Food safety and Ontario high school students: assessing education needs and the utility of existing food handler training in improving behaviours

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

The manuscripts presented in this thesis, including three that have been submitted or published, are the work of Ken Diplock, in collaboration with his co-authors and committee members. Exceptions to sole authorship include:

Chapter 4: Diplock, K. J., Jones-Bitton, A., Leatherdale, S. T., Rebellato, S., Dubin, J. A., & Majowicz, S. E. (2017). Over-confident and under-competent: exploring the importance of food safety education specific to high school students. *Environmental Health Review*, *60*(3), 65-72.

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As lead author of these three chapters, I was responsible for conceptualizing study design, carrying out data collection and analysis, and drafting and submitting manuscripts. My co-authors provided targeted methodological guidance and feedback on draft manuscripts. Dr. Shannon Majowicz, Dr. Andria Jones-Bitton, and Dr. Scott Leatherdale provided overall direction and editorial guidance throughout. Key informant interviews were initially transcribed by a transcription service, then reviewed, anonymized and corrected by myself and two other research assistants (under Dr. Majowicz's guidance) to ensure accuracy and completeness of the transcripts. In concert with Dr. Majowicz, I modified the existing food handler checklist (Byrd-Bredbenner et al., 2007) to meet the needs of the study, including the addition of Ontario specific

food handling requirements. Research assistants, trained by myself and Dr. Majowicz, were used to observed food handling behaviours in each school.

ABSTRACT

Foodborne disease poses a significant risk to Canadians, with substantial health and economic burdens. In response, education is a common strategy used to increase food safety knowledge and promote safe food handling behaviours. Although youth are considered an important population for food safety education, the specific needs of high school students, and the ability of food safety education to improve food handling behaviours, are unknown. Thus, this thesis explored: (1) food safety education needs of high school students in Ontario; (2) the suitability of the Ontario Ministry of Health and Long-Term Care's (MOHLTC's) Provincial Food Handler Training program for meeting identified education needs; and (3) whether students' food handling behaviours changed following delivery of the MOHLTC's program. These objectives were addressed predominantly via two studies with findings reported in four manuscripts.

To explore students' food safety education needs, key informant interviews with 20 food safety and education experts were conducted. Transcripts of the audio-recorded interviews were analysed inductively, uncovering the nuanced food safety needs of students. High school was identified as an ideal time to instil safe food handling habits to meet students' personal needs and help reduce the burden of foodborne disease. Experts also agreed that students generally need the same food safety education content as other demographic groups, but stressed the importance of focussing on students' own common food handling experiences, including: the use of microwaves for reheating and cooking; consumption of convenience meals; school events; transportation of food for lunches, school trips and sporting events; and food allergen awareness. These findings demonstrate that food safety education is important for high school students, and suggest that existing food safety education material may be suitable for such education efforts.

To assess whether the MOHLTC program could meet the education needs of high school students, the program's content was mapped against food safety education needs identified by the key informant experts, and relevant objectives of the Ontario high school curriculum. All the education needs identified by the experts were met, except one: preventing injuries during food preparation. Injury prevention, classified under kitchen safety, is not typically included in food safety education, but is an important consideration for youth given their inexperience with food preparation and cooking. All relevant food safety objectives from the high school curriculum were covered by the MOHLTC material. Thus, the MOHTLC's program appears suitable for meeting the identified food safety education needs of Ontario high school students.

To evaluate whether safe food handling behaviours changed following delivery of the MOHLTC's program, a repeated measures study was conducted with students (n=119) from four Ontario high schools. Students were observed preparing meals at three times during a semester: prior to receiving the food safety education, within two weeks post-education, and approximately three months later at the end of the semester. Prior to receiving the education, on average students only engaged in half of the observed safe food handling behaviours. Post-education, all behaviour scores increased significantly ~2 weeks post intervention and remained unchanged ~3 months later. However, students continued to perform risky behaviours post-education, suggesting that a risk of foodborne disease remained. Future consideration of how psychosocial factors influence behaviours and norms, and how changes in food handling behaviours translates to actual risk of foodborne disease, is needed.

This thesis demonstrates – for the first time – the importance of food safety education for high school students, and provides evidence that delivering an existing food handler training

program within high school food and nutrition classes may be a feasible way to meet students' education needs and improve their safe food handling behaviours.

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List of Abbreviations

BSE	Bovine spongiform encephalopathy
CFIA	Canadian Food Inspection Agency
DALY	Disability-adjusted life years
HACCP	Hazard Analysis and Critical Control Points
HALY	Health-adjusted life years
MOHLTC	Ministry of Health and Long-Term Care
QALY	Quality-adjusted life years
WHO	World Health Organization

Chapter 1 : Background

Foodborne disease is a substantial international public health problem resulting in significant health (World Health Organization [WHO], 2015) and economic impacts (Majowicz, et al, 2006; McLinden et al., 2014). In Canada, one in eight Canadians experiences a domestically-acquired foodborne disease each year (Thomas et al., 2013). Contaminated food is the vehicle for the transmission of numerous 'agents' of disease, including bacteria, viruses, parasites, chemicals, and prions, resulting in sporadic cases and outbreaks of foodborne disease across the globe (Kirk et. al, 2015). The globalization of the food supply means that 'agents' of foodborne disease can move rapidly across international borders (Coulombier, & Takkinen, 2013). In response, governments, international bodies, and the food industry have established complex systems and dedicated significant resources to prevent foodborne disease. Strategies to prevent foodborne disease include: food safety legislation and regulation (e.g., Keener, Nicholson-Keener, & Koutchma, 2014); inspection of food operations (e.g., Petran, White & Hedberg, 2012); import control (e.g., Bosilevac et al., 2007); disease surveillance (e.g., Newell, et al., 2010; Shlundt, 2002); outbreak investigations (e.g., Savelli, Abela-Ridder, & Miyagishma, 2013); food recalls (e.g., Charlebois, Massow, & Pinto, 2015); and consumer and commercial food handler education (e.g., Egan et al., 2007; Hersch, Perdue, Ambroz, & Boucher, 2014; Husain at al., 2016; McIntyre, Peng, & Henderson, 2014; McIntyre et al., 2013; Milton & Mullan, 2010; Park, Kwak, Chang, 2010; Rebellato, Cholewa, Chow, & Poon, 2011; Redmond & Griffith, 2003; Seaman & Eves, 2010; Sivaramalingam et al., 2015; Young et al., 2015; York et al., 2009).

Symptoms of foodborne disease range from self-limiting diarrhea and vomiting, to long term complications, including hemolytic uremic syndrome, septicemia, hepatitis, neurological

and neuromuscular diseases including Guillain-Barré Syndrome, spontaneous abortion, meningitis, and death (Allerberger & Wagner, 2009; Baird-Parker, 1990; Keithlin, Sargeant, Thomas, & Fazil, 2014; Leclair et al., 2013). Everyone is susceptible to foodborne disease; however, certain populations, including the elderly (e.g., Belliot, Lopman, Ambert-Belay, & Pothier, 2014), pregnant women, young children (e.g., Kalyoussef & Feja, 2014), and the immunocompromised (e.g., Acheson, 2013), are at increased risk for both foodborne disease and serious complications.

Foodborne disease occurs when the foods we consume become contaminated with microorganisms, chemicals or physical hazards (e.g., metal or glass shards; Kleter, Pradini, Filippi, & Marvin, 2009). Microorganisms that cause disease are referred to as pathogenic organisms, or pathogens (Addis & Sisay, 2015). Contamination can occur at numerous steps in a food item's journey from the farm to our forks, including during manufacturing, processing, transportation, sale, and final preparation and consumption (Addis & Sisay, 2015). However, a considerable amount of foodborne disease is estimated to be caused by unsafe food handling in the home (Byrd-Bredbenner et al., 2013; Redmond & Griffith, 2003). For example, a review of campylobacteriosis, a bacterial foodborne disease, in Ontario found that nearly 50 percent of cases were attributed to food prepared in the home (Papadopoulos et al., 2013). Further, consumers, particularly youth and young adults, frequently implement unsafe food handling practices and engage in risky food handling behaviours, including eating raw egg products, and undercooked meat; making youth-based consumer food safety education and food handling behaviours critical control points for the prevention of foodborne disease (Abbot et al., 2012, Alterkruse et al., 1999; Haapala & Probart, 2004; Redmond & Griffith, 2003; Sanlier, 2009; Turconi et al., 2008).

Food safety education aims to improve food safety standards, reduce the risk of foodborne disease, and raise food handler awareness of food safety risks and safe food handling practices, by increasing food safety knowledge and promoting safe food handling practices (Egan et al., 2007). Traditionally, food safety education has been directed at food handlers working in commercial food premises (Egan et al., 2007; Husain at al., 2016; McIntyre, Peng, & Henderson, 2014; McIntyre et al., 2013; Park, Kwak, Chang, 2010; Rebellato et al., 2011; Seaman & Eves, 2010; York et al., 2009) or consumers including adults, young people, youth, and children (Hersch et al., 2014; Milton & Mullan, 2010; Redmond & Griffith, 2003; Sivaramalingam et al., 2015; Young et al., 2015). In Canada, food safety education is delivered in a variety of ways, including: food handler training programs (e.g., McIntyle et al., 2013; Rebellato et al., 2011), consumer messages at point of sale (e.g., Fischer, Frewer, & Nauta, 2006), food labelling requirements (e.g., Canadian Food Inspection Agency [CFIA], 2016), and government and non-government websites (e.g., Health Canada, 2012; Canadian Partnership for Consumer Food Safety Education, n.d.). Food safety education is also incorporated into Ontario's high school curriculum, as part of the elective Food and Nutrition courses (Ministry of Education, 2013).

Although not a traditional at-risk population, youth and young adults are of interest to food safety educators because they often work in the food industry (Haapala & Probart, 2004; Usalcas, 2005; Yarrow et al., 2009), and are, or will soon be, taking greater responsibility for food handling and preparation decisions for themselves and others (Burke & Dworkin, 2015). Young adults can be considered an at-risk population, given the marked increase in foodborne diseases often observed in individuals in their early 20's (e.g., Arthur, Gournis, McKeown, & Yaffe, 2009), which has been coined the 'second weaning' phenomenon (Kolling, Wu, &

Guerrant, 2012; Majowicz et al., 2004; Tauxe, Hargrett-Bean, & Patton, 1988; Waltner-Toews, 2008). This increase in foodborne disease in young adulthood, combined with youths' increasing food handling responsibilities, suggests that high school may represent an important but overlooked opportunity for primary prevention efforts via food safety education, in order to prevent future foodborne disease.

Chapter 2 : Literature Review

This literature review provides an overview of the population burden of foodborne disease, causes and risk factors for disease, risk settings and common food handling errors, at-risk populations (of which youth are an under-studied group), education strategies to prevent foodborne disease, factors associated with food safety behaviours, and youth based food safety education. Where possible, emphasis is placed on food safety issues in Canada, and Ontario.

Population burden of foodborne disease

Globally, the WHO (2015) estimates that in 2010, there were 600 million foodborne disease cases and 420,000 foodborne disease related deaths. A common measure of the burden of disease is the health-adjusted life years (HALY), which measures the gap between ideal health and actual health that incorporates both morbidity and mortality (e.g., Kwong et al., 2012). As described by Kwong et al. (2012), HALY is a broad term that encompasses the other burden of disease measures, including the quality-adjusted life years (QALY) used in health economics, and the disability-adjusted life years (DALY) used in the Global Burden of Disease Study. The global burden of foodborne disease caused by the 31 most common foodborne hazards (microbiological and chemical) in 2010 was 33 million DALYs (WHO, 2015). Norovirus was the leading cause of foodborne disease causing 125 million cases, while *Campylobacter spp*. caused 96 million cases (Kirk et al., 2015).

In Canada, there are an estimated 4 million cases of domestically-acquired foodborne disease each year (Thomas et al., 2013), resulting in over 11,000 hospitalizations and over 200 deaths (Thomas et al. 2015). The leading pathogens causing domestically-acquired foodborne disease in Canada are: norovirus (1 million cases per year), and the bacteria *Clostridium perfringens* (177,000 cases per year), *Campylobacter spp*. (145,000 cases per year), and non-

typhoidal *Salmonella spp* (88,000 cases per year; Thomas et al., 2013). Other pathogens of significance include the bacteria *Escherichia coli* (*E. coli*), *Listeria monocytogenes*, *Bacillus cereus*, *Staphylococcus aureus*, the viruses Hepatitis A, rotavirus, adenovirus, and astrovirus (Thomas, et al., 2013), and the parasites *Cryptosporidium*, *Cyclospora,* and *Giardia* (Dixon et al., 2013). In Ontario, there are an estimated 1.2 episodes of acute gastrointestinal illness per person-year (Sargeant et al., 2008), where acute-gastroenteritis is a proxy for foodborne disease. The Ontario Burden of Infectious Disease Study by Kwong et al. (2012), found a total of 348 HALYs per 100,000 population, for the most common bacterial and viral foodborne diseases, including *Campylobacter* (170 HALYs), *Salmonella* (81 HALYs), *Listeria monocytogenes* (36 HALYs), *E. coli* 0157 (31 HALYs), Hepatitis A (26 HALYs) and *Shigella* (4 HALYs). Norovirus was not included in the Ontario Burden of Infectious Disease Study due to lack of availability of reliable data (Kwong et al., 2012).

In addition to the burden described above, foodborne disease can also play a role in the spread of antimicrobial resistance (Manges & Johnston, 2012; Newell et al., 2010; Schlundt, 2002). Foodborne bacteria can develop resistance to antimicrobial drugs, making them harder to treat, and potentially increasing the burden of disease for humans (Newell et al., 2010; Schlundt, 2002). This developed resistance can be shared between and across different strains and species of bacteria, resulting in more antimicrobial resistant organisms (AROs; Newell et al., 2010; Schlundt, 2002). Food is an important infection route for a number of bacteria, including their antibiotic resistant strains, namely *Salmonella*, *Campylobacter*, *Shigella*, *Staphylococcus aureus*, and *E. coli* (Newell et al., 2010). A recent study of *E. coli* infections found that many of the strains associated with urinary tract infections, sepsis, and other extra-intestinal infections may be transmitted via the food supply, with many of these strains becoming multi-drug resistant

(Manges & Johnson, 2012). Opportunistic pathogens like *Staphylococcus aureus* and *E. coli* can enter the human gastrointestinal system through our food, and from there, move to other organ systems (Manges & Johnson, 2012). Many of these pathogens, including their antibiotic resistant strains, are significant contributors to the burden of disease in Ontario, including *E. coli* accounting for 7826 HALY or 8.8 percent of total HALY in Ontario, *S. aureus* accounting for 4140 HALY or 4.65 percent of total HALY, and *Clostridium difficile* accounting for 3323 HALY or 3.75 percent of the total population HALY for Ontario (Kwong et al., 2012).

Health consequences of foodborne disease

In the majority of foodborne disease cases, the acute symptoms tend to last hours to days, often subsiding with limited or no medical intervention (Addis & Sisay, 2015). However, foodborne disease can result in severe symptoms requiring medical attention, that can result in long-term illnesses, health complications, and even death, as described further below. The most common clinical symptoms of foodborne disease, common across many pathogens, are diarrhea, vomiting, abdominal cramps, headache, and nausea (Addis & Sisay, 2015). Symptoms experienced during a foodborne disease episode can often help identify the foodborne pathogen; for example, bloody diarrhea is an indicator of a verotoxigenic *E. coli, Salmonella*, or *Shigella* infection (Addis & Sisay, 2015), while vomiting is often an indicator of norovirus, *Bacillus cereus* (López, Minnaard, Pérez, & Alippi, 2015), or *Staphylococcus aureus* infections (e.g., Johler et al., 2015).

Foodborne disease pathogens can also result in a number of long term complications or sequelae that can dramatically impact quality of life and productivity, including: hemolytic uremic syndrome, septicemia, hepatitis, neurological and neuromuscular diseases including Guillan-Barré Syndrome, spontaneous abortion and meningitis (Allerberger & Wagner, 2009;

Baird-Parker, 1990; Keithlin, Sargeant, Thomas, & Fazil, 2014; Leclair et al., 2013). For example, sequelae of *E. coli* 0157 infection include reactive arthritis, hemolytic uremic syndrome, irritable bowel syndrome, inflammatory bowel disease, and Guillian-Barré Syndrome (Keithlin et al., 2014). *Salmonella* infections can result in septicemia in patients with underlying disease, as well as a host of sequelae in relatively healthy individuals, including pericarditis, neurological and neuromuscular diseases, as well as damage to the mucous membrane of the small intestine and colon, leading to malabsorption and nutrient loss (Baird-Parker, 1990). Hepatitis A viral infections can result in fulminant hepatitis or acute liver failure (Koopmans et al., 2002). Botulism, caused by a neurotoxin secreted by the bacterium *Clostridium botulinum*, is linked to improperly canned foods, and can result in paralysis, and even death (Leclair et al., 2013). Listeriosis, caused by the bacterium *Listeria monocytogenes*, can result in a severe invasive form, leading to sepsis, meningitis, or spontaneous abortions (Allerberger & Wagner, 2009).

Causes and risk factors for foodborne disease

There are two ways to conceptualize the causes of foodborne disease: the ‘agents’, i.e. those microorganisms, physical or chemical contaminants that can cause disease; and the ways in which these ‘agents’ enter the food chain. Physical contaminants include foreign objects, such as rocks and glass, that find their way into food and can cause damage if eaten (Kleter et al., 2009), while chemical contaminants include “undeclared allergens”, unapproved pesticides, and metals, such as lead in candy or mercury in fish (Kleter et al., 2009). This literature review focuses on microorganisms, the largest group of agents for reported foodborne disease in Canada, and the ways in which these microorganisms contaminate, directly or indirectly, the foods we eat.

The agents of foodborne disease

In Canada and other developed countries, foodborne disease is most often caused by pathogenic microorganisms, which include bacteria, viruses, parasites, and prions (WHO, 2015). These pathogens contaminate our food through a variety of routes, discussed in detail in the following section. In Canada, the foodborne pathogens of significance include, the bacteria *Clostridium perfringens*, *Campylobacter*, non-typhoidal *Salmonella*, *E. coli*, *Listeria monocytogenes*, *Bacillus cereus*, *Staphylococcus aureus*, the viruses norovirus, Hepatitis A, rotavirus, adenovirus, and astrovirus (Thomas, et al., 2013), and the parasites *Cryptosporidium*, *Cyclospora*, and *Giardia* (Dixon et al., 2013).

Foodborne disease can be categorized into two types: intoxication or infection. Foodborne intoxications are caused by the ingestion of toxins in the food, from bacteria, or from accidental chemical contamination (Addis & Sisay, 2015; Miles, Braxton, & Frewer, 1999). Botulism is an example of a foodborne intoxication caused by the ingestion of food contaminated with the botulinum neurotoxin, secreted by the bacterium *Clostridium botulinum* as it grows in food (Leclair et al., 2013). The botulinum neurotoxin attacks the nervous system resulting in impaired coordination, muscle weakness, vision problems, difficulty speaking, respiratory distress and potential death (Addis & Sisay, 2015). Foodborne infection occurs when a person eats food containing pathogens, which then impact the intestinal tract and cause illness (Addis & Sisay, 2015; Miles et al., 1999). Foodborne infections include infections with the bacteria *E. coli* and *Shigella* which secrete a toxin as they grow and develop in the digestive system, resulting in a variety of symptoms, including intestinal hemorrhage that can lead to bloody diarrhea (Addis & Sisay, 2015). In the case of *Listeria* and *Campylobacter*, it is the pathogenic organisms and

their interaction with cells and homeostatic balance of the digestive system that causes the symptoms associated with infections (Addis & Sisay, 2015).

Similar to humans, bacteria need certain conditions to grow and reproduce. Most pathogenic bacteria require a common set of growth conditions, including: nutrients, preferably a protein rich environment; neutral acidity, around a pH of 7; oxygen for cellular respiration; sufficient amount of time in order to grow and multiply; a warm environment, preferably close to body temperature (37°C); and moisture (e.g., Jackson, et al., 2009). These conditions are present in most of the foods we consume, especially fruits and vegetables, as well as cooked and pre-prepared foods. Fresh fruits and vegetables provide ideal growth conditions for pathogens, especially when they are peeled, cut, or sliced, which results in pathogens being moved from the outside of the food to the moist and nutrient rich 'flesh' of the food (Erickson, Liao, Cannon, & Ortega, 2015). Meats, including chicken, steak, ground meats (such as hamburger, tartare, and shwarma), and mixed foods containing meat (such as lasagna and chili) provide ideal conditions for the survival and growth of pathogens (Newell et al., 2010). Seafood that is intended to be consumed raw (such as sushi and oysters) is another high risk food, especially for viruses and parasites, as there is no cooking step to kill any pathogens that may be in the products (Iwamoto, Ayers, Mahon, & Swerdlow, 2010). Other foods, including cooked rice, pasta, and grains also provide suitable conditions for pathogen growth (e.g., Tschiedel et al., 2015).

The conditions for ideal growth vary between organisms. For example, the bacterium *Clostridium botulinum*, the microbial cause of botulism, is found in soil, and marine environments, and grows in the absence of oxygen (Proverbio, Lamba, Rossi, & Siani, 2016). It poses a significant risk in home-canned foods (e.g. mushrooms, asparagus), baked potatoes, fresh herbs and garlic in oil, and in Canada especially, in traditional Aboriginal foods, including

fermented fish eggs, and marine animal dishes (Leclair et al., 2013; Walton et al., 2014). These foods have neutral acidity and are stored in low oxygen environments (Leclair et al., 2013; Walton et al., 2014). Canning removes oxygen using sealed containers, baked potatoes are often wrapped in tin foil, garlic is often immersed in oil, and traditional Aboriginal foods are often wrapped and buried or sealed in tight containers as part of the aging and fermentation process (Leclair et al., 2013; Walton et al., 2014). These preparation processes provide suitable growth conditions for *Clostridium botulinum*, resulting in the accumulation of botulinum neurotoxin in the food product.

In contrast to bacteria, foodborne viruses, such as Norovirus, Hepatitis A, and adenovirus, and parasites, including *Cryptosporidium*, *Cyclospora*, and *Giardia*, do not grow in our food; instead, they use food as a transport vehicle between the environment and the susceptible host, namely humans (e.g., Dixon et al., 2013). Viruses and parasites are frequently transmitted through salads, fresh fruits, and vegetables, as there is often no cooking step prior to eating, which would be needed to kill most viruses and parasites (e.g., Dixon et al., 2013). However, viruses and parasites can be transmitted through cooked foods if the virus or parasite is introduced into the food after cooking, by cross-contamination through food handlers, dirty utensils, or juices from raw foods coming into contact with the cooked food (Koopmans et al., 2002). Once inside the host, they attack the digestive tract or migrate to other organs through the blood stream, causing various symptoms (Koopmans et al., 2002).

Prions are yet another category of pathogens. Prions are infectious proteins that cause degenerative neurological diseases in mammals, including: scrapie in sheep, chronic wasting disease in deer and elk, and bovine spongiform encephalopathy (BSE) in cattle (Prusiner, 2001). Ingestion of meat contaminated with the prion that causes BSE in cattle can result in

Creutzfeldt–Jakob disease in humans, a degenerative fatal brain disease that results in confusion, depression, forgetfulness, behaviour changes, impaired vision, and difficulty with voluntary coordination, which eventually progresses to dementia, coma and death (Ryou, 2007). The estimated incidence of Creutzfeld-Jakob disease is one in one million population worldwide (Prusiner, 2001), with approximately 30-40 Canadians dying from the disease each year (Public Health Agency of Canada, 2016). Current estimates indicate that two percent of Cruetzfeld-Jakob cases in Canada are the variant form of BSE likely transmitted through food, while over 90 percent are sporadic non-variant cases (Public Health Agency of Canada, 2012).

Sources of foodborne disease pathogens

Sources of foodborne disease pathogens can be categorized into three groups: zoonoses, environmental, or human-to-human. The majority of foodborne diseases are zoonotic, originating from a wide range of animals, including livestock, pets, and wildlife (David et al., 2014). Many pathogens are naturally found in the intestinal tracts of animals including: the bacteria *E. coli* in cows; *Salmonella* and *Campylobacter* in chickens (Addis & Sisay, 2015); the parasites *Trichinella spiralis* in pigs and wild game (Robertson et al., 2014); *Toxoplasma gondii* in cats (Robertson et al., 2014), and *Giardia* in muskrat or beaver (Heitman et al., 2002). Prions, including BSE, are found in the central nervous system (brain and spinal cord) of numerous animal species including sheep and cattle (Prusiner, 2001). Contamination of the edible meat often occurs during slaughter when feces in the digestive tract, or in the case of prions, infected brain or spinal cord matter (Anil, Love, Helps, & Harbour, 2002), is transferred to the processing equipment, wash water, or directly to the meat (Konstinos, Drosinos, & Zoipoulos, 2014). Pathogens can also contaminate our food through exposure from the environment. Many pathogens exit their animal or human host through feces, saliva, or other bodily fluids, and can

survive in the environment for extended periods of time, eventually contaminating our food through soil, water, or dirty equipment (e.g. Addis & Sisay, 2015; Robertson et al., 2014). Other pathogens are considered ubiquitous, meaning they are commonly found in the environment, as is the case with *Clostridium botulinum* in soil (Leclair et al., 2013), and *Listeria monocytogenes* (Currie et al., 2015) in food processing plants. There are also pathogens that are unique to humans, for example, the bacterium *Salmonella typhi* and the virus Hepatitis A. These pathogens, similar to animal and environmental derived pathogens, spread from one person to another through the fecal-oral route, often through food or water contaminated with infected fecal material (e.g., Kanji et al., 2015; Kosak et al., 2013).

Routes of contamination

There are several transmission routes for pathogens to get from their host reservoirs (animals, environment, and other humans) and into humans, including via food (termed 'foodborne'), water (termed 'waterborne'), direct contact with animals, contact with infected people (Newell et al., 2010), and indirect contact (e.g., fomites; Boone & Gerba, 2007). Here, emphasis is on the direct and indirect routes of foodborne contamination. Direct contamination occurs when raw food or raw food juices contact ready-to-eat food (e.g. a thawing steak in a leaky bag dripping onto a pre-made sandwich in the refrigerator). Indirect contamination, most commonly called cross-contamination, occurs when pathogens pass from the source, such as raw chicken, to the food, such as salad, through something else, such as dirty knives and cutting boards (e.g., Erickson et al., 2015).

Contamination can occur at all levels of food production, manufacturing, preparation, and consumption, from farm to fork. Contamination of fruits and vegetables can occur in the fields through contaminated irrigation water (Brassard, Gagné, Généreux, & Côté, 2012), wild animals

and animal feces (e.g., grazing animals and birds; Laidler et al., 2013), as well as through unsanitary practices on farm, including workers defecating in the field and not properly washing hands regularly while working, and dirty equipment (Kosak, MacDonald, Landry, & Farber, 2013). Surveillance studies have detected parasitic organisms and viruses in irrigation water, linking irrigation water as a source of contamination for irrigated foods (Kosak et al., 2013). Contamination of fresh fruit and vegetables, through poor food handler hygiene, dirty equipment, and contaminated irrigation water, is an important consideration as these foods rarely undergo cooking, a step that could eliminate pathogens (Brassard et al., 2012; Dixon et al., 2013; Kozak et al., 2013). Contamination can also occur in food processing, through contaminated equipment; for example, the 2008 *Listeria monocytogenes* outbreak in Canada was linked to ready-to-eat meats processed at an Ontario meat processing plant (Currie et al., 2015). Foods may also become contaminated in transport from the farm to the processor, or from the processor or manufacturer to the restaurant or grocery store, through dirty equipment and unsanitary storage conditions (Kosak et al., 2013). Contamination can also occur at the retail level, including at the grocery store, farmers market, or other food distributor facilities, through contaminated surfaces, dirty equipment, and unhygienic food handling (e.g., Currie et al., 2007; Lunden, 2013). Lastly, contamination and the resulting foodborne disease often occurs in the final handling and preparation of food, either at home or in commercial kitchens (Medeiros, Hillers, Kendall, & Mason, 2001a; Redmond & Griffith, 2004; Vrbova, Johnson, Whitfield, & Middleton, 2012). A review by Byrd-Bredbenner et al. (2013) estimates that foodborne disease is linked to the home environment in one-third to as much as ninety-five percent of foodborne disease cases. Estimates varied depending on method of estimation; lower estimates were based on case follow-up and

higher estimates were based on expert opinion factoring in sporadic, mild, unconfirmed, and unreported cases (Byrd-Bredbenner et al., 2013).

Risk settings and common food handling errors

Risk settings for acquisition of foodborne disease include: food premises (e.g., restaurants, grocery stores, fast-food outlets, catered events, cafeterias, health care institutions and day cares), private homes, travel, and environmental (e.g., water, and animal exposure; Vrbova et al., 2012). In Ontario, the commonly reported exposure settings for foodborne disease cases are private homes and food premises (Vrbova et al., 2012). This review focuses on homes as a risk setting, given the large percentage of foodborne disease attributed to home-based food (e.g., Byrd-Bredbenner et al., 2013; Vrbova et al., 2013; Redmond & Griffith, 2003), reported poor food handling skills and lack of food handling experience in many homes (Al-Sakkaf, 2015; Byrd-Bredbenner et al., 2013; Milton & Mullan, 2010; Nesbitt et al., 2014; Redmond & Griffith, 2003), and the high frequency of meal consumption and preparation within the home environment, as reported in a 2008 food consumption study in the Region of Waterloo, Ontario (Nesbitt et al., 2008). For these reasons, the home environment is one of the last and most important lines of defence against foodborne disease (Redmond & Griffith, 2003).

Specific examples of risks for foodborne disease within home settings include fresh fruits and vegetables, as well as meats, including those prepared outside such as, on the barbeque, spit, or other form of outdoor cooking. Canadians have one of the highest per capita consumption rates for fruits and vegetables in the world (Kozak et al., 2013). In the period between 2001 and 2009, there were 27 outbreaks in Canada linked to produce, resulting in 1549 cases; the majority of the outbreaks were linked to bacteria including *Salmonella*, *Campylobacter*, and *E. coli*, with the remainder linked to parasites and viruses (Kozak et al., 2013). In 2011, 29 out of 59 people

attending a pig roast in a southwestern Ontario town became ill with gastrointestinal symptoms; 11 cases tested positive for *E. coli* 0157, which was linked to the roast pig being served (Trotz-Williams et al., 2012). An investigation concluded that the foodborne disease was most likely due to temperature abuse during preparation of the roast pig, meaning that the pig was either not cooked to a high enough temperature, not cooled properly, or that leftovers were not reheated to the original cooking temperature (Trotz-Williams et al., 2012).

Common food handling mistakes among consumers include poor hygiene, poor prevention of cross-contamination, inadequate temperature control of food, not using a thermometer to check cooking temperatures, and consumption of risky foods (e.g., Medeiros et al., 2001a; Nesbitt et al., 2009; Patil, Cates, & Morales, 2005). A review of consumer food safety studies by Redmond and Griffith (2003) stated that the majority of respondents, including those from at-risk populations, reported risky food handling behaviours, including: eating raw foods of animal origin (e.g., undercooked hamburger, and raw, uncooked, or runny eggs or egg products); using the same knife or cutting board to prepare raw meats and ready-to-eat foods; and failing to use a probe thermometer to determine cooking temperatures of meat. In the same review, when looking at results from observational studies, even more risky behaviours were identified, namely: only 6 percent of consumers adequately washed hands after handling raw meat; 17 percent of home-made chicken salads prepared in a model domestic kitchen tested positive for *Campylobacter*, a sign of cross-contamination; salad vegetables were not washed prior to preparation; knives and cutting boards were not cleaned between raw meat and ready-to-eat products; 93 percent of consumers relied on visual indicators to determine doneness of meat, instead of using a probe thermometer; and 24 to 47 percent of consumers used improper cooling procedures for leftovers. Similarly, in a review of Canadian consumers' self-reported food

safety behaviours, Nesbitt et al. (2014) found: over 40 percent reported eating undercooked eggs; 6 to 35 percent consumed raw egg products including raw cookie dough; 8 to 26 percent consumed raw fish, 44 percent consumed sushi, and 6 to 16 percent consumed raw shellfish; and 8 percent consumed undercooked hamburgers. To date, there are no direct observational food safety behaviour studies in any Canadian populations.

