 (-1.10, 0.30)	-0.21 (-0.94, 0.53)	-0.01 (-0.71, 0.69)
	Environment	**1.17 (0.35, 1.99)**	0.79 (-0.06, 1.63)	0.30 (-0.55, 1.15)	-0.32 (-1.14, 0.49)	**-0.86 (-1.70, -0.03)**	0.35 (-0.44, 1.14)
	Mathematics	**0.85 (0.10, 1.60)**	**1.06 (-0.06, 1.63)**	0.67 (-0.10, 1.44)	-0.64 (-1.37, 0.09)	-0.19 (-0.95, 0.57)	0.62 (-0.11, 1.35)
	Science	**0.69 (0.01, 1.37)**	**0.90 (0.19, 1.61)**	0.30 (-0.39, 0.99)	-0.66 (-1.33, 0.003)	-0.54 (-1.22, 0.15)	0.62 (-0.04, 1.28)
System of study (Referent = Regular)	Co-op	**-0.43 (-0.85, -0.01)**	-0.35 (-0.80, 0.09)	**-0.66 (-1.08, -0.23)**	**-0.45 (-0.87, -0.03)**	**-0.47 (-0.90, -0.04)**	**0.66 (0.25, 1.07)**
Work or volunteer	Restaurant	0.30 (-0.89, 1.50)	0.58 (-0.63, 1.79)	0.08 (-1.07, 1.23)	-0.05 (-1.23, 1.13)	**1.59 (0.36, 2.82)**	0.58 (-0.57, 1.72)

location (Referent = No)	Hospital	0.37 (-0.39, 1.12)	-0.08 (-0.88, 0.72)	0.23 (-0.53, 1.00)	0.48 (-0.28, 1.25)	-0.09 (-0.86, 0.67)	-0.004 (-0.75, 0.74)
	Daycare	-0.02 (-0.72, 0.68)	0.02 (-0.70, 0.73)	-0.10 (-0.78, 0.58)	-0.16 (-0.83, 0.52)	0.66 (-0.08, 1.39)	0.44 (-0.24, 1.11)
	Retirement home	1.08 (-0.20, 2.36)	**1.46 (0.14, 2.78)**	0.61 (-0.66, 1.88)	-0.01 (-1.30, 1.27)	0.22 (-1.16, 1.59)	0.97 (-0.33, 2.27)
Food handler (Referent = No)	Yes	0.21 (-0.99, 1.41)	-0.22 (-1.43, 0.99)	0.09 (-1.05, 1.23)	-0.08 (-1.26, 1.09)	**-1.57 (-2.77, -0.01)**	-0.49 (-1.62, 0.65)
Previous training (Referent = No)	Yes	0.04 (-0.32, 0.40)	0.29 (-0.09, 0.67)	0.15 (-0.22, 0.52)	-0.05 (-0.42, 0.31)	-0.26 (-0.64, 0.11)	0.34 (-0.02, 0.70)
Cooking ability	Instructions on the box	**-3.76 (-6.31, -1.20)**	-0.97 (-3.58, 1.63)	-0.41 (-2.91, 2.10)	-0.96 (-3.41, 1.50)	0.89 (-1.57, 3.36)	-2.17 (-4.70, 0.35)

(Referent = Don't know how)	Basics from scratch	**-3.37 (-5.91, -0.82)**	-0.56 (-3.18, 2.05)	0.35 (-2.17, 2.86)	-0.08 (-2.54, 2.39)	1.03 (-1.47, 3.52)	-2.03 (-4.56, 0.50)
	Simple meals with recipe	**-3.66 (-6.18, -1.15)**	-0.75 (-3.32, 1.82)	0.02 (-2.45, 2.50)	0.05 (-2.38, 2.48)	1.28 (-1.17, 3.74)	-1.78 (-4.27, 0.71)
	Almost anything	**-3.45 (-5.98, -0.91)**	-0.90 (-3.50, 1.69)	-0.01 (-2.50, 2.48)	0.59 (-1.86, 3.04)	1.53 (-0.95, 4.01)	-1.62 (-4.13, 0.89)
Living arrangement (Referent = Traditional-style residence	Suite-style residence	**-1.08 (-1.98, -0.18)**	**-1.75 (-2.69, -0.80)**	**-1.27 (-2.19, -0.36)**	**-1.04 (-1.94, -0.13)**	0.56 (-0.35, 1.47)	0.84 (-0.02, 1.71)
	Off campus	**-1.02 (-1.83, -0.22)**	**-0.96 (-1.80, -0.11)**	**-1.24 (-2.06, -0.42)**	**-0.90 (-1.69, -0.11)**	**0.93 (0.11, 1.74)**	0.68 (-0.09, 1.46)
	At home	-0.73 (-1.57, 0.12)	-0.65 (-1.54, 0.24)	-0.76 (-1.62, 0.10)	-0.43 (-1.27, 0.40)	0.82 (-0.04, 1.68)	0.39 (-0.43, 1.20)
Cooking frequency (Referent = Never)	At least once a day	0.96 (-0.29, 2.21)	0.64 (-0.67, 1.96)	0.70 (-0.56, 1.97)	0.12 (-1.12, 1.35)	-0.94 (-2.24, 0.35)	0.48 (-0.73, 1.70)
	A few times a week	0.49 (-0.73, 1.72)	0.48 (-0.80, 1.76)	0.47 (-0.77, 1.71)	-0.12 (-1.34, 1.09)	-1.07 (-2.34, 0.20)	0.27 (-0.92, 1.46)

	A few times a month	0.86 (-0.37, 2.10)	0.63 (-0.67, 1.92)	0.09 (-1.15, 1.33)	-0.59 (-1.82, 0.63)	-0.45 (-1.73, 0.84)	0.40 (-0.80, 1.61)
	A few times a year	-0.03 (-1.47, 1.42)	-0.21 (-1.74, 1.32)	-0.18 (-1.62, 1.26)	-0.22 (-1.65, 1.21)	-0.91 (-2.40, 0.58)	1.05 (-0.36, 2.47)

7. Exploration of the Application of Behaviour Change Theories to Food Safety Attitudes and Self-Reported Behaviours

The objective of this analysis was to explore if behaviour change theories can be used to examine the relationship between food safety attitudes and self-reported behaviours, for typically collected attitude and behaviour measurements (found in commonly applied questionnaires (19,89,114,117)).

7.1 Methods

The five behaviour change theories that have been previously applied to food safety attitudes and behaviours: (i) the Theory of Planned Behaviour, (ii) the Health Action Process Approach, (iii) the Health Belief Model, (iv) the Temporal Self-Regulation Theory, and (v) the Transtheoretical Model (see literature review; Chapter 2), were used. A newly developed behaviour change theory, the COM-B Model (137), was also included because it has been applied to public health issues such as gestational diabetes (138) and youth mental health (139), but has not yet been applied to food safety attitudes and behaviours.

The 20 attitude and 19 self-reported behaviour questions (Table 7) were mapped against the constructs in each of the behaviour change theories by matching the attitude and self-reported behaviour questions to the descriptions of the constructs in the original papers (128–131,137,140) to determine (i) how many of the constructs in the theory were covered by the attitude and self-reported behaviour questions, and (ii) how many attitude and self-reported behaviour questions covered each of the constructs. The behaviour change theories that had the most even distribution of attitude and self-reported behaviour questions across the greatest number of theoretical constructs were selected as frameworks to examine the relationship between food safety attitudes and self-reported behaviours.

