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Review

Baseline for consumer food safety knowledge and behaviour in Canada

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ABSTRACT

Understanding consumers' food safety practices is helpful in reducing food-borne illness. A systematic literature search was conducted to establish a baseline of consumer food safety practices in Canada, identify research gaps and make recommendations for future research. To date, this is the first study examining Canadian populations which gathers survey results measuring consumer food safety practices from both peer-reviewed, published literature and non-peer-reviewed public opinion research reports. The search found 26 Canadian publications from 1998 to 2011. Questions covered frequency of food preparation, sources of food safety information, consumer confidence and assigned food safety responsibility, awareness of food safety, knowledge of high-risk groups and high-risk foods, and personal experience with food-borne illness. Food safety behaviours were evaluated according to the 'clean', 'separate', 'chill' and 'cook' principles emphasized by the Canadian Partnership for Consumer Food Safety Education's FightBAC[®] Program. Overall, results differed considerably between studies due to variations in study designs, populations, survey questions and definitions of correct behaviour. However, the analysis provided a general indication of areas requiring targeted consumer food safety education such as increasing thermometer use when cooking meats, raising awareness of high-risk populations and knowledge of high-risk foods, and expanding messaging to the internet and social media. Consumer food safety studies in Canada were limited to self-reported behaviours. Future research could include observational studies to validate results from self-reported food safety practices, and provide more accurate information on consumer food handling practices. Finally, establishing a set of standard food safety questions that can be compared between future surveys would contribute to a comprehensive baseline against which future food safety interventions could be measured.

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Abbreviations: POR, public opinion research.

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1. Introduction

Enteric illness of food-borne origin remain an important public health issue in Canada and worldwide (Adak, Long, & O'Brian, 2000; Hoogenboom-Verdegaal, de Jong, During, Hoogenveen, & Hoekstra, 1994; Lee & Middleton, 2003; Majowicz et al., 2006; Mead et al., 1999). It is estimated that there are 4 million episodes of domestically acquired, food-borne illness in Canada (Thomas et al., 2013), with acute gastrointestinal illness costing approximately \$3.7 billion annually (Thomas, Majowicz, Pollari, & Sockett, 2008). Effective reduction of food-borne illnesses in Canada depends, in part, on an understanding of the ways in which humans come in contact with the bacteria, viruses and parasites that cause food-borne illness.

Mishandling of food can occur during food preparation, handling and storage; and studies show that consumers have inadequate knowledge about measures needed to prevent food-borne illness in the home (Medeiros, Hillers, Kendall, & Mason, 2001). There are a number of factors which are likely to contribute to outbreaks of food-borne illness in the home, including a raw food supply that may be contaminated, a lack of food safety knowledge among the general public, mistakes in food handling and preparation at home. Furthermore, the deliberate consumption of raw and undercooked foods often described as a 'risky' eating behaviour is an important factor contributing to food-borne disease (Kafarstein, 2003).

In Canada, a number of organizations (i.e. the Public Health Agency of Canada, Health Canada and Canadian Food Inspection Agency) promote safe food handling, most notably the Canadian Partnership for Consumer Food Safety Education's FightBAC® Program that emphasizes four main messages: 'Clean', 'Separate', 'Chill', and 'Cook'. The 'clean' step refers to washing of hands and kitchen surfaces appropriately, 'separate' to avoiding cross-contamination in the kitchen, 'chill' to refrigerating items promptly and at proper temperatures, and 'cook' to cooking items to recommended temperatures (Canadian Partnership for Consumer Food Safety Education, 2011). These programs are most effective when the messaging is appropriately targeted to the relevant audience (Jacob, Mathiasen, & Powell, 2010).

To date there is no single summary document regarding safe food handling behaviour and knowledge of Canadians, or an

analysis of research gaps. This paper is the first in Canada to compile all relevant literature including peer reviewed, published, and non-peer-reviewed public opinion reports (POR) to establish a baseline of Canadian consumer food safety knowledge and behaviour. The objectives of this review are: to establish a baseline of domestic consumer food safety handling practices in Canada; identify gaps in the knowledge of consumer food safety practices; and make recommendations for future research.

2. Materials and methods

An extensive systematic search of peer-reviewed published and grey (including POR) literature was conducted to locate relevant research on consumer food safety. Electronic searches of computer library databases included: PubMed, Web of Knowledge, the Cochrane Library, Google Scholar, Agricola, CAB Abstracts, Scopus, AgEcon Search and Proquest Theses. The search algorithm was composed of combinations of consumer terms ("consumer", "public", "home", "domestic", "household", "food preparer/food-preparer", "food-handler/food handler", "cook"), food safety terms ("food safety", "food-handling/food handling", "food preparation", "safe handling/safe-handling") and behaviour terms ("knowledge", "awareness", "behavior/behaviour", "practice", "perception", "belief", "attitude") and in some situations simplified due to the limitations of the search engines. The search was carried out in English and the timeframe was limited from 1997 to 2011.

The Library and Archives Canada online databases (Government of Canada, 2007, 2009; Public Works and Government Services Canada) were searched to obtain all relevant public opinion reports. Personal communication with library resource experts resulted in the acquisition of additional reports that were not available online. Screening of reference lists from relevant public opinion reports facilitated the identification of additional documents.

Studies selected for review were those that examined consumers' knowledge, perception and/or behaviour related to safe food handling practices within the home environment. The perception category dealt with questions of how food quality and safety is perceived by consumers, and how these perceptions influence consumer decision-making. The knowledge category comprised general knowledge of food safety and awareness of

high-risk foods, high-risk groups, and sources of information. The behaviour category consisted of data gathered through self-reported behaviour of respondents and is organized in terms of the 'cook', 'chill', 'clean' and 'separate' principles.

Only studies pertaining to Canadian consumers and that exclusively assessed individual consumer and targeted consumer groups were included in this review. Consumers were defined as anyone who prepared food on a regular basis within the home and was not a professional food handler. All methods of data collection including surveys, interviews, focus groups, and observational studies, were considered. Studies were classified as either externally peer-reviewed (i.e. published in scientific journal and subjected to a rigorous evaluation through the peer-review process) (Simon Fraser University, 2011) or POR (i.e. involved the planned gathering of opinions, attitudes, perceptions, judgements, feelings, ideas, reactions, or views from persons through quantitative or qualitative methods, irrespective of size or cost) (Government of Canada, 2007, 2009). Although not all response options were the same among studies, where there was substantial overlap, results were combined.

3. Results

3.1. Study types

A total of 323 international publications related to consumer food safety knowledge, perceptions and food safety behaviours were identified of which 26 were Canadian. Only Canadian studies were included in this review. These studies occurred between 1998 and 2011, with the majority ($n = 22$) classified as POR, the remaining ($n = 4$) were scientific peer-reviewed publications of which 3 publications were based on 1 study (Table 1). Of the 26 Canadian publications, 18 reports contained data related to knowledge, 16 reports contained data about perception, and 15 reports contained data on reported behaviour. Some reports included data from more than one category, and therefore may have been counted in more than one category.