At-risk populations, and youth as a population of interest

Foodborne disease does not impact everyone equally; vulnerable populations, namely the elderly, young children, and the immunocompromised, are at greater risk of contracting foodborne disease and of suffering more severe health outcomes (Addis & Sisay, 2015). For example, young children with an *E. coli* 0157 infection are at greater risk of hemolytic uremic syndrome and permanent kidney damage or failure than older populations, resulting in impaired renal function and potential need for a kidney transplant (Sockett et al., 2014). Pregnant mothers and their unborn children are also at increased risk of foodborne disease, specifically *Listeria monocytogenes*, which can cause stillbirths and miscarriages (Allerberger & Wagner, 2010).

Youth are not traditionally considered an at-risk population because of their general good health and lower rates of foodborne disease (e.g., Keegan et al., 2009; Vrbova et al., 2012) when compared to other groups, including the vulnerable groups mentioned above. However, there is evidence of increased foodborne disease rates in young adults aged 20 to 25 years, deemed the "second-weaning" phenomenon (Kolling et al., 2012; Majowicz et al., 2004; Tauxe et al., 1988; Waltner-Toews, 2008). In Canada, this spike has been seen in cases of campylobacteriosis (Papadopoulos et al., 2013) and overall gastrointestinal illness (Arthur et al., 2009; Majowicz et al., 2004; Majowicz, Horrocks, & Bocking, 2007; Thomas et al., 2006). It is hypothesized that this spike in foodborne disease may be attributed to young adults leaving home, being primarily

responsible for their own food preparation for the first time (hence the term 'second weaning'), and not properly handling, cooking or storing foods, resulting in illness (Majowicz et al., 2004).

In addition to an increased risk of disease in young adults, youth and young adults may be an important population to consider when conceptualizing risk, because they are, or will soon be, taking greater responsibility for food handling and preparation decisions for themselves and others, including caring for elderly, immunocompromised family members, younger siblings and even their own children (Burke & Dworkin, 2015). Food handling appears to shift over age groups, from helping make meals and snacks in middle school (Haapala & Probart, 2004), to being solely responsible for food preparation in college (Green & Knechtges, 2015), such that youth are developing and expanding their food handling skills and experiences. Also, youth and young adults are commonly employed in the food service industry, with food service work ranging from 6 percent of middle school students (Grade 8) (Haapala & Probart, 2004), 12 percent of high school students (aged 16-19) (Burke and Dworkin, 2015), to over 90 percent of college health majors (aged 21-49) (Yarrow et al., 2009). Youths' frequent employment in the food service industry means they are responsible for preparing and serving food to the general public, which includes at-risk populations.

Studies looking at middle school, high school, and college students, in the United States, United Kingdom, Australia, and Italy, illustrate that young people have poor food safety knowledge (e.g., Abbot et al., 2009; Burke & Dworkin, 2015; Endres, Welch, & Perseli, 2001; Green & Knechtges, 2015; Haapala & Probart, 2004; Lynch et al., 2008; Majowicz et al., 2015; Mullan et al. 2015; Turconi et al., 2008; Sanlier, 2009; Quick et al., 2013; Yarrow et al., 2009), lack safe food handling experience and skills (Nesbitt, et al., 2009; Abbot et al., 2012; Haapala & Probart, 2004; Morrone & Rathbun, 2003), and engage in risky food handling practices,

including: tasting food to see if it is safe; eating undercooked meats; eating raw eggs and products made from raw eggs; failing to put leftovers in the refrigerator; failing to wash hands before eating foods at school; and eating foods that have been left lying out at room temperature for longer than the recommended two hour limit (Abbot et al., 2012, Alterkruse et al., 1999; Haapala & Probart, 2004; Sanlier, 2009; Turconi et al., 2008). Studies have found that youth report routinely washing hands before handling food at home, including before handling raw meat or ready-to-eat products (Majowicz et al., 2015; Sanlier, 2009; Turconi et al., 2008), but less frequently report handwashing before eating foods at school (Sanlier, 2009). Additionally, youth regularly report routinely separating raw foods from ready-to-eat foods (Majowicz et al., 2015).

Youths' emerging roles as food handlers is worrisome given that food skills and nutrition knowledge among youth have diminished in recent years, due to decreased mentoring of food skills at home (Slater, 2013), and lack of exposure to food and food handling, often due to busy parents not involving others (including youth and young adults) in food preparation (Began, Chapman, D'Sylva, Bassett, 2008; Larson et al., 2006A; Tyrrell et al., 2015). Given that adults' food safety knowledge and practices are often inadequate and sometimes inconsistent (Mullan & Milton, 2010; Patil et al., 2005), the danger of youth learning unsafe practices and then putting themselves and others at risk is also present. Therefore, when it comes to food safety, youth should be considered an at-risk population based on increased rates of certain foodborne diseases, poor food safety knowledge, low food safety attitudinal scores, risky food handling behaviours, and their emerging roles in caring for other at-risk groups, including the elderly and young children.

Types of food safety initiatives

Food safety initiatives encompass the activities undertaken by government agencies, schools, the food and agricultural industries, and non-government organizations directed at the control and prevention of foodborne disease. In Canada, as in most of the developed world, food safety initiatives exist at every stage of the farm-to-fork continuum, and encompass all the steps and handling of food, including where it is grown, processed, manufactured, prepared, and eventually consumed (Keener et al., 2013). In Canada, there are extensive food safety initiatives at all stages, including: on-farm policies and best practices (Keener et al., 2013), food labelling requirements (CFIA, 2016), safe food legislation (Keener, Nicholson-Keener, & Koutchma, 2013), and food safety education (e.g., McIntyle et al., 2013; Rebellato et al., 2011). These practices and standards are consistent with other countries, which is necessary to permit the extensive international trade of food commodities (Keener, Nicholson-Keener, & Koutchma, 2013).

Most existing food safety initiatives have been focused on the food producer, including farmers and manufacturers, as well as on commercial food preparation (Keener, Nicholson-Keener, & Koutchma, 2013; Winickoff & Bushey, 2010). Farm level and food production interventions align with consumer perceptions that foodborne disease is most often caused by food prepared outside of the home (Nesbitt et al., 2014). However, a significant proportion of foodborne disease can be attributed to food handling mistakes with home prepared foods (Byrd-Bredbenner et al., 2013; Papadopoulos et al., 2013; Redmond & Griffith, 2003). The next sections of this literature review focus on food safety education as a foodborne disease prevention strategy, with emphasis on both consumer and youth based food safety education.

Food safety education: a strategy to prevent foodborne disease

The goals of food safety education are to improve food safety standards, reduce the risk of foodborne disease, and raise food handler and consumer awareness about food safety risks and proper safe food handling practices (Al-Sakkaf, 2013). Food safety education efforts typically aim to encourage desirable safe food handling practices and to discourage improper or unsafe practices (Al-Skkaf, 2013). Food safety education aims to increase food handler knowledge and improve food safety attitudes, with the belief that increased knowledge and improved attitudes will result in the adoption of good food handling behaviours, leading to the prevention of foodborne disease (Al-Sakkaf, 2013). Food safety education is delivered in a variety of ways, including: food handler training certification programs (e.g., McIntyle et al., 2013; Rebellato et al., 2011), consumer messages at point of sale (e.g., Fischer et al., 2006), food labelling requirements (e.g., CFIA, 2016), government and non-government websites (e.g., Health Canada, 2012; Canadian Partnership for Consumer Food Safety Education, n.d.); and via school curriculum (primarily high school and post-secondary culinary or nutrition programs; e.g., Ministry of Education, 2013).

Typically, food safety education is directed at individuals working in commercial food premises (e.g., Egan et al., 2007; Manes, Liu, & Dworkin, 2013; Mathias et al., 1995; McIntyre et al., 2013; McIntyre et al., 2014; Rebellato et al., 2011; Seaman & Eves, 2009; & York et al., 2009), vulnerable populations (i.e., the elderly, immunocompromised, and caregivers of the very young; e.g., Arnold & Sobal, 2000; Feng, Bruhn, & Marx, 2016; Finch & Daniel, 2005; Trepka et al., 2008), and consumers (Milton & Mullan, 2010; Young et al., 2015). However, young people, ranging from pre-teens to young adults, have also been specifically targeted for food safety education; of specific interest have been low income and vulnerable youth (Thomas &

Irwin, 2011; Townsend, Johns, & Shilts, 2006), students kindergarten through grade 12 (K-12)(Chapin et al., 2015; Dzubak et al., 2016), primary school students (Lasasso et al., 2013), middle school students (Byrd-Bredbenner, Abbot, & Quick, 2010; Lynch et al. 2008; Kim et al., 2012; Ovca et al., 2016; Quick et al., 2013; Zhou et al., 2014), high school students (Beffa-Negrini et al., 2007; Burke & Dworkin, 2016; Endres, Welch, & Perseli, 2001; McCurdy, Schmiege, & Winter, 2008; Shearer, Snider, & Kniel, 2013; Shearer, Snider, & Kniel, 2014), and college students (Abbot et al., 2012; Byrd-Bredbenner et al., 2008; Milton & Mullan, 2012; Mullan & Wong, 2010; Stein, Dirks, & Quinlan, 2010; Yarrow, Remig, & Higgins, 2009).

In contrast to studies involving middle school and college students, there are limited studies focused on high school students and the effect of food safety education on knowledge, practices or attitudes. Four high school based studies focussed on preparation and evaluation of teaching material for high school students (Beffa-Negrini et al., 2007; Burke & Dworkin, 2016; McCurdy et al., 2008; Shearer, Snider, & Kniel, 2013). Endres et al. (2001) used multi-media touch screen kiosks to assess food safety knowledge and convey food safety information to teachers and students. While teachers answered more questions correctly, both teachers and students often provided incorrect answers on critical food safety information including handwashing, sources of foodborne illness, and handling of leftovers. One study (Shearer, Snider, & Kniel, 2014) reported a positive change in students' food safety knowledge scores following a classroom food safety education lesson. McCurdy et al. (2008) reported higher food safey knowledge scores with classes using music parodies to support food safety education. While, Burke and Dworkin (2016) reported improved food safety knowledge and self reported beahviors following use of a comicbook based food safety education program.

In Ontario, a principal method of food safety education is the food handler training certification programs offered through Ontario's public health units, private training companies, and food industry employers. These programs predominantly target commercial food handlers. Public health recognizes the importance of food safety education, with a number of boards of health making or considering mandatory food handler certification for food premises (e.g., Regional Municipality of Niagara, 2010). In 2013, Ontario's Ministry of Health and Long-Term Care (MOHLTC) selected an existing food handler training program, consisting of a 155-page manual (MOHLTC, 2013) and 175-slide Power-Point presentation (Windsor-Essex County Health Unit, 2009), to be Ontario's provincial food handler training program model. This program is available, free of charge, for public health units to use in part or as a whole to deliver food safety education sessions, promoting a consistent and standardized food safety education program. In a study of predominantly commercial food handlers, Rebellato et al. (2011) found that York Region's PROTON food handler certification program, similar to the MOHLTC food handler training program, positively impacted participants' knowledge, attitudes, and self-reported food handling behaviours immediately after the training, suggesting that the food safety education program was effective at least in the short term (one month later). To date, there are no published reports on the effectiveness of the MOHLTC food handler training program in the short- or long-term.

Food safety education has been shown to improve food safety knowledge, attitudes, and safe food handling behaviours under certain circumstances. Reviews of consumer food safety education (Milton & Mullan, 2010; Young et al., 2015; Sivaramalingam et al., 2015) indicate improved food safety knowledge, attitudes and behaviours post-intervention. However, the reviews also identified heterogeneity across the studies' methods, resulting in a reduced

confidence in the overall findings of positive change. Further, Milton and Mullan (2010) found that significant consumer knowledge, attitude and behaviour gaps often remained post-intervention. This is consistent with Nesbitt et al.'s (2014) systematic review of consumer food safety practices in Canada, which identified significant gaps in consumers' applications of the key food safety guidelines, '*Clean, Separate, Chill and Cook*' advice from the Canadian Partnership for Consumer Food Safety Education (n.d.), and the WHO's '*five keys to safer food*': 1) keep clean, 2) separate raw and cooked, 3) cook thoroughly, 4) keep food at safe temperatures, and 5) use safe water and raw materials (2006). The Canadian Partnership for Consumer Food Safety Education and the WHO's recommended food safety practices are consistent with the literature that identifies personal hygiene (hand washing, not preparing food when sick, etc.), adequate cooking, use of a probe thermometer to check cooking temperatures, and avoiding cross-contamination as the key food safety emphases for youth and consumer food safety education efforts (Medeiros et. al, 2001; Abbot et al., 2009; Haapala & Probart, 2004; Yarrow et al., 2009; Byrd-Bredbenner, et al., 2010).

Similar to the consumer based food safety education studies outlined above, food safety education targeted at young people has been shown to improve knowledge and self-reported behaviours (Dzubak et al., 2016; Ovca et al., 2016; Zhou et al., 2016). Dzubak et al. (2016) found an increase in knowledge, attitudes, confidence, and intentions to improve safe handling after delivery of on-line, school garden based, food safety education for K-12 and college students. In a study of the effectiveness of workshop-based food safety education for primary school children, targeting barriers to control microbial hazards in domestic kitchens, Ovca et al. (2016) found that increased awareness of food safety-risks, as well as improved food safety knowledge and self-reported behaviours post intervention. Further, Ovca et al. (2016) noted that

food safety improvements became more significant if delivered with a practical activity (e.g., food preparation) in comparison to food safety messages delivered only orally. In a study of middle school students (grades 5 through 8) in China, Zhou et al. (2016) found improved food safety scores post intervention immediately following the intervention and at nine-months follow-up. Currently, there is no food safety based research targeted specifically to high school students in Ontario.

In a review of consumer food handling, Redmond and Griffith (2003) found that improvements in knowledge, attitudes, and self-reported behaviours did not correspond to observed food handling behaviours; specifically, direct observation revealed poor hand washing, and failure to use a thermometer to check cooking and reheating temperatures of potentially hazardous food. Further, Kendall et al. (2004) reported that only half (51 percent) of the 70 participants in an observational study of recent nutrition education program graduates correctly washed hands with soap and running water between working with raw hamburger and slicing a tomato, while less than a half (35 percent) washed their hands after slicing raw chicken and before slicing an apple for eating. These are clear examples of opportunities for cross contamination where microorganisms, such as *E. coli*, *Salmonella*, and *Campylobacter*, could be transferred from the raw meats into ready-to-eat foods, resulting in foodborne disease. These findings demonstrate that current food safety education efforts may not result in desired food handling behaviour changes.

Factors associated with food safety behaviours

A number of factors related to poor adoption of safe food handling behaviours by consumers have been identified, including: low risk perception, low sense of susceptibility, optimistic-bias, heuristics, and habitual practices. The application of behaviour change theories

may be useful in understanding the influence of these factors in the adoption of safe food handling behaviours, particularly with youth. The following sub-sections will address topics of risk perception, optimistic-bias, heuristics, and habitual practices and discuss their influence on food handling behaviours.

Risk perception and safe food handling behaviours

One of the key determinants for taking action related to safe food handling behaviours is risk perception (Fischer & Frewer, 2008; Miles & Scaife, 2003). In order for consumers to take action, they must first believe they are susceptible to foodborne disease, and that they are capable of taking action to prevent it (Schafer et al., 1993; Takeuchi et al., 2005; Byrd-Bredbenner et al., 2013). Consumers often underestimate the risk associated with foods prepared in the home, resulting in poor food handling behaviour (Miles & Scaife, 2003; Redmond & Griffith, 2004; Sivaramalingam et al., 2015). Many consumers do not believe that they can contract foodborne disease through foods prepared at home (Redmond & Griffith, 2003; Nesbitt et al. 2009, 2014), a phenomenon known as optimistic-bias (Fisher & Frewer, 2008; Redmond and Griffith, 2003); for example, only 9 to 23 percent of British, U.S., and Canadian consumers perceive their homes as a likely source for foodborne disease (Redmond & Griffith, 2003).

Young people appear to have a low perceived susceptibility to foodborne illness, meaning they do not see foodborne illness as a risk to their personal health (Green & Knetchges, 2015; Haalapa & Probart, 2004), due to a sense of invincibility, and lack of awareness around the consequences of foodborne disease (Byrd-Bredbenner et al., 2010). These findings are consistent with results of Milton and Mullan's (2010) systematic review that found that consumers do not believe foodborne disease is a common issue, despite acknowledging the importance of food safety behaviours. In addition, young people often engage in risky eating behaviours, like eating

raw or undercooked foods of animal origin (Byrd-Bredbenner et al., 2008; Nesbitt et al., 2009; Patil et al., 2005), and feel less responsible for their own food choices (Tyrell et al., 2015) and food safety (Redmond & Griffith, 2003). Both the sense of invincibility and engagement in risky food handling behaviour may stem from youths' developmental stage, where asynchronous development of various structures and functions in the adolescent brain result in increased risk taking (Smith, Chein, & Steinberg, 2013). Consistent with this, a number of psychosocial factors have been linked to poor food safety behaviours, including low perceived behavioural control (Mullan & Wong, 2010; Mullan, Wong & Kothe, 2013), low perceived susceptibility (Haapala & Probart, 2004), and learned habits (i.e., past behaviours; Chow & Mullan, 2009; Haapala & Probart, 2004; Byrd-Bredbenner et al., 2010).

Heuristics, habit formation, and safe food handling behaviours

Consumers often rely on heuristics or mental shortcuts to make decisions, especially with high frequency tasks like daily food handling, which also has low perceived risks for foodborne disease (Fischer & De Vries, 2008). An example of a common food handling heuristic is, 'meats are cooked when the juices run clear', ignoring the fact that a meat thermometer is the only reliable way to ensure meat is cooked to a safe temperature (Fischer & De Vries, 2008). The poor food handling behaviour is reinforced each time the low effort practice (i.e., meat juice running clear) results in the desired outcome, a tasty meal without symptoms of foodborne disease (Fischer & De Vries, 2008). Conversely, heuristics can be beneficial for food safety practices, such as: bad smelling foods indicate spoilage; 'when in doubt, throw it out'; and do not use the same cutting board for vegetables and raw meat.

Problems occur when the heuristics circumvent safe food handling practices in order to increase the efficiency of the process and make it less mentally taxing on the individual (Fischer

& De Vries, 2008). Safe food handling practices, especially hand hygiene, washing of ready-to-eat foods, and using a probe thermometer are seen by commercial and home-based food handlers as time consuming steps that can be hard and can slow down food preparation (e.g., Clayton, Griffith, Price, & Peters, 2002). Given the high frequency of general food handling practices and consumers' low risk perception of home-based foods, there is a high likelihood of consumers developing habitual poor food handling behaviours based on heuristics rather than incorporating safe food handling practices into their daily food handling.

For many people, food preparation becomes a repeated, habitual behaviour requiring very little cognitive effort (Byrd-Bredbenner et al., 2013). Therefore, it is important to instil good food handling practices at an early age, before bad habits are learned. In a study of middle and high school students in Minnesota, U.S.A, Larson et al. (2006) found the majority of youth helped prepare dinner, and nearly half helped grocery shop on a weekly basis. Involvement of youth in food handling activities means that they will be learning from their experiences and starting to form good handling habits; if they have good role models who practice safe food handling. Generally, people get most of their food safety information from family and friends, cooking classes at school, television, and the internet (Byrd-Bredbenner et al., 2007; Nesbitt et al. 2014). Youth predominantly learn food preparation and handling skills from family members, most often their mothers (Tyrell et al., 2015). Due to changes in family dynamics, increased youth responsibility for food preparation, and increased reliance on pre-prepared meals, youth are not being mentored in food preparation and food handling (Beagan et al., 2008; Larson et al., 2006a; Slater, 2013). Further, there has been a reduction of food skills and food safety teaching in elementary and secondary school (Caraher & Lang, 2015; Byrd-Bredbenner et al., 2013). Coupled with this is the concern that those who are mentored by family members are not

receiving the correct information, rather they are learning unsafe practices (e.g. thawing meat on the counter) given that adults' food handling practices are often inadequate and sometimes inconsistent (e.g., Mullan & Milton, 2010; Patil et al., 2005).

For these reasons, youth are a key target group for food safety education. Instilling safe food handling practices early and providing youth opportunities for practice are critically important to avoid the development of unsafe food handling behaviours (Caraher & Lang, 1999; Slater, 2013). As well, youth equipped with safe food handling knowledge and skills can play an important role in improving the health of their families through the transfer of their food safety knowledge and skills (Caraher & Lang, 1999). Youths' low perception of foodborne disease risk and ignorance of the proper food safety practices puts them at risk of developing poor food handling habits. Based on their limited food handling experiences, and low food safety scores, youth should be a primary target for food safety education.

Youth based food safety education: an opportunity

Opportunities for youth to learn and practice safe food handling in schools have declined as nutrition and home economics classes have become less common (Byrd-Bredbenner et al., 2013). In Ontario, for example, although food safety protocols and practices are included in a number of the courses in the Social Sciences and Humanities grade 9 to 12 curriculum (2013), these courses are electives only. A study of Manitoba middle school and high school students found that the majority of students do not take elective home economics food and nutrition courses; further, enrollment decreases significantly from grade 7 (45 percent) to grade 12 (7.6 percent; Slater, 2013). Slater (2013) also found that many administrators, non-home economics teachers, and even some parents, do not value home economics food and nutrition courses.

Currently, there is limited research on the effectiveness of school-based food safety education, despite arguments that appropriate health behaviours introduced at a young age can continue into adulthood (Sivaramalingam et al., 2015). Food safety, including food preparation and hygiene, are essential life skills that should be targeted to youth through home economics, food, and nutrition courses (Shearer et al., 2014; Slater, 2013). The inclusion of cooking skills in youth curricula is an important measure to prepare youth to be able to implement healthy food choices (Caraher & Lang, 1999).

Youth have limited food safety experience and knowledge of safe food handling practices (Abbot et al., 2012; Turconi et al., 2008). Young people report a general lack of confidence in food handling and cooking skills, often feeling they are not trusted in the kitchen (Tyrrell et al., 2015). Further, youth tend to engage in riskier food handling behaviours, hypothesized by Abbot et al. (2012) to be associated with a lack of food safety education. Turconi et al. (2008) indicate that youths' poor food handling behaviours may be because such behaviours are often learned habits from family. Youth represent an important development phase for food safety education because they are beginning to assume responsibility for their own food handling habits, attitudes, and behaviours (Turconi et al., 2008).

Chapter 3 : Study rationale and objectives

Foodborne disease poses a significant risk to Canadians, with substantial health and economic burdens, and youth are an important population to target for disease prevention efforts, specifically food safety education. In the context of food safety, youth can be considered an at-risk population given their emerging roles as food handlers, the 'second-weaning' phenomenon, and risky food handling habits. Given that youth are an audience of interest for food safety education, and given that the Ministry of Health and Long-Term Care (MOHLTC) has an existing standard food safety education program currently offered to commercial and domestic food handlers through Ontario's public health units, the overall purpose of this thesis was to explore the food safety education needs specific to Ontario high school students, and assess if their food safety behaviours could be improved via the MOHLTC's Provincial Food Handler Training Plan. The specific objectives of this thesis were to:

1. Explore the food safety education needs of high school students in Ontario (Chapters 4 & 5);
2. Assess the suitability of the MOHLTC's Provincial Food Handler Training program for meeting the education needs as identified from objective #1 (Chapter 6); and
3. Evaluate whether safe food handling behaviours change following delivery of the MOHLTC's Provincial Food Handler Training program (Chapter 7).

These objectives were addressed via research described in four manuscripts prepared for peer-reviewed publication.

Chapter 4

Manuscript 1 : Over-confident and Under-competent: Exploring the Importance of Food Safety Education Specific to High School Students

Manuscript as published in Environmental Health Review.

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Overview

The objective of this study was to explore age-specific reasons why food safety education might be important for high school students (in Ontario, Canada), from a variety of expert perspectives. In May 2014, semi-structured key informant interviews (n=20) were conducted with food safety and youth education experts. A thematic analysis of verbatim transcripts of the interviews was conducted. Participants identified three major reasons why food safety is important for high school students: (i) they have current and personal needs for food safety information, (ii) high school is an ideal time and place to instil life-long good habits, and (iii) they are part of the foodborne illness risk landscape. Food safety education was deemed important for high school students, who were seen as a unique and captive audience in need of safe food handling skills, now and in the future, for a variety of reasons: potential employment advantages, improved food literacy, combating their sense of 'invincibility', and helping instil essential life skills that they may not get elsewhere. These results confirm the importance of food safety education for high school students and highlight the need to determine age-appropriate interventions and methods to engage high school students and improve their safe food handling practices.

Introduction

Food safety education is an important part of foodborne disease prevention, and young people are an important demographic to target in North America. They often work in the food industry (Haapala & Probart, 2004; Usalcas, 2005; Yarrow, Remig, & Higgins, 2009), and are beginning to take greater responsibility for food handling (Burke & Dworkin, 2015). They also have low food safety knowledge (e.g., Abbot et al., 2009; Green & Knechtges, 2015; Haapala & Probart, 2004; Lynch et al., 2008; Majowicz et al., 2017; Pedigo et al., 2009; Quick et al., 2013; Richards et al., 2008; Yarrow et al., 2009), lack safe food handling experience and skills (Nesbitt, et al., 2009; Abbot et al., 2012; Haapala & Probart, 2004; Majowicz et al., 2017; Morrone & Rathbun, 2003), and engage in risky food handling practices (Abbot et al., 2012, Altekruse et al., 1999; Haapala & Probart, 2004).

To date, research has predominantly assessed the food safety education needs of middle school (e.g. Byrd-Bredbenner, Abbot, & Quick, 2010; Lynch et al. 2008; Kim et al., 2012; Quick et al., 2013), and college students (e.g. Abbot et al., 2012; Byrd-Bredbenner et al., 2008; Milton & Mullan, 2012; Mullan & Wong, 2010; Yarrow, Remig, & Higgins, 2009). High school students are another potentially important age group to target. They handle and prepare food for the public via work or volunteer positions (Majowicz et al., 2015), have low food safety knowledge, and report risky behaviours including tasting food to see if it is safe (Majowicz et al., 2015; Majowicz et al., 2017; Sanlier, 2009; Turconi et al., 2008). Given that this age group may represent an important but overlooked demographic for primary prevention efforts via food safety education, the objective of this study was to explore age-specific reasons why food safety education might be important for high school students (in Ontario, Canada), from a variety of expert perspectives.

Methods

We used a phenomenological approach (Creswell, 2007) within a constructivist paradigm (Guba & Lincoln, 1994) to understand participants' perceptions of food safety needs and the factors influencing food safety knowledge and behaviours. Twenty semi-structured key informant interviews were conducted with professionals with expertise in food safety in the province of Ontario, food safety education in youth, or high school education in Ontario. Interviewees who had expertise in more than one area, or were familiar with food safety education in Ontario, were prioritized. Experts were identified via: author lists from peer-reviewed literature; consultation with education and public health organizations; and snowball sampling (Merriam, 2009). We set out to conduct between 15 and 30 interviews, with approximately equal representation from public health professionals, educators, and food safety experts. Sampling continued until no new themes were identified (Morse et al., 2002). This study was approved through a University of Waterloo Research Ethics Committee (ORE# 19745).

A semi-structured interview guide[1] consisting of ten open-ended questions, with prompts, was developed to probe for the importance of food safety knowledge, skills, and education in youth, and was informed by question domains from previous youth food safety questionnaires (Byrd-Bredbenner et al., 2010; Yarrow et al., 2009). Participants were provided with Ontario's standardized food handler training document (Ministry of Health and Long-Term Care (MOHLTC), 2013) as background material, and were prompted throughout the interview to identify anything unique to high school students, including specific food safety risks or food handling behaviours. Telephone interviews were conducted between May and June 2014, and

[1] Semi-structured key informant interview tool provide in Appendix A [p. 197].

were audio recorded. Interviews were designed to take approximately 45 minutes to complete. At the start of each interview, participants provided verbal informed consent.

Interviews were transcribed verbatim including all utterances (e.g., “er”, “um”), anonymized, and corrected against the original audio recording, prior to analysis, with coding such as “[P1]” used to maintain participant confidentiality. For quotes reported here, utterances were removed, brackets were used to denote modifications, and tenses and omitted words were corrected using a denaturalized approach (Oliver, Serovich, & Mason, 2005). Interviews were analyzed using inductive thematic analysis (Braun & Clarke, 2006), facilitated by qualitative research software (ATLAS.ti, version 7.5.6; Cincom Systems, Inc., ©2015). Codes were iteratively derived from the interview data as per Fereday & Muir-Cochrane (2006), as follows. First, three researchers independently reviewed five transcripts and developed a preliminary list of codes. Preliminary codes were collated into a codebook, containing the draft codes, working definitions, and explanatory quotes. The codebook was revised by the three researchers in concert until it accurately captured the content of the five interviews. This revised codebook was then used by one researcher to code all transcripts, and was iteratively refined during coding, such that the final codebook represented the content and meaning of all interviews. Final codes were then grouped into themes. Themes were iteratively refined until they clearly represented the fundamental theme of the grouped codes. Finally, themes and codes were reviewed again, by all three researchers, to ensure that they corroborated the data from the interviews. Memos were used throughout the analysis to capture and detail decisions related to operational research steps, categorization of data, and exploration of relationships within the data (Birks, Chapman, & Francis, 2008). Standard techniques to enhance credibility of the findings were used, including:

audit trail, multiple coding, disconfirming evidence and inclusion of deviant cases (Green & Thorogood, 2005).

Results

Participants were predominantly female (n=15), the majority worked in Ontario (n=18), and all had at least 10 years' experience in their identified areas of expertise. Participants were educators (n=7), food safety experts (n=6), or public health professionals (n=7). Of the seven educators, six taught hospitality, food, and nutrition related courses at the high school (n=3) and college (n=3) levels, and one was a professional food safety educator. Of the six food safety experts, two were university researchers, two worked in food, food safety and nutrition policy, and two were home economists. Of the seven public health professionals, four were certified Public Health Inspectors, one was a public health manager, one was a public health specialist, and one was a health promoter.

Universally, participants spoke about the importance of food safety education for high school students, because: (i) they have current and personal needs for food safety information, (ii) high school is an ideal time and place to instil life-long good food safety habits, and (iii) they are part of the foodborne illness risk landscape (Tables 4.1-4.3 [pp. 48-54]). The codes underpinning these three major themes are described below and in Tables 4.1-4.3, and encapsulated constructs related to individual advantage and personal protection, population-level benefit of having food handlers trained to prevent foodborne illness, students' low food literacy levels, and a lack of good food handling role models. Further, participants described how these reasons, and their underlying factors, happen concurrently rather than independently, creating "a perfect storm" [P4] of factors that amplifies the need for education. Generally, participants were in agreement regardless of their background or area of expertise.

Personal need for food safety education

Students' current and personal need for food safety education (Table 4.1 [p. 48]) was seen as arising from their involvement in food preparation at home, at school, and while travelling for sports and other activities, as well as via working in the food industry. All participants viewed food safety as not only a marketable job skill, but also an essential life skill. Participants saw food safety education as offering students an employment advantage because the food industry is a common student employment area (e.g., "I could say that there are companies now that would…look at (students) having a food handler certification as a(n) employment advantage" [P15]).

Food safety was also seen as an important life skill, in part due to students' increasing responsibility for handling and preparing food for themselves ("students increasingly, as it gets towards graduation and beyond, they are being forced to take a more active role in food prep in the home, and they're not necessarily aware how to do it safely, and cheaply" [P6]), and others, ("it's an important life skill, to apply later in life to protect (themselves), and (their) family members and any friends [they're] serving food to in a private setting" [P7]). Students' imminent departure from home (e.g., to pursue post-secondary education, or to live on their own), and current or future roles in caring for kids and elderly parents, were also given as reasons education is important.

Participants talked about the importance of building general food literacy among high school students, in part "because we're finding that food literacy is really low in young adults" [P8], and because,

> "I think more and more, now-a-days we are seeing a real shift in culture into the fast food business… and more and more people not having the basic skill set to be able to prepare,

healthy, nutritious food at home, and I think by making people aware of how to do that, that opens up another set of possibilities" [P19].