7.2 Results

Results of the mapping of the six theories against the 20 attitude and 19 self-reported behaviour questions are shown in Table 13. Of the six behaviour change theories that were initially included in the mapping exercise, two theories (Transtheoretial Model, Health Action Process Approach) could not be mapped to the attitudes and self-reported behaviour questions because the questions and corresponding responses did not reference stages of change. For the four remaining behaviour change theories (Temporal Self-Regulation Theory, Health Belief Model, Theory of Planned Behaviour, COM-B Model), the attitude and self-reported behaviour questions mapped to some or most of the constructs in the theories, as follows.

All of the 19 self-reported behaviour questions (Table 7) mapped to the "behaviour" construct in each of the four theories due to the similarity of the "behaviour" constructs across the theories (128,130,137,140). Thus, the behaviour questions were not used to select the behaviour change theories with which to examine the relationship between food safety attitudes and self-reported behaviours.

In assessing the distribution of attitude questions across the greatest number of theoretical constructs, 19 of the 20 attitude questions mapped to five of the seven constructs in the Health Belief Model (Figure 1), and six of the eight constructs in Theory of Planned Behaviour (Figure 2). However, the one question that did not map to any of the constructs in the Health Belief the Theory of Planned Behaviour. Specifically, the one question that did not map to the constructs in the Health Belief Model was "I am interested in finding out how to avoid food poisoning", whereas the one question that did not map to the constructs in the Theory of Planned Behaviour was "I am confident that I can cook safe, health meals for myself and my family". The attitude question "Food poisoning is not currently a big threat to my health" could be mapped to both

"perceived susceptibility", and "perceived severity" in the Health Belief Model, but was mapped to "perceived severity" because it was the only attitude question that fit the description of the construct. All 20 attitude questions mapped to two of the three constructs that precede "behaviour" in the COM-B Model (Figure 3); 19 of the 20 attitude questions mapped to "motivation", and only 1 question, "I am confident that I can cook safe, health meals for myself and my family", was mapped to "capability". In the Temporal Self-Regulation Theory, one of the attitude questions, "I am interested in finding out how to avoid food poisoning" mapped to the construct "intention", but none of the attitude questions mapped to the constructs "behavioural prepotency" and "self-regulation" (Figure 4).

7.3 Discussion

In this chapter I explored if behaviour change theories could be used to examine the relationship between food safety attitudes and self-reported behaviours found in commonly applied questionnaires, and found that behaviour change theories can be used to examine the relationship between the food safety attitudes and self-reported behaviours I collected.

Previously conducted studies that have used behaviour change theory to explore the relationship between food safety attitudes and behaviour have used the Theory of Planned Behaviour, the Health Action Process Approach, the Health Belief Model, the Temporal Self-Regulation Theory, and the Transtheoretical Model (see literature review; Chapter 2) (118–127), and found that in a few studies, food safety attitudes were significantly associated with self-reported food safety behaviours (124,126). It should be noted that the majority of the studies used the theory of interest to develop the measurement tools used (118–123,125).

I mapped all the constructs from the behaviour change theories previously applied to food safety attitudes and behaviours, except for the Transtheoretical Model and Health Action Process

Approach because they are stage of change theories and do not align themselves with the questions asked in the study, to determine which behaviour change theories had the most even distribution of attitude and self-reported behaviour questions across the greatest number of theoretical constructs, and will be used to examine the relationship between food safety attitudes and self-reported behaviours. I also included the COM-B Model in the analysis because it is a newly developed behaviour change theory that has been applied to public health issues, but has yet to be applied to food safety attitudes and behaviours. Although the Theory of Planned Behaviour and the Health Belief Model were the two behaviour change theories that had the most even distribution of attitude questions across the greatest number of theoretical constructs, they have been used to understand the food safety attitudes and behaviours of young adults many times (see literature review). All 20 of the attitude questions and all 19 of the self-reported behaviour questions map to the constructs in the COM-B Model, and as previously discussed, the COM-B Model has not yet been used in food safety attitude and behaviour literature, so I used the COM-B Model to explore the relationship between food safety attitudes and behaviours of young adults.

The diagrammatic representation of the COM-B Model lends itself well to Structural Equation Modeling (SEM), as it is used to examine the relationships between directional variables in a theoretical model, similar to those found in the COM-B Model, while controlling for the other relationships in the model (141). Therefore, I used SEM based on the COM-B Model to determine the relationship between food safety and self-reported food safety behaviours.

This chapter is subject to several limitations, the first being that I did not map the attitude and behaviour questions to the constructs in all of the behaviour change theories that have been

applied to public health issues, such as the Social Cognitive Theory, which has been applied to exercise behavior and intentions of young adults (142). In addition, none of the attitude questions map to the construct "opportunity" in the COM-B Model because the attitude questions were not created to map to the constructs in the COM-B Model (Figure 3). As a result, I was not able to examine the association between the constructs "opportunity" and "motivation", and "opportunity" and "behaviour" using the food safety attitude questions from the survey.

Despite these limitations I was able to examine the association between all of the food safety attitudes and self-reported behaviours I collected using the relationship between the constructs "capability", "motivation", and "behaviour" from the COM-B Model as a framework for the analysis.

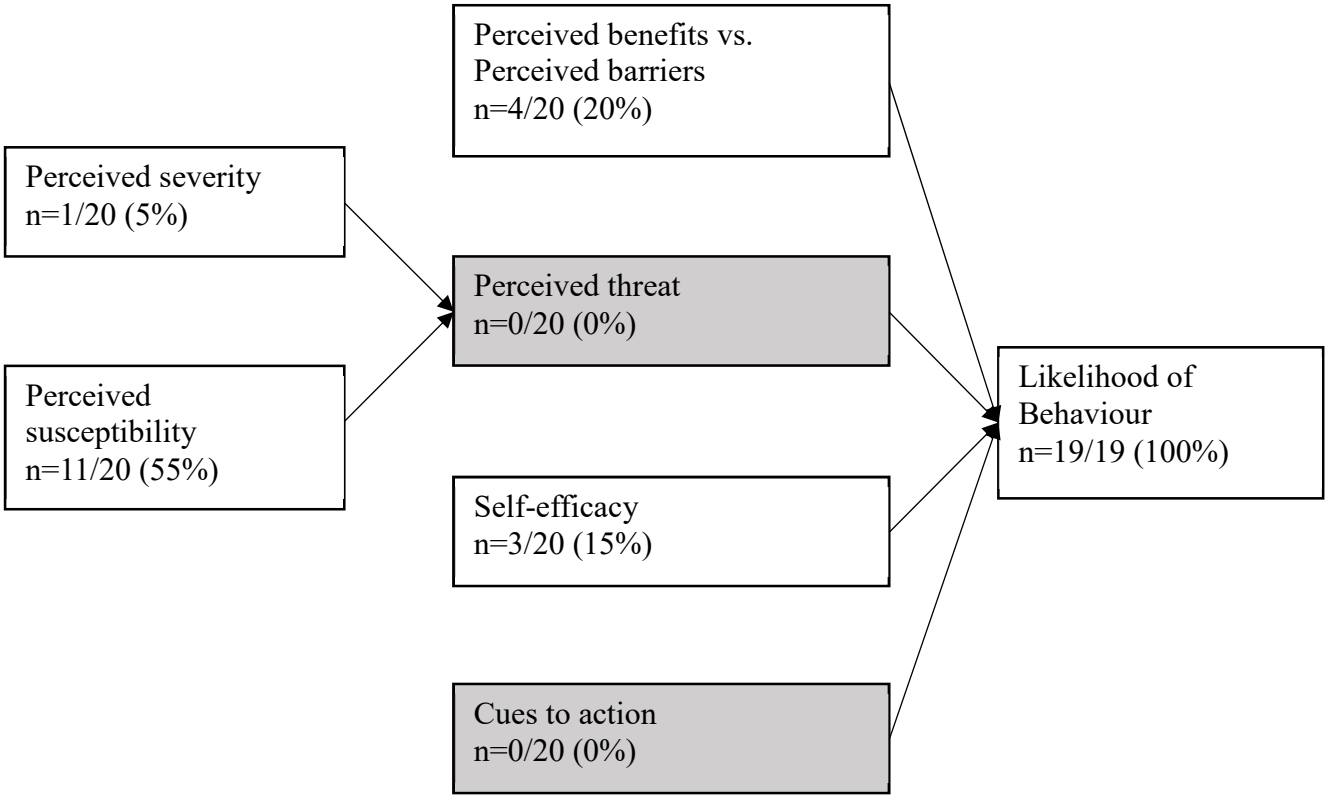

Figure 1: Diagram showing how 19 of the 20 attitude questions and all of 19 self-reported behaviour questions in the survey mapped to 5 of the 7 constructs in the Health Belief Model, adapted from Glanz et al. (130), with grey shading showing constructs that did not overlap with any of the questions