3.2. Study methods

Administration of surveys was most commonly performed by telephone ($n = 13$, 54%), followed by focus groups ($n = 4$, 17%), and a combination of both telephone and focus groups or online survey ($n = 5$, 21%; Table 1). The remaining studies ($n = 2$, 8%) were conducted by mail, in-person interviews. There were no observational studies conducted. Sample sizes used for consumer food safety studies ranged from 40 to more than 2500 (Table 1). An online survey had the largest number of consumers interviewed (3144 respondents) followed by telephone interviews (400–2566 respondents), a face-to-face interview (2013 respondents), a self-administered mail questionnaire (582 respondents), and focus group studies involved the fewest number of consumers (40–160 respondents).

3.3. Perception

3.3.1. Consumer confidence and assigned responsibility in food safety

Based on 10 POR studies (2003–2011), 61–96% of respondents gave the Canadian food safety system a favourable or moderately confident rating (COMPAS Inc., 2003; Decima Research, 2010; EKOS Research Associates Inc., 2010; IBM Business Consulting Services, Fall/Winter 2003; Ipsos-Reid Corporation, 2002, 2004, 2007b, 2010; Léger Marketing, 2011; The Strategic Counsel, 2009). Results from focus groups also showed high levels of confidence in the

Canadian food supply (Les Études de Marché Créatec, 2007; Phoenix Strategic Perspectives Inc., 2006; The Strategic Counsel, 2007). Two POR studies asked non-confident respondents what the main reasons were for their lack of confidence in the Canadian food supply (Ipsos-Reid Corporation, 2004, 2010). Unprompted responses from one study included beliefs that food products will never be 100% safe (28%), the 2008 listeriosis crisis (15%), food contamination or food poisoning (13%) and too many food recalls (12%) (Ipsos-Reid Corporation, 2010). Furthermore, in another study, when asked specifically about food safety concerns people had in the past 12 months, respondents identified animal diseases (26%), contamination from handling (15%) and agricultural production (11%) (Ipsos-Reid Corporation, 2004). In another POR study, consumers lacking confidence in the Canadian food safety system were more likely than those with confidence to report the farm as a likely place for food safety problems to develop (Ipsos-Reid Corporation, 2002). When consumers were asked of ways to feel more confident in the safety of their food, responses from two POR studies (EKOS Research Associates Inc., 2005; Ipsos-Reid Corporation, 2002) included: more detailed labels on food (23–34%), improvements in the regulatory system (8–13%), more information about food safety (10–11%), more frequent or better inspection (4–7%), better handling and preparation (6%) (Ipsos-Reid Corporation, 2002), fewer additives and preservatives or chemicals (3–7%), and reduce or eliminate use of pesticides (8–10%), hormones (6%), and antibiotics (4%) (EKOS Research Associates Inc., 2005).

Consumer confidence in the Canadian food safety system compared to other countries (Decima Research, 2010; Ipsos-Reid Corporation, 2004; The Strategic Counsel, 2009) and confidence in certain food products (Ipsos-Reid Corporation, 2010) were also measured. Many Canadians (67–92%) believed that food produced in Canada is safer than food produced in other countries (Decima Research, 2010; Ipsos-Reid Corporation, 2007a; The Strategic Counsel, 2009). In general, Canadians expressed the highest confidence in the safety of bread and baked goods (81%), followed by fruits and vegetables (76%), and dairy products (74%). In-store cut meats and pre-packaged cut meats were ranked the lowest with 52% and 38%, respectively (Ipsos-Reid Corporation, 2010).

In total, 10 POR studies included questions regarding the roles of various stakeholder groups in bearing responsibility for food safety (EnviroNics Research Group, 1998; Ipsos-Reid Corporation, 2002, 2007a, 2007c, 2010; Léger Marketing, 2011; Les Études de Marché Créatec, 2007; The Strategic Counsel, 2007, 2009). Two studies that provided a list of broad organization groups found that responsibility for the safety of food eaten at home was considered most commonly to be with industry (38%) (Léger Marketing, 2011) and the government (21–24%) (EnviroNics Research Group, 1998; Léger Marketing, 2011), followed by consumers (23–25%) (EnviroNics Research Group, 1998; Léger Marketing, 2011), food suppliers (15%) (EnviroNics Research Group, 1998), retailers (11%) (EnviroNics Research Group, 1998), and farmers (10%) (Léger Marketing, 2011). Focus group study results indicated that when probed on the role of government, most respondents felt the government should be most responsible for ensuring the safety of food in Canada (Les Études de Marché Créatec, 2007; The Strategic Counsel, 2007). When phrased as an open ended question, 15–36% of respondents identified the federal government (unspecified department or agency) (Ipsos-Reid Corporation, 2001, 2007c; The Strategic Counsel, 2009), 9–31% identified Agriculture and Agri-Food Canada (Ipsos-Reid Corporation, 2001, 2002, 2007c; The Strategic Counsel, 2009) 8–21% identified the Canadian Food Inspection Agency (Ipsos-Reid Corporation, 2001, 2002; The Strategic Counsel, 2009), 10–20% identified Health Canada (Ipsos-Reid Corporation, 2001, 2002, 2007c; The Strategic Counsel, 2009), and 6–8% identified the Department of Food and Drugs (Ipsos-Reid

Table 1
Summary of surveys of safe food handling behaviours and knowledge among Canadian populations.