Participants also discussed home-based, negative influences on food literacy, including students rarely being involved in grocery shopping and cooking, and a lack of good food safety role models from whom to learn knowledge and skills (e.g., "…young people are not getting a lot of the basic food skills and 'food literacy' understanding from their parents" [P16]).

Ideal time and place for food safety education

High school was seen as an ideal time and place to instil safe food handling life skills (Table 4.2 [p. 51]; e.g., "as a youth, they're developing life skills and, preparing food, eating food, and it keeps them healthy and vital so they can be active in their academics and active with their community and athletic endeavours" [P5]), because "…they are going to need these skills for the rest of their lives" [P14]. Food safety skills learned by high school students were seen as transferable to other people: "they probably could go home and (teach) their parents some things" [P15], and "a lot of it's common sense, and things that they can use in their home life as well; so, it is very applicable to everyone" [P16].

High school was also discussed as an ideal time and place because "(food safety) is knowledge that is appropriately aged for them…" [P18], and because of students' transitioning food handling responsibilities from passive observer to active participant. Students were also seen as a captive audience due to high school's required attendance, so that high school "is an ideal opportunity to make sure that we are, I don't know – 'vaccinating' them or 'inoculating' them with this knowledge - and we can do it in a very systematic way, because of the way that secondary (education) is set up versus post-secondary education" [P14]. These views connected

with thoughts expressed by Public Health Inspector participants who indicated that more high schools are requesting food safety information and training.

Participants connected food safety education within high schools to nutrition education, both within courses (e.g., "so I think in teaching nutrition, you are also teaching food safety, so that, people understand how to keep themselves safe" [P19]), and athletics (e.g., "one of the big problems that these kids have is buying food ahead of time to eat on the bus, to get to where they are going, and it is not refrigerated" [P14]). Participants suggested a unique opportunity to deliver education may be to connect with athletic coaches, to incorporate food safety messages and practices into their nutrition discussions:

> "I think there are, would be opportunities to coach and enhance these food handler skills or these life, food related life skills, with our sports groups, because they talk about nutrition, and, sport nutrition, and looking after themselves, and being vital and, you could incorporate, weave, that information into that type of an opportunity" [P5].

Despite widespread support for including food safety education in high schools, two significant challenges were discussed: it is difficult to change curriculum, and food safety in Ontario high schools is currently only taught in elective courses. As stated by one participant,

> "…foods and nutrition kind of programing would definitely be covered off, but typically that kind of course is more of an elective, it's not a core course, and so not every high school student would be receiving that kind of education" [P8].

High school students are part of the risk landscape

Participants saw high school students as part of the wider foodborne illness risk landscape including being both a risk to their future selves and others (Table 4.3 [p. 54]), as one participant stated,

> "There is a reasonable suspicion, or evidence, that would suggest that most episodes of foodborne illness are related to preparation in private or home settings as opposed to commercial establishments, and I think, by reaching people in high school, and training them in proper food safety, we can improve the food safety skills of the next generation of private home food preparers…" [P7].

Participants commented that students tend to take more risks, while being unaware of (a) how food mishandling can lead to foodborne illnesses, and (b) people's susceptibility to, and the potentially severe consequences of, foodborne illness. Further, most noted the importance of food safety education to combat students' sense of invincibility, or it is "not going to happen to me" [P6]. One participant expressed these concepts, stating,

> "I have (extended family members) who are entering that phase (high school) and they - I would classify them as over-confident, under-competent in some areas, and, maybe some of their decision making hasn't fully developed, so that they understand the consequences of their actions" [P5].

Participants also noted that students handle, prepare, and consume large amounts of 'convenience' foods (i.e., those that have few or no preparation steps like microwave meals, pre-packaged snacks, take-out), putting them at risk for foodborne disease. As stated by one participant,

> "in several outbreaks, which frozen food, so chicken nuggets, even frozen hamburgers too…the stuff that they think are already cooked. It's really important to be looking at your packaging to see how you need to prepare it, so whether using the oven, whether using a microwave, which most people tend to do to do it quickly, you need to verify your, your preparation steps, and the temperature that goes along with that" [P7].

Finally, participants discussed the many reasons and themes presented above as co-occurring in a variety of ways, and that the co-occurrence of these factors amplifies the need for education. One participant epitomized this confluence as follows:

> "So we have a 'perfect storm' of low food literacy with teenagers, who are now cooking to feed the growing seniors, the demographic is increasing in the senior population, elderly and immuno-compromised. That is a perfect storm. You want to be able to take care of that, with training and information to help them as they cook within their homes and occupations as well" [P4].

Discussion

Using interviews with 20 food safety and youth education experts, three overarching reasons for food safety education being important for high school students were identified: they have current and personal needs for the information, that the high school environment offers an ideal time and place to instil good food safety habits, and that – despite falling outside of the traditional high risk groups – youth are indeed part of the foodborne illness risk landscape. Further, the "perfect storm" [P4] of students' personal food safety needs, low food literacy levels, and poor food handling practices, was seen as amplifying the need for education in this demographic.

Broadly, these findings are consistent with the literature on middle school and college aged individuals, who also have low food literacy and poor food safety knowledge (Abbot et al., 2009; Green & Knechtges, 2015; Haapala & Probart, 2004; Lynch et al., 2008; Pedigo et al., 2009; Quick et al., 2013; Richards et al., 2008; Yarrow, Remig, & Higgins, 2009), limited food handling experience and skills (Nesbitt, et al., 2009; Abbot et al., 2012; Haapala & Probart, 2004; Morrone & Rathbun, 2003), and who regularly engage in risky food handling practices and

eating behaviours (Abbot et al., 2012, Altekruse et al., 1999; Byrd-Bredbenner et al., 2008; Haapala & Probart, 2004; Nesbitt et al., 2009; Patil et al., 2005). Although differences in study times and populations preclude specific comparisons, our findings from high school students may suggest that such factors may remain relatively unchanged across the middle school to college years.

Here, participants discussed how high school students are at an age of transition in food handling responsibilities; this finding was expected given that food handling responsibility appears to shift with age, from helping make meals and snacks in middle school (Haapala & Probart, 2004; Pedigo et al., 2009), to being solely responsible for food preparation in college (Green & Knechtges, 2015). Determining the ages at which young people take on particular responsibilities (e.g., helping to make meals, grocery shopping, making their own snacks or meals) is needed to help target safe food handling messages specific to age-relevant preparation steps and handling experiences. For example, participants discussed students' preparation and consumption of 'convenience' foods as an important potential risk. The range of 'convenience' foods available removes the need for developing basic cooking skills (Caraher & Lang, 1999), and outbreaks from convenience foods, including pre-made chicken quesadillas (Centers for Disease Control and Prevention, 2013) and cookie dough (Neil et al., 2012), have disproportionately impacted young people versus other ages. Thus, age-specific food safety education for high school students should teach them specifically how to safely prepare and consume these and other foods commonly consumed in this age group.

Participants identified food safety education for students as important, beyond simply providing a marketable and important job skill for those interested in the food industry. A main identified impetus for education was students' lack of good food handling role models, stemming

from lack of knowledge and skill transfer from parents, who may follow unsafe practices, as well as students rarely being involved in meal preparation. Indeed, food skills and nutrition knowledge in young people have diminished in recent years, due to decreased food skills home mentoring (Slater, 2013), and lack of exposure to food and food handling, often due to parents taking over and carrying out food work on their own without involving others (Larson et al., 2006; Beagan, Chapman, D'Sylva, & Bassett, 2008). Given that food safety knowledge and practices of consumers in general are often inadequate and inconsistent (Milton & Mullan, 2010; Patil et al., 2005), the danger of youth inadvertently learning unsafe practices exists. Fortunately, food-based school curriculum can offset food handling deficiencies learned elsewhere (Höijer, Hjälmeskog, & Fjellström, 2011), further supporting the argument for food safety education in school settings.

High school was identified as an ideal time and place to instil life-long good food safety habits, in part because students' required attendance makes them a 'captive audience'. Food safety education directed at students was seen as a mechanism for widespread "inoculation" of safe food handling practices, thereby combatting low food literacy, risky food handling practices, and lack of good food handling mentors in the home. However, an important identified barrier was that, in Ontario, food safety education is only found in elective Food and Nutrition courses (Ministry of Education, 2013), and thus only reaches a subset of students. Home economic, food, and nutrition courses are essential for developing important life-skills, including food preparation and hygiene (Shearer, Snider, & Kniel, 2014; Slater 2013), and including cooking skills in curricula is important to prepare individuals to be able to implement healthy food choices (Caraher & Lang, 1999). However, nutrition and home economics classes are becoming less common (Byrd-Bredbenner, 2013), and many young people opt not to enroll in such electives

(Yarrow et al., 2009). Enrollment appears to decline with age, from 45% of grade seven students, to 7.6% of grade twelve students, and many administrators, non-home economics teachers, and parents do not value such courses (Slater, 2013). Thus, relying on elective curriculum to deliver food safety education is likely insufficient. In addition to supporting food safety education in Food and Nutrition courses (e.g., via providing materials or guest lectures), public health professionals should seek other avenues for educating students, such as advocating for mandatory food safety education for all students and engaging athletic coaches to include food safety in their nutrition advices as identified here.

An additional advantage of wider food safety education for students in high schools is that, as suggested here, knowledge and skills can be transferred to parents and others at home. In general, young people equipped with food and nutrition education can play an important role in improving not only their health but the health of their families (Caraher & Lang, 1999). However, the transferability of food safety skills *per se* has not been explicitly demonstrated, and whether food safety education offers tangible benefits for others in the household should be assessed.

This study identified students as an important part of the foodborne illness risk landscape, in part because of their general sense of invincibility, a factor not limited to youth; Redmond and Griffith (2004) identify 'optimistic-bias' and 'illusion of control' as key factors in consumers' perceptions of invulnerability to illness from self-prepared food. Here, all participants but one felt students lacked an understanding of risks and personal susceptibility to foodborne illness. Perceptions of susceptibility to foodborne illness appear to vary by age; middle school students report strong feelings of susceptibility (Byrd-Bredbenner et al., 2010), approximately half of high school students report concern about getting foodborne illness

(Majowicz et al., 2015), and most undergraduate students report feeling not overly at risk of foodborne illness (Green and Knetchges, 2015). Interestingly, a recent study of Ontario high school students found their concern about foodborne illness did not change following food safety education (Majowicz et al., 2017), such that the role of food safety education in influencing perceptions of susceptibility remains unclear.

Students' sense of invincibility and risky food handling practices may stem from their developmental stage, where asynchronous development of the adolescent brain results in increased risk-taking (Smith, Chein, & Steinberg, 2013), and from psychosocial factors linked to poor food safety behaviours, including low perceived behavioural control (Mullan & Wong, 2010; Mullan et al., 2015), low perceived susceptibility (Haapala & Probart, 2004), and learned habits (i.e., past behaviours; Chow & Mullan, 2010; Haapala & Probart, 2004; Byrd-Bredbenner et al., 2010). Since successfully changing risky food handling behaviours is predicated on feeling susceptible to illness, having incentives to take action, and feeling competent to carry out appropriate actions (Schafer et al., 1993), further research investigating psychological factors and how they can influence students' food safety behaviours is needed.

The main limitation of the findings presented here is that participants were experts in food safety or youth education. Parents and students may have different perspectives about the importance of food safety education than those reported here. Including student and parent perspectives in future will further our understanding of youth-specific food safety education needs, particularly around topics for which they might be most receptive. Generalizability is not a goal of qualitative research; nevertheless, readers may want to note that study participants may not be representative of all educators, experts, and public health professionals given the sampling approach and size.

Conclusion

High school students are a unique and captive audience in need of safe food handling skills, to reduce both current and future risk. Food safety education for this demographic is important, beyond offering an employment advantage; it is needed by all students to improve food literacy and instil essential life skills that may not be cultivated at home. However, relying on existing curriculum to deliver food safety education will not reach all students. Thus, public health professionals should seek other avenues for education (e.g., engaging athletic coaches, providing student specific food safety messages), and advocating for mandatory food safety education in high schools.

Tables

Table 4.1. Codes and exemplar quotes under the theme "high school students have current and personal needs for food safety information", derived from key informant interviews of 20 food safety and youth education experts (May – June, 2014)

Code	Code Description	Exemplar Quote
Food safety education is an employment advantage	Food safety education can offer an employment advantage for high school students. If they become a certified food handler, they may be a more valuable potential employee in the food industry, a common source of employment for students.	"So for them, they're wanting to get the [food safety training] certificate, as kind of a 'foot in the door,' to make them look better than the other applicants…" [P2]
They have a current need to prepare food safely	High school students currently need to prepare food safely, for themselves and others, including (a) family and friends, and (b) customers (if youth are working in the food industry).	"So they would be the first one home, and so they would be responsible for making meals." [P18]

They are “food illiterate”	High school students are not food literate: they do not have the food skills to choose and prepare healthy, safe, and nutritious meals. Also, reading and understanding food labels and cooking instructions is an issue for students.	“Because unfortunately, we’re getting to be a bunch of ‘food illiterates’, in society. Where not only do we not know how to cook properly, but when we do finally cook…if it’s not reheated in the microwave, we’re not sure exactly what to do with it.” [P2]
They lack good role models for safe food handling	High school students often lack good role models when it comes to food safety and safe food handling behaviours. There is less passing down of 'traditional' cooking skills in the home setting due to changes in family dynamics, increased eating out, and reliance on pre-packaged foods. Some of the skills and advice being passed down may be	“...I think people have gotten away from home cooking a little bit, and maybe some of the practical experience in handling food, that they may not have had passed down from their parents…” [P15]

	incorrect (e.g., thawing food on the counter or in the sink overnight).

Table 4.2. Codes and exemplar quotes under the theme "high school is an ideal time and place to instil life-long good habits", derived from key informant interviews of 20 food safety and youth education experts (May – June, 2014)

Code	Code Description	Exemplar Quote
They are developing life skills in preparation for living on their own	High school students are developing life skills (e.g., budgeting and cooking) in high school, and safe food handling is one of the skills that should be developed in students.	"I think it should be offered absolutely, probably, cooking skills, and budget skills, and other, you know, life skills… doing your taxes - you know, a whole bunch of things that you're not really taught from an academic stand point." [P6]
Food safety knowledge and skills are transferable from students to others	Food safety knowledge and good food safety skills can be transferred immediately, and in the future, to life outside the classroom. For example, skills can be transferred to parents and siblings at home, or to workplace colleagues if the student is working in the food industry. In future, skills can be transferred to	"I had a situation (in) a parent-teacher interview, a parent actually said something about how that message had come home, when the student in my class was watching her sister getting some chicken ready for a family meal... and reminding the sister what she should be doing and not doing in terms of chicken... so thinking about the transferability that can happen; that was a positive thing." [P12]

	those being cared for, including children and the elderly.	
Students' food handling responsibilities are undergoing a transition from passive observer to active participant	High school students are expanding their food handling roles and responsibilities, from non-participant, to observer, to helper, to preparer. They are, or will be, transitioning from simple (e.g., bowl of cereal, making a sandwich), to moderate (e.g., reheating leftovers, cooking using a microwave), and possibly to complex meal preparation (e.g., full meals, cooking raw meats). They will also eventually have expanded responsibilities for selecting and purchasing of food.	"Food safety I think is very important for lots of reasons. One is they are preparing more and more foods themselves, and families are giving them more and more responsibilities, and very soon after they get out of secondary education, many of them are going to be… living independently, and are going to have responsibility for (food handling) in their own homes, or apartments or dorms or wherever they happen to be living..." [P14]

High school students are a “captive audience”	Youth are required to attend and participate in high school courses. Material offered in mandatory courses reaches most, if not all, youth in high school. After high school or outside the classroom it is much harder to effectively deliver food safety education messages to youth.	“…it is an ideal opportunity to reach them. Once they leave high school, unless they go to college - and even in college it is kind of hard to reach them - but they are a captive audience in secondary school.” [P14]

Table 4.3. Codes and exemplar quotes under the theme "high school students are part of the foodborne illness risk landscape", derived from key informant interviews of 20 food safety and youth education experts (May – June, 2014)

Code	Code Description	Exemplar Quote
They pose a risk to their future selves	In future, because of changing behaviours and immune status, they will be at risk for food borne illness and other health issues related to poor food handling.	"Young males…who haven't cooked, and, they make all these mistakes and may get food poisoning, and we did see that with higher *Campylobacter* rates in university male students, so, even though their immune systems are pretty strong, we're still seeing cases emerge in that group." [P4]
They pose a risk to others, now and in the future	High school students pose a current and future risk to others, e.g., family and friends, if they are preparing and sharing food, and customers if they work in the food industry.	"Many of them will have children and we know that children…have reduced ability to resist foodborne infections... These kids are going to grow up at some point and probably be taking care of their own parents, and we know that elderly folks have a greater risk of really succumbing to some of the more severe effects of foodborne illness." [P14]

They take more risks because, it's "not going to happen to me"	High school students engage in riskier behaviours, because they have a skewed perception of the risks associated with food and foodborne illness, due to adolescent life stage, egocentricity, sense of invincibility, and poor risk evaluation skills.	"I think you will find that teens are, take more risks, because of this, in this focus on not being vulnerable to those risks, like it is 'not going to happen to me'." [P6]
They consume convenience meals but do not realize some of these products need to be fully cooked	High school students handle, prepare, and eat a large amount of meals that have, or can be perceived to have, few or no preparation steps (e.g. microwave meals, leftovers, take out, pre-packaged foods). These meals, marketed to youth, are convenient for them to prepare (no or very few preparation steps), and easy to take and go. These	"There have been cases where kids are maybe taking chicken nuggets and things like that, and cooking them in the microwave just so they're hot enough, but really when they are not fully cooked product, that's not appropriate." [P11]

	meals often contain specific preparation directions (e.g., cook, reheat, refrigerate immediately) that need to be followed to keep the food safe.

Chapter 5

Manuscript 2: Leftovers, lunches, and microwaves: priority food safety education needs of high school students (Ontario, Canada)

Manuscript as submitted to Journal of School Health, including a section that highlights the implications for school health as per journal requirements. Referencing appears as per journal standards.

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Overview

BACKGROUND: We explored priority areas of food safety education needed by high school students within Ontario, Canada.

METHODS: We analyzed transcripts from interviews with 20 experts in food safety, food safety education in youth, and high school education in Ontario. Inductive thematic analysis was used to identify priority food safety education needs.

RESULTS: We identified four priority action areas for food safety education targeting students: how to safely do the things they typically do with food; how to keep themselves and their kitchens clean and safe; about microorganisms and how they can result in foodborne disease; and how to keep food out of the 'danger zone' of 4^{o}C to 60^{o}C. Experts discussed that students need specific education around use of microwaves, consumption of convenience meals, preparing and handling foods at school events, and safe transportation of food for lunches, school trips, and sporting events.

CONCLUSION: High school students need food safety education specific to their usual interactions with food, including the foods, tools, and settings students regularly encounter. Delivery of food safety education should emphasize sequences of safe food handling behaviours for specific food interactions (e.g., reheating a meal in the microwave) rather than traditional food safety concepts (e.g., temperature abuse).

Introduction

In Canada, 4 million cases of domestically-acquired foodborne disease occur each year,[1] resulting in over 11,000 hospitalizations and 200 deaths.[2] A significant proportion can be attributed to mistakes during food preparation, either at home or in commercial kitchens,[3,4] emphasizing the importance of food safety education for consumers and food service workers. In Canada, the most common method of food safety education is food handler training, offered by public health units, private training companies, and food industry employers, and predominantly targeted at commercial food handlers.[5,6] Consumer-oriented education is less common, and includes messages at point-of-sale,[7] and government and non-government websites like the Canadian Partnership for Consumer Food Safety Education.[8]

Canadian consumers' food safety practices are generally lacking and include poor hygiene, poor prevention of cross-contamination, inadequate temperature control of food, not using a thermometer to check cooking temperatures, and consumption of risky foods.[9,10] A recent study of Ontario high school students found low safe food handling knowledge, and poor self-reported behaviours around hand hygiene, food thermometer use, and temperature control of lunches and snacks outside of the home.[11] Because high school students are increasingly responsible for food handling and preparation within and outside the home, and are often employed or volunteer in environments where they regularly handle and prepare food for the public,[11] it is important that this demographic receives good food safety education. Although food safety is included within Food and Nutrition courses in the current Ontario high school curriculum,[12] these elective courses do not reach all students and are often geared towards students with career interests in the commercial realm. Because the specific education needs of high school students overall have not been previously elucidated, the objective of this study was

to explore priority content areas of food safety education for high school students, hereafter referred to as 'students', within the Ontario, Canada context and from the educator perspective.

Materials and Methods

We analyzed transcripts from 19 interviews, conducted between May and June 2014, with 20 experts in food safety in Ontario, food safety education in youth, and high school education in Ontario. These audio-recorded telephone interviews explored nuanced food safety needs of students, including the importance of food safety education for this demographic (results presented elsewhere) and priority content areas for education, presented here. Details of the methods used to gather the interview data, including participant selection, development of the interview guide, and interview conduct and transcription are given elsewhere.[13] Briefly, participants were identified from the peer-reviewed literature, from education, food safety, and public health organizations, and using snowball sampling. Prior to the interview, participants were given the Ontario Ministry of Health and Long Term Care's (MOHLTC) food safety training manual,[14] as a guide to stimulate discussion about student-oriented food safety education needs. At the start of the interview, participants provided verbal informed consent, and participant confidentiality was maintained in the final, anonymized transcripts using coding such as [P3, P15] instead of names. The study was approved through a University of Waterloo Research Ethics Committee.

To identify and interpret concepts related to priority content areas for student-oriented food safety education, inductive thematic analysis[15] was used to analyse the transcripts. Analysis was facilitated by qualitative research software ATLAS.ti, version 7.5.6 (Cincom Systems, Inc., © 2015). Codes were iteratively derived using the process outlined by Fereday & Muir-Cochrane,[16] as follows. Three researchers independently reviewed five transcripts, purposively

selected to capture the breadth of interview content, and separately developed preliminary codes. These transcripts and preliminary codes were discussed among the three researchers, and final codes decided. These were then collated into a codebook, containing codes, working definitions, and explanatory quotes. The codebook was revised until it accurately captured the content of the five selected interviews. Codes were then grouped under researcher-identified food safety themes. The codebook was then used to code all transcripts, and was refined as needed, resulting in a final codebook that contained the most important areas to cover when teaching food safety to high school students.

Results

Participants discussed four priority areas in which high school students need food safety education, specifically that they need to be taught: how to safely do the things they typically do with food (Table 5.1 [p. 75]); how to keep themselves and their kitchens clean and safe (Table 5.2 [p. 77]); about microorganisms and how they can result in foodborne disease (Table 5.3 [p. 79]); and four specific things to do to keep food out of the 'danger zone' (Table 5.4 [p. 82]). These concepts and several other noteworthy findings are further described below. On the whole, participants were in agreement; any points of dissention are noted below.

Students need to be taught how to safely do the things they typically do with food

Participants discussed specific food interactions that were common to high school students (e.g., travelling with food for school trips or sporting events, school fundraisers) or that students were potentially exposed to more frequently than other food handlers (e.g., using a microwave to cook or reheat food; Table 5.1 [p. 75]). For example, participants identified that students need to be taught how to safely handle foods outside of the home, particularly, how to

pack and store a safe lunch, and how to prepare and handle food safely during school events (e.g., bake sales, fundraisers, sporting events). One expert stated,

> "I have a really close friend who works a lot with sports teams and one of the big problems that these kids have is buying food ahead of time to eat on the bus, to get to where they are going, and it is not refrigerated, and they're buying…cold cuts and that kind of thing. So there is a real opportunity there for kids to see a big improvement, I think, in their ability to keep themselves safe when it comes to those kinds of foods" [P14].

Participants also noted the need to teach students how to properly use a microware to cook and reheat food, the importance of avoiding sharing food and drink, and how to prevent contamination with allergens, because "allergens would probably be of interest to that group as well…probably as one of the top items, because … in their class there is probably somebody has an allergy" [P15].

Students need to be taught how to keep themselves and their kitchen spaces clean and safe

Participants identified that students need to be taught how to keep themselves and their food preparation areas clean and safe, and conceptualized 'safety' as preventing both injuries and foodborne disease (Table 5.2 [p. 77]). Teaching personal hygiene, including why and how to wash hands properly, and why and how to keep the things food can touch (e.g., counters, utensils) clean, were identified as key for foodborne disease prevention.

> "I would say that personal hygiene would be on the top five list for sure, for this group, especially around hand washing and understanding the importance of disease transmission through hands" [P6].

Teaching knife safety, and how to prevent slips, falls, and burns were also identified as key in teaching students how to prevent food related injuries (e.g. "…burning themselves, when they heat in the microwave. Heating up a [microwavable pizza sandwich] and then biting into it and burning themselves" [P15]).

Students need to be taught about microorganisms and how they can result in foodborne disease

Participants stressed that students need to be taught about microorganisms, including which ones cause disease, ideal microbial growth conditions in foods, how microorganisms can contaminate the food, what happens when you get a foodborne disease, and what you should do as a sick food handler (Table 5.3 [p. 79]).

> "I really think we need to emphasize how serious the outcomes from foodborne illness can be, and get it beyond the 'it's a day or two of diarrhea', which is frequently true, but tragically not always true" [P7];

One participant highlighted the importance of understanding microbiology in order to understand other food safety measures, "help[ing] them understand basic microbiology [is] key, because then you can transfer it to all those other intervention steps, if you understand microbiology, you'll understand hand washing, cross-contamination, temperature; so, that's critical" [P4]. Participants stressed the importance of understanding how foods become contaminated, and how to prevent contamination of food, particularly when grocery shopping and storing food in the refrigerator.

> "What do you put on top, in the middle, and then on the bottom [grocery carts and bags]? Stacking of things, but also bringing stuff home from the grocery store" [P8];

"Don't put the dripping (raw) hamburger above the vegetables in the fridge, just because it's a flat surface that can hold more…" [P7].

Students need to be taught four specific things to do to keep food out of the 'danger zone'

Participants identified four specific actions that students need to learn to keep potentially hazardous foods out of the 'danger zone' of 4°C to 60°C, namely: (1) not leaving food at room temperature, (2) not thawing foods on the counter, (3) properly reheating leftovers, and (4) using a food thermometer (Table 5.4 [p. 82]). In essence, students need to learn how to keep "hot foods hot and cold foods cold" to prevent the growth and survival of potentially hazardous microorganisms. Paramount among these actions was using a food thermometer to determine when food is properly cooked or reheated: "it's important that all Canadians…know how to use a food thermometer, and that it becomes a, as much a part of their life as a toothbrush" [P5]. Participants also discussed the need for students to learn about the 'danger zone' in school, because they may not be not learning about it at home or elsewhere: "I'm not sure that kids do have a clear understanding of…the 'danger zone'…and how perishable food [is], like cooked foods and so on…because when do they have that exposure otherwise?" [P16]. Additionally, students may be learning poor food handling habits at home, increasing their risk of foodborne disease, for example: "…like thawing food, you know on the counter, taking it out in the morning, practices that their parents have done…" [P18].

Experts also indicated that students often are seeking answers for 'how long' foods can stay in the fridge, freezer, cupboard, and even on the counter before they have to be eaten, moved, or thrown away, for example: "[h]ow long is something good in the fridge?" [P2]. Of particular concern were proper cooling of foods and the handling of leftovers. For example:

"…they need to put their pizza in the fridge. And the leftovers in the fridge. Don't leave them out all night" [P9].

Participants also identified the need for students to understand cooking instructions, use caution when using a microwave to cook foods, and to monitor cooking temperatures with a probe thermometer:

"My daughter cooked a chicken-based, frozen dinner, and didn't cook it properly, and I'm pretty sure she had *Salmonella* poisoning, so, I think things like proper cooking, following instructions, and maybe not using microwaves for certain types of, you know, for proper cooking of food, and also the use of thermometers is important to make sure that you know the food's been cooked to a proper temperature" [P11].

Priority food safety messages for students

Several participants volunteered their top priority student-oriented food safety messages, including:

"Wash your hands, wash your hands, wash your hands" [P2];

"I'm thinking cross-contamination being, I think, probably one of the bigger ones" [P3];

"…in order I would say, hand washing for teenagers, bacteria growth, or microbial growth second, and then third cooking and cooling temperatures, and then food storage" [P7].

In aggregate, the top five food safety education messages needed by high school students ranked as: (1) wash your hands; (2) avoid cross contaminating your food; (3) avoid temperature abuse of foods (focusing on reheating, handling leftovers, lunches, and snacks); (4) keep yourself and food preparation areas clean; and (5) understand how microbes can make you sick.

Low priority food safety topics for students

In addition to identifying the most important areas students need to be taught, participants also identified a number of topics within the provided MOHLTC manual that they felt were not necessary for student-oriented food safety education, specifically: pest control, receiving and storage of food within commercial settings, Hazard Analysis and Critical Control Points (HACCP), and food safety legislation.

Discussion

From interviews with food safety and youth education experts, we identified four priority areas for high school student-oriented food safety education, namely that students need to be taught: how to safely do the things they typically do with food; how to keep themselves and their kitchens clean and safe; how microorganisms grow and how they can result in foodborne disease; and four specific ways to keep food out of the 'danger zone', specifically (1) not leaving food at room temperature, (2) not thawing foods on the counter, (3) properly reheating leftovers, and (4) using a food thermometer. Participants noted that students need to be taught safe food handling behaviours specific to students' common food handling experiences, including reliance on microwaves for reheating and cooking, consumption of convenience meals, fund raisers and social gatherings, storage and transportation of food for lunches, school trips and sporting events, and preventing food allergen exposure and contamination.

The focus on how to handle food safely during specific food interactions, versus a focus on learning food safety concepts (e.g., cross-contamination, time and temperature abuse), is a nuanced but important distinction separating our findings from traditional food safety education formats,[6,17] which focus on increasing food safety knowledge under the assumption that improved knowledge will lead to improved behaviours.[18] Here, emphasis on imparting

knowledge was limited to why personal hygiene is important, and understanding basic microbiology, particularly how pathogens grow and spread, with the idea that such knowledge will help students understand the importance of hand washing, avoiding cross-contamination, and temperature control of food. Our experts emphasized that food safety education should prioritize teaching students appropriate sequences of actions and decisions within specific food interactions they commonly encounter, including packing a safe lunch, properly washing hands, and using a food thermometer, and what to do as a sick food handler. Being explicit about sequences of safe food handling behaviours has been previously noted by Levine et al.[19] who examined recipes for the presence of safe food handling directions, and found that the majority failed to include these steps, particularly around the use of food thermometers, appropriate cooking temperatures, and avoiding washing raw meats. How recipe modification and other mechanisms can support behaviour change and the development of safe habits bears further investigation. Nevertheless, engaging students in age-specific food safety activities and experiences should reinforce these behaviours and highlight the importance of food safety in their daily lives.[20]

As expected, the education needs identified by our participants align with Ontario's Social Sciences and Humanities grade 9 to 12 curriculum,[12] where safe food handling is explicit in elective Food and Nutrition courses; indeed, food and nutrition courses have been identified as key mechanisms to teaching these skills to students.[23,24] However, opportunities to teach and enforce safe food handling behaviours exist any time that food, food preparation, healthy eating, or microorganisms are discussed across the high school curriculum, and many of the education needs identified here fit within curriculum beyond elective foods courses. For example, food and foodborne pathogens can be used to explain chemical and biological processes to meet Ontario's

Science curriculum objectives, such as the current grade 10 applied chemistry curriculum question, "what types of chemical reactions do chefs need to be aware of when they process or store food?"[25] Additional microbiological principles, including which organisms cause disease, microbial growth factors, how microbes contaminate food, and the potential severity of diseases, align with the biological sciences curriculum, as does, food allergen information. Safe food handling practices could also be incorporated into health and physical education classes, supporting existing healthy eating and food insecurity learning objectives.[18]

Although local public health units are acknowledged in Ontario's health and physical education curriculum as a key community partner,[26] links between educators and public health professionals to support other curriculum objectives are less developed. Involving local public health practitioners with expertise in food safety in addressing the education needs identified here, within existing elective Food and Nutrition courses as well as required Science and Health courses, may be a useful, value-added mechanism to provide high schools with needed food safety education. Richards et al.[20] emphasized that teachers' level of food safety knowledge was critical to classroom success, local public health could help maintain and enhance high school teachers' food safety knowledge and resources through provision of training sessions, supplies and materials, and on-site instructional support especially early in delivery.[20] Clearly, this is an opportunity for local public health to collaborate with schools and educators to enhance food safety education and meet students' food safety education needs.