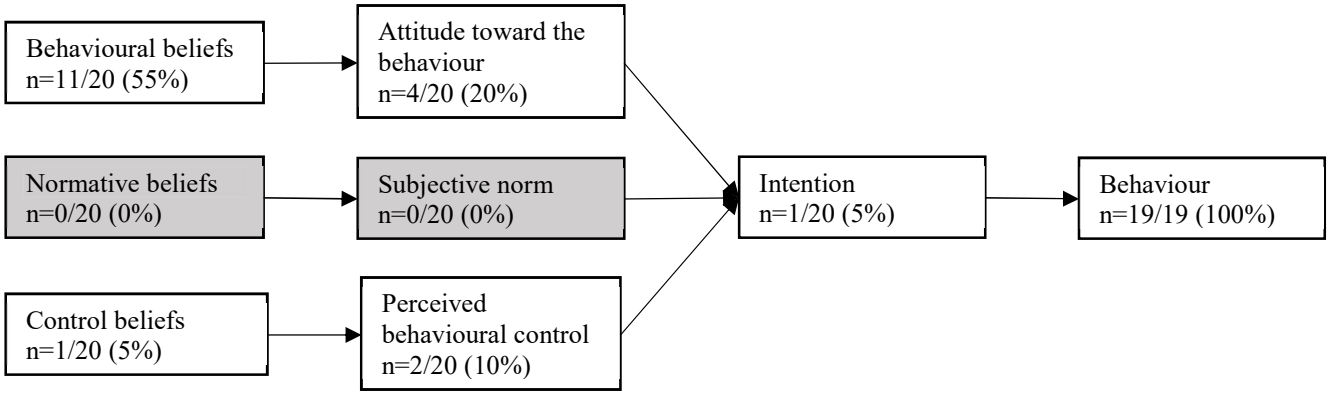

Figure 2: Diagram showing how 19 of the 20 attitude questions and all of 19 self-reported behaviour questions in the survey mapped to 6 of the 8 constructs in the Theory of Planned Behaviour, adapted from Ajzen (140), with grey shading showing constructs that did not overlap with any of the questions

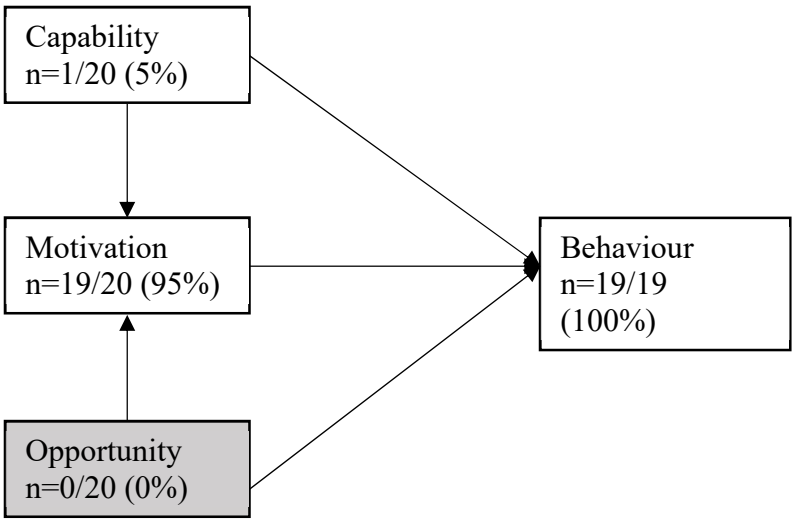

Figure 3: Diagram showing how all of the 20 attitude questions and all of 19 self-reported behaviour questions in the survey mapped to the constructs in the COM-B Model, adapted from Michie et al. (137), with grey shading showing constructs that did not overlap with any of the questions

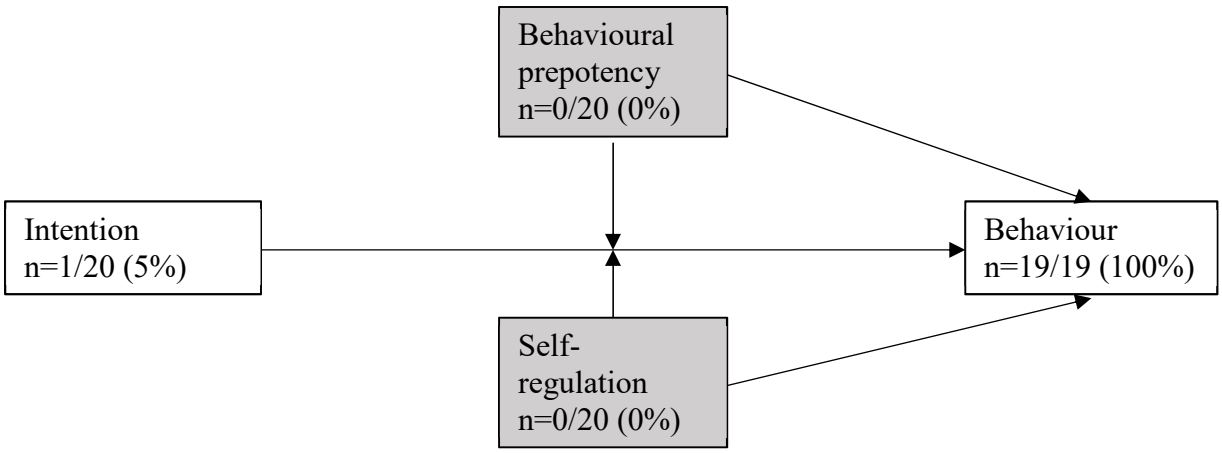

Figure 4: Diagram showing how 1 of the 20 attitude questions and all of 19 self-reported behaviour questions in the survey mapped to the constructs in the Temporal Self-Regulation Theory, adapted from Hall et al. (128), with grey shading showing constructs that did not overlap with any of the questions

Table 17: The overlap of the 20 attitude and 19 self-reported behaviour questions to the constructs in the 4 behaviour change theories, with grey shading showing theories with constructs that did not overlap with the questions

Question	**Temporal Self-Regulation Theory**	**Health Belief Model**	**Theory of Planned Behaviour**	**COM-B Model**
I am interested in finding out how to avoid food poisoning.	Intention		Intention	Motivation
It is not worth my time to learn about preventing food poisoning.		Barrier	Attitude towards behaviour	Motivation
I like learning about how to keep my foods safe to eat.		Benefit	Attitude towards behaviour	Motivation
It is of little use to me to learn about how to prevent food poisoning.		Barrier	Attitude towards behaviour	Motivation
I would like to learn about how to prevent food poisoning.		Benefit	Attitude towards behaviour	Motivation