Agency	Survey type	Survey mode	Year of survey	No. of participants	Population	Method of participant selection	Survey instrument available
Léger Marketing/ CFIA (Léger Marketing, 2011)	POR	Telephone/ focus groups	2011	Wave 1: 1003 called; Wave 2: 1001 called/6 focus groups (12 participants per group)	Canada, conducted in English and French	Telephone survey used random digit dialling/ focus groups recruited from random phone calls to the general population as well as a panel of individuals who previously agreed to be contacted regarding research	Yes
Decima Research/ CFIA (Decima Research, 2010)	POR	Telephone/ Focus groups	2010	1001 called/6 focus groups (12 participants per group)	Canada, aged 18+, conducted in English and French	Telephone survey used random digit dialling/ focus groups recruited from random phone calls to the general population	Yes
EKOS Research Associates Inc./ Health Canada (EKOS Research Associates Inc., 2010)	POR	Telephone	2010	1536	Canada, 5 distinct demographic groups: seniors (aged 65+), pregnant women and those who expect to become pregnant within one year, parents of children under 6 years of age, immunocompromised individuals, and the general public	Older Canadians and the general public were selected using random digit dialling, and pregnant women, parents and immunocompromised individuals were selected randomly from an existing survey participant panel recruited by random digit dialling	Yes
Fraser Health, Vancouver Coastal Health (Fraser Health and Vancouver Coastal Health, 2010)	POR	Telephone	2010	1000	Vancouver Coastal Health Authority and Fraser Health Authority, aged 19+, conducted in English, Cantonese and Punjabi	Random sample selection	No, some questions provided
Ipsos-Reid/ Agriculture and Agri-Food Canada ^a (Ipsos-Reid Corporation, 2010)	POR	Telephone/ Online survey	2010	400 called/3144 online survey	Canada, aged 18+, conducted in English and French	Telephone survey recruitment unknown/ online survey participants pre- recruited using online panel	Yes
Nesbitt et al. (3 reports) ^b (Nesbitt, 2007; Nesbitt et al., 2008; Nesbitt et al., 2009)	1 Master's Thesis, 2 peer reviewed publications	Telephone	2005–2006	2332	Waterloo Region, Ontario, Canada, aged >18 months, conducted in English	Random digit dialling	Yes
The Strategic Counsel/CFIA ^a (The Strategic Counsel, 2009)	POR	Telephone/ Focus groups	2009	1014 called/10 focus groups (8–10 participants per group)	Canada, aged 18+, conducted in English and French; focus group participants were main food shopper and food preparer	Telephone survey used random digit dialling/ focus groups recruitment unknown	Yes
Ipsos-Reid/Health Canada ^a (Ipsos-Reid Corporation, 2007c)	POR	Telephone	2007	2000	Canada, aged 18+	Random digit dialling	Yes
Ipsos-Reid/CFIA (Ipsos-Reid Corporation, 2007b)	POR	Telephone	2007	1018	Canada, aged 18+	Random digit dialling	No
Ipsos-Reid ^a (Ipsos-Reid Corporation, 2007a)	POR	Telephone/ Focus groups	2007	Phase One: 4 focus groups; Phase Two: telephone interview with 1200 participants; Phase Three: 8 focus groups	Canadians, aged 18 to 70 and parents with children aged 10 years or younger, English and French	Phase One: focus group recruitment unknown; Phase Two: telephone survey used random sample selection; Phase Three: focus group recruitment unknown	Yes

Table 1 (continued)

Agency	Survey type	Survey mode	Year of survey	No. of participants	Population	Method of participant selection	Survey instrument available
Les Études de Marché Créatec ^a (Les Études de Marché Créatec, 2007)	POR	Focus groups	2007	8 focus groups (6–8 participants per group); total 60 participants	Canadians, aged 25–59, conducted in English and French	Random recruitment based on a client-approved recruitment screener	Yes
Patterson, Langlois Consultants ^a (Patterson, 2007)	POR	Focus groups	2007	8 focus groups (7–8 participants per group)	Canada, primary food preparers were interviewed, conducted in English and French	Recruitment questionnaire with screening criteria	Yes
The Strategic Counsel (The Strategic Counsel, 2007)	POR	Focus groups	2007	16 focus groups (8–10 participants per group)	Canada, aged 18+, conducted in English and French	Focus group recruitment unknown	Yes
Phoenix Strategic Perspectives (Phoenix Strategic Perspectives Inc., 2006)	POR	Focus groups	2006	4 focus groups (10 participants per group)	Canada, aged 18–44, parents of children aged 0–10 years old, conducted in English and French	Telephone recruitment screener	Yes
EKOS Research Associates Inc. ^a (EKOS Research Associates Inc., 2005)	POR	Telephone	2005	1008	Canada, aged 18+	Random sample selection	No, some questions provided
Ipsos-Reid/ Agriculture and Agri-Food Canada (Ipsos-Reid Corporation, 2004)	POR	Telephone	2004	1600	Canada, aged 18+, individuals primarily or jointly responsible for deciding which foods were purchased for the home were interviewed	Random digit dialling	No, some questions provided.
Serecon Management Consulting Inc./ CPCFSE (Serecon Management Consulting Inc., 2004)	POR	Telephone	2004	1213	Canada, aged 18+, conducted in English and French	Random digit dialling	Yes
COMPAS Inc. ^a (COMPAS Inc., 2004)	POR	Telephone	2004	1423	Canada	National representative sample	No, some questions provided
COMPAS Inc. ^a (COMPAS Inc., 2003)	POR	Telephone	2003	1200	Canada, Adults	National representative sample	No
IBM ^a (IBM Business Consulting Services, 2003)	POR	Telephone	2003	2566	Canada, aged 15+, conducted in English and French	Random digit dialling	No
Ipsos-Reid (Ipsos-Reid Corporation, 2002)	POR	Telephone	2002	1000	Canada, aged 18+, individuals primarily or jointly responsible for making food purchase decisions for their household were interviewed	Random digit dialling	Yes
Ipsos-Reid ^a (Ipsos-Reid Corporation, 2001)	POR	Telephone	2001	2203	Canada, Adults	Random sample selection	Yes
Environics Research Group/ CFIA (Environics Research Group, 1998)	POR	Face-to-face (in-home interviews)	1998	2013	Canada, aged 18+, individuals who prepared meals at home at least once per year or more were interviewed	Participant selection unknown	No, some questions provided
UBC/Wyne (Wyne, 2001)	Published Master's Thesis	Self-administered mail questionnaire	1998	582	Vancouver, British Columbia, aged 15+	Random sample selection	Yes

POR: public opinion research.

^a The article contains some questions relevant to the topic of the review.

^b Multiple publications based on a single survey.

Corporation, 2001, 2007c; The Strategic Counsel, 2009) as organizations responsible for food safety, while fewer identified provincial/territorial governments (4–7%) (Ipsos-Reid Corporation, 2001, 2007c; The Strategic Counsel, 2009) or the Ministry of Health (2–5%) (Ipsos-Reid Corporation, 2001, 2007c), retailers (5%) (The Strategic Counsel, 2009), producers (4%) (The Strategic Counsel, 2009), or manufacturers and distributors (4%) (Ipsos-Reid Corporation, 2001). Between 21% and 26% of respondents were unaware of a government organization responsible for food safety (Ipsos-Reid Corporation, 2001, 2007c; The Strategic Counsel, 2009). When asked why some of these groups should be held responsible, respondents mentioned the government's ability to control and enforce standards, and suppliers' ability to have control over food at its source (Enviro-nics Research Group, 1998). Some studies did, however, find that most consumers believe that a combination of institutions and consumers themselves are responsible for food safety (Enviro-nics Research Group, 1998; Léger Marketing, 2011; Les Études de Marché Créatec, 2007).