Other opportunities to embed food safety education within high schools, as discussed by our participants, included addressing student needs around extra-curricular activities like sports teams, fundraisers, and student events. Students regularly participate in such activities, which require them to transport food for significant amounts of time, or prepare or distribute food to

others, presenting a food safety risk. Therefore, these events offer opportunities for intervention, for example, providing school teams, coaches, and student athletes with coolers, cooler bags, ice packs, and directions for packing and transporting food safely. Coaches and other school officials could connect with public health professionals to access resources and materials to help them develop safe food handling messages catered to their specific needs, potentially enhancing performance and keeping student athletes healthy. Further, public health professionals could work with student groups to provide tools and materials they can use to prepare and serve safe foods at fund raisers and parties. These extra-curricular avenues for potential intervention and education have not been previously identified, and may offer new mechanisms for supporting food safety education in high schools. Another avenue may be to link education actions to existing school policies, particularly school allergy policies. Framing the prevention of cross-contamination with the example of allergens (versus pathogens) may be a more impactful message for students, who have grown up in a school environment of food allergy policies and school food restrictions, and who may be more likely to identify with food allergic classmates than those who have experienced a foodborne infection.

In addition to the curricular and extra-curricular mechanisms identified above, there may be other opportunities to support safe food practices within schools. For example, schools could be equipped with food thermometers and cleaning and sanitizing wipes next to microwaves and other food preparation areas, and schools could advocate for student refrigeration units or other methods to allow students to store lunches and leftovers at safe temperatures. Although the physical set up of school teaching kitchen classrooms supports safe food handling with food and nutrition courses,[27] similar evaluations have not been done to look at the wider high school setting including cafeteria equipment, adequate handwashing facilities, and student access to

refrigerated space for food storage. How these physical attributes of schools enhance or impede safe practices bears further investigation.

Many food safety education materials targeting commercial[5,6,14] and consumer[8] food handlers exist, and certain content areas and behaviours are consistent across materials, namely: practice good personal hygiene, particularly hand washing; keep foods at safe temperatures; ensure foods are cooked or reheated to proper temperatures; separate raw and ready to eat foods; and ensure cooking spaces, utensils, and equipment are clean. These concepts, particularly the emphasis on how to handle and prepare foods safely, align with the student-oriented food safety themes identified in our study, suggesting existing resources may be useful references for schools, with four important additions.

First, the knife safety and burn prevention needs identified by our participants are not routinely contained in food safety education material, and for students with limited food handling experience, explicitly adding such skills to food safety education is needed. Second, participants indicated students want to know how to safely store foods and for how long, particularly leftovers. Storage and use of leftovers has implications beyond food safety; in a study of undergraduate students at a Canadian university, the majority thought leftovers need to be thrown out after 1-2 days (versus the recommended 3-4 days),[28] potentially contributing to food waste and security issues. Third, the use of microwaves as an important target for food safety education for high school students as identified here is a concept that is not explicit in most food handler training materials. For example, within the MOHLTC[14] material, safe microwave use is restricted to the thawing of small amounts of food. However, because microwaves are a convenient, easy method to prepare a large variety of foods, being able to use a microwave safely (e.g., following directions, warming versus cooking foods) is an important domestic skill for

students to acquire, particularly given that this is an age group that appears to reheat foods using microwaves at least multiple times a week.[29] Finally, students need specific education on safe preparation and consumption of 'convenience meals', which are perceived to have few or no preparation steps. Our participants indicated that students handle, prepare, and eat a large amount of 'convenience meals', at home and away, and this, combined with students' low food safety knowledge, poor food handling behaviours, and risky food handling habits, puts them at increased risk for foodborne disease if these products are prepared incorrectly.[11] There is a need to balance teaching kids to cook full meals from scratch – to develop life-long food safety habits,[23] and improve healthy eating[24] – with a 'harm reduction' approach of teaching students how make less healthy foods like convenience meals in safe ways.

Limitations. This study is subject to several limitations. Most importantly, we used expert perspectives to determine the food safety education needs of students, and did not include student or parent views, which may be different than those reported here. Future studies should seek to determine student and parent perspectives, particularly as such views may overlap or contrast with expert perspectives. Nevertheless, these findings from youth and food safety education perspectives suggest important ways that current food safety education efforts can be reframed or revised, to target food safety education to meet the needs of high school students.

Conclusion

High school students have food safety education needs that centre on needing to be taught how to safely do the things they typically do with food, as well as some basic knowledge of microbiology and the importance of personal hygiene. Subsumed within this, students need to be taught to practice good personal hygiene, keep foods at safe temperatures, use a food thermometer, separate raw and ready to eat foods, and ensure cooking spaces, utensils, and

equipment are clean. Food safety education should focus on students' own current food handling experiences, including: the use of microwaves for reheating and cooking; consumption of convenience meals; school events; transportation of food for lunches, school trips and sporting events; and food allergen awareness. Our results suggest that education should focus on sequences of safe food handling behaviours relevant within specific student food interactions (e.g., packing a lunch, or microwaving or reheating a convenience meal) rather than traditional food safety concepts (e.g., cross-contamination, time and temperature abuse).

Implications for School Health

Schools can enhance students' safe food handling behaviours and potentially reduce the burden of foodborne disease, with little-to-no budgetary impacts, by:

- Connecting with public health practitioners and other food safety experts, who can provide existing food safety education materials, help maintain and enhance high school teachers' food safety knowledge, and provide on-site instructional support.
- Modifying existing food safety education material to address high school students' education needs by omitting commercially-oriented content (e.g., shipping and receiving), and adding student-specific messages including: food allergen awareness, proper use of microwaves for reheating and cooking, safe consumption of convenience meals, and safe transportation of food for lunches, school trips, and sporting events.
- Using existing school kitchens for teaching so students can practice safe food handling.
- Equipping schools with food thermometers and cleaning and sanitizing wipes next to microwaves and other food preparation areas.
- Using school events, including sporting events, bake sales, and parties, to reinforce safe food handling practices such as hand washing, safe food temperature control, and preventing cross contamination of foods with pathogens and allergens.
- In science courses, using foodborne pathogens to help teach cellular biology and biological and chemical pathways.
- In physical education and foods and nutrition courses, incorporating safe food handling messages alongside healthy eating and nutrition materials, including embedding safe food handling steps in all recipes.

- Linking safe food handling actions to existing school policies, particularly school allergy policies (e.g., explaining the importance of avoiding cross-contamination by discussing the potential spread of a food allergen in a classroom).

Tables

Table 5.1. Codes and exemplar quotes underpinning the theme, "students need to be taught how to safely do the things they typically do with food", derived from key informant interviews of 20 food safety and youth education experts (May – June, 2014)

Code	Code Description	Primary Example of Code used
How to pack a safe lunch and travel with food	Use an ice pack in your lunch bag to keep foods cold, and select foods that are safe to travel (i.e., can be in the danger zone for longer periods).	"Well, a lot of them carry lunch bags, right, so having lunches and the importance of keeping it cold and they never really thought about and the types of foods they would put in…that is part of the food safety discussion." [P18]
How to deal with leftovers	Do not leave foods out overnight (e.g., pizza), refrigerate leftovers within 2 hours, and reheat leftovers to 74ºC before eating.	"The other thing, too, is definitely refrigerating those leftovers, because in the homes that we visited, and the kids that we talked to, you know food gets left out on the counter overnight and they just have it for breakfast in the morning, and that is not such a good idea, but they do." [P14]
What to do at school fund raisers and for parties	Be aware of and follow safe food handling practices – particularly around under-	"And, we had an incident…groups were fund-raising and they were selling hamburgers, and one of the teachers just

	cooked foods, cross-contamination, temperature abuse, and sharing of foods (i.e., transfer of saliva) - at charity events (e.g., bar-b-ques, bake sales, pizza sales) and during other youth social gatherings (e.g., dances, parties).	happened to take a look at the hamburgers, and they were quite pink inside, which raised the whole issue, okay, so what about when kids are doing fund raisers, be it hamburgers, hot dogs, pizza? Those kinds of things." [P16]
How to use a microwave for food preparation	Understand when and how to safely use the microwave to thaw, reheat, and cook foods, as well as safety considerations when using the microwave to avoid injury (e.g., letting foods cool down, not testing heat with finger).	"So I would think having a microwave and microwave safety - what is thawing and heating and reheating foods in the microwave, what does it mean, what is cooking in the microwave." [P15]

Table 5.2. Codes and exemplar quotes underpinning the theme, "students need to be taught how to keep themselves and their kitchens clean and safe", derived from key informant interviews of 20 food safety and youth education experts (May – June, 2014)

Code	Code Description	Primary Example of Code used
Why and how to wash hands properly	Students need to know the importance of handwashing and specifically when and how to properly wash their hands using soap and water.	"They have to wash their hands many times, before, during, and after…and not just run them under the water, they need to use soap, they need to spend that time washing their hands." [P18]
Use good personal hygiene to prevent contamination	Students need good personal hygiene habits - beyond hand washing - to help protect food from contamination and keep the food handler clean and safe (e.g., wearing clean clothing, coughing into their sleeves, and not smoking while preparing food).	"Like, why they should have clean clothing. Why they shouldn't be eating or smoking in their food area." [P18]
Why and how to keep the things your	Students need to know the importance of keeping kitchen areas clean and	"You know, if you can somehow drill that in about cleaning the counters, before and after food preparation,

food could touch clean	organized, and specifically how to properly clean utensils (knives, mixing bowls, plates, etc.), equipment (ovens, mixers) and surfaces (cutting boards, counters, and floors).	minimizing the clutter off the counter that can become contaminated with, heaven knows what... I just think about the kinds of things that we saw in these kitchens, …gerbil cages…on top of the refrigerator, and near the food preparation areas." [P14]
How to prevent injury	Students need to know how to work safely around food and in a kitchen to prevent injury, including: prevention of burns from hot food; organization, and storage of utensils (e.g., knives); proper cleaning and use of equipment (e.g., mix master); and prevention of slips, trips, and falls (e.g., mopping spills immediately).	"The 'kitchen safety' would deal with accidents…and the prevention of accidents and using equipment properly, knives as an example." [P16]

Table 5.3. Codes and exemplar quotes under the theme, “students need to be taught about microorganisms and how they can result in foodborne disease”, derived from key informant interviews of 20 food safety and youth education experts (May – June, 2014)

Code	Code Description	Primary Example of Code used
Basic microbiology: what are pathogens, how do they grow, and how do they spread?	Students need a general understanding of microbiology; they need to know what a 'pathogen' is and understand how they replicate, multiply and can contaminate their foods. This general understanding of microbiology provides the context for safe food handling practices (cooking, cleaning, hand washing, etc.).	“They need to know how these types of pathogens, well first, what is a pathogen, and then, two, how do they grow, how do they reproduce, how are they spread?” [P2]
What foods can make me sick and how do I avoid getting sick?	Students want to know what foods can make them sick (i.e., potentially hazardous foods), and what safe food handling practices they can	“So they really wanted to know what foods would make them sick, and/or could make them sick.” [P14], and, “How to, “make sure that they don’t get sick.” [P16]

	use to avoid getting sick from the foods they eat.	
Who is susceptible to foodborne disease, and what are consequences?	Students need to understand and care about the potential impacts of foodborne illnesses, why different people are more or less susceptible to illness (e.g., dose, immune status, immunization, past exposure, general health status), and that they are at risk of foodborne illnesses.	"I really think we, we need to emphasize how serious the outcomes from foodborne illness can be, and get it beyond the 'it's a day or two of diarrhea'…which is frequently true, but tragically not always true." [P7]
How can I prevent the spread of pathogens and allergens?	Students need to learn how to control the spread of pathogens and allergens by first identifying opportunities for contamination (e.g., move from food, hands, utensils, and surfaces to food), and then using safe food handling practices to stop	"Demonstrate the use of safe food handling practices required to prevent cross contamination by pathogens, parasites and allergens." [P16]

	the spread (e.g., handwashing, washing fruits and vegetables, storing raw meats separate from ready-to-eat foods).	
What should I do as a sick food handler?	Students working in the food industry need to understand not to handle food when they are sick (diarrhea or vomiting), to report their illness to their employer, stay off work until fully healthy, and where they can go for information and help (e.g., doctor, public heath).	"The whole idea of not passing on germs, because you know, there is this stigma about calling in sick, and there is a lot of pressure from managers about… "you need to be here", but the bottom line is, people who are sick should not be working in food services." [P12]

Table 5.4. Codes and exemplar quotes under the theme, "students need to be taught four key things to do to keep food out of the 'danger zone' ", derived from key informant interviews of 20 food safety and youth education experts (May – June, 2014)

Code	Code Description	Primary Example of Code used
Do not leave cooked or perishable foods at room temperature	Cooked foods that are not going to be eaten right away (e.g., leftovers) and perishable foods (e.g., cheese and yogurt) need to be put in the refrigerator as quickly as possible to keep them safe.	"Understanding that perishable food needs to be refrigerated, within a certain short time frame…" [P5]
Do not thaw food on the counter	Do not thaw potentially hazardous foods (i.e., foods that microorganisms can grow in), like roasts and chicken, on the counter or in the sink; thaw them in the refrigerator instead.	"Thawing seems to be, and I think it's because we've all, kind of, learned from our grandmothers, and then they teach their parents and they've learned the same bad habits, but, thawing things seems to always be an 'ah-ha' moment, when they realize, 'oh, you mean, I can't take the steak out or the chicken and leave it on the counter when I go to school, and cook it at home later?'" [P2]

Properly reheat food before eating	Students need to know which foods needed to be reheated and the difference between reheating to make food safe (temperature above 74ºC) and warming food up so it tastes better.	"Understanding 'does the product need to be reheated?', 'does it need to be cooked?' " [P11] "I think that's the reheating, that people forget about the importance of reheating to 74 [degrees Celsius], right?" [P9]
Use a probe thermometer to determine when food is properly cooked or reheated	Use a food thermometer - the only method to check that food is actually cooked - to verify foods are properly cooked or reheated. Get an accurate temperature by placing the thermometer into either the thickest part of the meat, or the middle of the food (e.g., soup, chili), and avoid touching anything else (e.g., the cooking surface, equipment, or bones in meat).	"It's really important that all Canadians, including high school students…when they start to cook, know how to use a food thermometer, and that it becomes a, as much a part of their life as a toothbrush" [P5].

Chapter 6

Manuscript 3: Assessing the Suitability of the Ministry of Health and Long-Term Care's food safety education program to meet the education needs of high school students in Ontario

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Diplock, K.J. Assessing the Suitability of the Ministry of Health and Long-Term Care's food safety education program to meet the education needs of high school students in Ontario.

Overview

Given the specific food safety education needs of youth identified by both experts (Chapter 5), and in the existing Ontario high school curriculum (Ministry of Education, 2013), the objective of this study was to determine if the MOHLTC's food safety education program, designed for commercial food handlers, could be used to address food safety education needs for high school students. Assessment was done using the MOHLTC key food safety principles, based on section headings (e.g., Microorganisms) and topic areas (e.g., Potentially Hazardous Foods) from the MOHLTC food safety manual (MOHLTC, 2013). The content of the MOHLTC program was mapped against the priority food safety content needs identified in Chapter 5, specifically: how to safely do the things they typically do with food; how to keep themselves and their kitchens clean and safe; how microorganisms can result in foodborne disease; and four specific things to do to keep food out of the 'danger zone', as well as the food safety specific teaching objectives from the Food and Nutrition high school curricula. This assessment demonstrated that the MOHLTC food safety material meets all needs but one of the identified food safey education needs for high school students, injury prevention, and that it aligns with Ontario's high school Food and Nutrition courses food safety objectives. Delivery of the MOHLTC program would support student learning objectives within existing Food and Nutrition courses. Inclusion of the full MOHLTC program within the classroom would also permit students to write the food handler certification exam, resulting in students possessing a valuable qualification for successful employment in the food industry. Increased numbers of certified food handlers would help food premises meet regulatory requirements for certified food handlers as well as reduce overall food safety risks by increasing food safey knowledge and hopefully behaviours of food handlers at home and in food premises.

Introduction

Food safety skills, including food preparation and hygiene, are essential life skills that should be targeted to youth through home economics, food, and nutrition courses (Shearer et al., 2014; Slater, 2013). In Ontario, a predominant component of food safety education is the food handler training certification programs offered through Ontario's public health units, private training companies, and food industry employers, predominantly targeting commercial food handlers. In 2013, the Ministry of Health and Long-Term Care (MOHLTC) selected an existing food handler training program, consisting of a 155-page manual (MOHLTC, 2013) and 175-slide Power-Point presentation (Windsor-Essex County Health Unit, 2009), to be the standardized food handler training program model in the province. This program is available, free of charge, for public health units to use in part or as a whole to deliver food safety education sessions, promoting a consistent and standardized food safety education program. To date, the efficacy of the MOHLTC program to improve food safey knowledge and behaviours in commercial food premises or beyond has not been assessed.

Food safety education is important for Ontario youth given their emerging roles as food handlers, the fact that they are part of the foodborne illness risk landscape, and the opportunity high school presents to instil life-long safe food handling behaviours (Diplock et al., 2017; Chapter 4). The inclusion of cooking skills in youth high school curricula is an important measure to prepare youth to be able to implement healthy and safe food choices (Caraher & Lang, 1999). In Ontario, food safety protocols and practices are included in a number of the elective courses in the Social Sciences and Humanities grade 9 to 12 curriculum (2013), but use of MOHLTC approved food safety education material within these courses appears inconsistent and not well documented. Given the specific food safety education needs of youth identified by

both experts (Chapter 5), and in the existing Ontario high school curriculum (Ministry of Education, 2013), the objective of this study was to determine if the MOHLTC's Provincial Food Handler Training program originally designed for commercial food handlers, could be used to address food safety education needs for high school students.

Methods

To assess whether the MOHLTC food safety education program met the food safety content education needs of high school students, the MOHLTC content was mapped against the identified food safety education needs (Chapter 5) and the food safety specific teaching objectives from the Ontario High School Food and Nutrition courses Curricula (Appendix C [p. 202]). Assessment was done using the MOHLTC key food safety principles, based on the manual section headings (e.g., Foodborne Illness, Microorganisms, and Time and Temperature), and topic areas (e.g., Allergens, Potentially Hazardous Foods, Types of Microorganisms, The Probe Thermometer, Cooking, Hot and Cold Holding, and Cross-contamination), from the MOHLTC food safety manual (MOHLTC, 2013). A full list of these sections and topic areas is given in Appendix D [p. 211]. The content of the MOHLTC manual and Power Point slides were then mapped against the priority food safety content needs identified in Chapter 5, specifically: how to safely do the things they typically do with food; how to keep themselves and their kitchens clean and safe; how microorganisms can result in foodborne disease; and four specific things to do to keep food out of the 'danger zone'. This process was repeated for the food safety specific teaching objectives from the Food and Nutrition curricula. Content needs and teaching objectives not covered by the MOHLTC material were identified, as were content needs and objectives that were only partially covered or may require additional resources to meet student needs. Mapping was organized by objective rather than by Food and Nutrition course, given that

the majority of objectives are consistent across all Food and Nutrition courses. For example, course objectives related to the causes and symptoms of food-borne illnesses *(e.g., E. coli* poisoning*, botulism* poisoning*, Clostridium perfringens* poisoning*, salmonellosis, listeriosis*) and techniques for preventing them, are found in all Food and Nutrition courses (Ministry of Education, 2013). The objectives from Food and Healthy Living, Grade 12 Workplace Preparation course (HFL4E; Ministry of Education, 2013) were used for mapping as they included the widest range of food safety related topics (Table 6.1 [p. 98]).

Results

This assessment showed that the MOHLTC food handler training material covered all but one of the food safety education content needs identified for high school students by the food safety experts (Chapter 5). The exception was injury prevention (Tables 6.2 to 6.5 [pp. 101-107]; Appendix D [p. 211]). There are three sections in the MOHLTC program that are not relevant to the identified content needs of high school students: Introduction, Pest Management, and Food Safety Management. Additionally, specific topic areas were deemed not relevant for the identified needs of high school students, appearing as blank rows in Appendix D (e.g., benefits for food premises, responsibilities, and rejecting a shipment). While the MOHLTC material meets the majority of the identified content needs of high school students (noted by check marks in Appendix D) as well as components of the Food and Nutrition courses teaching objectives (noted by codes, eg., B2), some topic areas were only applicable to the Food and Nutrition teaching objectives (e.g., Food Safety Legislation, and Shipping and Receiving).

Food safety information related to “how to safely do the things they typically do with food” (Chapter 5: Theme 1) was covered by the material in ‘Time and Temperature’ (MOHLTC manual pp. 43-57; Table 6.2 [p. 101]); while, “how to keep themselves and their kitchens clean

and safe" (Chapter 5: Theme 2) was addressed in the 'Personal Hygiene' (MOHLTC manual pp. 78-88) and 'Cleaning and Sanitation' (MOHLTC manual pp. 89-103) chapters (Table 6.3 [p. 102]). Material about microorganisms and how they can result in foodborne disease (Chapter 5: Theme 3) was covered in three chapters: 'Foodborne Illness' (MOHLTC manual pp. 12-25), 'Microorganisms' (MOHLTC manual pp. 26-42), and 'Microbial Contamination' (MOHLTC manual pp. 69-77), and additional information related to how microorganisms spread and grow was also found in 'Time and Temperature' (MOHLTC manual pp. 43-57; Table 6.4 [p. 104]). Finally, how to keep food out of the 'danger zone' (Chapter 5: Theme 4) was covered in 'Time and Temperature' (MOHLTC manual pp. 43-57; Table 6.5 [p. 107]).

The MOHLTC material did not address how to prevent injury during food handling, nor did it expressly cover school related food handling activities such as parties and fundraisers. However, the 'Food Safety Sequence' (MOHLTC manual p. 44; slides 66-67) can be used to outline safe food handling practices to follow in all food preparation and handling situations. Information on the use of microwaves to thaw foods was provided, while use of microwaves for cooking and reheating was not. The MOHLTC manual identifies the very young, immunocompromised, pregnant, and elderly as the key groups susceptible to foodborne disease (MOHLTC manual p. 36), with no direct mention of susceptibility or vulnerability for other groups including high school students.

The food safety related high school teaching objectives (Table 6.1 [p. 98]) from the Food and Nutrition courses (Ministry of Education, 2013) are grouped under four objective areas, using the codes (e.g., B1, B3) from Food and Health Living, Grade 12 Workplace Preparation: food safety (B2), food preparation (B3), food shopping (D1), and preparing to work in the food industry (E1). These four areas are consistent across the curricula, but may be coded differently

by course (e.g., E2 Food Safety for Food and Nutrtion, Grade 9 or 10). All of the school objectives are at least partially covered by the MOHLTC material, with the exception of food preparation: demonstrate skills needed in food preparation (B3; Tables 6.2 to 6.5 [pp. 101-107]; Appendix D [p. 211]). There are some components of the food safety related objectives from the Food and Nutrition courses not covered by the MOHLTC, including: canning (D1.5), personal skills and attitudes that make students suitable for employment in food industry (E1.2), and knowledge of Workplace Hazardous Materials Information System (WHMIS) regulations and Smart Serve training (E1.3).

The MOHLTC material can be used as a framework and resource to help address the food safety content needs identified by the food safety experts for high school students, including "how to safely do the things they typically do with food" (Chapter 5: Theme 1), as well as meet specific teaching objectives (e.g., "B2.4 follow appropriate protocols to ensure food safety (e.g., cook foods to recommended temperatures; keep hot foods hot and cold foods cold; store food appropriately; wipe tops of cans before opening; check "best-before" dates; demonstrate awareness of common allergenic ingredients").

Discussion

Here, an existing food handler training program, *Food Safety: A Guide for Ontario's Foodhandlers* (MOHLTC, 2013), was compared against food safety education needs idenfied by food safety experts (Chapter 5) and the food safety specific teaching objectives from the Ontario High School Food and Nutrition courses (Appendix C). The MOHLTC materials covers all but one of the needs identified by the key informants - injury prevention - and covers all of the school food safety teaching objectives at least partially, with the exception of food preparation: demonstrate skills needed in food preparation. There are three sections in the MOHLTC program

that are not relevant to the identified needs of high school students: Introduction, Pest Management, and Food Safety Management. The Introduction deals with benefits of food safety for food premises, food safety legislation, and roles and responsibilities related to commercial food safety. Pest Management, covers the identification, food safety risks, and control of pest issues in food premises, and Food Safety Management, addresses the principles of Hazard Analysis and Critical Control Points (HACCP). Additionally, specific topic areas were deemed not relevant for the identified needs of high school students, (e.g., benefits for food premises, responsibilities, and shipping and receiving). However, components of 'Shipping and Receiving, including "check fresh fruits and vegetables for wilting, mould or any signs of infestation by bugs or other pests"; MOHLTC, 2013, p. 64) could be adapted to meet the curriculum objective related to shopping practices needed to ensure food quality (e.g., D1, assessing ripeness, buying fresh vegetables and fruits in season). Thus, the MOHLTC materials can be used as a framework and resource to help address high school students' specific education needs, in addition to the intended target audience of commercial food handlers. The detailed results provided in Appendix D [p. 211] provide an easy to use reference tool for food safety educators, including environmental public health professionals and high school teachers. Despite the fact that the MOHLTC's program meets the majority of the content needs of high school students, its delivery would need to be adapted to address the nuanced difference in approach, stressed by food safety and youth education experts (Chapter 5), focussing on context and how to do things safely, compared to stressing why food safety is important; as well incorporate high school students unique food handling experiences (e.g., microwaves, convenience meals, and school events; Chapter 5).

Food safety principles, including '*Clean, Separate, Chill and Cook*' advice from the Canadian Partnership for Consumer Food Safety Education (n.d.), and the WHO's '*five keys to safer food*': 1) keep clean, 2) separate raw and cooked, 3) cook thoroughly, 4) keep food at safe temperatures, and 5) use safe water and raw materials (2006), can be considered universal. Despite the Ontario, Canada, focus of the study design, including the observation and applicability of the MOHLTC program material to meet students' identified food safety needs, the majority of the food safety findings from this reaseach should be transferable to other jurisdictions within Canada, as well as potentially abroad. Educators in any jurisdiction could use the MOHLTC material alongside Tables 6.2 to 6.5 [pp. 101-107] and Appendix D [p. 211] to support local food safety education needs.

Meeting high schools students' food safety education needs

As outlined by food safety and education experts (Diplock et al., 2017; Chapter 4) high school students are part of the foodborne disease risk landscape, posing a risk to themselves and others, and often practice risky food handling behaviours due to a lack of understanding and a sense of invincibility. Despite this, there is still a need to increase awareness among high school students of the risks associated with improperly handled and prepared foods and the potential serious consequences related to contracting a foodborne disease (Diplock et al., 2017; Chapter 4). The MOHLTC material in the microorganisms and microbial contamination topic area addresses the serious nature of foodborne diseases, as well as how pathogens grow and spread.

Foodborne pathogens are commonly transmitted via food handling mistakes including: poor hygiene, poor prevention of cross-contamination, inadequate temperature control of food, not using a food thermometer to check cooking temperatures, and consumption of risky foods (Medeiros et al., 2001a; Nesbitt et al., 2009; Patil, Cates, & Morales, 2005; Redmond and

Griffith, 2003). The MOHLTC materials provide practical examples of safe food handling behaviours directed at reducing these common food handling mistakes and controlling the spread of pathogens in order to reduce the risk of foodborne disease. The safe food handling steps for avoiding cross-contamination, ensuring foods are adequately cooked, and good kitchen cleaning and personal hygiene practices are applicable regardless of whether one is preparing food in a commercial or home kitchen. Further, teachers and food safety experts can take material from the MOHLTC materials and adapt them to meet specific needs; including addressing high school students' food safety needs related to parties and fundraisers, as well as common microwave use. Specifically, the MOHLTC material provides detailed instructions on the proper use of probe thermometers to determine when food is properly cooked or reheated, as well as the control of food allergens. Food allergens are a significant concern in the food industry (Hefle & Taylor, 2004) and were identified as a key food safety topic for high school students (Chapter 5).

Although often exempt from regulatory oversight, the safety of food prepared for and served at high school parties (e.g., dances) or for fundraisers could be better ensured if food handlers were encouraged to follow the safe food handling principles outlined in the MOHLTC materials. This may include food handlers having to complete a training session, in person or on-line, prior to being permitted to serve high school students. Public health units often provide food safety resources, based on the principles of the MOHLTC materials, via websites or pamphlets for volunteer food handlers (e.g., Northwestern Health Unit's guidelines for bake sales https://www.nwhu.on.ca/ourservices/EnvironmentalHealth/Pages/Safety-Guidelines-for-Bake-Sales.aspx). The application of safe food handling principles to all common youth-specific food interactions including parties, fund raisers, trips and sporting events should be considered in order to demonstrate the applicability of skills and safe food handling messages contained within

the MOHLTC program across all food interactions. The broader the range of applications for the MOHLTC material the more important it becomes for high school students and food safety educators. Further, The MOHLTC material also has the potential to support food safety educators and education needs outside of the Ontario high school context. Originally designed to support commercial food safety education, its adaptability and feasibility of use in other food safety settings, namely youth-based education has been demonstrated by this research. It stands to reason that food safety educators in other jurisdictions, outside of Ontario could use the MOHLTC material alongside the Tables 6.2 to 6.5 [pp. 101-107] and Appendix C [p. 202] to support local food safety education needs. The core food safety messages related to cleaning and sanitizing, hand hygiene, avoiding cross-contamination, cooking thoroughly, keeping foods at safe temperatures, and using safe ingredients are consistent with most food safety initiatives, regardless of jurisdiction (e.g., Burke & Dworkin, 2016; Canadian Partnership for Consumer Food Safety Education, n.d.; Mederios et al., 2001; Redmond & Griffith, 2003; WHO, 2006)

Meeting Ontario high school Food and Nutrition courses teaching objectives

This assessment demonstrated that the MOHLTC materials can fully or partially meet the majority of the food safety related teaching outcomes across the Food and Nutrition courses (Ministry of Education, 2013). For students in the Food and Nutrtion courses, course codes HFN10/20, HFC3E, and HFL4E, delivering the full MOHLTC program, including a path to food handler certification, may be the best approach, given the extensive food safety scope of the courses, and workplace preparation focus of HFC3E, and HFL4E. At a minimum, the courses can use the MOHLTC sections outlined in Tables 6.2-6.5 [pp. 101-107] to meet each teaching objective. Interestingly, the high school curriculum pairs food safety with kitchen safety (i.e., injury prevention and safe use of equipment and utensils), and food preparation (i.e., demonstrate

skills needed food preparation) across all courses (Ministry of Education, 2013). Injury prevention and demonstration of food preparation skills are not included in most commercial food safety education courses (e.g., Rebellato et al. 2011; MOHLTC, 2013). A recent study of occupational injuries in Canadian youth (10-17 years of age) found that youth working in the food and beverage industry made up the majority of work related injury hospital visits (Pratt et al., 2016). Pratt et al. (2016) suggest inexperience, lack of training, and indifference as contributing factors to youth related occupational injuries. Inclusion of injury prevention and food skill demonstration may be important enhancements to MOHLTC food safety education material to address youth specific education needs, as well as potentially making the MOHLTC food safety program more appealing to commercial food handlers, employers, and consumers in general.

The ability to practice safe food handling has been championed as a key component of food safety education for the development of safe food handling behaviours (Caraher & Lang, 1999; Slater, 2013). Food safety educators should try to include hands-on safe food handling demonstrations as part of their education programs, especially for high school students. In schools, this could be accomplished by using existing kitchen teaching classrooms or partnering with school cafeterias or nearby businesses. Inclusion of kitchen safety material would provide opportunities for students to familiarize themselves with work place hazards and potentially complete Workplace Hazardous Material Identification System training, another ready for work objective from the Food and Nutrition courses (Ministry of Education, 2013). Enhanced food safety, kitchen safety, and food preparation skills would further prepare students to compete for employment in the food industry, while helping to reduce foodborne disease rates and kitchen injuries in the home and commercial kitchens.