I believe that I could get food poisoning.		Perceived susceptibility	Behavioural belief	Motivation
I have a chance of getting food poisoning.		Perceived susceptibility	Behavioural belief	Motivation
It is possible that I could get food poisoning this year.		Perceived susceptibility	Behavioural belief	Motivation
I'm not someone who will get food poisoning.		Perceived susceptibility	Behavioural belief	Motivation
Food poisoning is not currently a big threat to my health.		Perceived susceptibility, severity *	Behavioural belief	Motivation
I do not worry about getting food poisoning from the food I eat.		Perceived susceptibility	Behavioural belief	Motivation
I am not concerned about getting food poisoning.		Perceived susceptibility	Behavioural belief	Motivation
Getting food poisoning is not a problem I worry about.		Perceived susceptibility	Behavioural belief	Motivation
I am concerned about getting food poisoning.		Perceived susceptibility	Behavioural belief	Motivation

I worry about getting food poisoning.		Perceived susceptibility	Behavioural belief	Motivation
Anyone can get sick with food poisoning, even me.		Perceived susceptibility	Behavioural belief	Motivation
There is little I can do to change my food preparation habits.		Self-efficacy	Perceived behavioural control	Motivation
I am worried that I may get sick if I eat a lunch that has sat out all day.		Perceived susceptibility	Control beliefs	Motivation
I have no real control over the food I eat.		Self-efficacy	Perceived behavioural control	Motivation
I am confident that I can cook safe, health meals for myself and my family.		Self-efficacy		Capability

* The only instance where a variable can be mapped to more than one construct

8. Application of Structural Equation Modeling to Understand the Relationship between Food Safety Attitudes and Self-Reported Behaviours

The objective of this analysis was explore the relationship between students' attitudes and behaviours, in light of the findings from objective 3.

8.1 Methods

Structural equation modeling was used to model the relationship between the collected food safety attitudes and self-reported food safety behaviours. An overall food safety behaviour score was created by averaging the results from the 19 self-reported behaviour questions, all of which mapped to the construct "behaviour" in the COM-B Model, and was used to represent self-reported food safety behaviours in the structural equation model (Table 17). The relationships between the food safety attitudes and self-reported behaviours in the structural equation model were determined by the relationships between the constructs in the COM-B Model to which they were mapped (Chapter 7). The demographic and food skills and cooking experience variables that were significantly associated with the food safety attitudes and overall food safety behaviour score were included in the structural equation model to control for potential confounding.

8.2 Results

The results of the structural equation modeling using the imputed data can be found in Figure 5 and Table 18. The only "capability" attitude, "I am confident that I can cook safe, healthy meals for myself and my family", was significantly associated with self-reported food safety behaviours (0.19; 95% Confidence Interval [CI] 0.14, 0.24). One of the eight (12.5%) "motivation" attitudes, perceived personal susceptibility to food poisoning, was not significantly associated with either "capability" or self-reported food safety behaviour. Another "motivation"

attitude (1/8; 12.5%), perceived personal threat of food poisoning, was significantly associated with both "capability" and self-reported food safety behaviour; students with lower confidence in their ability to cook safe, healthy meals for themselves and their families had significantly higher perceived personal threat of food poisoning (-0.14; 95% CI -0.23, -0.04), and students with higher perceived personal threat of food poisoning had significantly higher self-reported food safety behaviours (0.06; 95% CI 0.01, 0.11). The remaining six of the eight (75.0%) "motivation" attitudes were significantly associated with either "capability" or self-reported food safety behaviour. Students who had greater confidence that they can cook safe, healthy meals for themselves and their families were significantly more likely to believe that anyone can get sick with food poisoning, even them (0.15; 95% CI 0.08, 0.22), that they can change their food preparation habits (0.10; 95% CI 0.01, 0.19), and that they have control over the food they eat (0.27; 95% CI 0.17, 0.36), and had significantly greater interest in learning about avoiding food poisoning (0.08; 95% CI 0.01, 0.16) than students who had less confidence that they can cook safe, healthy meals for themselves and their families. Students who had greater concern that they may get sick if they ate a lunch that has sat out all day (0.06; 95% CI 0.03, 0.10) and students who had greater beliefs that they are not someone who will get food poisoning (-0.05; 95% CI -0.09, -0.01) had significantly higher self-reported food safety behaviours than students who had less concern that they may get sick if they ate a lunch that has sat out all day and students who had lesser beliefs that they are not someone who will get food poisoning.

8.3 Discussion

In this chapter I examined the association between the food safety attitudes and self-reported food safety behaviours of undergraduate students at the University of Waterloo using

the COM-B Model as the framework for the analysis. I found that some food safety attitudes were significantly associated with self-reported food safety behaviours.

The significant associations between food safety attitudes, specifically capability and some motivations, and self-reported behaviours found here were dissimilar to the majority of previously conducted studies, which used the Theory of Planned Behaviour to examine the association between food safety attitudes and behaviours, and found that food safety attitudes were not significantly associated with self-reported food safety behaviours, but were significantly associated with food safety intentions (118,121,122,125). However, one of the two studies that did find a significant relationship between food safety attitudes and self-reported behaviours, found that the construct "maintenance self-efficacy" from the Health Action Process Approach (129) was significantly associated with self-reported behaviours (124) which falls under the construct "motivation" in the COM-B Model (137,143), and supports the finding that motivations were significantly associated with self-reported food safety behaviours.

High self-confidence in the ability to cook safe, healthy meals was significantly associated with better self-reported food safety behaviours, but low self-confidence in the ability to cook safe, healthy meals was significantly associated with higher perceived personal threat of food poisoning, which was significantly associated with better self-reported food safety behaviours. Both high confidence in the ability to cook safe, healthy meals and low confidence in the ability to cook safe, healthy meals, via perceived personal threat of food poisoning, were significantly associated with higher self-reported food safety behaviour, which suggests that students who experienced either high or low confidence have better self-reported food safety behaviours than students who are unsure if they can cook safe, healthy meals.

The significant associations between attitudes and self-reported behaviours appears to be divided into two groups: motivations that were significantly associated with capability, but not self-reported behaviours and motivations that were significantly associated with self-reported behaviours, but not the capability. This finding may suggest that for some attitudes, students require an increase in their motivation via an increase in their capability before they can change their self-reported food safety behaviours, but for other attitudes, an increase in motivation will improve their self-reported food safety behaviours.

This chapter is subject to several limitations, the most notable being, other than comparing the association between food safety attitudes and self-reported behaviours, I cannot compare the findings of this chapter to the previously conducted studies because I used a behaviour change theory that has not been previously used in food safety attitudes and behaviours literature. In addition, the COM-B Model may not be the behaviour change theory that best fits the data.

Despite these limitations, I examined the association between the food safety attitudes and self-reported behaviours I collected using the COM-B Model. I also identified that undergraduate students at the University of Waterloo should be targeted with messaging about how to cook safe and healthy meals for themselves and their families, the threat of food poisoning, why they are someone who could get food poisoning, and the dangers of eating a lunch that has sat-out all day, because improving these attitudes will ultimately improve self-reported food safety behaviours.