3.4. Knowledge

3.4.1. Food safety awareness

Two POR studies showed that just over half (52–54%) of Canadians believed that food contamination primarily occurred before food reached their kitchen and 40–43% believed that it occurred as a result of improper food handling and storage in the home (Decima Research, 2010; Léger Marketing, 2011). In three POR studies, when respondents were asked about where food safety problems were likely to occur, the most common response was during food processing or in manufacturing plants (31–39%) (Enviro-nics Research Group, 1998; Ipsos-Reid Corporation, 2002, 2004), followed by restaurants (15–25%) (Enviro-nics Research Group, 1998; Ipsos-Reid Corporation, 2002, 2004), at home (8–16%) (Enviro-nics Research Group, 1998; Ipsos-Reid Corporation, 2002, 2004), at the farm level (15%) (Ipsos-Reid Corporation, 2002, 2004), during transportation (10–12%) (Enviro-nics Research Group, 1998; Ipsos-Reid Corporation, 2004) and at the grocery store (9–10%) (Enviro-nics Research Group, 1998; Ipsos-Reid Corporation, 2002, 2004). Similarly, results from a focus group study found that participants felt that most instances of food-borne illness occurred from food consumed outside the home, in public places such as restaurants and cafeterias, especially salad bars (Les Études de Marché Créatec, 2007).

In one POR study, 75% of Canadians felt that the most important thing that they did to keep food safe from germs was washing their hands, followed by refrigerating food promptly (34%), cooking food to proper temperatures (33%) and keeping different foods separate from each other to avoid cross-contamination (16%) (Enviro-nics Research Group, 1998). When the question was worded slightly differently, food safety measures that first came to mind when thinking about food preparation and storage at home included proper refrigeration of food (22–23%), general washing and cleaning (12–14%), washing hands (8–9%), maintaining food at appropriate temperatures (5–7%), proper storage and separation of foods (4–7%), ensuring food is cooked properly (3–5%), and proper freezing of food (3–4%) (Léger Marketing, 2011). Three POR studies looked at the level of awareness related to a number of food safety-related subjects (COMPAS Inc., 2003, 2004; EKOS Research Associates Inc., 2010). There was a moderate to high level of awareness related to proper cooking and cooling instructions (47–77%) (COMPAS Inc., 2003, 2004; EKOS Research Associates Inc., 2010), safe food handling (34–74%) (COMPAS Inc., 2003, 2004; EKOS Research Associates Inc., 2010), proper storage (48–73%) (COMPAS Inc., 2003, 2004; EKOS Research Associates Inc., 2010), and contamination (42–55%) (COMPAS Inc., 2003, 2004). In another study (Serecon Management Consulting Inc., 2004), when

asked in an unprompted manner about the most common things that people did that might cause food poisoning, 60% of respondents reported practices related to the message of “chill”, followed by 44% “clean”, 20% “cook” and 10% “separate”.

3.4.2. Sources of information for food safety

Questions about consumers' sources of information on food safety and/or how they learned about food preparation were assessed in several studies (Table 2). In surveys prior to 2010, family and friends as well as television/radio were generally the most common sources of food safety information or knowledge (11–75%) (Enviro-nics Research Group, 1998; Ipsos-Reid Corporation, 2004; Nesbitt, 2007; Serecon Management Consulting Inc., 2004; Wyne, 2001), while surveys after 2010 indicated that the internet is a common source for Canadians to obtain information on food safety (Decima Research, 2010; EKOS Research Associates Inc., 2010; Ipsos-Reid Corporation, 2010; Léger Marketing, 2011). The percentage of consumers who mentioned cookbooks as a source of food safety information decreased over time, from 32–67% in 1998 (Enviro-nics Research Group, 1998; Wyne, 2001) to 3% in 2011 (Léger Marketing, 2011). One survey found that consumers were most likely to turn to academics and health experts (44%) as the most trusted source of information on food safety (EKOS Research Associates Inc., 2005). From public opinion research, common food safety topics of interest included safe food handling practices (3–17%) (Decima Research, 2010; EKOS Research Associates Inc., 2010; Enviro-nics Research Group, 1998; Ipsos-Reid Corporation, 2004; Léger Marketing, 2011), agricultural production (23%) (Ipsos-Reid Corporation, 2004) and processing (7–23%) (Decima Research, 2010; Ipsos-Reid Corporation, 2004), food recalls (8–15%) (EKOS Research Associates Inc., 2010; Léger Marketing, 2011), contaminations (5–6%) (Léger Marketing, 2011) or a combined response of food recalls and contaminations (22%) (Decima Research, 2010), food-borne illness (8%) (EKOS Research Associates Inc., 2010), best cooking practices (1–8%) (EKOS Research Associates Inc., 2010; Léger Marketing, 2011), best before dates (4–6%) (Decima Research, 2010; EKOS Research Associates Inc., 2010; Léger Marketing, 2011), risks associated with different foods (5%) (EKOS Research Associates Inc., 2010), information about meats (5–8%) (Decima Research, 2010; Léger Marketing, 2011) and fruits and vegetables (1–2%) (Léger Marketing, 2011), foods' origin (4–6%) (Decima Research, 2010; Léger Marketing, 2011), and food contents or ingredients (3–5%) (Decima Research, 2010; EKOS Research Associates Inc., 2010; Léger Marketing, 2011). From another public opinion report, when specifically asked about information on the proper way to cook, store and handle food, 27% of respondents wanted more information on these topics (Enviro-nics Research Group, 1998). From one focus group study, a prompted discussion found that participants used a wide range of sources for information about food safety, including: television, radio, newspapers, and magazines, the internet, word of mouth through friends and family, with no mention of getting information from health practitioners, retail outlets, or the government (Les Études de Marché Créatec, 2007).

3.4.3. Incidence of food-borne illness

Two peer-reviewed (Nesbitt, 2007; Wyne, 2001) and seven POR studies (Enviro-nics Research Group, 1998; Ipsos-Reid Corporation, 2004, 2007b, 2010; Les Études de Marché Créatec, 2007; Patterson, 2007; Serecon Management Consulting Inc., 2004) asked whether respondents or someone they knew well had suffered from a food-borne illness. The survey results varied, with one study reporting approximately 8% of consumers reporting food-borne illness in the last month (Nesbitt, 2007), while other studies ranged from 10–23% experiencing food-borne illness over the last year (Enviro-nics Research Group, 1998; Ipsos-Reid Corporation, 2004, 2007b, 2010; Serecon Management Consulting Inc., 2004), and another

Table 2
Information sources on food preparation/proper cooking, storage, and handling.