The MOHLTC's program material (manual and PowerPoint) contains nearly all of the food safety content needed by high school students. However, the material, either itself or via its delivery, should be adapted to address the nuanced difference in approaches, stressed by food safety and youth education experts (Chapter 5), focussing on context and how to do things safely, compared to stressing why food safety is important. Further the material should be adapted to address high school students unique food handling experiences (e.g., microwaves, convenience meals, and school events; Chapter 5). As discussed in Chapter 5, schools could also explore ways that the MOHLTC materials may support teaching objectives, outside of Food and Nutrition courses, including in science and health related courses. Public health and food safety education experts should also engage with teachers and students to explore how best to deliver material and potentially repackage material to meet student needs. Youth may have more difficulty with food management practices (e.g., fruits and vegetable washing, and food preparation) compared to handwashing, a common practice (Losasso et al., 2013). Therefore, it is important to focus on context and youth specific experiences for students (Chapter 5; Winter, 2009).

Once adapted, the MOHLTC and local public health units should explore options for making the material available to high school Food and Nutrition teachers, as well as providing any additional professional development training for teachers to help them become familiar with the material. Lack of teacher training and food safety expertise have been identified as significant barriers to effective food safety education (Richards et al., 2008). Additionally, teachers need to be aware that inclusion of the full MOHLTC program material (topics and key messages) within the classroom could permit students to write the food handler certification exam, resulting in students possessing a valuable qualitification for successful employment in the

food industry. This is more important today given the new Ontario Food Premises Regulations (O. Reg. 493/17), specifically section 32 which states: “Every operator of a food service premise shall ensure that there is at least one food handler or supervisor on the premise who has completed food handler training during every hour in which the premise is operating.”

In summary, this assessment demonstrated that the MOHLTC food safety material meets the majority of the food safety education content needs identified for high school students’ and aligns with Ontario high school Food and Nutrition courses food safety teaching objectives. This means that delivery of the program in whole or part would support student learning within existing high school curricula. Efforts to adapt the MOHLTC material to address students’ unique food handling experiences could enhance the appeal of the program to teachers and increase its use in high school classrooms. Ultimately, increased food safety education would result in improved food safety knowledge and food handling behaviours both at home and in food premises, reducing the burden of foodborne disease.

Tables

Table 6.1. Food safety related objectives from the Food and Healthy Living, Grade 12 Workplace Preparation course (HFL4E; Ministry of Education, 2013).

Topic Area	Objective code	Teaching objective
Food safety	B2	Demonstrate an understanding of practices that ensure or enhance food safety.
	B2.1	Outline the causes and symptoms of foodborne illnesses (e.g., *E. coli* poisoning, botulism poisoning, *Clostridium perfringens* poisoning, salmonellosis, listeriosis) and techniques for preventing these illnesses.
	B2.2	Use appropriate personal hygiene practices to prevent contamination of food (e.g., wash hands frequently; cover a cough or sneeze in their sleeve; use gloves to cover cuts or wounds; tie hair back).
	B2.3	Use safe food-handling practices to prevent cross-contamination by pathogens, parasites, and allergens in the food-preparation area (e.g., wash fresh produce; sanitize cutting boards after contact with meat products; sanitize implements that come into contact with allergens when preparing food for or with people with known allergies; sanitize work surfaces; replace or sanitize sponges or cloths frequently; use proper clean-up procedures).

	B2.4	Follow appropriate protocols to ensure food safety (e.g., cook foods to recommended temperatures; keep hot foods hot and cold foods cold; store food appropriately; wipe tops of cans before opening; check "best-before" dates; demonstrate awareness of common allergenic ingredients).
Food	B3	Demonstrate skills needed in food preparation.
preparation	B3.1	Identify and select appropriate tools, equipment, and ingredients for use in food preparation.
	B3.2	Demonstrate the ability to safely use, maintain, clean, and store tools and equipment used in food preparation.
Food	D1	Demonstrate an understanding of efficient and economical purchasing strategies that ensure food safety
shopping		and quality.
	D1.4	Describe shopping practices they can use to ensure food quality and safety (e.g., assessing ripeness, avoiding dented cans, checking "best-before" dates, buying fresh vegetables and fruits in season).
	D1.5	Identify proper methods for storing perishable and non-perishable foods (e.g., refrigeration, freezing, drying, canning).
Preparing	E1	Identify food-related occupations for which they are personally suited.
to Work in	E1.2	Identify personal knowledge, skills, and attitudes that may make them suited to occupations in the food industry Teacher prompts: "How do your skills compare to the skills suggested for various food-related

the Food Industry		jobs/careers? What are your strengths? Where do you need further training or skills development?" "How could skills such as creativity or attention to detail be valuable for careers in the food industry?"
	E1.3	Describe the training and knowledge required for a variety of occupations in the food industry (e.g., knowledge of WHMIS regulations, Smart Serve training, Food Handler training, knowledge of common allergenic ingredients, CPR training, First Aid training, knowledge of workers' rights and responsibilities).
	E.2	Demonstrate an understanding of the qualifications and skills required for successful employment in the food industry.

Table 6.2. MOHLTC food safety manual sections that meet or partially meet the theme "how to safely do the things they typically do with food", and identification of corresponding food safety teaching objectives from the Food and Nutrition courses.

MOHLTC Food Safety Manual Sections	**Topic Area from MOHLTC manual**	**High school curriculum teaching objective**	**Theme 1: How to safely do the things they typically do with food**			
			How to pack a safe lunch and travel with food	**How to deal with leftovers**	**What to do at school fund raisers and for parties**	**How to use a microwave for food preparation**
Time and Temperature	Food Safety Sequence	B2; B2.1; B2.4; B3	pp. 44 Slides 66-67	pp. 47-56 Slides 65-84	p. 44 Slide 67	pp. 47-56 Slides 65-84
	Thawing	B2; B2.1; B2.4; B3				p. 49 Slides: 72-73
	Cooking	B2; B2.1; B2.4; B3				p. 52 Slides 75-76
	Hot and Cold Holding	B2; B2.1; B2.4; B3	pp. 53-54 Slides 77-78			
	Cooling	B2; B2.1; B2.4; B3		pp. 54-55 Slides 79-82		
	Reheating	B2; B2.1; B2.4; B3		p. 56 Slides 83-84		p. 56 Slides 83-84

Table 6.3. MOHLTC food safety manual sections that meet or partially meet the theme "how to keep themselves and their kitchen spaces clean and safe", and identification of corresponding food safety teaching objectives from the Food and Nutrition courses.

MOHLTC Food Safety Manaul Sections	**Topic Area from MOHLTC manual**	**High school curriculum teaching objective**	**Theme 2: How to keep themselves and their kitchen spaces clean and safe**			
			Why and how to wash hands properly	**Use good personal hygiene to prevent contamination**	**Why and how to keep the things your food could touch clean**	**How to prevent injury**
Personal Hygiene	Uniforms, Clothing and Aprons	B2; B2.1; B2.2		p. 79 Slide 119		
	Hair	B2; B2.1; B2.2		p. 80 Slides 120-21		
	Hands and Nails	B2; B2.1; B2.2		p. 80 Slide 122		
	Handwashing	B2; B2.1; B2.2	p. 81 Slides 123-27	p. 81 Slides 123-27		
	Using the Washroom	B2; B2.1; B2.2		p. 81 Slide 124		
	Nose or Mouth Contact	B2; B2.1; B2.2		p. 81 Slide 124		
	Cough or Sneeze	B2; B2.1; B2.2		p. 82 Slide 124		
	Other Times	B2; B2.1; B2.2		p. 83 Slide 124		
	How to Wash	B2; B2.1; B2.2		P. 84 Slide 125		

	No-Touch Techniques	B2; B2.1; B2.2		p. 85 Slide 128	
	The Work at Hand	B2; B2.1; B2.2		p. 86	
	When You Need Gloves	B2; B2.1; B2.2		p. 87 Slide 129-30	
	When You're Sick	B2; B2.1; B2.2		p. 87 Slide 131	
	Returning to Work	B2; B2.1; B2.2		p. 87 Slide 131	
Cleaning and Sanitizing	How to Clean and Sanitize	B2; B2.1; B2.3; B3; B3.2			p. 89-102 Slides 132-143
	Food Contact Surfaces	B2; B2.1; B2.3; B3; B3.2			p. 97-8 Slide n/a
	Handwash Sink	B2; B2.1; B2.3; B3; B3.2	p. 100 Slide 123-6		

Table 6.4. MOHLTC food safety manual sections that meet or partially meet the theme "microorganisms and how they can result in foodborne disease", and identification of corresponding food safety teaching objectives from the Food and Nutrition courses.

MOHLTC Food Safety Manaul Sections	**Topic Area from MOHLTC manual**	**High school curriculum teaching objective**	**Theme 3: Microorganisms and how they can result in foodborne disease**				
			Basic microbiology : what are pathogens, how do they grow, and how do they spread?	**What foods can make me sick and how do I avoid getting sick?**	**Who is susceptible to foodborne disease, and what are consequences ?**	**How can I prevent the spread of pathogens and allergens?**	**What should I do as a sick food handler?**
Foodborne Illness	Introduction	B2.1		p. 13-24 Slides 17-36			
	Symptoms	B2.1		p. 13-24 Slides 17-36			
	Causes of Foodborne Illness	B2.1; B3.1		p. 13-24 Slides 17-36			
	Chemical Hazards	B2.1; B3.1		p. 13-24 Slides 17-36			
	Examples of Chemical Foodborne Illness	B2.1; B3.1		p. 13-24 Slides 17-36			
	Physical Hazards	B2.1; B3.1		p. 13-24 Slides 17-36			
	Allergens	B2.1; B2.3; B2. 4; B3.1				pp. 18-23 Slides 29-33	

	Impacts	B2.1			p. 23 Slide 36
Microorganisms	Types of Microorganisms	B2.1	p. 26-35 Slides 37-41		
	Examples of Microbiological Illness	B2.1			p. 34 - chart p. 36 Slide 20
	Who Gets Sick?	B2.1			Youth not listed - need to expand who is at risk.
	Bacteria	B2.1	pp. 37-38 Slides 54-56		
	Bacterial Growth	B2; B2.1	pp. 37-38 Slides 54-56		
	Potentially Hazardous Foods	B2; B2.1		p. 41 Slide 64	
Microbiological Contamination	Cross-Contamination	B2; B2.1; B2.3; B3; D1.5	p. 70 Slides 110-11	p. 70 Slides 110-11	p. 70 Slides 110-11
(Same principles for avoiding allergen contamination)	Refrigerate Right	B2; B2.1; B2.3; B3; D1.5	p. 71 Slide 112	p. 71 Slide 112	p. 71 Slide 112
	Serving Food	B2; B2.1; B2.3; B3	p. 72 not on slides	p. 72 not on slides	p. 72 not on slides
	Equipment	B2; B2.1; B2.3; B3; B3.1	p. 73 and 75 Slides 114-15	p. 73 and 75 Slides 114-15	p. 73 and 75 Slides 114-15

	How Could This Happen?	B2; B2.1; B2.3; B3; B3.1	p. 74 Not on slides	p. 74 Not on slides	p. 74 Not on slides		
	Tasting Food	B2; B2.1; B2.3; B3; B3.1	p. 76 Slide 116	p. 76 Slide 116	p. 76 Slide 116		
Personal Hygiene	When You're Sick	B2; B2.1; B2.2					p. 87 Slide 131
	Returning to Work	B2; B2.1; B2.2					p. 87 Slide 131
Cleaning and Sanitizing	Facility	B2; B2.1; B2.3; B3; B3.2				p. 99 Slides 145-6	

Table 6.5. MOHLTC food safety manual sections that meet or partially meet the theme "four specific things to do to kep food out of the 'danger zone'", and identification of corresponding food safety teaching objectives from the Food and Nutrition courses.

MOHLTC Food Safety Manaul Sections	**Topic Area from MOHLTC manual**	**High school curriculum teaching objective**	**Theme 4: Four specific things to do to keep food out of the 'danger zone'**			
			Do not leave cooked or perishable foods at room temperature	**Do not thaw food on the counter**	**Properly reheat food before eating**	**Use a probe thermometer to determine when food is properly cooked or reheated**
Time and Temperature	Food Safety Sequence	B2; B2.1; B2.4; B3	p. 44 Slides 66-7			
	The Probe Thermometer	B2; B2.1; B2.4; B3; B3.2				p. 45 Slide 68
	Receiving and Storage	B2; B2.1; B2.4; B3; D1.5				
	Freezing	B2; B2.1; B2.4; B3				
	Thawing	B2; B2.1; B2.4; B3		p. 49 Slides: 72-73		
	Refrigeration	B2; B2.1; B2.4; B3	p. 50 Slides 70-1			
	Food Preparation	B2; B2.1; B2.4; B3; D1.5	p. 51 Slide 74			

Cooking	B2; B2.1; B2.4; B3			
Hot and Cold Holding	B2; B2.1; B2.4; B3	p. 54 Slide 70 Some modification required		
Cooling	B2; B2.1; B2.4; B3	pp. 54-55 Slides 79-82		pp. 54-55 Slides 79-82
Reheating	B2; B2.1; B2.4; B3		p. 55 Slides 83-84	

Chapter 7

Manuscript 4: Observation of high school students' food handling behaviors: do they improve following a food safety education intervention?

Manuscript as accepted for publication in Journal of Food Protection. Referencing and American English spelling of 'behavior' appears as per journal standards.

Diplock, K.J., Dubin, J. A., Leatherdale, S.T., Hammond, D., Jones-Bitton, A., & Majowicz, S.E. Observation of high school students' food handling behaviors: do they improve following a food safety education intervention? *Journal of Food Protection* (*in press*).

Overview

Youth are a key audience for food safety education: they often engage in risky food handling behaviors, prepare food for others, and have limited experience and knowledge of safe food handling practices. Our goal was to investigate the effectiveness of an existing food handler training program (the intervention) in improving safe food handling behaviors among high school students in Ontario, Canada. However, because no schools agreed to be control groups, we evaluated whether behaviors changed following delivery of the intervention program and whether changes were sustained over the school term. We measured 32 food safety behaviors, before the intervention and at 2-week and 3-month follow-up evaluations by in-person observations of students (n = 119) enrolled in Grade 10 and 12 "Food and Nutrition" classes (n = 8) and who individually prepared recipes. We examined within-student changes in behaviors across the three time points, using mixed effects regression models to model trends in the total food handling score (of a possible 32 behaviors), as well as the "clean" (17 behaviors), "separate" (14 behaviors), and "cook" (1 behavior), adjusting for student characteristics. At baseline, students (n = 108) averaged 49.1% (15.7 of 32 behaviors; standard deviation = 5.8) correct food handling behaviors, and only 5.5 % (6) of the 108 students used a food thermometer to check the doneness of the chicken (the "cook" behavior). All four behavior score types increased significantly ~2 weeks postintervention and remained unchanged ~3 months later. Student characteristics (e.g., prior food handling course) were not significant predictors of the total number of correctly performed food handling behaviors or of the "clean" or "separate" behaviors and frequency of cooking and self-described cooking ability were the only characteristics significantly associated with food thermometer use (i.e., "cook"). Despite the

statistically significant increase in correct behaviors, students continued to perform risky practices postintervention, suggesting that the risk of foodborne disease remained.

Food safety education aims to encourage safe food handling behaviors and increase food safety knowledge to help prevent foodborne disease (*3*). Although such education can improve food safety knowledge, attitudes, and safe food handling behaviors under certain circumstances, significant behavior gaps often remain post-intervention (*15, 24, 37, 47*). Because many studies have used self-reported behaviors (*7, 15, 18, 19, 29, 33, 42*), which over-represent safe food handling behaviors compared to direct observations (*1, 4, 32*), ascertaining the true impacts of education on behaviors can be difficult.

Consumers are an important target audience for food safety education (e.g., *25, 47*), yet studies that measure safe food handling behaviors using direct observation have been infrequent (*1, 4, 12, 16, 32*). The sole consumer study to date that used directly observed behaviors to assess the effectiveness of food safety education was conducted in South Wales, United Kingdom, and found that behaviors improved immediately after intervention but then waned by 4-6 weeks later (*31*).

Among consumers, youth are a key target demographic; they are assuming responsibility for their own food handling (*42*), often engage in risky food handling behaviors (*2*), prepare food for others (*21*), and have limited experience and knowledge of safe food handling practices (*2, 21, 42*). For these reasons, food safety, including food preparation and hygiene, have been identified as important life skills that should be taught to youth through home economics, food, and nutrition courses (*14, 35, 38*). Although youth are an important demographic of consumers and extensive assessment of baseline food safety behaviors has been conducted with middle school (*10, 17, 20, 28, 30, 33*) and college-age individuals (*2, 11, 12, 25, 27, 39, 44*), little research has been conducted on food safety behaviors among high school-age youth (*6, 21, 34, 42*). Studies of cooking classes (*7*), food safety and hygiene lessons (*19*), and food safety music

parodies (*43*) have revealed improved self-reported behaviors in youth; however, no research has been done on the effectiveness of high school-based food safety education for implementing changes in behaviors over time.

Our goal was to investigate the effectiveness of existing food safety education for improving safe food handling behaviors among high school youth in Ontario, Canada. Our specific objectives were to observe whether food handling behaviors of high school students improved following an intervention using a modified version of the standardized food handler training program from the Ontario Ministry of Health and Long Term Care's (MOHLTC) (*26*) and whether those changes were sustained over the school term (~3 months). We predicted that safe food handling behaviors would be poor at baseline and would improve directly following the intervention (*1, 12*) and that safe behaviors would be sustained from after the intervention to the end of the term.

Materials and Methods

Overall study design and the intervention. We conducted a repeated measures study with students (n = 119) enrolled in Grade 10 and 12 "Food and Nutrition" classes (n = 8) in four high schools located in southern Ontario, Canada. The schools and kitchen classrooms are described elsewhere (*8, 21*), as are the details about school and student recruitment, consent and debriefing, remuneration, and creation and delivery of the intervention (*22*). At enrollment in the study, students were told that this was a food skills study (with the food safety focus only disclosed during poststudy debriefing) and that researchers from the University of Waterloo (Waterloo, Ontario, Canada) would observe the students preparing meals. We visited each classroom during class time at four points during the February to June 2015 school term: (i) the first week to collect baseline data (February 2015; T_1); (ii) within 2 weeks of T_1 to deliver the

intervention, (iii) within 2 weeks after the intervention to collect follow-up data (February to March 2015; T_2), and (iv) ca. 11 to 13 weeks following T_2, to collect final data (May to June 2015; T_3). Dates of school visits were published previously (22)[2]. Although our original design included a control group of four classes of students that would not receive the intervention, no teachers were willing to participate in the study unless their students received food safety education; hence all eight classes received the intervention. Prior to T_1, students explicitly did not receive any food safety instruction from either their teacher or the research team, except for instructions on how to prevent slips, falls, and knife injuries. Following T_1, one researcher (K.J.D.; a public health inspector with experience delivering the intervention) went into each classroom and delivered the intervention, which was the MOHLTC program modified to fit classroom time constraints (i.e., 3 h of instruction time), and to omit topics relevant solely to commercial settings (e.g., receiving and shipping of food). K.J.D. delivered the intervention in the same manner used by public health inspectors across Ontario. No additional formal food handler training was provided. However, between T_2 and T_3, teachers were instructed to teach their classes as usual, meaning that they likely reminded students about various food safety practices during food preparation sessions occurring within this time frame. Although teachers were not provided specific prompts or food safety messages to use following the intervention, they were present during intervention delivery and may have made reference to the intervention or reinforced specific intervention messages between T_2 and T_3. Before T_1, as part of their remuneration participating classrooms were equipped with all kitchen supplies needed for the safe food handling behaviors we measured (e.g., digital food thermometers). The study was approved by a University of Waterloo Research Ethics Committee.

[2] Dates of school visits including intervention delivery and food handling observations provided in Appendix B [p. 201].

Food safety behavior measurement. We measured food safety behaviors at T_1, T_2, and T_3 via in-person observations of students who individually prepared recipes. We measured 32 food safety behaviors (Table 7.2 [p.127])[3], across three categories: "clean" (17 behaviours), "separate" (14 behaviors), and "cook" (1 behavior), using a modified version of the food safety observation checklist (available upon request)[4] created by Byrd-Bredbenner et al. (*12*), which was modified to be relevant to our recipes, to omit storage, thawing, and glove use behaviors, and to assess hand washing after cell phone use.

We designed three recipes, one for each observation time, that followed an identical sequence of food handling steps using the same types of foods and preparation methods (Table 7.1 [p. 125]). Recipes were reviewed by participating teachers to ensure they complied with school policies and that no modifications were required due to allergies or dietary restrictions. Each student was given a copy of the recipe at their classroom cooking station. Recipes included the following instructions: "Make this recipe on your own. Different people like to follow recipes in different ways, so make this recipe the way you would do it"; and "Do not help your classmates. If you need help, ask one of the researchers."

Six observers conducted the food handling observations, with each responsible for observing one to four students (all at the same cooking station). Prior to data collection, observers were trained by reviewing the expected safe food handling behaviors, observing three mock recipe preparations, and establishing agreements on how potential situations and observations would be recorded (*16*). Mock recipe observations were done in both a home kitchen (to mimic our participating noncommercial style teaching kitchens) and a culinary

[3] Description of observed food handling items and which observations comprise the food safety scores is provided in Appendix F [p. 228].
[4] Observation checklist provided in Appendix E [p. 227].

teaching kitchen (to mimic our participating commercial style teaching kitchens). For each, all observers recorded the behaviors of a set of individuals 9 to 25 years of age, each preparing the T_1 recipe. This group of recipe preparers was selected to reflect the widest possible range of kitchen skills we expected of the high school participants. Following each mock recipe observation, the observers and two researchers (K.J.D. and S.E.M.) collectively reviewed the training session, discussed any questions or challenges, and established agreement about recording specific behaviors. After each session, interobserver agreement was calculated, using percent agreement between observations of the same participants; practice sessions continued until all pairwise agreements between observers were $\geq$90 percent. During data collection, observers positioned themselves to allow maximal view of food preparation areas while not interfering with student movement. Observers did not communicate with students during meal preparation, and referred any student questions to one of the researchers not involved in observations.

Data entry and coding. Checklist observations were entered into an Excel spreadsheet (2016; Microsoft, Redmond, WA). Double entry of 44 randomly selected checklists confirmed a very low data entry error rate (0.09%; 7 of 7,700 entries), so on the remaining checklists the data were entered only once. Checklist observations were combined into food safety behaviors; for example, checklist items "hands washed before beginning any food preparation" (yes), combined with "using soap" (yes), and "running water" (yes) to yield the behavior "hands washed with soap and water before beginning any food preparation." Each of the 32 food safety behaviors was scored as correctly (score = 1) or incorrectly (score = 0) performed. For each student, behavior scores for total (32 behavors), "clean" (17 behaviors), "separate" (14 behaviors), and "cook" (1 behavior) were tallied. The student's unique identifier was used to link (i) observations

across the three time points and (ii) student demographic and food skills characteristics (Table 7.2 [p. 127]) that had been collected at baseline using a self-reported paper survey (*21*).

Analysis. Data were analysed using Excel (2016) and SAS software version 9.4 (SAS System for Windows, 2013, SAS Institute, Cary, NC). Scores for total observed food handling, "clean", and "separate" were treated as continuous outcomes, and the single "cook" (i.e., use of a thermometer) was a binary outcome. Baseline student characteristics and food handling behaviors were assessed for all students present at T_1. Crude differences (i.e., unadjusted for other measured factors) between mean total, "clean", and "separate" behavior scores across time points were tested using paired *t* tests, and differences in the use of a food thermometer were tested using McNemar's chi-square test.

Changes in observed food handling behaviors were then determined at the student level (i.e., we examined within-student changes in outcomes across time points), using all available data from all 119 students participating in the study. Linear mixed effects regression models (*36*) were used to model the trends in the total food handling, "clean", and "separate" scores, and logistic mixed effect regression models for "cook" scores, with separate models fit for each outcome. We considered missing data as missing at random, given that students missed observations periods for a variety of reasons and there was no indication that students missed class in order to avoid the observation period. All models included the following fixed effects: two slopes, the change in observed behavior from T_1 to T_2 (i.e., T_1–T_2), and the change from T_2 to T_3 (i.e., T_2–T_3); school; and all seven student characteristics. Regression analyses were conducted using PROC MIXED for total, "clean", and "separate" scores, and PROC GLIMMIX for "cook". In all linear mixed effects regression models, random intercept and slopes were included as student-level random effects to account for repeated measurements within students, whereas in

the logistic mixed effects regression model only random intercepts were included. Model fit was determined based on minimizing the Akaike Information Criterion.

Results

Of the 119 participants, 108 participated at T_1, 102 at T_2, and 92 at T_3; 71 participated at all three time points. Reasons for non-participation were absences for sports, illness, vacation, or other personal reasons (n = 38); absence due to injury (n = 1) or academic reasons (n = 12); dropping the class (n = 2); and withdrawing from the study (n = 2).

Baseline food handling behaviors. At baseline, students (n = 108) used a mean of 49.1% (15.7 of 32 behaviors; standard deviation [SD] = 5.8) correct total food handling behaviors, 47.6% (8.1 of17; SD = 2.2) of "clean" behaviors, and 53.6% (7.5 of 14; SD = 4.6) of correct "separate" behaviors, and 5.5 % (6) of the 108 students used a food thermometer to check the doneness of the chicken (the "cook" behavior) (Table 7.2 [p. 127]). The total, "clean", and "separate" food handling scores all had acceptable internal consistency, with Cronbach's alpha values of 0.85, 0.83, and 0.80, respectively (*41*).

Changes in observed food handling behaviors. Mean unadjusted behaviors for the total, "clean" and "separate" scores are shown by time point in Table 7.3 [p. 132] for all students (n = 119). For thermometer use, the unadjusted percentage of students (n = 119) using a thermometer was 5% at T_1, increased significantly to 36% ($p<0.0001$) at T_2, but then decreased significantly to 30% at T_3 ($p=0.0072$).

Results from the regression models indicated food safety behaviors increased postintervention. From T_1 to T_2, the total number of correctly performed food handling behaviors increased significantly, by 4.4 points of 32 possible (standard error [SE] = 0.55, $p<0.0001$), and then did not change significantly from T_2 to T_3 (Table 7.4 [p. 134]). Student characteristics were

not significant predictors of the total number of correctly performed food handling behaviors (Table 7.4 [p. 134]). Scores for both the "clean" (Table 7.5 [p. 135]) and "separate" (Table 7.6 [p. 136]) behaviors followed the same pattern: they increased significantly between T_1 and T_2 and did not change significantly from T_2 to T_3, and student characteristics were not significant predictors of the numbers of correctly performed behaviors. From T_1 to T_2, use of a food thermometer increased significantly, by an additional 31% (SE = 0.05, $p<0.0001$), and then did not change significantly from T_2 to T_3. Working or volunteering in a food service establishment was the only student characteristic significantly associated with the use of a food thermometer to check chicken doneness (Table 7.7 [p. 137]).

Discussion

Our goal was to evaluate the effectiveness of an existing food handler training program for improving safe food handling behaviors among high school students. However, because no schools agreed to be control groups, we were able to only investigate whether high school students' safe food handling behaviors were different before versus after in-class delivery of a modified version of the Ontario MOHLTC standardized food handler training program (*26*). Before the intervention, the vast majority of students' exhibited poor safe food handling behaviors in areas including general cleaning activities, hand hygiene practices, cross contamination prevention, and use of food thermometers. Our baseline findings are consistent with previous observation studies of consumers, which revealed poor hand washing, inadequate cleaning of kitchen surfaces, and failure to use a thermometer to check cooking temperatures (*1, 4, 12, 16, 32*). Our hypothesis was guided by results reported by Redmond and Griffith (*31*) in their observation study that found safe food handling behaviors among consumers following an intervention. We also found that students' overall safe food handling behaviors improved

following the intervention. Studies examining self-reported behaviors have also revealed similar improvements postintervention (*7, 15, 19, 23, 43*). We observed no change in behaviors between T_2 and T_3, which is not consistent with the findings of Redmond and Griffith (*31*), who observed waning behaviors at 4 to 6 weeks' postintervention. This discrepancy raises interesting points, namely the role played by regular food handling practice and safe food handling prompts in the maintenance of safe food handling behaviors. In our study, between T_2 and T_3, students continued to handle food within their "Food and Nutrition" class under their teacher's instruction, suggesting that investigation of how other factors influence changes in food safety behaviors over time (e.g., psychosocial and social norms) (*45*) is warranted. Because results in our study and that by Redmond and Griffith (31) were obtained with different interventions, the findings are not directly comparable.

In our study, student characteristics were not significantly associated with safe food handling behaviors; the one exception was working or volunteering in a food service establishment, which was associated with more thermometer use. Even though one-third of our participants had taken a previous food handling or preparation course prior to the study (*22*), this previous training was not associated with better behaviors. This finding is alarming and highlights again the need to examine factors associated with safe food handling behaviors, including how they change over time. In previous studies, researchers have identified gender as related to behavior, with males having lower food safety behavior scores than females (*12, 42*), and this has been suggested to be related to females' greater involvement in meal preparation and cooking (*42*). We did not identify a gender difference when accounting for other factors including experience, previous training, and weekly involvement in food handling. This finding

appears to confirm what others previously indicated (*42*), that gender is a proxy for experience and involvement in meal preparation.

Because of the small number of schools in our study, we included school as a fixed effect only. However, we did observe that school was significantly associated with students' total, "clean", "separate", and "cook" behaviors, suggesting that school characteristics may either inhibit or promote safe food handling behaviors. Because all "Food and Nutrition" classes within a given school were taught by the same teacher, it is possible that school is a proxy for teacher. Teachers' limited backgrounds and interest in the material and lack of resources have been identified as potential barriers to safe food handling education (*33*). However, these barriers represent an opportunity for Ontario-based food safety experts to support food and nutrition courses through the provision of resources and teacher training, as has been done elsewhere (*19, 20, 28, 30, 33, 35, 43*).

In the present study, although the use of food thermometers improved significantly after delivery of food handler training, the percentage of students using a thermometer remained below 50%. These findings are consistent with those from Takeuchi et al. (*40*), who found that self-reported thermometer use by consumers increased significantly to 52% following an intervention. The infrequent use of food thermometers observed in our study at baseline was expected and is consistent across consumer studies (1, *4, 9, 12, 16*). However, infrequent use of thermometers in this study persisted, even though thermometers were readily available in each classroom and their use was explicitly encouraged as part of the intervention.

We used mixed effects regression models, enabling us to analyze behavior changes at the individual student level and account for potential confounders such as work experience and previous training. In contrast, in the majority of studies that have included examinations of

behaviors, mean food behavior scores have been compared at different time points (i.e., assessed changes at the group level) to assess the impact of food safety education (*7, 15, 17, 32, 33, 43*). The advantages of mixed effects regression models are the ability to describe how individual student's food handling behaviors change over time while also exploring whether the trajectory of changes vary by different predictors (e.g., previous food handling training, handling food for the public) (*36*). We recommend that future studies use similar regression models to describe within-individual change over time and relate predictors to interindividual differences in change (*36*), providing a clearer insight into what drives food handling behaviors.

Despite significant improvements in safe food handling behaviors, students in our study continued to perform numerous risky behaviors that could result in contaminated food and subsequently foodborne disease. Students routinely failed to wash hands after handling raw chicken or vegetables, carried raw and ready-to-eat foods on the same plate, and used the same knife and or cutting board to prepare raw chicken and then ready-to-eat products. These food handling lapses are consistent with other consumer observation studies, where inconsistent handwashing between meal preparation steps (*16*) and cross-contaminated ready-to-eat foods (*4, 32*) have been reported.

Food safety behaviors can be considered a function of practice and habits. Given that these students' are early in the process of developing habits (*5*), high school may be an ideal time to teach food safety education. Family and friends also may play in propagating unsafe practices (*47*), particularly because young adults report first learning about food safety from their mothers, followed by fathers, school, and television (*13*), and because social pressures (*46*) and other psychosocial factors (*45*) appear to drive changes in food safety behaviors. Although we did not address these social and psychosocial factors, the high school environment may represent an

opportunity to avoid development of unsafe food handling habits, combat potential negative influences of family and peers, and establish new social norms for safe food handling behaviors.