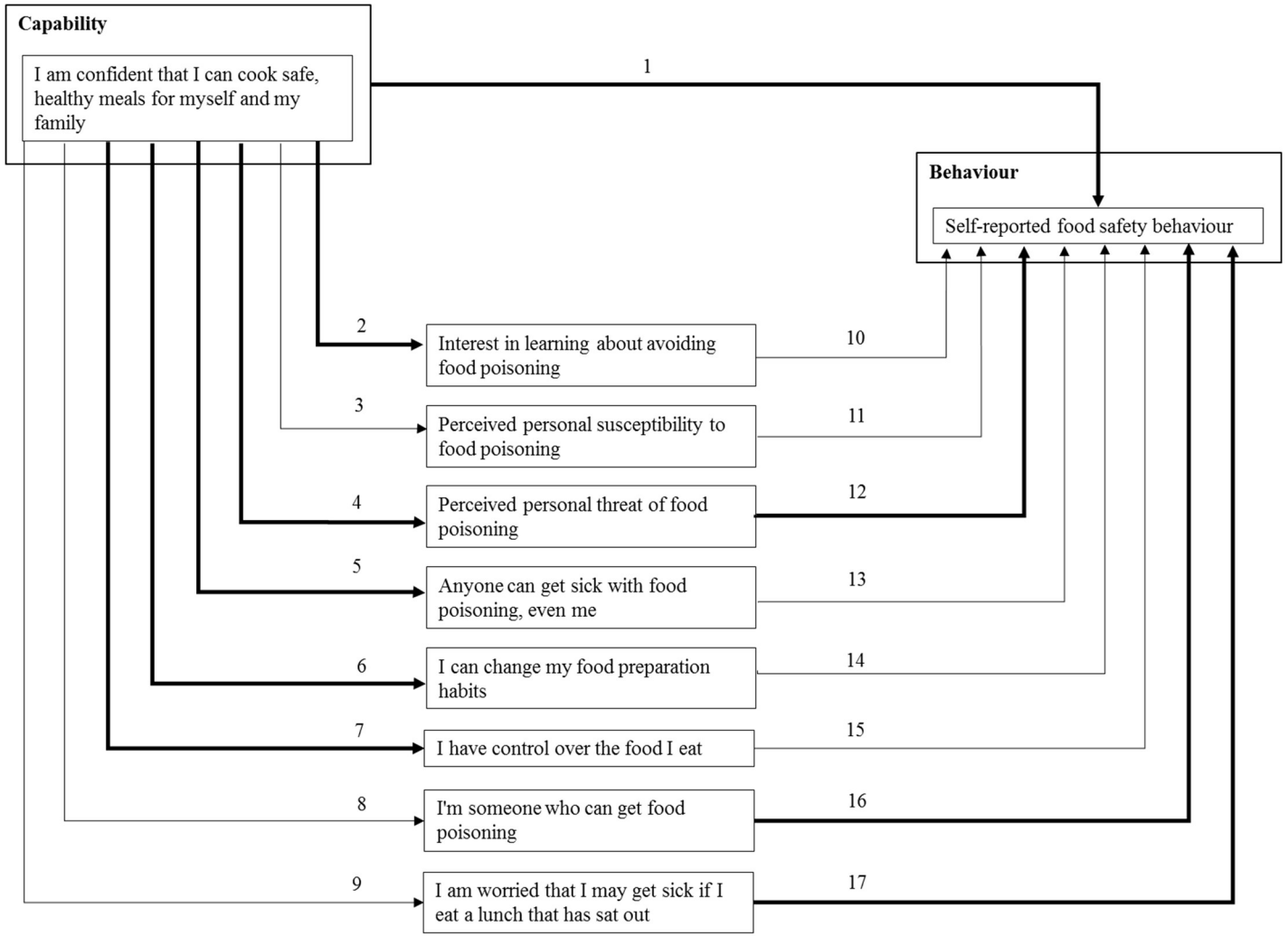

Figure 5: Diagram showing the relationship between food safety attitudes and self-reported behaviours in the context of the COM-B Model, adapted from Michie et al. (137), with bolded pathways representing significant associations; the numbers on the pathways represent the rows in Table 18 where the estimate and 95% confidence interval for each relationship can be found

Table 18: The associations between food safety attitudes and self-reported behaviours in the context of the COM-B Model; the statistically significant associations at a 95% confidence interval are shown in bold

Number	From		To		Estimate (95% Confidence Interval)
	Construct	**Question**	**Construct**	**Question**	
1	Capability	I am confident that I can cook safe, health meals for myself and my family	Behaviour	Overall behaviour score	**0.19 (0.14, 0.24)**
2	Capability	I am confident that I can cook safe, health meals for myself and my family	Motivation	Interest in learning about avoiding food poisoning	**0.08 (0.05, 0.16)**
3	Capability	I am confident that I can cook safe, health meals for myself and my family	Motivation	Perceived personal susceptibility to food poisoning	0.07 (-0.02, 0.16)

4	Capability	I am confident that I can cook safe, health meals for myself and my family	Motivation	Perceived personal threat of food poisoning	**-0.13 (-0.23, -0.04)**
5	Capability	I am confident that I can cook safe, health meals for myself and my family	Motivation	Anyone can get sick with food poisoning, even me	**0.15 (0.08, 0.22)**
6	Capability	I am confident that I can cook safe, health meals for myself and my family	Motivation	I can change my food preparation habits	**0.10 (0.01, 0.19)**
7	Capability	I am confident that I can cook safe, health meals for myself and my family	Motivation	I have control over the food I eat	**0.27 (0.17, 0.36)**
8	Capability	I am confident that I can cook safe, health meals for myself and my family	Motivation	I'm someone who can get food poisoning	0.07 (-0.04, 0.17)

9	Capability	I am confident that I can cook safe, health meals for myself and my family	Motivation	I am worried that I may get sick if I eat a lunch that has sat out all day	-0.05 (-0.17, 0.07)
10	Motivation	Interest in learning about avoiding food poisoning	Behaviour	Overall behaviour score	-0.003 (-0.06, 0.06)
11	Motivation	Perceived personal susceptibility to food poisoning	Behaviour	Overall behaviour score	0.04 (-0.01, 0.09)
12	Motivation	Perceived personal threat of food poisoning	Behaviour	Overall behaviour score	**0.06 (0.01, 0.11)**
13	Motivation	Anyone can get sick with food poisoning, even me	Behaviour	Overall behaviour score	0.05 (-0.01, 0.12)
14	Motivation	I can change my food preparation habits	Behaviour	Overall behaviour score	0.01 (-0.04, 0.06)
15	Motivation	I have control over the food I eat	Behaviour	Overall behaviour score	-0.01 (-0.06, 0.04)

16	Motivation	I'm someone who can get food poisoning	Behaviour	Overall behaviour score	**-0.05 (-0.09, -0.01)**
17	Motivation	I am worried that I may get sick if I eat a lunch that has sat out all day	Behaviour	Overall behaviour score	**0.07 (0.03, 0.11)**

9. Conclusion

9.1 Research questions and summary of findings

The overall goal of this thesis was to explore what undergraduate students at the University of Waterloo think about food safety and what they do to prevent foodborne disease. Specifically, the objectives of this thesis were to measure students' personal interest in learning about avoiding food poisoning, perceived personal susceptibility to food poisoning, perceived personal threat of food poisoning, and other food safety attitudes, understand students' self-reported food safety behaviours, explore if behaviour change theories can be used to examine the relationship between attitudes and behaviours for typically collected attitude and behaviour measurements, and explore the relationship between students' attitudes and behaviours, in light of the findings from the previous objective. To accomplish this, data from an electronic, cross-sectional survey administered to undergraduate students at the University of Waterloo were analyzed.

Overall, undergraduate students at the University of Waterloo had positive food safety attitudes, similar to what was found by all previously conducted studies that examined the food safety attitudes of young adults (17,41,100,102–107,112). All but one of the food safety attitudes measured in this thesis ("anyone can get sick with food poisoning, even me") were significantly associated with one or more demographic and food skills and cooking experience characteristics.