Information Source ^a	UBC/Wyne (1998) (Wyne, 2001)	Environics Research Group (1998) (Environics Research Group, 1998)	Serecon Management Consulting Inc. (2004) (Serecon Management Consulting Inc., 2004)	Ipsos-Reid (2004) (Ipsos-Reid Corporation, 2004)	Nesbitt et al. (2005–2006) (Nesbitt et al., 2009)	EKOS Research Associates Inc. (2010) (EKOS Research Associates Inc., 2010)	Decima Research (2010) (Decima Research, 2010)	Ipsos-Reid (2010) (Ipsos-Reid Corporation, 2010)	Léger Marketing (2011) (Léger Marketing, 2011)
Cookbooks/books	67%	32%	N/A	N/A	3.70%	4%	N/A	8% (movies, books, documentaries)	3%
Family/friends	65%	58%	66%	11%	75.10%	7%	3%	27% (word of mouth)	1%
Magazines/newspapers/publications	52% (magazines, newspaper)	N/A	N/A	9% (books, magazines, brochures)	N/A	N/A	8% (newspaper article)	9% (publications)	5% (magazine, newspaper, health journal/report)
TV/radio/other media	47% (TV, radio)	22% (TV, radio)	43% (TV, radio, and internet)	59% listed as media	18.7% (electronic media, e.g. TV, internet)	42% (newspapers, radio, TV or other media)	7% (TV news)	59% (TV, radio, newspaper, or internet media)	6%(TV, radio)
Internet/social media	N/A	N/A	N/A	11%	N/A	24%	76%	6% (social media)	79%
School, clubs	21%	N/A	13%	3%	15.10%	4% (includes on the job)	N/A	N/A	N/A
On the job	12%	N/A	16%	N/A	5.20%	N/A	N/A	0%	N/A
Product labels/food packaging	56%	27%	N/A	2%	N/A	4%	N/A	N/A	1%
Consumer information brochures	31%	N/A	N/A	N/A	6.40%	N/A	N/A	N/A	N/A
Health professionals	17%	N/A	N/A	5%	1.20%	N/A	3%	N/A	2%
Government	19%	N/A	N/A	4%	N/A	N/A	19% (HC, CFIA, other)	15%	19% (HC, CFIA, PHAC, AG Canada)
Retailer/grocery store	12%	N/A	N/A	8%	N/A	N/A	N/A	N/A	3%
Self-experience	N/A	N/A	N/A	N/A	7.90%	6%	N/A	N/A	N/A
Courses	N/A	N/A	3% (cooking course)	1%	0.8% (food safety)	N/A	N/A	N/A	N/A

N/A: not applicable.

^a Values represent the proportion of respondents who rely on different sources of information on food issues/safety and/or how they learned about food preparation.

study indicating 39% of respondents experienced food-borne illness in their lifetime (Wyne, 2001). Qualitative findings suggested that many Canadians either knew someone or personally experienced food-borne illness and participants were open to the possibility that they had had food-borne illness without knowing it (Les Études de Marché Créatec, 2007; Patterson, 2007). In two POR studies, 72% of respondents thought they contracted their food-borne illness from food prepared away from home, while 13–16% thought it was from food prepared at home (Environics Research Group, 1998; Serecon Management Consulting Inc., 2004). Similarly, of those who believed they had experienced a food-borne illness, 47% believed they contracted it from a meal prepared at a restaurant or dining establishment, 29% from food prepared outside the home, but eaten at home (i.e. take-out meals or already prepared meals), 14% from food prepared at their home, and 10% from food prepared outside their home, but not a restaurant (Ipsos-Reid Corporation, 2010). Furthermore, results from a peer-reviewed study indicated a meal at a restaurant (31%), a meal at a banquet, reception or catered function (7%), a meal prepared at home (7%), or a meal at a family/friends home (6%) were meals believed to be the most common sources of illness (Wyne, 2001).

3.4.4. High-risk population groups

One POR study specifically selected participants from high-risk groups including pregnant women, parents of young children, the elderly and immunocompromised individuals (EKOS Research

Associates Inc., 2010). The majority of respondents (84%) were aware that certain groups were at a higher risk for food-borne illness complications (EKOS Research Associates Inc., 2010). When asked about specific groups, 62% identified the elderly, 61% identified children less than 6 years old, 54% identified those with pre-existing health issues and 9% identified pregnant women as high-risk groups (EKOS Research Associates Inc., 2010). Persons in high-risk groups did not tend to recognize their own group as high-risk (EKOS Research Associates Inc., 2010). For example, 25% of pregnant women identified pregnant women as a high-risk group and 50% of seniors identified seniors as a high-risk group. This tendency to not self-identify as high-risk was further highlighted when respondents were asked about their own risk for complications from food-borne illness: 27% of pregnant women, 28% of immunocompromised individuals, and 11% of elderly people felt that they were at a higher risk for food-borne illness complications (EKOS Research Associates Inc., 2010).

3.4.5. High-risk foods

Nine surveys assessed consumers' knowledge and/or consumption of high-risk foods (Environics Research Group, 1998; EKOS Research Associates Inc., 2010; Fraser Health & Vancouver Coastal Health, 2010; Ipsos-Reid Corporation, 2002; Léger Marketing, 2011; Les Études de Marché Créatec, 2007; Nesbitt et al., 2009; Serecon Management Consulting Inc., 2004; Wyne, 2001). The list of specific food items defined as high-risk in terms of food-

borne illness transmission varied between the surveys, and appeared to expand over time (Table 3). These studies asked questions about consumers' knowledge or beliefs about risky foods, rating food-borne illness risks related to specific foods, or identifying foods that are high-risk (Enviro-nics Research Group, 1998; EKOS Research Associates Inc., 2010; Fraser Health & Vancouver Coastal Health, 2010; Ipsos-Reid Corporation, 2002; Léger Marketing, 2011; Les Études de Marché Créatec, 2007; Nesbitt et al., 2009; Serecon Management Consulting Inc., 2004; Wyne, 2001). Overall, food items identified as high-risk were consistent across many of the studies with the most frequently cited foods including meats and poultry, followed by fish and seafood, dairy products, eggs, and produce. In 2010, however, consumers identified deli meats as the most high-risk food associated with food-borne illness (EKOS Research Associates Inc., 2010). Finally, food consumption of high-risk foods was measured in one peer-reviewed study (Nesbitt et al., 2009) and one POR study (Fraser Health & Vancouver Coastal Health, 2010). Both studies found that over 40% of respondents consumed undercooked eggs, 11–42% consumed alfalfa or other raw bean sprouts, 6–35% consumed raw egg products such as raw cookie dough, 8–26% consumed raw fish and 44% consumed sushi, and 6–16% consumed raw shellfish. Other less frequently consumed high-risk foods included rare hamburger (8%) (Fraser Health & Vancouver Coastal Health, 2010), chicken nuggets or strips (19%) (Nesbitt et al., 2009), unpasteurized cider (6%) (Nesbitt et al., 2009), cheese made with unpasteurized milk (1%) (Nesbitt et al., 2009), and unpasteurized milk (0.7%) (Nesbitt et al., 2009).