This study had several limitations, most notably the lack of a control group. As described, our original design included a control group, but teachers were unwilling to have their classes participate unless students received food safety education. Although this attitude may reflect the importance of this topic to the teachers we approached to recruit, it also illustrates a major methodological challenge of applied research, especially in schools. Another important consideration when interpreting our study results is that we assessed behavior changes solely based on statistical significance; whether the changes observed here translate into changes in the foodborne disease risk faced by these students must still be determined. Our total food handling behavior score was a tally of the individual behaviors measured, giving each measured behavior equal weight; thus, the score did not account for the different degrees of risk associated with individual behaviors. Finally, because of in-class time constraints, we did not observe behaviors related to the concept “chill”, in particular how high school students deal with leftovers, which may be a food handling step of particular importance to this demographic group.

This study provides evidence that food safety behaviors among high school students are generally poor but improve significantly after in-class delivery of food handler training, specifically behaviors around cleaning activities, including hand hygiene, avoiding cross contamination of foods, and the use of food thermometers. Our findings suggest that existing programs like the Ontario MOHLTC’s standardized food hander training program, which was originally designed for commercial food handlers, can be effective with high school students and that delivering such education within existing food and nutrition courses and high school kitchen classrooms is feasible. However, despite improved behaviors, students continued to perform

risky practices postintervention, indicating that there may be other factors that impact students' safe food handling behaviors. Future studies should include examination of how psychosocial factors influence behaviors norms and how changes in food handling behaviors translates to actual risk of foodborne disease.

Tables

Table 7.1. Recipes used for the observation of safe food handling behaviors by high school students at baseline (T_1) and after the intervention (T_2, T_3) in Ontario, Canada, February to May 2015.

Recipe (T_1)	Recipe (T_2)	Recipe (T_3)
BBQ chicken ranch sliders	Open-faced chicken bruschetta	Butter chicken
RECIPE STEP		
Ingredient List		
1 boneless, skinless chicken breast, cut into two pieces.	1 boneless, skinless chicken breast, cut into thirds.	1 boneless, skinless chicken breast, cut into strips.
BBQ sauce, to taste, about ¼ cup	¼ cup Italian marinade	¼ cup of butter chicken sauce
Monterey jack cheese, sliced	Shredded mozzarella cheese, about ¼ cup	Paneer cheese, about 1/3 cup
Iceberg lettuce, torn into bite sized pieces	½ cup chopped plum tomatoes	3-4 spinach leafs, torn into bite sized pieces
Tomato slices	Minced fresh basil, to taste	1-2 green onions, thinly sliced
4 mini slider buns, toasted	3 slices of baguette, toasted	1 pita
Ranch dressing, to taste	Italian dressing, to taste	2-3 tbs heavy cream
Recipe steps		

1.Gather all ingredients to your work station before beginning	1.Gather all ingredients to your work station before beginning	1.Gather all ingredients to your work station before beginning
2. Preheat over to 350ºC	2. Preheat over to 350oC	2. Preheat over to 350oC
3. Cover chicken with BBQ sauce. Bake 20-25 min. or until chicken is cooked.	3. Cover chicken with marinade, and bake 20-25 min, or until chicken is cooked.	3. Cover chicken with butter chicken sauce, and bake 15-20 min. or until chicken is cooked.
4. Spread buns with ranch dressing, and place chicken on buns. Top with cheese, lettuce, and tomato.	4. Place chicken on toasted baguette slice. Top with cheese, tomatoes and basil. Add additional Italian dressing, if desired.	4. Assemble the pita pocket: layer in the spinach, green onion, cheese, and chicken. Drizzle the pocket contents with heavy cream, if desired.
5. Plate the sliders, and take the final plated food to the specified area.	5. Plate the bruchetta, and take the final plated food to the specified area.	5. Plate the butter chicken, and take final plated food to the specified area.
6. Clean up your cooking station.	6. Clean up your cooking station.	6. Clean up your cooking station.

Table 7.2. Demographic characteristics and baseline (T_1) observed food handling behaviors of all participating high school students and students present at all three observation time points in Ontario, Canada, February 2015

Factor measured		**Students present at T_1 (n=108)**	**Students present at all three time points (n=71)**
Mean (SD) age (yr)		15.6 (1.2)	16.5 (1.4)
% female		64.8	64.8
% works or volunteers at food a service premise		39.8	45.1
% handling food for the public in a work or volunteer capacity		26.7	26.8
% who had ever taken a food preparation/handling course*		31.0	30.1
Frequency of cooking from basic ingredients	% "never"	22.2	15.5
	% "a few times a year"	34.3	40.8
	% "a few times a month"	24.1	23.9
	% "a few times a week"	6.5	8.5
	% "at least once a day"	11.1	11.3
Self-described cooking ability	% "don't know how to cook"	3.7	1.4
	% "can only cook when the instructions are on the box"	9.3	9.9
	% "can do the basics from scratch (like boil an egg…) but nothing more complicated"	12.0	8.5
	% "can prepare simple meals if I have a recipe to follow"	49.1	52.1

% “can cook almost anything”	21.2	21.1
Mean total number of correctly performed safe food handling behaviors (SD); perfect score = 32	15.7 (0.35)	15.3 (0.32)
Mean total number of correctly performed ‘clean’ safe food handling behaviors (SD); perfect score = 17	8.8 (0.15)	8.0 (0.14)
Mean total number of correctly performed ‘separate’ safe food handling behaviors (SD); perfect score = 14	9.7 (0.27)	7.3 (0.25)
% of students who used a food thermometer to check chicken doneness, ‘cook’	5.6	5.6
Specific ‘clean’ safe food handling behaviors		
% “Hands were washed with soap and running water before beginning any food preparation.”	75.9	76.1
% “Hands were washed with soap and running water after handling produce.”	8.3	7.0
% “Hands were washed with soap and running water after getting raw chicken.”	26.9	28.2
% “Hands were washed with soap and running water after slicing raw chicken.”	24.1	19.7
% “Leafy greens were washed with running water (soap and/or wipes may or may not have been used) before use.”	13.9	8.5
% “Vegetable (e.g. tomato, green onion) was washed with running water (soap and/or wipes may or may not have been used) before use.”	10.2	5.6
% “Food items and sauces left on dishes were scraped off before washing the dishes.”	25.9	26.7

% “Dirty dishes/equipment were washed with soap and water after use.”	80.6	81.7
% “When dishes were washed, a clean cloth (i.e., towel, rag, sponge, paper towel, or wipe) was used.”	80.6	83.0
% “When dishes were washed, they were dried using a clean cloth (i.e., towel, rag, sponge, paper towel, or wipe) or allowed to air dry after washing.”	80.6	83.0
% “Kitchen counters were adequately cleaned after all food preparation activities were complete.”	30.6	29.6
% “Kitchen counters were adequately cleaned if they became dirty (i.e., contaminated) during food preparation.”	2.8	2.8
% “When counters were washed, a clean cloth (i.e., towel, rag, sponge, paper towel, or wipe) was used.”	30.6	31.0
% “When counters were washed, they were dried using a clean cloth (i.e., towel, rag, sponge, paper towel, or wipe) or allowed to air dry after washing.”	33.3	33.8
% “Student wore clothes that appeared to be clean at the start of class.”	100.0	100.0
% “Student wore an apron during food preparation.”	88.0	88.7
% “Student’s hair was suitably confined (e.g., pulled back, hair net, hat) during food preparation.”	90.7	84.5
Specific ‘separate’ food handling behaviors		
% “Leafy greens were placed on a clean surface at student’s work station.”	52.8	49.3

% “Vegetable (e.g. tomato, green onion) was placed on a clean surface at student’s work station.”	53.7	50.7
% “Cheese was placed on a clean surface at student’s work station.”	55.6	53.5
% “Bread was placed on a clean surface at student’s work station.”	50.0	47.9
% “Leafy greens were prepared (e.g., sliced, torn) on a clean surface.”	57.4	54.9
% “Vegetable (e.g. tomato, green onion) was sliced/chopped on a clean surface.”	53.7	50.7
% “Cheese was sliced, shredded, or crumbled on a clean surface.”	53.7	50.7
% “Bread was sliced on a clean surface.”	53.7	54.9
% “Finished food item was assembled on a clean surface.”	73.1	71.8
% “Raw chicken was carried from the supply station to work station in a manner that prevented dripping of raw chicken juices: (by either placing it in the middle of a plate, bowl, or cutting board; or using a plastic food storage bag with no visible leaks.”	85.2	84.5
% “Ready-to-eat foods were kept from contacting raw chicken or raw chicken juices.”	36.1	31.0
% “Dishes (e.g., plate, bowl, cutting board) and/or utensils (e.g., knife, spoon) that touched raw chicken were kept separate from clean ones during use and storage.”	61.1	64.8
% “Ready-to-eat foods were protected from contamination while using the cutting board (by either: properly washing the cutting board, using soap and running water after use with raw chicken, and before use with ready-to-eat food; or using a different cutting board for raw chicken and ready-to-eat food or cooked food).”	28.7	26.8

% “Ready-to-eat foods were protected from contamination while using knives (by either: properly washing knives, using soap and running water, after slicing raw chicken; or using a separate knife for raw chicken and ready-to-eat or cooked food).”	31.4	29.6

* Prior to the current food and nutrition course in which the student was enrolled during the study; includes courses such as cooking classes, previous food and nutrition courses, and food handler certification

Table 7.3. Number of correctly performed food safety behaviors, unadjusted for student characteristics and repeated measures, for high school students in Ontario, Canada before (T_1) and after (T_2, T_3) food safety education intervention

	Mean			T_1 to T_2		T_2 to T_3		T_1 to T_3	
Factor measured	**T_1**	**T_2**	**T_3**	**Diff.***	**p-value**	**Diff.***	**p-value**	**Diff.***	**p-value**
Total no. correctly performed food safety behaviors (out of 32)	15.7	19.9	20.2	**4.2**	**<.0001**	0.3	0.61	**4.5**	**<.0001**
Total no. correctly performed 'clean' behaviors (out of 17)	8.1	9.1	9.0	**1.1**	**<.0001**	-0.15	0.64	**0.9**	**0.0076**
Total no. correctly performed 'separate' behaviors (out of 14)	7.5	10.4	10.9	**2.8**	**<.0001**	0.53	0.26	**3.4**	**<.0001**

[a]Students (n = 119) were observed February to May 2015. Values are results of paired t tests Diff, mean difference in total number of correctly performed food handling behaviors between each pair of time points.

Table 7.4. Change in the total number of correctly performed food safety behaviors of Ontario, Canada high school students after the intervention (T_1 to T_2) and at the end of the school term (T_2 to T_3)[a]

Fixed Effects Parameters		**Co-efficient**	**SE**	**p-value**
Intercept		**15.92**	**2.02**	**<0.0001**
Slope: $T_1 - T_2$		**4.40**	**0.55**	**<0.0001**
Slope: $T_2 - T_3$		0.56	0.53	0.296
School (1: referent)	2	-0.50	1.03	0.631
	3	**-2.7**	**0.66**	**<0.0001**
	4	**-4.05**	**0.88**	**<0.0001**
Age (in years)		-0.04	0.04	0.3278
Gender (female: referent)		-0.19	0.60	0.7716
Works or volunteers at a food service premises		0.30	0.89	0.7406
Handles food for the public		0.89	0.82	0.2891
Has ever taken a food preparation/handling course		-0.27	0.61	0.6663
Frequency of cooking from basic ingredients		-0.25	0.28	0.3809
Self-described cooking ability		0.58	0.35	0.0984

[a] Results of the linear mixed effects regression model for 119 students and 32 possible behaviors. SE, standard error.

Table 7.5. Change in the number of correctly performed behaviors related to the concept ‘‘clean’’ of Ontario, Canada high school students after the intervention (T_1 to T_2) and at the end of the school term (T_2 to T_3)[a]

Fixed Effects Parameters		**Co-efficient**	**SE**	**p-value**
Intercept		**8.76**	**0.93**	**<0.0001**
Slope: $T_1 – T_2$		**1.22**	**0.27**	**<0.0001**
Slope: $T_2 – T_3$		-0.06	0.28	0.8391
School (1: referent)	2	-0.27	0.45	0.5557
	3	**-0.79**	**0.29**	**0.0078**
	4	**-1.70**	**0.37**	**<0.0001**
Age (in years)		0.01	0.03	0.7364
Gender (female: referent)		-0.42	0.27	0.214
Works or volunteers at a food service premises		0.40	0.41	0.3434
Handles food for the public		0.28	0.37	0.4709
Has ever taken a food preparation/handling course		-0.39	0.27	0.161
Frequency of cooking from basic ingredients		-0.11	0.12	0.356
Self-described cooking ability		-0.01	0.15	0.9733

[a] Results of the linear mixed effects regression model for 119 students and 17 possible behaviors. SE, standard error.

Table 7.6. Change in the number of correctly performed behaviors related to the concept ‘‘separate’’ of Ontario, Canada high school students after the intervention (T_1 to T_2) and at the end of the school term (T_2 to T_3)[a]

Fixed Effects Parameters		**Co-efficient**	**SE**	**p-value**
Intercept		**8.12**	**1.55**	**<0.0001**
Slope: $T_1 – T_2$		**2.95**	**0.44**	**<0.0001**
Slope: $T_2 – T_3$		0.69	0.42	0.1015
School (1: referent)	2	-0.96	0.76	0.2113
	3	**-1.86**	**0.49**	**0.0002**
	4	**-2.75**	**0.66**	**<0.0001**
Age (in years)		-0.04	0.03	0.1499
Gender (female: referent)		0.34	0.45	0.5002
Works or volunteers at a food service premises		-0.07	0.67	0.9156
Handles food for the public		0.52	0.61	0.4008
Has ever taken a food preparation/handling course		-0.11	0.46	0.8144
Frequency of cooking from basic ingredients		-0.19	0.21	0.3729
Self-described cooking ability		0.34	0.27	0.1981

[a] Results of the linear mixed effects regression model for 119 students and 14 possible behaviors. SE, standard error.

Table 7.7. Change in the use of a food thermometer to check chicken doneness (‘‘cook’’ behavior) of Ontario, Canada high school students after the intervention (T_1 to T_2) and at the end of the school term (T_2 to T_3)[a]

Fixed Effects Parameters		**Co-efficient**	**SE**	**p-value**
Intercept		0.04	0.12	0.7172
Slope: $T_1 – T_2$		**0.30**	**0.05**	**<0.0001**
Slope: $T_2 – T_3$		-0.06	0.06	0.2649
School (1: referent)	2	**0.53**	**0.06**	**<0.0001**
	3	0.00	0.03	0.9626
	4	0.07	0.05	0.1165
Age (in years)		-0.01	0.00	0.1272
Gender (female: referent)		-0.03	0.03	0.4277
Works or volunteers at a food service premises		**0.12**	**0.05**	**0.0260**
Handles food for the public		-0.03	0.05	0.4803
Has ever taken a food preparation/handling course		-0.01	0.03	0.7936
Frequency of cooking from basic ingredients		0.01	0.01	0.5893
Self-described cooking ability		0.01	0.02	0.5801

[a] Results of the logistic mixed effects regression model for 119 students. SE, standard error.

Chapter 8:

General Discussion

Overview

Youth, specifically high school students, can be considered an at-risk population given their emerging roles as food handlers, risky food handling habits, and poor food safety knowledge, attitudes, and self reported behaviours. Currently, there are numerous food safety education programs in use across Canada, including the Ministry of Health and Long-Term Care (MOHLTC) program offered to commercial and domestic food handlers through Ontario's public health units. However, the impact of the MOHLTC program on changing food safety behaviours has not been formally evaluated. Given that youth are an important audience for food safety education, the existence of provincial food safety programming, and the lack of studies evaluating training effectiveness, the overall purpose of this thesis was to explore the food safety education needs specific for Ontario high school students, and assess if their food safety behaviours could be improved via the MOHLTC's Provincial Food Handler Training Plan.

To accomplish this, this thesis explored the food safety education needs of high school students (Chapters 4 and 5), assessed the suitability of the MOHLTC's Provincial Food Handler Training program for meeting the identified education needs of high school students (Chapter 6), and evaluated whether food handling behaviours changed following the delivery of the MOHLTC's Provincial Food Handler Training program (Chapter 7).

Summary of key findings

The key informants highlighted the importance of food safety education for high school students, because: (i) they have current and personal needs for food safety information, (ii) high school is an ideal time and place to instil life-long good food safety habits, and (iii) they are part

of the foodborne illness risk landscape. Further, high school students are a unique and captive audience in need of safe food handling skills to reduce both current and future risk. Food safety education for this demographic is important. Beyond offering an employment advantage, it is needed by all students to improve food literacy and instil essential life skills that may not be cultivated at home (Slater, 2013). However, relying on existing high school curriculum to deliver food safety education will not reach all students, as food and nutrition classes are primarily elective. This has been identified in Chapter 4 (Diplock et al., 2017) and in the literature (Slater, 2013; Yarrow et al., 2009). Thus, food safety education experts, including public health professionals, should seek other avenues for education (e.g., engaging athletic coaches, providing student specific food safety messages), and advocating for mandatory food safety education in high schools.

High school students have food safety education needs that centre on how to safely do the things they typically do with food, as well as some basic knowledge of microbiology and the importance of personal hygiene. Subsumed within this, students need to be taught to practice good personal hygiene, keep foods at safe temperatures, use a food thermometer, separate raw and ready to eat foods, and ensure cooking spaces, utensils, and equipment are clean. Food safety education should focus on students' own current food handling experiences, including: the use of microwaves for reheating and cooking; consumption of convenience meals; school events; transportation of food for lunches, school trips and sporting events; and food allergen awareness. The results suggest that education should focus on sequences of safe food handling behaviours relevant within specific student food interactions (e.g., packing a lunch, or microwaving or reheating a convenience meal) rather than traditional food safety concepts (e.g., cross-contamination, time and temperature abuse).

The MOHLTC food safety education materials used in this thesis covered the majority of high school students' identified food safety education content needs (Chapter 5) and teaching objectives for Food and Nutrition courses (Chapter 6). The MOHLTC materials are useful resources that meet high school students' specific education content needs, alongside their intended target audience of commercial food handlers. Material can be used to teach specific food safety topics by referencing specific pages and slides (Appendix E [p. 227]), or the program can be taught in its entirety giving students the chance to become certified food handlers, meeting both high school educational objectives and providing students with a potential employment advantage.

This thesis (Chapter 7) provides evidence that food safety behaviours among high school students are generally poor, but improve significantly after in-class delivery of food handler training, specifically behaviours around the use of probe thermometers and cleaning activities, including hand hygiene, avoiding cross contamination of foods. Despite these noted improvements post-intervention, students continued to perform numerous unsafe food handling practices, which could lead to foodborne illness for themselves and others. Continued risky behaviours post-intervention indicate that there may be other factors that impact the safe food handling behaviours of students. Future consideration of how psychosocial factors influence behaviour norms, and how changes in food handling behaviours translates to actual risk of foodborne disease, is needed.

Contributions to the food safety literature

This thesis includes the first Canadian direct observation study of safe food handling practices in any population, and only the second study ever to use direct observation to measure changes in behaviour following a food safety education intervention (Redmond & Griffith, 2006;

Chapter 7). Further, this thesis included post-post observation allowing changes in behaviour to be observed over a time period of approximately three months. As well, the use of logistic regression models to measure intra-student differences provided more powerful analyses than comparing group means (e.g., using Chi square) as has been used in many previous studies (Brown & Hermann, 2005; Egan et al., 2007; Kim et al., 2012; Redmond et al., 2004; Richards et al., 2008; Sanlier et al., 2009). This thesis also established the importance of food safety education for high school students. Students are an important audience given their emerging food handling roles, poor food safety knowledge, poor self reported practices, and risky food safety behaviours (Turconi et al., 2008). High school was also identified as an ideal time and location to educate future food handlers, improve safe food handling behaviours, and reduce the burden of disease.

The expert opinions identified in this thesis (Chapter 4) acknowledged the importance of audience-specific food handling practices and experiences to enhance learning and improve changes in behaviour. Chapter 6 also demonstrated that existing food safety education materials can be adapted to meet the food safety education needs of high school students, as well as meet existing teaching objectives, and require little to no investment in resources. What is not clear is how best to package and deliver material. Food safety experts and educators routinely call for the need to practice safe food handling in order to establish good food handling habits (Caraher & Lang, 1999; Slater, 2013). Also unknown within the school setting is the ideal method for delivery. Here, traditional lecture style with practical examples was used; however, other research has investigated electronic kiosks (Endres et al., 2001), music parodies (Winter, 2009), on-line modules (Howton et al., 2016)), comics (Burke & Dworkin, 2016), and video games (Crovato et al., 2016; Quick et al., 2013).

This thesis demonstrated that behaviours were better after the delivery of an existing and widely used food safety education program. This is consistent with the literature that has shown improved knowledge, attitudes, and self-reported behaviours (Milton & Mullan, 2010; Young et al., 2015; Sivaramalingam et al., 2015), as well as observed behaviours (Redmond & Griffith, 2006) post-food safety education. However, this thesis (Chapter 7) found that poor food handling behaviours persist post intervention, putting food handlers and consumers at risk. Of particular interest was low use of probe thermometers to verify cooking temperatures. This despite themometers being promoted as the only method to verify safe food temperatures (Fischer & De Vries, 2008), the availability of probe thermometers in all study classrooms, and demonstrations of proper use as part of the food safety education. Thermometer use to verify proper cooking termperatures needs to be promoted in all recipes and students should be routinely reminded that the only way to ensure that foods are adequately cooked or reheated is with a food thermometer. Future studies should explore ways to make a food thermomter as common and important a kitchen utensil as a spoon.

Poor food safety practices persist post intervention in commercial (e.g., McIntyre, 2013) and domestic (Milton & Mullan, 2010; Nesbitt et al., 2014) settings, indicating that there are other factors impacting the ability and willingness of people to adopt safe food handling behaviours. The maintenance of food safety knowledge and practices is important to consider in determining how food safety education is delivered, the frequency of food safety education, and needs related to refresher courses or re-training. McIntyre et al. (2013) report decreased food safety knowledge and self-reported behaviours months to years post intervention, resulting in a call for re-certification or booster food safety education courses for commercial food handlers.

Timing of re-certification or boosters is not well established. Nor is the need for on-going training. The frequency and type of each require further research.

Many schools have kitchen facilities that can help further skill development by giving students an opportunity to practice safe food handling behaviours. The need to practice skills is consistent with the literature (Caraher & Lang, 1999; Slater, 2013) and is featured heavily in the Food and Nutrition course curricula (Ministry of Education, 2013). Others have looked at middle school (Byrd-Bredbenner etal., 2010; Kim et al., 2012; Lynch et al. 2008; Ovca et al., 2016; Quick et al., 2013) and college students (Abbot et al., 2012; Byrd-Bredbenner et al., 2008; Milton & Mullan, 2012; Mullan & Wong, 2010; Stein et al., 2010; Yarrow et al., 2009) as key target audiences for food safety education. A concern is that middle school students may be too young to grasp technical aspects of safe food handling behaviours; they are also not involved in complex food handling (Haapala & Probart, 2004), compared to high school and college students who participate in more food handling (Burke and Dworkin, 2015; Green & Knechtges, 2015; Yarrow et al., 2009).

This thesis identified that youth have unique food safety education needs, focused primarily on how to do the things they typically do with food; how to keep themselves and their kitchens clean and safe; how microorganism contaminate food, and how they can result in foodborne disease. This nuanced difference in approach, stressed by food safety and youth education experts, focuses on context and how to do things safely, compared to stressing why it is important to do things safely, which is a common feature of traditional food safety education. Traditionally, food safety education has been knowledge-based, emphasizing ‘the why’ and providing scientific rationale behind safe food handling behaviours with the belief that if people know the risks related to foodborne disease they will opt to do the right thing. In this thesis

experts emphasized teaching how to handle food safely, embedding key food safety messages and behaviours in directions, with the idea that practicing correct behaviours will result in safe food handling habits, without the need for food handlers to consciously choose to handle food safely. The importance of habit forming in food safety is consistent with the literature (Byrd-Bredbenner et al., 2010; Byrd-Bredbenner et al., 2013; Chow & Mullan, 2009; Haapala & Probart, 2004; Turconi et al., 2008). Recently, Levine et al. (2017) identified the lack of safe food handling directions and messages in recipes. There appears to be an inherent belief that food handlers know and will practice safe food handling, without the need for consistent prompting.

Safe food handling is not just about knowing how to do the right thing and trying to establish safe food handling habits. In this thesis, experts did emphasised the importance for students to understand 'the why' of food safety, but only when it comes to foodborne pathogens, individual susceptibility to disease, and the potentially severe consequences of foodborne diseases. Experts indicated it was hard to get youth to accept personal risk, and appreciate the need for safe food handling. This is consistent with the literature that demonstates that youth have a low perceived susceptibility to foodborne illness, meaning they do not see foodborne illness as a risk to personal health (Haalapa & Probart, 2004) due to sense of invincibility, and not understanding consequences (Byrd-Bredbenner et al., 2010). These findings are consistent with results of Milton and Mullan's (2010) systematic review that indicates despite consumers' acknowledgement of the importance of food safety behaviours, they do not believe food-related illnesses are a common issue. According to Schafer et. al. (1993) perception of vulnerability to illness and self-efficacy influence food safety behaviours in an adult population. McArthur et al. (2006) explain that students' willingness to adopt safe food handling behaviours may be due to a

low priority being placed on food safety, as well as low self-efficacy and knowledge. The reported low perception of risk related to food and youths' low priority for food safety lend further evidence for the need to teach food safety education to high school students. Incorporation of microbiology and foodborne disease risks throughout the high school curriculum should help to increase students' sense of susceptibility to foodborne disease, in turn, increasing the priority they place on the importance of safe food handling practices in order to prevent becoming sick.

For food safety behaviour to occur, people must feel susceptible to illness, have an incentive to take action, and feel competent (high self-efficacy) to carry out the action (Schafer et al., 1993). A study of an injury prevention program with Toronto, Ontario, high school students, found that the risk perception of students increased following the intervention and that students identified a skewed sense of invincibility and their own skills as barriers to injury prevention (Monneuse, et al., 2008). Wickman, Anderson, and Greenberg (2008) found that high school students' perception of invinicibility stemmed from the belief that 'it won't happen to me' (p.463); while sharing personal stories, targeting student specific activities, and allowing students to experience situations could combat the adolescent sence of invincibility. Incorporation of food safety material, including hands on food preparation, into high school curriculum should go a long a way to increasing students' perceptions of risk as well as their confidence to take actions, including good hygiene practices and checking cooking temperatures in order to reduce food risks. Motivation appears to be a key component of health promotion, especially with youth (Schafer et al., 1993). If youth do not perceive themselves as susceptible to, or recognize the potential severity of, foodborne illness, they will not be motivated to adopt or change behaviour (McArthur et al., 2006). Measures to counter this would be to increase knowledge about

foodborne illnesses and potential severity of illnesses and to increase awareness of foodborne illness rates, especially in domestic environments, through inclusion of foodborne disease material in science, health, and food and nutrition courses.

Often, food preparation becomes a repeated, habitual behaviour requiring very little cognitive effort (Byrd-Bredbenner et al., 2013). Therefore, it is important to instil good food handling practices at an early age, before bad habits are learned. Youth predominantly learn food preparation and handling skills from family members, most often their mothers (Tyrell et al., 2015). Additionally, socioeconomic status, ethnicity, and culture may also be important factors related to food safety risks and safe food handling practices. Research on food safety knowledge and behaviours among low inome and minority consumers has identified unique risk factors including: comparatively lower food safety knowledge, misperceptions on freezing and cooling of foods, very rare use of food therometers, and microbial quality of food available at small retail markets, especially in food deserts (Quinlan, 2013). Cultural and socioeconomic factors are important considerations for future food safety education research. Lastly, Moan and Rise (2006) report past behaviour to be another important factor in determining youths' intentions and actions towards health behaviours. Food safety educators and public health professionals need to consider the role of habits and habit forming activities as well as the socioeconomic status and cultures of their target audiences when designing and delivering food safety education programs.

Implications for public health practice

This thesis identified an opportunity for food safety educators, including environmental public health professionals, to share resources and help facilitate learning in high school environment. This may include the provision of up-to-date food safety education materials, classroom presentations, and training for high school teachers. The MOHTLC material meets the

identified student education content needs, as well as the food and nutrition learning objectives. However, some of the material may require modifications, focussing more on practices to prepare food safely versus why it is important prepare food safely.

Although the MOHLTC's program material (manual and PowerPoint) contains nearly all the food safety education content needed by high school students, it needs to be adapted to focus on context and how students' can handle food safety, rather than stressing why food safety is important; a nuanced, yet, important distinction indentified by food safety and education experts in Chapter 5. Additional modifications would include incorporating high school students' unique food handling experiences (e.g., microwaves, convenience meals, and school events; Chapter 5). As discussed in Chapter 5, schools could also explore ways that the MOHLTC materials may support teaching objectives, outside of Food and Nutrition courses, including in science and health related courses. Once updated, the MOHLTC and local public health units should explore options for making the adapted MOHLTC program material readily available to high school Food and Nutrition teachers, as well as providing any additional professional development training for teachers to help them become familiar with the material and hopefully increase use of the material in high schools.

Further, this thesis highlights the need to have a greater emphasis on the development of safe food handling behaviours over increasing individuals' food safety knowledge. There are numerous opportunities to embed safe food handling behaviours in everyday youth based activities, from the high school curriculum, sports, special events, and other gatherings identified in this thesis (Chapter 7). A key finding is the need to make students care about food safety education and understand their personal risks resulting from poor food handling practices. We need to find ways to defeat the 'sense of invincibility' that many youth experience with respect

to foodborne illness and food safety risks. Food safety education experts should ask themselves two important questions: 1) How do we make it popular to care about safe food handling practices?; and 2) how do we make it cool to use a probe thermometer?

Implications for high school food safety education

Schools can enhance the safe food handling behaviours of students and potentially reduce the burden of foodborne disease, with little-to-no budgetary impacts, by connecting with public health practitioners and other food safety experts. These people can provide existing food safety education materials, help maintain and enhance high school teachers' food safety knowledge, and provide on-site instructional support. Studies have demonstrated that development and delivery of tailored food safety education for high school students (Burke and Dworkin, 2016; McCurdy, Schmiege & Winter, 2008) and middle school students (Richards et al., 2008) can improve students food safety knowledge, attitudes, and self reported behaviours. As discussed previously, delivery methods for food safety education vary from traditional lecture style used here (Chapter 7; Diplock et al., in press), to electronic kiosks (Endres et al., 2001), music parodies (Winter, 2009), on-line modules (Howton et al., 2016), comics (Burke & Dworkin, 2016), and video games (Crovato et al., 2016; Quick et al., 2013).

Where possible, educators should use existing school kitchens for teaching so students can practice safe food handling to develop lifelong safe handling habits. To facilitate students' safe food handling practices, schools should be equipped with food thermometers, and cleaning and sanitizing wipes next to microwaves and other food preparation areas, as well as adequate refrigeration space or reminders for students to use cooler bags and ice packs for the safe storage of their potentially hazardous foods. The use of school events, including sporting events, bake sales, and parties, represent another opportunity to reinforce safe food handling practices such as

hand washing, safe food temperature control, and preventing cross contamination of foods with pathogens and allergens. Schools could increase the reach of food safety messages by incorporating them into other areas of the curriculum, outside of food and nutrition courses. For example in science courses, food safety principles and information on foodborne pathogens could be used to support scientific concepts and provide practical applications (Koeppl & Robey, 1998). In physical education courses, safe food handling messages could be incorporated alongside healthy eating and nutrition materials, including embedding safe food handling steps in all recipes. Lastly, schools could link safe food handling actions to existing school policies, particularly school allergy policies (e.g., explaining the importance of avoiding cross-contamination by discussing the potential spread of a food allergen in a classroom).

Limitations

The main limitation pertaining to the key informant interviews is that participants were limited to experts in food safety or youth education. Parents and students, who may have different perspectives about the importance of food safety education, were not included in the study. Future inclusion of student and parent perspectives would further the understanding of youth-specific food safety education needs.