Undergraduate students at the University of Waterloo also had good overall self-reported food safety behaviours, however the majority of previously conducted studies found that students had poor self-reported and observed food safety behaviours (17,41,99,101,102,104–106,108–113). Again, all but one of the self-reported food safety behaviours ("If I have a cut or sore on

my hand, I cover it before preparing food") were significantly associated with at least one of the measured demographic and food skills and cooking experience characteristics.

I determined that behaviour change theory can be used to examine the relationship between the food safety attitudes and self-reported behaviours collected for this study, and although the Theory of Planned Behaviour and the Health Belief Model had the most even distribution of attitude questions across the greatest number of theoretical constructs, many previously conducted studies have already applied the theories to food safety attitudes and behaviours of young adults (118–123,125,127). All of the attitude and self-reported behaviour questions mapped to constructs in the COM-B Model, and it had not yet been applied to food safety attitude and behaviour literature, so the COM-B Model was used to explore the relationship between food safety attitudes and behaviours of young adults.

Using the COM-B Model, I found that some of the measured food safety attitudes were significantly associated with self-reported food safety behaviours. The attitude questions that were significantly associated with self-reported food safety behaviours in the COM-B Model did not map to any of the constructs in the Temporal Self-Regulation Theory, but mapped to "behavioural beliefs" and "control beliefs" in the Theory of Planned Behaviour and "perceived susceptibility" and "self-efficacy" in the Health Belief Model. However, previously conducted studies found that "behavioural beliefs" and "control beliefs" were not significantly associated with self-reported food safety behaviours in the Theory of Planned Behaviour (118–121,123,125) and "perceived susceptibility" and "self-efficacy" were not significantly associated with self-reported food safety behaviours in the Health Belief Model (127).

9.2 Contributions of this thesis

To the best of my knowledge, this is the first study to examine the food safety attitudes and self-reported behaviours of exclusively young adults in Canada, and so it is the first study to explore what a sample of young adults in Canada think about food safety and what they say they do to prevent foodborne disease. This is also the only study that has examined the association between demographic and cooking skills and experience characteristics, other than gender or race (41,107), and both food safety attitudes and self-reported behaviours, which provides insight into the sub-groups of young adults that may have poor food safety attitudes and self-reported behaviours. In addition, this is the first study that has applied the newly developed COM-B Model (137,143) to food safety attitudes and self-reported behaviours, which provides a new way of thinking about the relationship between food safety attitudes and self-reported behaviours.

9.3 Limitations

This thesis is subject to several limitations. First, self-reported behaviours rather than observed behaviours were examined, and so results of the survey may been influenced by the social desirability bias. Students may have agreed or strongly agreed that they use the food safety behaviours in the survey because they know they should use them in order to protect themselves from foodborne disease, even though they actually do not use them while preparing, cooking, or storing food. Also, there are a limited number of validated food safety attitude and self-reported behaviour measurement tools available for use, so the results of this thesis may not be comparable to the results of other food safety attitude and self-reported behaviour studies that developed their own surveys, especially if the surveys were not validated. In addition, the pre-existing food safety attitudes and self-reported behaviours questionnaire used does not perfectly

align with the theoretical constructs in any of the previously applied behaviour change theories (118–123,125,127), as well as the COM-B Model (137,143), so the relationship between theoretical constructs important to food safety, such as social norms (118–121,123,125), and self-reported food safety behaviours were unable to be explored.

9.4 Future research and recommendations

Future research should build on this thesis by examining undergraduate students' observed food safety behaviours, in order to understand the food safety practices young adults actually use to protect themselves from foodborne disease. In addition, a new food safety attitudes and self-reported behaviours questionnaire should be created, using a selected behaviour change theory to guide the development of the questions, to ensure that the relationship between self-reported food safety behaviours and all the theoretical constructs in the selected behaviour change theory can be examined.

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Appendix A: Food safety attitudes and behaviours questionnaire

This survey was previously published in BMC Public Health and has been used in accordance with the CC-BY-NC-ND license.

Courtney SM, Majowicz SE, Dubin JA. Food safety knowledge of undergraduate students at a Canadian university: results of an online survey. BMC Public Health. 2016; 16:1147–63. Available from: doi: 10.1186/s12889-016-3818-y.

Food Safety Knowledge, Behaviours, and Beliefs among Undergraduate Students at the University of Waterloo

UNIVERSITY OF WATERLOO

University of Waterloo School of Public Health and Health Systems

Consent to Participate in Research ORE # 20347

Food Safety Knowledge, Behaviours and Beliefs in Undergraduate Students at the University of Waterloo

You are being asked to participate in a research study led by Sarah Courtney, BSc candidate, and advisor Dr. Shannon Majowicz from the School of Public Health and Health Systems, University of Waterloo. The results of this study will contribute to Ms Courtney's honours thesis. If you have any questions specific to the research, please feel free to contact Dr. Shannon Majowicz at (519) 888-4567 ext. 31790 or smajowicz@uwaterloo.ca.

Purpose of the Study

To investigate the food safety knowledge, behaviours, and beliefs in undergraduate students at the University of Waterloo.

Procedures

If you agree to participate in this study, we would ask you to complete a 15-20 minute internet survey, which includes some background questions about you, questions about food safety practices and procedures, and questions surrounding your thoughts about food safety. Your participation in this study is completely voluntary. Your responses will remain anonymous, such that you are not asked for your name or any identifying information. It is important for you to know that any information that you provide will be confidential. All of the data will be summarized and no individual could be identified from these summarized results. Furthermore, the website is programmed to collect responses alone and will not collect any information that could potentially identify you (such as machine identifiers). You may stop the survey at any time or skip any questions that you prefer not to answer without penalty. This survey uses "Hosted in Canada Surveys" which is a Canadian company. If you prefer not to submit your data through Hosted in Canada Surveys, please contact one of the researchers so you can participate using an alternative method such as through an email or paper-based questionnaire. The alternate method may decrease anonymity but confidentiality will be maintained.

The information collected in this study will be kept for 30 years, as this is the anticipated length of the researcher's career, because we also want to look at how knowledge of food and health may change over future generations. However, no personally identifying information will be collected. The data will be accessible only by the project researchers and will be kept in a password protected database.

the end of the survey, you will be directed to a new site where you can choose to enter your email address for the gift card draw. Information collected to draw for the prize(s) will not be linked to the study data in any way, and this identifying information will be stored separately, then destroyed after the prize(s) have been provided. The amount received is taxable. It is your responsibility to report this amount for income tax purposes.

The draw will occur in April 2015.

Rights of Research Participants

You may withdraw your consent at any time and discontinue participation without penalty by not submitting your responses. You are not waiving any legal claims, rights or remedies because of your participation in this research study. This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee. There are no known or anticipated risks associated with participation in the study. However, the final decision about participation in the study is ultimately yours. If you have questions regarding your rights as a research participant, contact Dr. Maureen Nummelin, Chief Ethics Officer at (519) 888-4567 ext. 36005 or maureen.nummelin@uwaterloo.ca.

Acceptance by Research Participant

Proceeding with the survey will indicate you accept our invitation to participate in the research project "Food Safety Knowledge, Behaviours and Beliefs in Undergraduate Students at the University of Waterloo" as described herein, and you are agreeing to participate in this study with the assurance that your responses will remain confidential.

There are 25 questions in this survey

Participant Consent

[]With full knowledge of all foregoing, I agree, of my own free will, to participate in this study. *

Please choose **only one** of the following:

- ○ I agree to participate.
- ○ I do not wish to participate (please close your web browser now).