3.5. Behaviour

3.5.1. Frequency of food preparation

Three POR studies (Enviro-nics Research Group, 1998; Ipsos-Reid Corporation, 2004; Serecon Management Consulting Inc., 2004) and one peer-reviewed study (Wyne, 2001) looked at frequency of food preparation in the home. Of those that prepared meals at home at least once per year, 65% prepare food every day or almost every day (Enviro-nics Research Group, 1998). Similarly, another study found that 68% of respondents identified themselves as personally responsible for preparing the main meal every day or almost every day in their households (Serecon Management

Consulting Inc., 2004). In an average week, 75% of Canadians ate fewer than 3 meals prepared outside the home (Ipsos-Reid Corporation, 2004). One peer-reviewed study showed that 84% of respondents prepared 5 or more meals per week (Wyne, 2001).

3.5.2. Reported frequency of hand washing ('Clean')

Two peer-reviewed studies (Nesbitt et al., 2009; Wyne, 2001) and seven POR studies (COMPAS Inc., 2004; EKOS Research Associates Inc., 2010; Fraser Health & Vancouver Coastal Health, 2010; Ipsos-Reid Corporation, 2007b; Léger Marketing, 2011; Les Études de Marché Créatec, 2007; Serecon Management Consulting Inc., 2004) assessed self-reported hand-washing behaviours (Table 4). Most (85%) considered hand-washing to be very important in the prevention of disease (Nesbitt et al., 2009) and almost all (98–99%) reported washing their hands frequently (Léger Marketing, 2011). The majority of Canadians (56–83%) reported always washing their hands before preparing food (COMPAS Inc., 2004; EKOS Research Associates Inc., 2010; Fraser Health & Vancouver Coastal Health, 2010; Nesbitt et al., 2009), and 75–87% reported always washing their hands after preparing food or handling raw meat (EKOS Research Associates Inc., 2010; Fraser Health & Vancouver Coastal Health, 2010). Furthermore, results from a focus group showed that those that identified themselves as primary shoppers, were more likely than those who did not identify themselves as primary shoppers to say they always washed their hands during food preparation (Ipsos-Reid Corporation, 2007b).

In one peer-reviewed study (Wyne, 2001), Canadians frequently reported using soap and water to wash their hands (61%) followed by water and a disinfectant soap (30%), or water only (13%). In a POR study (Serecon Management Consulting Inc., 2004), nearly three quarters of respondents (72%) reported always or sometimes washing their hands with soap and water for the recommended minimum time of 20 s.

The main reasons mentioned in one peer-reviewed study (Nesbitt et al., 2009) for washing hands before eating or handling food were to remove bacteria/kill germs (76%), followed by hygiene and general cleanliness (29%). Similarly, results from a focus group indicated that participants included hand washing as a safety precaution to avoid food contamination (Les Études de Marché Créatec, 2007).

Table 3
Proportion of respondents that identified food as high-risk for food-borne illness.

Author	Year	High Risk Food Items
UBC/Wyne (Wyne, 2001)	1998	Pink chicken (76%), cooked hamburger contaminated with raw meat juice (77%), vegetables contaminated with raw meat juice (71%), and 3-minute eggs (7%)
Enviro-nics Research Group/CFIA (Enviro-nics Research Group, 1998)	1998	Chicken (53%), meats-unspecified (43%), ground meats-unspecified (31%), pork (24%), poultry (24%), beef (20%), fish (29%) and seafood (25%), dairy products (21%), mayonnaise (18%), eggs (15%), dented cans (12%), turkey (10%), and fruits and vegetables (10%)
Ipsos-Reid (Ipsos-Reid Corporation, 2002)	2002	Ground beef (37%), poultry (23%), fish and seafood (14%), beef steaks and roasts (9%), pork (5%), vegetables (4%), dairy products (3%), fruit (2%), and eggs (1%)
Serecon Management Consulting Inc./CPCFSE (Serecon Management Consulting Inc., 2004)	2004	Chicken, turkey, poultry (5%), meat-unspecified (5%), beef (<1%), fish and seafood (<1%), fruits, vegetables, nuts, sprouts, mayonnaise (<1%), lamb/pork/game (<1%), and eggs (<1%)
Nesbitt, 2007 (Nesbitt, 2007)	2005–2006	Hamburger (84%), chicken (84%), unpasteurized milk (52%), alfalfa and mung bean sprouts (38%), raw oysters (34%), and unpasteurized cider (30%), eggs (7%), meat-unspecified (5%), raw or undercooked foods (4%), seafood-unspecified (4%), fruits (3%) and vegetables (3%)
Les Études de Marché Créatec (Les Études de Marché Créatec, 2007)	2007	Fish, undercooked chicken and pork, fresh fruits and vegetables, meats including hamburger, processed foods, mayonnaise, eggs, seafood and shellfish, canned foods, and dairy products
EKOS Research Associates Inc./Health Canada (EKOS Research Associates Inc., 2010)	2010	Deli meat (73%), raw/smoked seafood (71%), soft/unpasteurized cheeses (49%), unpasteurized juices (46%), frozen chicken nuggets (38%), pasteurized milk (18%), and hard cheeses (15%)
Léger Marketing/CFIA (Léger Marketing, 2011)	2011	Meat or poultry (64%), produce (5%), dairy products and eggs (5%), fish (3%), and ready-to-eat foods (3%)

Table 4
Self-reported behaviours related to safe food handling ('clean', 'chill', 'separate', 'cook').