The observation component (Chapter 7) of this thesis is subject to several limitations, including the lack of a control group. As described, the original design included a control group, but teachers were unwilling to have their classes participate unless students received food safety education, illustrating a major methodological challenge of applied research, especially in schools. Another important consideration when interpreting these results is that changes in behaviour assessed solely on changes over time. Whether the changes observed translate into changes in the foodborne disease risk faced by these students still needs to be determined.

Additionally, the use of different teaching and cooking environments, including students working next to each other, may have increased peer influence on food handling behaviours, altering what students may have done if working alone in a kitchen. Finally, due to in-class time constraints, behaviours related to the concept 'chill', in particular how high school students deal with leftovers, which may be a food handling step of particular importance to this demographic, were not observed.

Nevertheless, this thesis suggests important ways that current food safety education efforts can be reframed or revised, to target food safety education to meet the needs of students. As well, this thesis demonstrates the feasibility of conducting observation based food safety studies, and highlights the potential to better understand the effects of food safety education interventions on food handling behaviours.

Directions for future research

Ideally, future studies would include direct observation of food safety behaviours, with larger sample sizes and control group(s). Research is also needed to determine the most effective means of delivering food safety education to youth, by exploring the use of in class applied learning as well as on-line modules, video games, and even comics. Cultural and socioeconomic factors are also important considerations for future food safety education research, to ensure the identification of specifc food safety education needs and development of educational material to meet those needs. Future research should also consider the use of a standardized kitchen with closed circuit cameras (Redmond & Griffith, 2003) to reduce chances of participants altering behaviours to meet study conditions, and control influence of different cooking environments on observed behaviours. The inclusion of a comparison of food safety knowledge scores with observed food handling behaviours for both control and study groups would further enhance

research findings. Another route to consider would be the inclusion of measures of risk analysis of food handling practices (e.g., Byrd-Bredbenner et al., 2008), in order to identify the most important food handling behaviours (i.e., those most likely to result in foodborne disease). Future research could also include the development and evaluation of food safety education material targeted specifically to changing food handling behaviours linked to the greatest increase in foodborne disease risk. Lastly, there is a need to explore barriers to safe food handling, and the potential impact of including behaviour theories into food safety education design and research.

References

This section includes the references from all earlier chapters, presented by chapter. Reference formatting for the manuscripts (Chapters) matches the journals to which each manuscript was submitted.

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Appendix A: Key informant interview script and semi-structured question guide

Introduction, Information, and Consent

Hi <NAME> - thank you so much for agreeing to participate in our Key Informant Interviews, which should take about 45 minutes.

Is this still an ok time to talk? [CONFIRM OR REBOOK]

Great! As you know, we are going to record this interview. I'm going to turn the recorder on now, and then provide you with some information and record your consent, and then we'll begin the interview proper.

[TURN RECORDER ON]

[READ VERBATIM]:
"As outlined in the invitation letter, we are conducting about 20 key informant interviews, to identify the top priority food safety messages needed by youth in Ontario. We will use the results of these interviews to identify general food safety needs in this demographic, and to prioritize the most important messages and materials to include in the in-school, food safety training materials for Ontario high school students, which we are currently developing from the Ontario Ministry of Health and Long-term Care's newly standardized Provincial Food Handler Training Plan.

"You were provided details about the study in the invitation letter, including the voluntary nature of your participation, the confidentiality of your responses, how the information you provide will be stored and used, the potential that we may include non-identifying verbatim quotes in published materials and presentations, and your ability to stop the interview at any time, skip any questions that you prefer not to answer, or withdraw your consent at any time, all without penalty.

"As mentioned, we are audio recording this interview. So, before we begin, can you please indicate your consent to participate?"

[CONSENT GIVEN, OR INTERVIEW STOPPED]

Thank you.

Interview

(LEAD–IN / EXPERTISE)

"Our goal with these interviews is to identify priority food safety training and education needs for youth in Ontario, specifically high school students.

[ASIDE: IF THE INTERVIEWEE IS OUTSIDE OF ONTARIO, MENTION THAT THEIR EXPERTISE IS RELEVANT TO A COMPARABLE POPULATION]

"To start, can you briefly outline your expertise and experience in this area?

[PROBE THESE THREE DOMAINS, PARTICULARLY THEIR INTERSECTION:
→ FOOD SAFETY
→ HIGH SCHOOL STUDENTS/NEW FOOD HANDLERS
→ TRAINING / EDUCATION

(DOMAIN A: THE OVERALL NEED FOR & IMPORTANCE OF FOOD SAFETY IN HS/Y)

"Now, can you tell us your overall thoughts about food safety in high school students/youth? Is food safety an issue in this demographic?

[PROMPTS:
→ WHY? WHY NOT?
→ IMPORTANCE OF FS?

→ DO HS/Y FACE FOOD SAFETY RISKS?
- NOW, VS LATER IN LIFE? {I.E. PRE-SECOND WEANING}?
- PERSONALLY?
- HOW ABOUT FOR WHOM THEY MAKE/HANDLE FOOD?

→ PERSONAL LIFE SKILL, VS MARKETABLE JOB SKILL

"Can you give some more specifics about food safety needs of high school students?

[PROMPTS:
→ ANY RISKS UNIQUE TO THIS GROUP, VS POPULATION AT-LARGE
→ ANY UNIQUE BEHAVIORS OR EXPOSURES?
→ ANY UNIQUE BARRIERS TO SAFE FOOD HANDLING?
→ SPECIFIC TRAINING OR EDUCATION NEEDS?
→ SPECIFIC DELIVERY MECHANISMS FOR FOOD SAFETY MESSAGES?

"In the past five years or so, have there been any specific food safety events relevant to high school students or youth in your jurisdiction? For example, any foodborne outbreaks or suspected clusters, any relevant food recalls, any messaging campaigns, any requests for information or training…

[FOR ANY IDENTIFIED, PROBE:
→ DOES THIS REVEAL A SPECIFIC CONCERN?

(DOMAIN B: SELECTING THE PRIORITY FOOD SAFETY MESSAGES/OBJECTIVES FOR HS/Y, FROM MOHLTC TRAINING PLAN)

"The Ontario Ministry of Health and Long-term Care has a Provincial Food Handler Training plan, which is a standardized set of materials that's used to provide food safety training for food handlers in the province. The material covers all aspects about safe food handling and preparation, mostly from a commercial setting perspective, and gives lots of details about things like personal hygiene, time and temperature, cleaning and sanitation, shipping and receiving, cross contamination, etc.

"We are tailoring this plan, creating in-class educational material for Ontario high school students, that could eventually form part of the high school curriculum. Following from what you've mentioned already, where you talked about
[REITERATE RISKS/NEEDS FROM ABOVE],
and given the wide range of information covered by the Ministry's training material, of all the things high school students could be taught about food safety, what are the key things they need to learn?

[PROMPTS:
→ EXPAND ON POINTS ALREADY MENTIONED
→ PERSONAL, VS COMMERCIAL/RESTAURANT FOCUS?
→ WHAT SPECIFIC BEHAVIORS DO WE WANT THEM TO LEARN/INTERNALIZE?
→WHAT FOOD PREP SITUATION(S) ARE MOST IMPORTANT?
→WHAT ERRORS ARE MOST CRITICAL TO AVOID?

→ IF LOTS LISTED, NARROW DOWN TO TOP ONES
→ IF FEW LISTED, PROMPT FOR OTHERS

→ ***HIGH PRIORITY ITEMS FROM THE MOHLTC PLAN WE MUST COVER
→ ***LOW PRIORITY ITEMS FROM THE MOHLTC PLAN WE CAN IGNORE

[PROBE TO GET TO THE SPECIFIC BEHAVIORS:
E.G. IF "SEPARATE", ASK FOR AN EXAMPLE OR DEFINITION OF THE SPECIFIC BEHAVIOR
E.G. IF "COOKING TEMPERATURES/DONENESS", IS IT IMPORTANT TO HAVE THE ACTUAL TEMPERATURE MEMORIZED, OR KNOW THERE IS ONE AND USE IT CORRECTLY?

(DOMAIN C: DELIVERY OF FOOD SAFETY MESSAGES/EDUCATION FOR HS/Y)

"So, you identified

[REITERATE PRIORITIES FROM LAST SECTION]

as the priority food safety messages/behaviors for high school students to have. Do you know if, and how, any education on these is currently being provided via high school curriculum?

"What do you think should be offered in high school curriculum?

[PROMPT:

→ WHY?

"Are you aware of any other additional opportunities for offering food safety training in the high school environment or to high school students?

[PROMPT:

→ IN THE PAST ~5 YEARS, HAS ANY SUCH THING OCCURRED IN YOUR JURISDICTION?

"Do you have any other comments that you would like to share, about food safety and the high school aged population?

(WRAP-UP / THANK YOU)

"That was my last question; on behalf of my colleagues, thank you so much for your thoughtful responses, and for your time today. We really do appreciate your expertise, and your participation. At this time, before we wrap up, I'll just ask if you have any questions for me?

Appendix B: Food preparation and food safety education schedule for participating schools, February – May, 2015.

	School #1	School #2	School #3	School #4
Food Preparation #1	Feb 02	Feb 06	Feb 12	Feb 09
Food Safety Education – 1st hour	Feb 03	Feb 06	Feb 23	Feb 10
Food Safety Education - 2nd hour	Feb 04	Feb 13	Feb 24	Feb 11
Food Safety Education – 3rd hour	Feb 12	Feb 13	Feb 25	Feb 17
Food Preparation #2	Feb 27	Feb 19	Mar 02	Feb 20
Food Preparation #3	May 25	May 21	May 22	May 19

Appendix C: Ontario high school food and nutrition courses food safety expectations, included verbatim from the Ontario Curriculum Grades 9 to 12 Social Sciences and Humanities (Ministry of Education, 2013)

Food and Nutrition, Grade 9 or 10 open HFN1O/2O

E1. Kitchen Safety: demonstrate an understanding of practices that ensure or enhance kitchen safety.

E1.1 describe common accidents that can occur in the kitchen (e.g., cuts, burns, fires, falls, poisoning, electric shocks).

E1.2 demonstrate an understanding of safe practices within the food-preparation area (e.g., safely handle hot foods; prevent spatters, scalds, and cuts; wipe up spills immediately).

E1.3 demonstrate an understanding of appropriate emergency responses to common accidents associated with food preparation (e.g., cuts, burns, scalds, fires).

E2. Food Safety: demonstrate an understanding of practices that ensure or enhance food safety.

E2.1 describe the causes and symptoms of foodborne illnesses (e.g., *E. coli* poisoning, botulism poisoning, *Clostridium perfringens* poisoning, salmonellosis, listeriosis) and techniques for preventing them.

E2.2 use appropriate personal hygiene practices to prevent contamination of food (e.g., wash hands frequently; cover a cough or sneeze in their sleeve; use gloves to cover cuts or wounds; tie hair back).

E2.3 demonstrate the use of safe food-handling practices required to prevent cross-contamination by pathogens, parasites, and allergens in the food-preparation area (e.g., wash fresh produce; sanitize cutting boards after contact with meat products; sanitize implements that come into contact with allergens when preparing food for or with people with known allergies; sanitize

work surfaces; replace and/or sanitize sponges and cloths frequently; use proper clean-up procedures).

E2.4 follow appropriate protocols to ensure food safety (e.g., cook foods to recommended temperatures; keep hot foods hot and cold foods cold; store food appropriately; wipe tops of cans before opening; check “best-before” dates; demonstrate awareness of common allergenic ingredients).

E3. Food Preparation: demonstrate skills needed in food preparation.

E3.2 demonstrate the ability to safely use, maintain, clean, and store tools and equipment used in food preparation.

Food and Culture, Grade 11 University/College Preparation HFC3M

D1. Kitchen Safety: demonstrate an understanding of practices that ensure or enhance kitchen safety.

D1.2 demonstrate an understanding of safe practices within the food-preparation area (e.g., safely handle hot foods; prevent spatters, scalds, and cuts; wipe up spills immediately).

D2. Food Safety: demonstrate an understanding of practices that ensure or enhance food safety.

D2.1 explain the causes of food-borne illnesses (e.g., *E. coli* poisoning, botulism poisoning, *Clostridium perfringens* poisoning, salmonellosis, listeriosis) and describe the symptoms of, and the techniques for preventing, these illnesses.

D2.2 use appropriate personal hygiene practices to prevent contamination of food (e.g., wash hands frequently; cover a cough or sneeze in their sleeve; use gloves to cover cuts or wounds; tie hair back).

D2.3 use safe food-handling practices to prevent cross-contamination by pathogens, parasites, and allergens in the food-preparation area (e.g., wash fresh produce; sanitize cutting boards after

contact with meat products; sanitize implements that come into contact with allergens when preparing food for or with people with known allergies; sanitize work surfaces; replace and/or sanitize sponges or cloths frequently; use proper clean-up procedures).

D2.4 follow appropriate protocols to ensure food safety (e.g., cook foods to recommended temperatures; keep hot foods hot and cold foods cold; store food appropriately; wipe tops of cans before opening; check “best-before” dates; demonstrate an awareness of common allergenic ingredients).

D3. Food Preparation: demonstrate skills used in food preparation in various countries/cultures.

D3.2 demonstrate the ability to safely use, maintain, clean, and store tools and equipment used in food preparation.

Food and Culture, Grade 11 Workplace Preparation HFC3E

D1. Kitchen Safety: demonstrate an understanding of practices that ensure or enhance kitchen safety.

D1.2 demonstrate an understanding of safe practices within the food-preparation area (e.g., safely handle hot foods; prevent spatters, scalds, and cuts; wipe up spills immediately).

D2. Food Safety: demonstrate an understanding of practices that ensure or enhance food safety.

D2.1 describe the causes and symptoms of foodborne illnesses (e.g., E. coli poisoning, botulism poisoning, Clostridium perfringens poisoning, salmonellosis, listeriosis) and techniques for preventing these illnesses.

D2.2 use appropriate personal hygiene practices to prevent contamination of food (e.g., wash hands frequently; cover a cough or sneeze in their sleeve; use gloves to cover cuts or wounds; tie hair back).

D2.3 use safe food-handling practices to prevent cross-contamination by pathogens, parasites, and allergens in the food-preparation area (e.g., wash fresh produce; sanitize cutting boards after contact with meat products; sanitize implements that come into contact with allergens when preparing food for or with people with known allergies; sanitize work surfaces; replace and/or sanitize sponges or cloths frequently; use proper clean-up procedures).

D2.4 follow appropriate protocols to ensure food safety (e.g., cook foods to recommended temperatures; keep hot foods hot and cold foods cold; store food appropriately; wipe tops of cans before opening; check “best-before” dates; demonstrate awareness of common allergenic ingredients).

D3. Food Preparation: demonstrate skills used in food preparation in various countries/cultures;

D3.2 demonstrate the ability to safely use, maintain, clean, and store tools and equipment used in food preparation.

Nutrition and Health, Grade 12 University Preparation HFA4U

E1. Kitchen Safety: demonstrate an understanding of practices that ensure or enhance kitchen safety.

E1.1 describe common accidents that can occur in the kitchen (e.g., cuts, burns, fires, falls, poisoning, electric shocks).

E1.2 demonstrate an understanding of safe practices within the food-preparation area (e.g., safely handle hot foods; prevent spatters, scalds, and cuts; wipe up spills immediately).

E1.3 demonstrate an understanding of appropriate emergency responses to common accidents associated with food preparation (e.g., cuts, burns, scalds, fires).

E2. Food Safety: demonstrate an understanding of practices that ensure or enhance food safety.

E2.1 outline the causes and symptoms of foodborne illnesses (e.g., E. coli poisoning, botulism poisoning, Clostridium perfringens poisoning, salmonellosis, listeriosis) and techniques for preventing these illnesses.

E2.2 use appropriate personal hygiene practices to prevent contamination of food (e.g., wash hands frequently; cover a cough or sneeze in their sleeve; use gloves to cover cuts or wounds; tie hair back).

E2.3 use safe food-handling practices to prevent cross-contamination by pathogens, parasites, and allergens in the food-preparation area (e.g., wash fresh produce; sanitize cutting boards after contact with meat products; sanitize implements that come into contact with allergens when preparing food for or with people with known allergies; sanitize work surfaces; replace and/or sanitize sponges or cloths frequently; use proper clean-up procedures).

E2.4 follow appropriate protocols to ensure food safety (e.g., cook foods to recommended temperatures; keep hot foods hot and cold foods cold; store food appropriately; wipe tops of cans before opening; check “best-before” dates; demonstrate awareness of common allergenic ingredients).

E3. Food Preparation: demonstrate skills needed in food preparation.

E3.1 identify and select appropriate tools, equipment, and ingredients for use in food preparation.

E3.2 demonstrate the ability to safely use, maintain, clean, and store tools and equipment used in food preparation.

Nutrition and Health, Grade 12 College Preparation HFA4C

E1. Kitchen Safety: demonstrate an understanding of practices that ensure or enhance kitchen safety.

E1.1 describe common accidents that can occur in the kitchen (e.g., cuts, burns, fires, falls, poisoning, electric shocks).

E1.2 demonstrate an understanding of safe practices within the food-preparation area (e.g., safely handle hot foods; prevent spatters, scalds, and cuts; wipe up spills immediately).

E1.3 demonstrate an understanding of appropriate emergency responses to common accidents associated with food preparation (e.g., cuts, burns, scalds, fires).

E2. Food Safety: demonstrate an understanding of practices that ensure or enhance food safety.

E2.1 outline the causes and symptoms of foodborne illnesses (e.g., E. coli poisoning, botulism poisoning, Clostridium perfringens poisoning, salmonellosis, listeriosis) and techniques for preventing these illnesses.

E2.2 use appropriate personal hygiene practices to prevent contamination of food (e.g., wash hands frequently; cover a cough or sneeze in their sleeve; use gloves to cover cuts or wounds; tie hair back).

E2.3 use safe food-handling practices to prevent cross-contamination by pathogens, parasites, and allergens in the food-preparation area (e.g., wash fresh produce; sanitize cutting boards after contact with meat products; sanitize implements that come into contact with allergens when preparing food for or with people with known allergies; sanitize work surfaces; replace or sanitize sponges or cloths frequently; use proper clean-up procedures).

E2.4 follow appropriate protocols to ensure food safety (e.g., cook foods to recommended temperatures; keep hot foods hot and cold foods cold; store food appropriately; wipe tops of cans before opening; check “best-before” dates; demonstrate awareness of common allergenic ingredients).

E3. Food Preparation: demonstrate skills needed in food preparation.

E3.1 identify and select appropriate tools, equipment, and ingredients for use in food preparation.

E3.2 demonstrate the ability to follow a recipe.

E3.4 demonstrate the ability to safely use, maintain, clean, and store tools and equipment used in food preparation.

Food and Healthy Living, Grade 12 Workplace Preparation HFL4E

B1. Kitchen Safety: demonstrate an understanding of practices that ensure or enhance kitchen safety.

B1.1 describe common accidents that can occur in the kitchen (e.g., cuts, burns, fires, falls, poisoning, electric shocks).

B1.2 demonstrate an understanding of safe practices within the food-preparation area (e.g., safely handle hot foods; prevent spatters, scalds, and cuts; wipe up spills immediately).

B1.3 demonstrate an understanding of appropriate emergency responses to common accidents associated with food preparation (e.g., cuts, burns, scalds, fires).

B2. Food Safety: demonstrate an understanding of practices that ensure or enhance food safety.

B2.1 outline the causes and symptoms of foodborne illnesses (e.g., *E. coli* poisoning, botulism poisoning, *Clostridium perfringens* poisoning, salmonellosis, listeriosis) and techniques for preventing these illnesses.

B2.2 use appropriate personal hygiene practices to prevent contamination of food (e.g., wash hands frequently; cover a cough or sneeze in their sleeve; use gloves to cover cuts or wounds; tie hair back).

B2.3 use safe food-handling practices to prevent cross-contamination by pathogens, parasites, and allergens in the food-preparation area (e.g., wash fresh produce; sanitize cutting boards after contact with meat products; sanitize implements that come into contact with allergens when

preparing food for or with people with known allergies; sanitize work surfaces; replace or sanitize sponges or cloths frequently; use proper clean-up procedures).

B2.4 follow appropriate protocols to ensure food safety (e.g., cook foods to recommended temperatures; keep hot foods hot and cold foods cold; store food appropriately; wipe tops of cans before opening; check “best-before” dates; demonstrate awareness of common allergenic ingredients).

B3. Food Preparation: demonstrate skills needed in food preparation.

B3.1 identify and select appropriate tools, equipment, and ingredients for use in food preparation.

B3.2 demonstrate the ability to safely use, maintain, clean, and store tools and equipment used in food preparation.

D1. Food Shopping: demonstrate an understanding of efficient and economical purchasing strategies that ensure food safety and quality.

D1.4 describe shopping practices they can use to ensure food quality and safety (e.g., assessing ripeness, avoiding dented cans, checking “best-before” dates, buying fresh vegetables and fruits in season).

D1.5 identify proper methods for storing perishable and non-perishable foods (e.g., refrigeration, freezing, drying, canning).

E1. Preparing to Work in the Food Industry: identify food-related occupations for which they are personally suited.

E1.2 identify personal knowledge, skills, and attitudes that may make them suited to occupations in the food industry Teacher prompts: “How do your skills compare to the skills suggested for various food-related jobs/careers? What are your strengths? Where do you need further training

or skills development?" "How could skills such as creativity or attention to detail be valuable for careers in the food industry?"

E1.3 describe the training and knowledge required for a variety of occupations in the food industry (e.g., knowledge of WHMIS regulations, Smart Serve training, Food Handler training, knowledge of common allergenic ingredients, CPR training, First Aid training, knowledge of workers' rights and responsibilities).

E2. Successful Employment in the Food Industry: demonstrate an understanding of the qualifications and skills required for successful employment in the food industry.

Appendix D: MOHLTC food safety manual sections that meet or partially meet the identified high school students' food safety needs, and the identification of corresponding food safety teaching objectives from the Food and Nutrition courses.

Table D.1. MOHLTC food safety manual sections that meet or partially meet the identified high school students' food safety needs for Theme 1: How to safely do the things they typically do with food and the identification of corresponding food safety teaching objectives from the Food and Nutrition courses.

Section	**Topic Area** (MOHTLC Manual pages; MOHLTC PowerPoint Slide numbers)	**Foods and Nutrition courses - food safety objectives** (see Table 6.1)	**Theme 1: How to safely do the things they typically do with food**			
			How to pack a safe lunch and travel with food	**How to deal with leftovers**	**What to do at school fund raisers and for parties**	**How to use a microwave for food preparation**
Introduction	Introduction to Food Safety (p. 5, slide 3)	B2				
	Benefits for Food Premises (p. 6; slide 4)					
	Food Safety Legislation (pp. 6-10; slides 5-15)	B2				
	Responsibilities (p. 11; slides 16)					
Foodborne Illness	Introduction (p. 13; slides 17-20)	B2.1				
	Symptoms (p. 14; slides 21-22)	B2.1				
	Causes of Foodborne Illness (p. 14; slide 23)	B2.1; B3.1				
	Chemical Hazards (p. 14-17; slides 24 and 26)	B2.1; B3.1				
	Examples of Chemical Foodborne Illness (p. 17; slide 25)	B2.1; B3.1				
	Physical Hazards (p. 17; slides 27-28)	B2.1; B3.1				
	Allergens (pp. 18-23; slides 29-33)	B2.1; B2.3; B2. 4; B3.1				
	Impacts (p. 23; slide 36)	B2.1				
Microorganisms	Types of Microorganisms (pp. 27-33; slides 40-52)	B2.1				
	Examples of Microbiological Illness (p. 34; no slide)	B2.1				

	Carriers (p. 35; slide 53)	B2.1				
	Who Gets Sick? (p. 36; no slide)	B2.1				
	Bacteria (p. 37; Slide 54)	B2.1				
	Bacterial Growth (pp. 38-40; slide 55-63)	B2; B2.1				
	Potentially Hazardous Foods (p. 41; slide 64)	B2; B2.1				
Time and Temperature	Food Safety Sequence (pp. 44; slides 66-67)	B2; B2.1; B2.4; B3	✓	✓	✓	✓
	The Probe Thermometer (pp. 45-47; slide 58)	B2; B2.1; B2.4; B3; B3.2				
	Receiving and Storage (p. 47; slide 69)	B2; B2.1; B2.4; B3; D1.5				
	Freezing (pp. 47-48; slide 70-71)	B2; B2.1; B2.4; B3				
	Thawing (p. 49; slides 72-73)	B2; B2.1; B2.4; B3				✓
	Refrigeration (p. 50; slide 70-71)	B2; B2.1; B2.4; B3				
	Food Preparation (p. 51; slide 74)	B2; B2.1; B2.4; B3; D1.5				
	Cooking (p. 52; slides 75-76)	B2; B2.1; B2.4; B3				✓
	Hot and Cold Holding (pp. 53-54; slides 77-78)	B2; B2.1; B2.4; B3	✓			
	Cooling (pp. 54-55; slides 79-82)	B2; B2.1; B2.4; B3		✓		
	Reheating (p. 56; slides 83-84)	B2; B2.1; B2.4; B3		✓		✓
Receiving and Storage	Shipping and Receiving (pp. 59-64; slides 86-102)	D1; D1.4; D1.5				
	Rejecting a Shipment (p. 65; slide 103)					
	Storage (p. 66; slide 104)	D1.5				
	Storage Guidelines (pp. 66-67; slides 105-106)	D1.5				
	Stock Rotation (p. 67; slide 107)	D1.5				
Microbiological Contamination	Cross-Contamination (p. 70; slides 110-111)	B2; B2.1; B2.3; B3; D1.5				
	Refrigerate Right (p. 71; slide 112)	B2; B2.1; B2.3; B3; D1.5				
	Serving Food (p. 72; slide xx)	B2; B2.1; B2.3; B3				
	Equipment (p. 73 and 75; slide 114-115)	B2; B2.1; B2.3; B3; B3.1				
	How Could This Happen? (p. 74; no slide)	B2; B2.1; B2.3; B3; B3.1				
	Tasting Food (p. 76; slide 116)	B2; B2.1; B2.3; B3; B3.1				
Personal Hygiene	Uniforms, Clothing and Aprons (p. 79; slide 131)	B2; B2.1; B2.2				

	Hair (p. 80; slides 120-21)	B2; B2.1; B2.2
	Hands and Nails (p. 80; slides 120-21)	B2; B2.1; B2.2
	Handwashing (p. 81; slide 131)	B2; B2.1; B2.2
	Using the Washroom (p. 81; slide 131)	B2; B2.1; B2.2
	Nose or Mouth Contact (p. 81; slide 124)	B2; B2.1; B2.2
	Cough or Sneeze (p. 82; slide 124)	B2; B2.1; B2.2
	Other Times (p. 83; slide 124)	B2; B2.1; B2.2
	How to Wash (p. 84; slide 125)	B2; B2.1; B2.2
	No-Touch Techniques (p. 85; slide 128)	B2; B2.1; B2.2
	The Work at Hand (p. 86; no slide)	B2; B2.1; B2.2
	When You Need Gloves (p. 87; slide 129-30)	B2; B2.1; B2.2
	When You're Sick (p. 87; slide 131)	B2; B2.1; B2.2
	Returning to Work (p. 87; slide 131)	B2; B2.1; B2.2
Cleaning and Sanitizing	How to Clean and Sanitize (pp. 82-96; slides 132-43)	B2; B2.1; B2.3; B3; B3.2
	After Washing (p. 97; no slide)	B2; B2.1; B2.3; B3; B3.2
	General Cleaning (p. 97; slide 144-147)	B2; B2.1; B2.3; B3; B3.2
	Food Contact Surfaces (pp. 97-98; no slide)	B2; B2.1; B2.3; B3; B3.2
	Clearing Tables (p. 98; no slide)	B2; B2.1; B2.3; B3; B3.2
	Equipment (p. 99; no slides)	B2; B2.1; B2.3; B3; B3.2
	Facility (p. 99; slide 145)	B2; B2.1; B2.3; B3; B3.2
	Washrooms (p. 100; slide 147)	B2; B2.1; B2.3; B3; B3.2
	Handwash Sink (p. 100; no slide)	B2; B2.1; B2.3; B3; B3.2
	Garbage Control (p. 101; slide 148)	B2; B2.1; B2.3; B3; B3.2
	Live Animals (p. 101; slide 149)	B2; B2.1; B2.3; B3; B3.2
	Kitchen Layout and Plans (p. 102; no slides)	B2; B2.1; B2.3; B3; B3.2
Pest Control	Cockroaches (p. 105; slide 152)	
	Common Types of Cockroaches (p. 106; no slides)	
	Flies (p. 107; slide 153)	B2

	Other Insects (p. 107; slide 154)	
	Rodents (p. 108; slide 151)	B2
	Prevention and Control (pp. 109-112; slides 156-160)	B2
Food Safety Management	Before You Start (p. 115; slide 162-163)	
	HACCP Principles (p. 116; slide 164)	
	Step 1: Hazard Analysis (p. 117; slide 168)	
	Step 2: Critical Control Points (p. 118; slide 169)	
	Step 3: Critical Limits (p. 119; slide 170)	
	Step 4: Monitoring (p. 119; slide 171)	
	Step 5: Corrective Action (p. 120; slide 172)	
	Step 6: Verification (p. 121; slide 173-174)	
	Step 7: Documentation (p. 122; slide 175)	

Table D.2. MOHLTC food safety manual sections that meet or partially meet the identified high school students' food safety needs for Theme 2: How to keep themselves and their kitchen spaces clean and safe and the identification of corresponding food safety teaching objectives from the Food and Nutrition courses.