Demographic Information

[]How old are you?

Only answer this question if the following conditions are met:
Answer was 'I agree to participate.' at question '1 [ACT] (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)'

Please choose **only one** of the following:

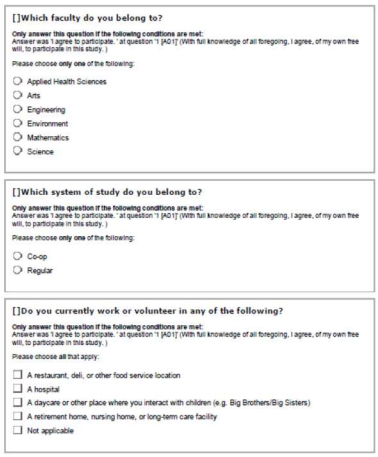
- 18 years or younger
- 19 years
- 20 years
- 21 years
- 22 years
- 23 years or older

[]Please select your gender.

Only answer this question if the following conditions are met:
Answer was 'I agree to participate.' at question '1 [ACT] (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)'

Please choose **only one** of the following:

- Male
- Female
- Other



[]Which faculty do you belong to?

Only answer this question if the following conditions are met:
Answer was '1 agree to participate. ' at question '1 [AD1]' (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)

Please choose **only one** of the following:

- Applied Health Sciences
- Arts
- Engineering
- Environment
- Mathematics
- Science

[]Which system of study do you belong to?

Only answer this question if the following conditions are met:
Answer was '1 agree to participate. ' at question '1 [AD1]' (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)

Please choose **only one** of the following:

- Co-op
- Regular

[]Do you currently work or volunteer in any of the following?

Only answer this question if the following conditions are met:
Answer was '1 agree to participate. ' at question '1 [AD1]' (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)

Please choose **all** that apply:

- A restaurant, deli, or other food service location
- A hospital
- A daycare or other place where you interact with children (e.g. Big Brothers/Big Sisters)
- A retirement home, nursing home, or long-term care facility
- Not applicable

[ ]If you checked any of the answers in (3), do you handle or prepare food in those places?

Only answer this question if the following conditions are met:
Answer was 'I agree to participate.' at question 'I [AD1]' (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)

Please choose **only one** of the following:

- Yes
- No
- Not Applicable

[ ]Have you ever taken a course where you are taught how to prepare food or meals (e.g. high school classes, university classes, food handler certification)?

Only answer this question if the following conditions are met:
Answer was 'I agree to participate.' at question 'I [AD1]' (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)

Please choose **only one** of the following:

- Yes
- No

[ ]How would you describe your ability to cook from basic ingredients?

Only answer this question if the following conditions are met:
Answer was 'I agree to participate.' at question 'I [AD1]' (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)

Please choose **only one** of the following:

- I don't know how to cook
- I can only cook food when the instructions are on the box (like Kraft® Dinner)
- I can do the basics from scratch (like boil an egg or make a grilled cheese sandwich) but nothing more complicated
- I can prepare simple meals if I have a recipe to follow
- I can cook almost anything

[ ]Where do you currently live?

Only answer this question if the following conditions are met:
Answer was 'I agree to participate.' at question 'I [ACT] (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)'

Please choose **only one** of the following:

- ○ Traditional-style residence (V1, REV, St. Jerome's, St. Paul's, Renison, Conrad Grebel)
- ○ Suite-style residence (MKV, UWP, CLV)
- ○ Off campus
- ○ At home

[ ]How often do you cook food or meals from basic ingredients?

Only answer this question if the following conditions are met:
Answer was 'I agree to participate.' at question 'I [ACT] (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)'

Please choose **only one** of the following:

- ○ At least once a day
- ○ A few times a week
- ○ A few times a month
- ○ A few times a year
- ○ Never

Food Safety Knowledge

[]Which procedure for cleaning kitchen counters is best?

Only answer this question if the following conditions are met:
Answer was 'I agree to participate.' at question '1 [A0-1]' (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)

Please choose **only one** of the following:

- Spray with a strong sanitizing solution
- Wash with a detergent, rinse, then wipe with a sanitizing solution
- Wipe with a sanitizing solution, then rinse with clean water and wipe dry
- Brush off any dirt or food pieces, then wipe with sanitizing solution

[]Which is the most hygienic way to wash your hands?

Only answer this question if the following conditions are met:
Answer was 'I agree to participate.' at question '1 [A0-1]' (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)

Please choose **only one** of the following:

- Apply sanitizer, run water, rub hands together for 20 seconds, rinse hands, dry hands, rub on an antiseptic hand lotion
- Apply soap, rub hands together for 20 seconds, rinse hands under water, dry hands, apply sanitizer
- Run water, moisten hands, apply soap, rub hands together for 20 seconds, rinse hands, dry hands
- Run water, moisten hands, apply sanitizer, rub hands together for 20 seconds, rinse hands, dry hands, rub on antiseptic hand lotion

[]Imagine that your electricity went off and the meat, chicken, and/or seafood in your freezer thawed and felt warm. What should you do?

Only answer this question if the following conditions are met:
Answer was 'I agree to participate.' at question 'I [A01]' (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)

Please choose **only one** of the following:

- ○ Throw them away
- ○ Cook them right away
- ○ See how they smell or look before deciding what to do
- ○ Immediately re-freeze until solidly frozen, then cook them

[]Which of the following is considered the most important way to prevent food poisoning?

Only answer this question if the following conditions are met:
Answer was 'I agree to participate.' at question 'I [A01]' (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)

Please choose **only one** of the following:

- ○ Spray for pests in the kitchen area at least every week
- ○ Rarely or never serve leftovers
- ○ Keep foods refrigerated until it's time to cook or serve them
- ○ Clean kitchen counters with sanitizing solutions weekly

[]If a family member is going to be several hours late for a hot meal, how should you store the meal to keep it safe until this person is ready to eat it?

Only answer this question if the following conditions are met:
Answer was 'I agree to participate.' at question 'I [A01]' (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)

Please choose **only one** of the following:

- ○ Store it in the refrigerator and reheat it when the person is ready to eat it
- ○ Store it in on the kitchen counter until the person is ready to eat it
- ○ Store it in a cool oven until the person is ready to eat it
- ○ Store it in a warm oven until the person is ready to eat it

[]All foods (except whole poultry) are considered safe when cooked to an internal temperature of:

Only answer this question if the following conditions are met:
Answer was 'I agree to participate.' at question '1 [A01]' (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)

Please choose **only one** of the following:

- 130 degrees Fahrenheit (54 degrees Celsius)
- 140 degrees Fahrenheit (60 degrees Celsius)
- 150 degrees Fahrenheit (66 degrees Celsius)
- 165 degrees Fahrenheit (74 degrees Celsius)

[]Which method is the best way of determining whether hamburgers are cooked enough?

Only answer this question if the following conditions are met:
Answer was 'I agree to participate.' at question '1 [A01]' (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)

Please choose **only one** of the following:

- Cut one to check the color of the meat inside
- Check the color of the juice to be sure it is not pink
- Measure the temperature with a food thermometer
- Check the texture or firmness of the meat
- Measure the length of time the hamburgers cook

[]To prevent food poisoning, how long should leftover foods be heated?

Only answer this question if the following conditions are met:
Answer was 'I agree to participate.' at question '1 [A01]' (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)

Please choose **only one** of the following:

- Until they are boiling hot
- Just until they are hot, but not too hot to eat right away
- Just until they are at least room temperature
- Reheating isn't necessary

[ ]Chilling or freezing eliminates harmful germs in food.