Food safety issue	Peer-reviewed studies	Non-peer-reviewed studies (POR)	Focus Groups (POR)
Clean			
Frequency of hand-washing	67% always, 24% usually, 7% sometimes, 2% rarely, <1% never washed their hands before eating or handling food; 90% washed hands with soap, 6% rinsed hands, 1% continue cooking, and <1% wiped hands after handling raw meat (Nesbitt et al., 2009) 61% used soap and water to clean hands, 30% washed with a disinfectant soap and 13% rinsed with water only (Wyne, 2001)	98% reported washing hands frequently in 2010, and 99% in 2011 (Léger Marketing, 2011) 83% always washed their hands with soap/water before preparing food, 75% always washed their hands with soap/water after preparing food (EKOS Research Associates Inc., 2010) 68% always washed their hands before preparing food, 87% always washed their hands after handling raw meat, chicken or seafood (Fraser Health and Vancouver Coastal Health, 2010) 56% washed hands 100% of the time and 22% washed hands 75–99% of the time before handling food (COMPAS Inc., 2004) 49% always and 23% sometimes washed their hands with soap and water for at least 20 s before preparing food in their kitchen (Serecon Management Consulting Inc., 2004)	Those who identified themselves as primary shoppers were more likely to say they always washed their hands during food preparation (Ipsos-Reid Corporation, 2007) Participants in all locations included hand-washing as a safety precaution (Les Études de Marché Créatec, 2007): <i>"I wash my hands between touching everything"</i>
Frequency of washing poultry		58% always rinsed poultry before cooking it (EKOS Research Associates Inc., 2010)	Some participants in various groups washed meat, poultry or fish (Les Études de Marché Créatec, 2007): <i>"I wash the chicken with lemon juice or vinegar"</i> <i>"I only wash chicken, not beef"</i> <i>"I wash my fish before I cook it"</i>
Frequency of washing fruits and vegetables	71% always, 21% usually, 6% sometimes, 1% rarely, and <1% never washed raw fruits before they prepared and ate them; 76% always, 19% usually, 4% sometimes, <1% rarely, and <1% never washed raw vegetables before they prepared and ate them (Nesbitt et al., 2009)	96% reported rinsing fruit and vegetables with water in 2010 and 94% in 2011 (Léger Marketing, 2011) 77% always washed fresh fruits and vegetables before consuming them (EKOS Research Associates Inc., 2010) 81% always rinsed fresh vegetables before eating them (Fraser Health and Vancouver Coastal Health, 2010) 50% always, 29% sometimes and 21% never washed peelable fresh fruit and vegetables before cutting into them (Serecon Management Consulting Inc., 2004)	Most participants washed fruits and vegetables to get rid of pesticide residues and some reported washing the skins of fruits that required peeling to avoid contamination by a knife (Les Études de Marché Créatec, 2007): <i>"I always wash my produce more. I peel a lot of my fruits"</i> <i>"I wash melons because when you are peeling it the chemicals, preservatives or pesticides are on the skin of the melon and when you cut it you contaminate the inside"</i>
Cleaning food preparation surfaces, sinks and reusable grocery bags	65% used soap and water, 17% used bleach and water, 12% used the dishwasher, 7% used antibacterial cleaner/disinfectant, 4% used plain water, and <1% used other methods such as vinegar/lemon juice, salt, baking soda, or rubbing alcohol to clean the kitchen/sink or cutting board after preparing raw meat (Nesbitt et al., 2009) 60% used an appropriate method for treating the cutting utensils, 59% for treating the cutting board, 71% treating the kitchen counter, and 68% for treating the kitchen sink; 35% cleaned cutting utensils, 41% cleaned cutting boards, 26% cleaned kitchen counters, 39% cleaned kitchen sink and 41% cleaned dishcloth/sponge with detergent and water (Wyne, 2001)	96% used warm soapy water to clean utensils and surfaces used for food preparation in 2010 and 2011 (Léger Marketing, 2011) 83% reported always cleaning the surface used to prepare foods on; 59% used soap and water, 41% used disinfectant, 7% used water only, 6% used bleach, and 6% used vinegar to clean surfaces; 38% never, 17% rarely, 21% sometimes, 13% often, and 7% always reported washing reusable grocery bags (EKOS Research Associates Inc., 2010) 83% always washed items that contact raw meat, chicken or seafood; 93% always washed the plate used to hold raw meat, chicken or seafood (Fraser Health and Vancouver Coastal Health, 2010) 56% always washed and disinfected the cutting surface after handling raw meat and before using the surface to prepare other food (COMPAS Inc., 2004) 51% washed and disinfected their cutting board after cutting raw meat, and 46% washed only without disinfecting; 21% changed the sponge,	Participants in various groups took precautions to keep kitchen counters and cooking utensils clean, to avoid cross-contamination (Les Études de Marché Créatec, 2007): <i>"I clean the counter tops"</i> <i>"I'm very careful with chicken, I sterilize the cutting board and utensils"</i> Participants were unsure of how often to clean or about specific cleaning practices (Patterson, 2007)

(continued on next page)

Table 4 (continued)

Food safety issue	Peer-reviewed studies	Non-peer-reviewed studies (POR)	Focus Groups (POR)
Separate Separation of raw meats from other food items		cloth, rag they used to clean their kitchen every day and 36% changed it several times a week (Serecon Management Consulting Inc., 2004) 40% always put meat, poultry and seafood on the bottom shelf of fridge or in a special drawer; 48% never put meat or poultry and fresh produce in the same shopping bag (EKOS Research Associates Inc., 2010) 81% always, 12% sometimes, and 7% never took precautions to prevent seepage of raw meat juices to other foods in the refrigerator; 72% discarded the marinade used for meats, poultry, fish and seafood, 13% full boiled it for 1 min, 10% used it without boiling, and 2% used either method depending on the situation; 92% always, 5% sometimes and 3% never switched to a clean plate for the cooked meat after putting raw meat from a plate to the barbeque or cooking pan (Serecon Management Consulting Inc., 2004) 61% strongly agreed/agreed with the statement: 'I have separate cutting boards for raw meats and vegetables' (Ipsos-Reid Corporation, 2004)	Some participants used separate cutting surfaces and storage shelves for different foods (Les Études de Marché Créatec, 2007): "I've got colour coded cutting sheets, I use one for chicken, another for vegetables and another for meat, to avoid cross contaminations" "We use different shelves in the fridge, and don't have hamburger high because of dripping blood. I clean the fridge weekly"
Chill Refrigerator temperatures	60% did not know the recommended refrigerator temperature; among respondents who were aware of their actual refrigerator temperature, 93% had it set at 0–5 °C when they checked it, and 4% had it set between 6–10 °C, < 1% had it set between 11–15 °C, <1% had it set between 16–20 °C, and 1% more than 20 °C (Nesbitt et al., 2009)	95% reported keeping refrigerators clean and at a temperature below 4 °C or 40 °F in 2010 and 94% in 2011 (Léger Marketing, 2011) 30% had a thermometer in their fridge; 59% were able to provide a response when asked what the minimum internal fridge temperature should be with the average temperature being 40 °F (recommended is 35–38 °F): 22% said it should be below 38 °F, 16% at 39 °F, 18% at 40–50 °F, 2% over 50 °F, and 41% didn't know (EKOS Research Associates Inc., 2010) 80% did not use a thermometer to determine if their refrigerator is cold enough (Fraser Health and Vancouver Coastal Health, 2010) 67% did not know the recommended temperature for inside a refrigerator, 11% said below 4 °C, 13% said at 4 °C, 7% said at 5–10 °C, and 2% said above 10 °C (Serecon Management Consulting Inc., 2004)	There was confusion about the precise meaning of the reference to 4 °C in the "chill" message, and some participants hesitated about whether this meant a minimum, maximum or ideal temperature (Patterson, 2007)
Handling of leftovers and defrosting	74% consumed leftovers within one to two days of initial preparation, 22% within 3–4 days, and 3% beyond 4 days (Nesbitt et al., 2008) 51% defrosted frozen meat in the refrigerator, 31% in the microwave, 26% at room temperature, 8% in water and <1% cooked meat from frozen; 47% used a plate to defrost meat, 37% in the packaged container, 19% in another container and 2% on a cutting board (Nesbitt et al., 2009) 93% were aware of the need to put leftovers from a meal into the refrigerator or freezer within 2 h of cooking the meal (Wynne, 2001)	89% reported freezing or consuming leftovers within four days of cooking in 2010 and 86% in 2011 (Léger Marketing, 2011) 43% sometimes to always defrosted frozen meat/poultry on the counter at room temperature; 58% never dated leftover food that they refrigerated; 40% never kept leftover food after reheating it once; 79% never re froze food after being completely defrosted; 65% always refrigerate leftover food within 2 h of cooking (EKOS Research Associates Inc., 2010) 14% always and 31% sometimes defrosted frozen meat, fish or seafood on the counter at room temperature; 14% defrosted whole chickens or turkeys on the counter, 57% used the refrigerator, 22% defrosted in cold water, and 7% used the microwave; 37% refrigerated leftovers immediately, 16%	While many participants knew it was best to thaw in the fridge, it was very evident that most will continue to thaw at least partially on counter tops because thawing in the fridge requires a level of planning and foresight that is beyond many participants (Patterson, 2007)