Section	**Topic Area** (MOHTLC Manual pages; MOHLTC PowerPoint Slide numbers)	**Foods and Nutrition courses - food safety objectives** (see Table 6.1)	**Theme 2: How to keep themselves and their kitchen spaces clean and safe**			
			Why and how to wash hands properly	**Use good personal hygiene to prevent contamination**	**Why and how to keep the things your food could touch clean**	**How to prevent injury**
Introduction	Introduction to Food Safety (p. 5, slide 3)	B2				
	Benefits for Food Premises (p. 6; slide 4)					
	Food Safety Legislation (pp. 6-10; slides 5-15) Responsibilities (p. 11; slides 16)	B2				
Foodborne Illness	Introduction (p. 13; slides 17-20)	B2.1				
	Symptoms (p. 14; slides 21-22)	B2.1				
	Causes of Foodborne Illness (p. 14; slide 23)	B2.1; B3.1				
	Chemical Hazards (p. 14-17; slides 24 and 26) Examples of Chemical Foodborne Illness (p. 17; slide 25)	B2.1; B3.1 B2.1; B3.1				
	Physical Hazards (p. 17; slides 27-28)	B2.1; B3.1				
	Allergens (pp. 18-23; slides 29-33) Impacts (p. 23; slide 36)	B2.1; B2.3; B2. 4; B3.1 B2.1				
Microorganisms	Types of Microorganisms (pp. 27-33; slides 40-52) Examples of Microbiological Illness (p. 34; no slide) Carriers (p. 35; slide 53)	B2.1 B2.1 B2.1				
	Who Gets Sick? (p. 36; no slide)	B2.1				
	Bacteria (p. 37; Slide 54)	B2.1				
	Bacterial Growth (pp. 38-40; slide 55-63)	B2; B2.1				

	Potentially Hazardous Foods (p. 41; slide 64)	B2; B2.1		
Time and Temperature	Food Safety Sequence (pp. 44; slides 66-67)	B2; B2.1; B2.4; B3		
	The Probe Thermometer (pp. 45-47; slide 58)	B2; B2.1; B2.4; B3; B3.2		
	Receiving and Storage (p. 47; slide 69)	B2; B2.1; B2.4; B3; D1.5		
	Freezing (pp. 47-48; slide 70-71)	B2; B2.1; B2.4; B3		
	Thawing (p. 49; slides 72-73)	B2; B2.1; B2.4; B3		
	Refrigeration (p. 50; slide 70-71)	B2; B2.1; B2.4; B3		
	Food Preparation (p. 51; slide 74)	B2; B2.1; B2.4; B3; D1.5		
	Cooking (p. 52; slides 75-76)	B2; B2.1; B2.4; B3		
	Hot and Cold Holding (pp. 53-54; slides 77-78)	B2; B2.1; B2.4; B3		
	Cooling (pp. 54-55; slides 79-82)	B2; B2.1; B2.4; B3		
	Reheating (p. 56; slides 83-84)	B2; B2.1; B2.4; B3		
Receiving and Storage	Shipping and Receiving (pp. 59-64; slides 86-102)	D1; D1.4; D1.5		
	Rejecting a Shipment (p. 65; slide 103)			
	Storage (p. 66; slide 104)	D1.5		
	Storage Guidelines (pp. 66-67; slides 105-106)	D1.5		
	Stock Rotation (p. 67; slide 107)	D1.5		
Microbiological Contamination	Cross-Contamination (p. 70; slides 110-111)	B2; B2.1; B2.3; B3; D1.5		
	Refrigerate Right (p. 71; slide 112)	B2; B2.1; B2.3; B3; D1.5		
	Serving Food (p. 72)	B2; B2.1; B2.3; B3		
	Equipment (p. 73 and 75; slide 114-115)	B2; B2.1; B2.3; B3; B3.1		
	How Could This Happen? (p. 74; no slide)	B2; B2.1; B2.3; B3; B3.1		
	Tasting Food (p. 76; slide 116)	B2; B2.1; B2.3; B3; B3.1		
Personal Hygiene	Uniforms, Clothing and Aprons (p. 79; slide 131)	B2; B2.1; B2.2		✓
	Hair (p. 80; slides 120-21)	B2; B2.1; B2.2		✓
	Hands and Nails (p. 80; slides 120-21)	B2; B2.1; B2.2		✓
	Handwashing (p. 81; slide 131)	B2; B2.1; B2.2	✓	✓
	Using the Washroom (p. 81; slide 131)	B2; B2.1; B2.2		✓
	Nose or Mouth Contact (p. 81; slide 124)	B2; B2.1; B2.2		✓

	Cough or Sneeze (p. 82; slide 124)	B2; B2.1; B2.2		✓	
	Other Times (p. 83; slide 124)	B2; B2.1; B2.2		✓	
	How to Wash (p. 84; slide 125)	B2; B2.1; B2.2		✓	
	No-Touch Techniques (p. 85; slide 128)	B2; B2.1; B2.2		✓	
	The Work at Hand (p. 86; no slide)	B2; B2.1; B2.2		✓	
	When You Need Gloves (p. 87; slide 129-30)	B2; B2.1; B2.2		✓	
	When You're Sick (p. 87; slide 131)	B2; B2.1; B2.2		✓	
	Returning to Work (p. 87; slide 131)	B2; B2.1; B2.2		✓	
Cleaning and Sanitizing	How to Clean and Sanitize (pp. 82-96; slides 132-43)	B2; B2.1; B2.3; B3; B3.2			✓
	After Washing (p. 97; no slide)	B2; B2.1; B2.3; B3; B3.2			
	General Cleaning (p. 97; slide 144-147)	B2; B2.1; B2.3; B3; B3.2			
	Food Contact Surfaces (pp. 97-98; no slide)	B2; B2.1; B2.3; B3; B3.2			✓
	Clearing Tables (p. 98; no slide)	B2; B2.1; B2.3; B3; B3.2			
	Equipment (p. 99; no slides)	B2; B2.1; B2.3; B3; B3.2			
	Facility (p. 99; slide 145)	B2; B2.1; B2.3; B3; B3.2			
	Washrooms (p. 100; slide 147)	B2; B2.1; B2.3; B3; B3.2			
	Handwash Sink (p. 100; no slide)	B2; B2.1; B2.3; B3; B3.2	✓		
	Garbage Control (p. 101; slide 148)	B2; B2.1; B2.3; B3; B3.2			
	Live Animals (p. 101; slide 149)	B2; B2.1; B2.3; B3; B3.2			
	Kitchen Layout and Plans (p. 102; no slides)	B2; B2.1; B2.3; B3; B3.2			
Pest Control	Cockroaches (p. 105; slide 152)				
	Common Types of Cockroaches (p. 106; no slides)				
	Flies (p. 107; slide 153)	B2			
	Other Insects (p. 107; slide 154)				
	Rodents (p. 108; slide 151)	B2			
	Prevention and Control (pp. 109-112; slides 156-160)	B2			
Food Safety Management	Before You Start (p. 115; slide 162-163)				
	HACCP Principles (p. 116; slide 164)				

Step 1: Hazard Analysis (p. 117; slide 168)

Step 2: Critical Control Points (p. 118; slide 169)

Step 3: Critical Limits (p. 119; slide 170)

Step 4: Monitoring (p. 119; slide 171)

Step 5: Corrective Action (p. 120; slide 172)

Step 6: Verification (p. 121; slide 173-174)

Step 7: Documentation (p. 122; slide 175)

Table D.3. MOHLTC food safety manual sections that meet or partially meet the identified high school students' food safety needs for Theme 3: Microorganisms and how they can result in foodborne disease and the identification of corresponding food safety teaching objectives from the Food and Nutrition courses.

Section	**Topic Area** (MOHTLC Manual pages; MOHLTC PowerPoint Slide numbers)	**Foods and Nutrition courses - food safety objectives** (see Table 6.1)	**Theme 3: Microorganisms and how they can result in foodborne disease**				
			Basic microbiology : what are pathogens, how do they grow, and how do they spread?	**What foods can make me sick and how do I avoid getting sick?**	**Who is susceptible to foodborne disease, and what are consequences?**	**How can I prevent the spread of pathogens and allergens?**	**What should I do as a sick food handler?**
Introduction	Introduction to Food Safety (p. 5, slide 3)	B2					
	Benefits for Food Premises (p. 6; slide 4)						
	Food Safety Legislation (pp. 6-10; slides 5-15) Responsibilities (p. 11; slides 16)	B2					
Foodborne Illness	Introduction (p. 13; slides 17-20)	B2.1		✓			
	Symptoms (p. 14; slides 21-22)	B2.1		✓			
	Causes of Foodborne Illness (p. 14; slide 23)	B2.1; B3.1		✓			
	Chemical Hazards (p. 14-17; slides 24 and 26)	B2.1; B3.1		✓			
	Examples of Chemical Foodborne Illness (p. 17; slide 25)	B2.1; B3.1		✓			
	Physical Hazards (p. 17; slides 27-28)	B2.1; B3.1		✓			
	Allergens (pp. 18-23; slides 29-33)	B2.1; B2.3; B2. 4; B3.1				✓	
	Impacts (p. 23; slide 36)	B2.1			✓		
Microorganisms	Types of Microorganisms (pp. 27-33; slides 40-52)	B2.1	✓				

	Examples of Microbiological Illness (p. 34; no slide)	B2.1			✓
	Carriers (p. 35; slide 53)	B2.1			
	Who Gets Sick? (p. 36; no slide)	B2.1			✓
	Bacteria (p. 37; Slide 54)	B2.1	✓		
	Bacterial Growth (pp. 38-40; slide 55-63)	B2; B2.1	✓		
	Potentially Hazardous Foods (p. 41; slide 64)	B2; B2.1		✓	
Time and Temperature	Food Safety Sequence (pp. 44; slides 66-67)	B2; B2.1; B2.4; B3			
	The Probe Thermometer (pp. 45-47; slide 58)	B2; B2.1; B2.4; B3; B3.2			
	Receiving and Storage (p. 47; slide 69)	B2; B2.1; B2.4; B3; D1.5			
	Freezing (pp. 47-48; slide 70-71)	B2; B2.1; B2.4; B3			
	Thawing (p. 49; slides 72-73)	B2; B2.1; B2.4; B3			
	Refrigeration (p. 50; slide 70-71)	B2; B2.1; B2.4; B3			
	Food Preparation (p. 51; slide 74)	B2; B2.1; B2.4; B3; D1.5			
	Cooking (p. 52; slides 75-76)	B2; B2.1; B2.4; B3			
	Hot and Cold Holding (pp. 53-54; slides 77-78)	B2; B2.1; B2.4; B3			
	Cooling (pp. 54-55; slides 79-82)	B2; B2.1; B2.4; B3			
	Reheating (p. 56; slides 83-84)	B2; B2.1; B2.4; B3			
Receiving and Storage	Shipping and Receiving (pp. 59-64; slides 86-102)	D1; D1.4; D1.5			
	Rejecting a Shipment (p. 65; slide 103)				
	Storage (p. 66; slide 104)	D1.5			
	Storage Guidelines (pp. 66-67; slides 105-106)	D1.5			

	Stock Rotation (p. 67; slide 107)	D1.5				
Microbiological Contamination	Cross-Contamination (p. 70; slides 110-111)	B2; B2.1; B2.3; B3; D1.5	✓	✓	✓	
	Refrigerate Right (p. 71; slide 112)	B2; B2.1; B2.3; B3; D1.5	✓	✓	✓	
	Serving Food (p. 72; slide xx)	B2; B2.1; B2.3; B3	✓	✓	✓	
	Equipment (p. 73 and 75; slide 114-115)	B2; B2.1; B2.3; B3; B3.1	✓	✓	✓	
	How Could This Happen? (p. 74; no slide)	B2; B2.1; B2.3; B3; B3.1	✓	✓	✓	
	Tasting Food (p. 76; slide 116)	B2; B2.1; B2.3; B3; B3.1	✓	✓	✓	
Personal Hygiene	Uniforms, Clothing and Aprons (p. 79; slide 131)	B2; B2.1; B2.2				
	Hair (p. 80; slides 120-21)	B2; B2.1; B2.2				
	Hands and Nails (p. 80; slides 120-21)	B2; B2.1; B2.2				
	Handwashing (p. 81; slide 131)	B2; B2.1; B2.2				
	Using the Washroom (p. 81; slide 131)	B2; B2.1; B2.2				
	Nose or Mouth Contact (p. 81; slide 124)	B2; B2.1; B2.2				
	Cough or Sneeze (p. 82; slide 124)	B2; B2.1; B2.2				
	Other Times (p. 83; slide 124)	B2; B2.1; B2.2				
	How to Wash (p. 84; slide 125)	B2; B2.1; B2.2				
	No-Touch Techniques (p. 85; slide 128)	B2; B2.1; B2.2				
	The Work at Hand (p. 86; no slide)	B2; B2.1; B2.2				
	When You Need Gloves (p. 87; slide 129-30)	B2; B2.1; B2.2				
	When You're Sick (p. 87; slide 131)	B2; B2.1; B2.2				✓
	Returning to Work (p. 87; slide 131)	B2; B2.1; B2.2				✓
Cleaning and Sanitizing	How to Clean and Sanitize (pp. 82-96; slides 132-43)	B2; B2.1; B2.3; B3; B3.2				
	After Washing (p. 97; no slide)	B2; B2.1; B2.3; B3; B3.2				
	General Cleaning (p. 97; slide 144-147)	B2; B2.1; B2.3; B3; B3.2				
	Food Contact Surfaces (pp. 97-98; no slide)	B2; B2.1; B2.3; B3; B3.2				

	Clearing Tables (p. 98; no slide)	B2; B2.1; B2.3; B3; B3.2	
	Equipment (p. 99; no slides)	B2; B2.1; B2.3; B3; B3.2	
	Facility (p. 99; slide 145)	B2; B2.1; B2.3; B3; B3.2	✓
	Washrooms (p. 100; slide 147)	B2; B2.1; B2.3; B3; B3.2	
	Handwash Sink (p. 100; no slide)	B2; B2.1; B2.3; B3; B3.2	
	Garbage Control (p. 101; slide 148)	B2; B2.1; B2.3; B3; B3.2	
	Live Animals (p. 101; slide 149)	B2; B2.1; B2.3; B3; B3.2	
	Kitchen Layout and Plans (p. 102; no slides)	B2; B2.1; B2.3; B3; B3.2	
Pest Control	Cockroaches (p. 105; slide 152)		
	Common Types of Cockroaches (p. 106; no slides)		
	Flies (p. 107; slide 153)	B2	
	Other Insects (p. 107; slide 154)		
	Rodents (p. 108; slide 151)	B2	
	Prevention and Control (pp. 109-112; slides 156-160)	B2	
Food Safety Management	Before You Start (p. 115; slide 162-163)		
	HACCP Principles (p. 116; slide 164)		
	Step 1: Hazard Analysis (p. 117; slide 168)		
	Step 2: Critical Control Points (p. 118; slide 169)		
	Step 3: Critical Limits (p. 119; slide 170)		
	Step 4: Monitoring (p. 119; slide 171)		
	Step 5: Corrective Action (p. 120; slide 172)		
	Step 6: Verification (p. 121; slide 173-174)		
	Step 7: Documentation (p. 122; slide 175)		

Table D.4. MOHLTC food safety manual sections that meet or partially meet the identified high school students' food safety needs for Theme 4: Four specific things to do to keep food out of the 'danger zone'and the identification of corresponding food safety teaching objectives from the Food and Nutrition courses.

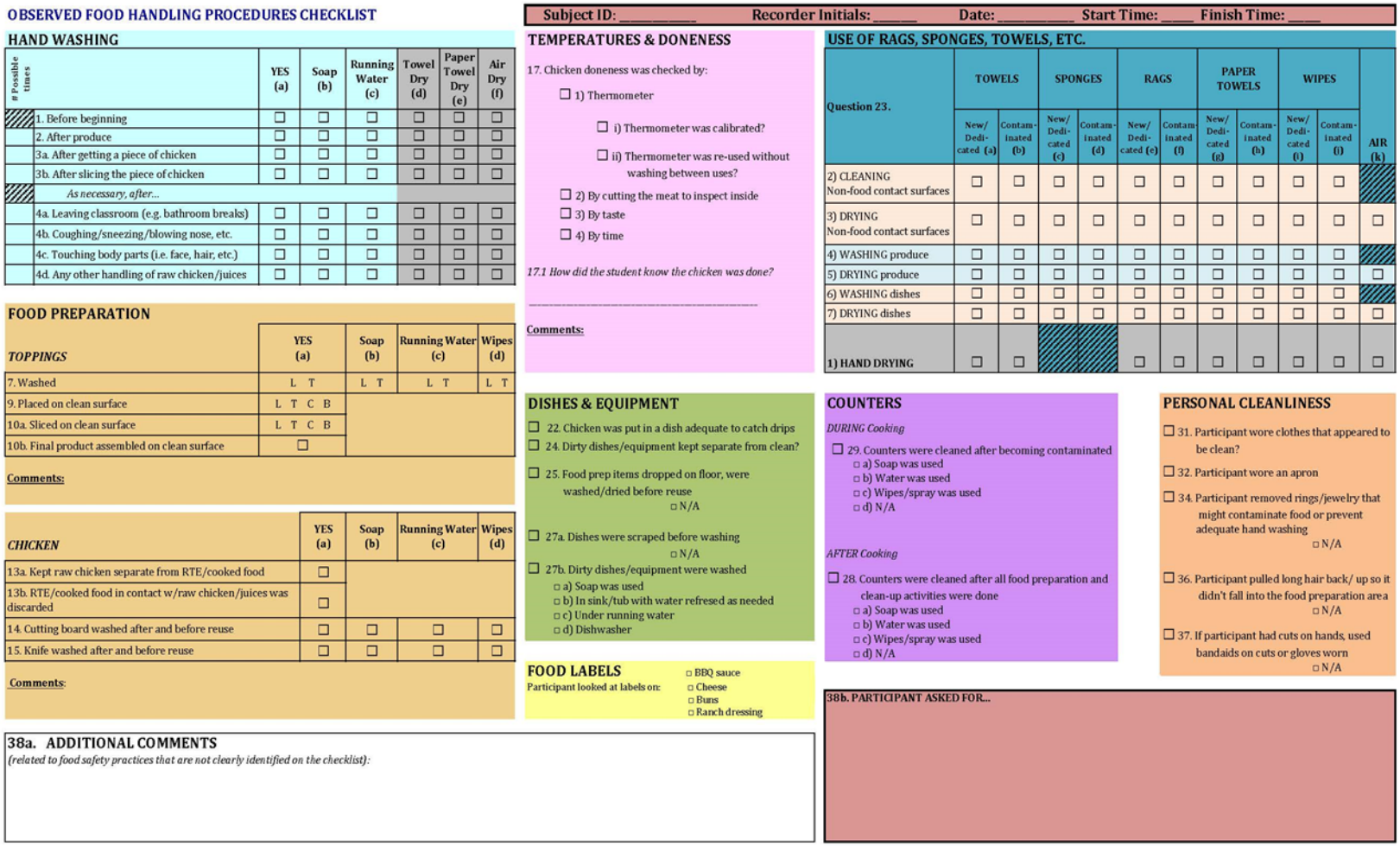
Section	**Topic Area (MOHTLC Manual pages; MOHLTC PowerPoint Slide numbers)**	**Foods and Nutrition courses -** food safety objectives (see Table 6.1**)**	**Theme 4: Four specific things to do to keep food out of the 'danger zone'**			
			Do not leave cooked or perishable foods at room temperature	**Do not thaw food on the counter**	**Properly reheat food before eating**	**Use a probe thermometer to determine when food is properly cooked or reheated**
Introduction	Introduction to Food Safety (p. 5, slide 3)	B2				
	Benefits for Food Premises (p. 6; slide 4)					
	Food Safety Legislation (pp. 6-10; slides 5-15) Responsibilities (p. 11; slides 16)	B2				
Foodborne Illness	Introduction (p. 13; slides 17-20)	B2.1				
	Symptoms (p. 14; slides 21-22)	B2.1				
	Causes of Foodborne Illness (p. 14; slide 23)	B2.1; B3.1				
	Chemical Hazards (p. 14-17; slides 24 and 26) Examples of Chemical Foodborne Illness (p. 17; slide 25)	B2.1; B3.1 B2.1; B3.1				
	Physical Hazards (p. 17; slides 27-28)	B2.1; B3.1				
	Allergens (pp. 18-23; slides 29-33)	B2.1; B2.3; B2. 4; B3.1				
	Impacts (p. 23; slide 36)	B2.1				
Microorganisms	Types of Microorganisms (pp. 27-33; slides 40-52)	B2.1				

	Examples of Microbiological Illness (p. 34; no slide)	B2.1					
	Carriers (p. 35; slide 53)	B2.1					
	Who Gets Sick? (p. 36; no slide)	B2.1					
	Bacteria (p. 37; Slide 54)	B2.1					
	Bacterial Growth (pp. 38-40; slide 55-63)	B2; B2.1					
	Potentially Hazardous Foods (p. 41; slide 64)	B2; B2.1					
Time and Temperature	Food Safety Sequence (pp. 44; slides 66-67)	B2; B2.1; B2.4; B3	✓				
	The Probe Thermometer (pp. 45-47; slide 58)	B2; B2.1; B2.4; B3; B3.2					✓
	Receiving and Storage (p. 47; slide 69)	B2; B2.1; B2.4; B3; D1.5					
	Freezing (pp. 47-48; slide 70-71)	B2; B2.1; B2.4; B3					
	Thawing (p. 49; slides 72-73)	B2; B2.1; B2.4; B3		✓			
	Refrigeration (p. 50; slide 70-71)	B2; B2.1; B2.4; B3	✓				
	Food Preparation (p. 51; slide 74)	B2; B2.1; B2.4; B3; D1.5	✓				
	Cooking (p. 52; slides 75-76)	B2; B2.1; B2.4; B3					
	Hot and Cold Holding (pp. 53-54; slides 77-78)	B2; B2.1; B2.4; B3	✓				
	Cooling (pp. 54-55; slides 79-82)	B2; B2.1; B2.4; B3	✓				✓
	Reheating (p. 56; slides 83-84)	B2; B2.1; B2.4; B3			✓		
Receiving and Storage	Shipping and Receiving (pp. 59-64; slides 86-102)	D1; D1.4; D1.5					
	Rejecting a Shipment (p. 65; slide 103)						
	Storage (p. 66; slide 104)	D1.5					
	Storage Guidelines (pp. 66-67; slides 105-106)	D1.5					

	Stock Rotation (p. 67; slide 107)	D1.5
Microbiological Contamination	Cross-Contamination (p. 70; slides 110-111)	B2; B2.1; B2.3; B3; D1.5
	Refrigerate Right (p. 71; slide 112)	B2; B2.1; B2.3; B3; D1.5
	Serving Food (p. 72; slide xx)	B2; B2.1; B2.3; B3
	Equipment (p. 73 and 75; slide 114-115)	B2; B2.1; B2.3; B3; B3.1
	How Could This Happen? (p. 74; no slide)	B2; B2.1; B2.3; B3; B3.1
	Tasting Food (p. 76; slide 116)	B2; B2.1; B2.3; B3; B3.1
Personal Hygiene	Uniforms, Clothing and Aprons (p. 79; slide 131)	B2; B2.1; B2.2
	Hair (p. 80; slides 120-21)	B2; B2.1; B2.2
	Hands and Nails (p. 80; slides 120-21)	B2; B2.1; B2.2
	Handwashing (p. 81; slide 131)	B2; B2.1; B2.2
	Using the Washroom (p. 81; slide 131)	B2; B2.1; B2.2
	Nose or Mouth Contact (p. 81; slide 124)	B2; B2.1; B2.2
	Cough or Sneeze (p. 82; slide 124)	B2; B2.1; B2.2
	Other Times (p. 83; slide 124)	B2; B2.1; B2.2
	How to Wash (p. 84; slide 125)	B2; B2.1; B2.2
	No-Touch Techniques (p. 85; slide 128)	B2; B2.1; B2.2
	The Work at Hand (p. 86; no slide)	B2; B2.1; B2.2
	When You Need Gloves (p. 87; slide 129-30)	B2; B2.1; B2.2
	When You're Sick (p. 87; slide 131)	B2; B2.1; B2.2
	Returning to Work (p. 87; slide 131)	B2; B2.1; B2.2
Cleaning and Sanitizing	How to Clean and Sanitize (pp. 82-96; slides 132-43)	B2; B2.1; B2.3; B3; B3.2
	After Washing (p. 97; no slide)	B2; B2.1; B2.3; B3; B3.2
	General Cleaning (p. 97; slide 144-147)	B2; B2.1; B2.3; B3; B3.2
	Food Contact Surfaces (pp. 97-98; no slide)	B2; B2.1; B2.3; B3; B3.2
	Clearing Tables (p. 98; no slide)	B2; B2.1; B2.3; B3; B3.2

	Equipment (p. 99; no slides)	B2; B2.1; B2.3; B3; B3.2
	Facility (p. 99; slide 145)	B2; B2.1; B2.3; B3; B3.2
	Washrooms (p. 100; slide 147)	B2; B2.1; B2.3; B3; B3.2
	Handwash Sink (p. 100; no slide)	B2; B2.1; B2.3; B3; B3.2
	Garbage Control (p. 101; slide 148)	B2; B2.1; B2.3; B3; B3.2
	Live Animals (p. 101; slide 149)	B2; B2.1; B2.3; B3; B3.2
	Kitchen Layout and Plans (p. 102; no slides)	B2; B2.1; B2.3; B3; B3.2
Pest Control	Cockroaches (p. 105; slide 152)	
	Common Types of Cockroaches (p. 106; no slides)	
	Flies (p. 107; slide 153)	B2
	Other Insects (p. 107; slide 154)	
	Rodents (p. 108; slide 151)	B2
	Prevention and Control (pp. 109-112; slides 156-160)	B2
Food Safety Management	Before You Start (p. 115; slide 162-163)	
	HACCP Principles (p. 116; slide 164)	
	Step 1: Hazard Analysis (p. 117; slide 168)	
	Step 2: Critical Control Points (p. 118; slide 169)	
	Step 3: Critical Limits (p. 119; slide 170)	
	Step 4: Monitoring (p. 119; slide 171)	
	Step 5: Corrective Action (p. 120; slide 172)	
	Step 6: Verification (p. 121; slide 173-174)	
	Step 7: Documentation (p. 122; slide 175)	

Appendix E: Safe Food Handling Observation Checklist



OBSERVED FOOD HANDLING PROCEDURES CHECKLIST

Subject ID: _____ Recorder Initials: _____ Date: _____ Start Time: ____ Finish Time: ____

HAND WASHING

# Possible times		YES (a)	Soap (b)	Running Water (c)	Towel Dry (d)	Paper Towel Dry (e)	Air Dry (f)
	1. Before beginning	☐	☐	☐	☐	☐	☐
	2. After produce	☐	☐	☐	☐	☐	☐
	3a. After getting a piece of chicken	☐	☐	☐	☐	☐	☐
	3b. After slicing the piece of chicken	☐	☐	☐	☐	☐	☐
	As necessary, after…						
	4a. Leaving classroom (e.g. bathroom breaks)	☐	☐	☐	☐	☐	☐
	4b. Coughing/sneezing/blowing nose, etc.	☐	☐	☐	☐	☐	☐
	4c. Touching body parts (i.e. face, hair, etc.)	☐	☐	☐	☐	☐	☐
	4d. Any other handling of raw chicken/juices	☐	☐	☐	☐	☐	☐

FOOD PREPARATION

TOPPINGS	YES (a)	Soap (b)	Running Water (c)	Wipes (d)
7. Washed	L T	L T	L T	L T
9. Placed on clean surface	L T C B			
10a. Sliced on clean surface	L T C B			
10b. Final product assembled on clean surface	☐			

Comments:

CHICKEN	YES (a)	Soap (b)	Running Water (c)	Wipes (d)
13a. Kept raw chicken separate from RTE/cooked food	☐			
13b. RTE/cooked food in contact w/raw chicken/juices was discarded	☐			
14. Cutting board washed after and before reuse	☐	☐	☐	☐
15. Knife washed after and before reuse	☐	☐	☐	☐

Comments:

TEMPERATURES & DONENESS

17. Chicken doneness was checked by:

- ☐ 1) Thermometer
  - ☐ i) Thermometer was calibrated?
  - ☐ ii) Thermometer was re-used without washing between uses?
- ☐ 2) By cutting the meat to inspect inside
- ☐ 3) By taste
- ☐ 4) By time

17.1 How did the student know the chicken was done?

_____

Comments:

USE OF RAGS, SPONGES, TOWELS, ETC.

Question 23.	TOWELS		SPONGES		RAGS		PAPER TOWELS		WIPES		AIR (k)
	New/ Dedi-cated (a)	Contam-inated (b)	New/ Dedi-cated (c)	Contam-inated (d)	New/ Dedi-cated (e)	Contam-inated (f)	New/ Dedi-cated (g)	Contam-inated (h)	New/ Dedi-cated (i)	Contam-inated (j)	
2) CLEANING Non-food contact surfaces	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
3) DRYING Non-food contact surfaces	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4) WASHING produce	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
5) DRYING produce	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
6) WASHING dishes	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
7) DRYING dishes	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1) HAND DRYING	☐	☐			☐	☐	☐	☐	☐	☐	☐

DISHES & EQUIPMENT

- ☐ 22. Chicken was put in a dish adequate to catch drips
- ☐ 24. Dirty dishes/equipment kept separate from clean?
- ☐ 25. Food prep items dropped on floor, were washed/dried before reuse ☐ N/A
- ☐ 27a. Dishes were scraped before washing ☐ N/A
- ☐ 27b. Dirty dishes/equipment were washed
  - ☐ a) Soap was used
  - ☐ b) In sink/tub with water refresed as needed
  - ☐ c) Under running water
  - ☐ d) Dishwasher

FOOD LABELS

Participant looked at labels on: ☐ BBQ sauce ☐ Cheese ☐ Buns ☐ Ranch dressing

COUNTERS

DURING Cooking

- ☐ 29. Counters were cleaned after becoming contaminated
  - ☐ a) Soap was used
  - ☐ b) Water was used
  - ☐ c) Wipes/spray was used
  - ☐ d) N/A

AFTER Cooking

- ☐ 28. Counters were cleaned after all food preparation and clean-up activities were done
  - ☐ a) Soap was used
  - ☐ b) Water was used
  - ☐ c) Wipes/spray was used
  - ☐ d) N/A

PERSONAL CLEANLINESS

- ☐ 31. Participant wore clothes that appeared to be clean?
- ☐ 32. Participant wore an apron
- ☐ 34. Participant removed rings/jewelry that might contaminate food or prevent adequate hand washing ☐ N/A
- ☐ 36. Participant pulled long hair back/ up so it didn't fall into the food preparation area ☐ N/A
- ☐ 37. If participant had cuts on hands, used bandaids on cuts or gloves worn ☐ N/A

38a. ADDITIONAL COMMENTS

(related to food safety practices that are not clearly identified on the checklist):

38b. PARTICIPANT ASKED FOR…

Appendix F: Total and sub-scale observed food handling items used to assess observed food handling behaviors

Scale	# of items	Item	Checklist #	Observations from checklist
Clean	19	Hands washed with soap and water before beginning any food preparation.	1	Before Beginning = YES, AND Soap = YES, AND Running Water = YES
		Hands washed with soap and water before after handling produce.	2	After Produce = YES, AND Soap = YES, AND Running Water = YES
		Hands washed with soap and after handling raw chicken.	3a	After getting a piece of chicken = YES, AND Soap = YES, AND Running Water = YES
		Hands washed with soap and water after slicing raw chicken.	3b	After slicing a piece of chicken = YES, AND Soap = YES, AND Running Water = YES
		Leafy greens washed before use.	7	Washed = YES
		Vegetable (e.g. tomato, green onions) washed before use.	7	Washed = YES

Non-food contact surfaces washed with a clean towel, rag, sponge, paper towel, or wipe.	23.2	New-dedicated towel, rag, sponge, paper towel, or wipe = YES
Non-food contact surfaces properly dried after washing.	23.3	New-dedicated towel, rag, sponge, paper towel, or wipe = YES OR, Air = YES
Produced properly washed.	23.4	New-dedicated towel, rag, sponge, paper towel, or wipe = YES, OR, Note indicating washed using running water.
Produce dried properly.	23.5	New-dedicated towel, rag, sponge, paper towel, or wipe = YES, OR, Air = YES
Dishes washed with a clean towel, rag, sponge, paper towel, or wipe.	23.6	New-dedicated towel, rag, sponge, paper towel, or wipe = YES
Dishes properly dried after washing.	23.7	New-dedicated towel, rag, sponge, paper towel, or wipe = YES

		OR, Air = YES
Dishes scraped before washing.	27a	Dishes scraped before washing = YES
Dirty dishes/equipment were washed with soap and water and properly dried after use.	27b	Soap was used = YES In sink/tub with water refreshed as needed = YES OR, Under running water = YES OR, Dishwasher = YES
Counters cleaned after all food preparation and clean-up activities were done.	28	Soap was used = YES, AND Water was used = YES OR, Wipes / spray was used = YES
Counters cleaned after becoming contaminated during food preparation.	29	Soap was used = YES, AND Water was used = YES OR, Wipes / spray was used = YES
Student wore clothes that appeared to be clean.	31	Participant wore clothes that appeared to be clean = YES
Student wore an apron.	32	Participant wore an apron = YES
Student's hair was suitably confined.	36	Participant pulled long hair back/up so it didn't fall into the

				food preparation area = YES OR, Note about student wearing hairnet or hat = YES
Separate	12	Leafy greens placed on a clean surface.	9	(L) Placed on clean surface = YES
		Tomato placed on a clean surface.	9	(T) Placed on clean surface = YES
		Cheese placed on clean surface.	9	(C) Placed on clean surface = YES
		Bread placed on clean surface.	9	(B) Placed on clean surface = YES
		Leafy green prepared (e.g. sliced, torn) on a clean surface.	10.a	(L) Sliced on clean surface = YES
		Tomato sliced on a clean surface.	10.a	(T) Sliced on clean surface = YES
		Cheese sliced, shredded, or crumbled on a clean surface.	10.a	(C) Sliced on clean surface = YES
		Bread sliced on a clean surface.	10.a	(B) Sliced on a clean surface = YES
		Final product assembled on a clean surface.	10.b	Final product assembled on clean surface = YES
		Ready-to-eat or cooked food kept separate from raw chicken, or	13.a,b	Kept raw chicken separate from RTE/cooked food = YES, AND

		discarded after coming into contact with raw chicken.		RTE/cooked food in contact w/raw chicken/juices was discarded = YES or N/A
		Cutting board washed after and before reuse.	14	Cutting board washed after and before reuse = YES, AND Soap = YES and Running Water = YES, OR Wipes = YES
		Knife washed between uses or different knife used for raw chicken and ready-to-eat or cooked food.	15	Knife washed after and before reuse = YES, AND Soap = YES and Running Water = YES, OR Wipes = YES
Cook	1	Chicken doneness checked using a food thermometer.	17	Thermometer = YES
Total	32			