Only answer this question if the following conditions are met:
Answer was 1.agree to participate. ' at question '1 [AD1]' (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)

Please choose **only one** of the following:

- ○ True
- ○ False

[ ]Where do you think food safety problems are most likely to occur?

Only answer this question if the following conditions are met:
Answer was 1.agree to participate. ' at question '1 [AD1]' (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)

Please choose **all** that apply:

- ☐ Farms
- ☐ Food processing plants
- ☐ Warehouses
- ☐ Supermarkets
- ☐ Restaurants
- ☐ Homes
- ☐ Don't know

[ ]How long should leftovers be stored in the refrigerator?

Only answer this question if the following conditions are met:
Answer was 1.agree to participate. ' at question '1 [AD1]' (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)

Please choose **only one** of the following:

- ○ 1 to 2 days
- ○ 3 to 4 days
- ○ Up to 7 days
- ○ Base on look, smell, and taste of food

[]What are microorganisms?

Only answer this question if the following conditions are met:
Answer was 'I agree to participate.' at question '1 [A01] (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)'

Please choose **only one** of the following:

- Poisons that can contaminate our food and water
- Small living things that are too small to be seen with our eyes
- Small insects that we can see
- Large bugs that can land on our food and surfaces

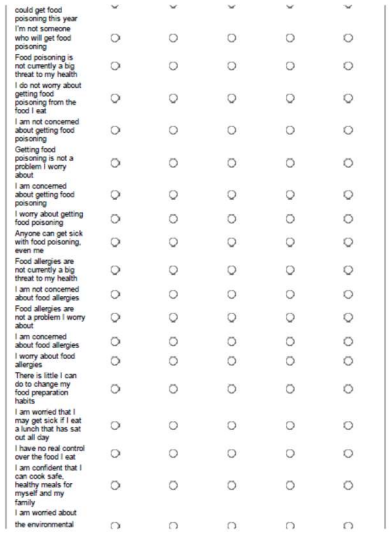
Food Safety Beliefs and Attitudes

[ ]Please read each question, and circle the answer that is the closest match to your own opinion.

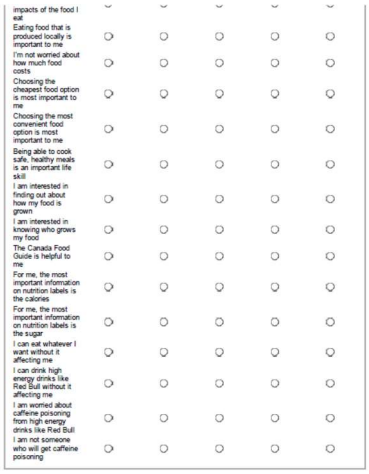
Only answer this question if the following conditions are met:
Answer was 'I agree to participate.' at question 'I [A1]' (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)

Please choose the appropriate response for each item:

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I am interested in finding out how to avoid food poisoning	○	○	○	○	○
It is not worth my time to learn about preventing food poisoning	○	○	○	○	○
I like learning about how to keep my foods safe to eat	○	○	○	○	○
It is of little use to me to learn about how to prevent food poisoning	○	○	○	○	○
I would like to learn about how to prevent food poisoning	○	○	○	○	○
I am interested in finding out how to read nutrition labels	○	○	○	○	○
It is not worth my time to learn about how to read nutrition labels	○	○	○	○	○
I like learning about how to choose nutritious foods to eat	○	○	○	○	○
It is of little use to me to learn about nutrition labels	○	○	○	○	○
I would like to learn about how to read nutrition labels	○	○	○	○	○
I believe that I could get food poisoning	○	○	○	○	○
I have a chance of getting food poisoning	○	○	○	○	○
It is possible that I	○	○	○	○	○



could get food poisoning this year					
I'm not someone who will get food poisoning					
Food poisoning is not currently a big threat to my health					
I do not worry about getting food poisoning from the food I eat					
I am not concerned about getting food poisoning					
Getting food poisoning is not a problem I worry about					
I am concerned about getting food poisoning					
I worry about getting food poisoning					
Anyone can get sick with food poisoning, even me					
Food allergies are not currently a big threat to my health					
I am not concerned about food allergies					
Food allergies are not a problem I worry about					
I am concerned about food allergies					
I worry about food allergies					
There is little I can do to change my food preparation habits					
I am worried that I may get sick if I eat a lunch that has sat out all day					
I have no real control over the food I eat					
I am confident that I can cook safe, healthy meals for myself and my family					
I am worried about the environmental					



impacts of the food I eat					
Eating food that is produced locally is important to me					
I'm not worried about how much food costs					
Choosing the cheapest food option is most important to me					
Choosing the most convenient food option is most important to me					
Being able to cook safe, healthy meals is an important life skill					
I am interested in finding out about how my food is grown					
I am interested in knowing who grows my food					
The Canada Food Guide is helpful to me					
For me, the most important information on nutrition labels is the calories					
For me, the most important information on nutrition labels is the sugar					
I can eat whatever I want without it affecting me					
I can drink high energy drinks like Red Bull without it affecting me					
I am worried about caffeine poisoning from high energy drinks like Red Bull					
I am not someone who will get caffeine poisoning					

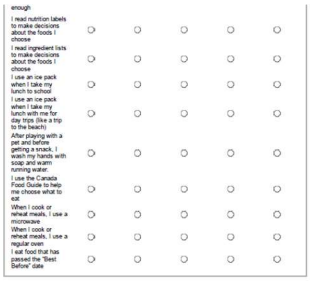
Food Preferences

[ ]These next questions are about food preferences and the ways you fix or prepare food. For each statement, select the answer that describes how you usually do things.

Only answer this question if the following conditions are met:
Answer was 'I agree to participate.' at question '1 [AD1]' (With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.)

Please choose the appropriate response for each item:

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I plan, or help plan, the meals in my household	○	○	○	○	○
Before preparing or handling food, I wash my hands with soap and warm running water	○	○	○	○	○
If I have a cut or sore on my hand, I cover it before preparing food	○	○	○	○	○
I wash the plate used to hold raw meat or chicken with hot soapy water before using it for anything else	○	○	○	○	○
I wash my hands with soap and warm running water after working with raw meat or chicken	○	○	○	○	○
I clean countertops with hot soapy water after preparing food	○	○	○	○	○
I refrigerate hot food within two hours of preparing and eating	○	○	○	○	○
I keep raw meat and chicken away from ready-to-eat foods like raw vegetables	○	○	○	○	○
I use a thermometer to check if meat or chicken has been cooked enough	○	○	○	○	○
I use a thermometer to check if leftovers have been reheated	○	○	○	○	○


enough

I read nutrition labels to make decisions about the foods I choose	○	○	○	○	○
I read ingredient lists to make decisions about the foods I choose	○	○	○	○	○
I use an ice pack when I take my lunch to school	○	○	○	○	○
I use an ice pack when I take my lunch with me for day trips (like a trip to the beach)	○	○	○	○	○
After playing with a pet and before getting a snack, I wash my hands with soap and warm running water.	○	○	○	○	○
I use the Canada Food Guide to help me choose what to eat	○	○	○	○	○
When I cook or reheat meals, I use a microwave	○	○	○	○	○
When I cook or reheat meals, I use a regular oven	○	○	○	○	○
I eat food that has passed the 'Best Before' date	○	○	○	○	○

If you would like more information about food safety, please go to:
http://www.regionofwaterloo.ca/en/safe/healthycommunity/foodsafety.asp
http://www.phac-aspc.gc.ca/fs-sa/index-eng.php

To enter into the draw, please click on the following link:

Submit your survey.
Thank you for completing this survey.