Table 4 (continued)

Food safety issue	Peer-reviewed studies	Non-peer-reviewed studies (POR)	Focus Groups (POR)
		<p>within 1–15 min, 21% within 16–30 min, 14% within 31 min to 1 hour, 7% within 1–2 h, and 3% within more than 2 h after serving (Serecon Management Consulting Inc., 2004)</p> <p>55% refrigerated or froze meat leftovers within 1 hour and 18% within 2 h after cooking; 87% believed that defrosting a turkey in the refrigerator is safe; 41% believed it is safe and 38% believed it was unsafe to defrost a turkey in the microwave just before cooking; 45% believed it was safe and 36% believed it was unsafe to defrost it in water at room temperature; 29% believed it was safe and 57% believed it was unsafe to defrost at room temperature (Enviro-nics Research Group, 1998)</p> <p>10% strongly agreed/agreed with the statement: 'as long as I reheat leftovers thoroughly, it doesn't matter how long I store leftovers in the fridge', and 76% strongly disagreed/disagreed (Ipsos-Reid Corporation, 2004)</p>	
Cook			
Use of thermometers	<p>14% used a thermometer, 64% used visual cues, 33% used time, 10% used taste, 3% used another tool, and <1% used other methods to determine when meat is cooked enough to eat (Nesbitt et al., 2009)</p> <p>69% used appropriate methods to determine whether whole poultry was cooked enough to eat; 78% and 71% used appropriate methods to determine whether large and small pieces of poultry, respectively, was cooked enough to eat; 71% used appropriate methods to determine if hamburger beef patties were cooked enough to eat (Wyne, 2001)</p>	<p>35% reported using a digital thermometer to ensure that meat is cooked to the recommended internal temperature in 2010 and 32% in 2011; not owning a digital thermometer was the main reason for not using one cited by 33% in 2010 and 32% in 2011; 50% reported never using a food thermometer to determine if meat, poultry and leftovers are heated to the correct temperature in 2010 and 51% in 2011 (Léger Marketing, 2011)</p> <p>13% always, 16% often, 15% sometimes, 14% rarely, and 42% never used a food thermometer to cook food; of those that sometimes to always used a food thermometer to cook food, 40% use a digital food thermometer (EKOS Research Associates Inc., 2010)</p> <p>86% did not use a thermometer to determine if hamburger is cooked enough; 82% did not use a thermometer to determine if chicken breast is cooked enough; 95% did not use a thermometer to determine if leftovers are reheated enough (Fraser Health and Vancouver Coastal Health, 2010)</p> <p>7% always, 12% sometimes and 81% never used a food thermometer when cooking ground meat; 21% always, 13% sometimes and 66% never used a food thermometer when roasting whole chickens or turkeys (Serecon Management Consulting Inc., 2004)</p>	<p>When it came to safe food handling methods, participants were least likely to use a meat thermometer (Ipsos-Reid Corporation, 2007)</p> <p>Some participants were more careful with regard to cooking and cooking temperatures, with a tendency to cook meat longer (Les Études de Marché Créatec, 2007):</p> <p>"I overcook everything"</p> <p>"I notice now, certain meat products, cook at this temperature. I went out and bought a temperature gauge"</p> <p>"My husband cooks his meats and uses thermometers"</p> <p>Most participants did not use thermometers except to verify that food is not overcooked (Patterson, 2007)</p>

POR: public opinion research.

3.5.3. Reported frequency of washing poultry, vegetables and fruits ('Clean')

One peer-reviewed study (Nesbitt et al., 2009) and five POR studies (EKOS Research Associates Inc., 2010; Fraser Health & Vancouver Coastal Health, 2010; Léger Marketing, 2011; Les Études de Marché Créatec, 2007; Serecon Management Consulting Inc., 2004) reported on practices related to washing poultry, vegetables, and fruits (Table 4). From four POR studies, 50% to 96% of respondents reported always washing fruits and/or vegetables (EKOS Research Associates Inc., 2010; Fraser Health & Vancouver Coastal Health, 2010; Léger Marketing, 2011; Serecon

Management Consulting Inc., 2004). From focus groups, most participants washed fruits and vegetables to remove pesticide residues and some to avoid contamination by the knife prior to peeling (Les Études de Marché Créatec, 2007). From a single peer-reviewed study, 71% and 76% of respondents always wash raw fruits and vegetables, respectively, before they prepare and eat them (Nesbitt et al., 2009). Always rinsing poultry prior to cooking it was reported by 58% of respondents in one POR study (EKOS Research Associates Inc., 2010). Some participants in a focus group also reported washing meat, poultry and fish (Les Études de Marché Créatec, 2007).

3.5.4. Reported frequency of washing or cleaning food preparation surfaces, sinks, and reusable grocery bags ('Clean')

Nesbitt et al., 2009; Wyne, 2001) and seven POR studies (COMPAS Inc., 2004; EKOS Research Associates Inc., 2010; Fraser Health & Vancouver Coastal Health, 2010; Léger Marketing, 2011; Les Études de Marché Créatec, 2007; Patterson, 2007; Serecon Management Consulting Inc., 2004) reported on consumers' cleaning practices for food preparation surfaces, sinks (Table 4) or grocery bags. The majority (83%) of respondents in one POR study reported always cleaning the surface(s) used to prepare foods on (EKOS Research Associates Inc., 2010). More specifically, from four POR studies, 56% always washed and disinfected the cutting surface after handling raw meat and before using the surface to prepare other food (COMPAS Inc., 2004), 51% of respondents washed and disinfected their cutting board after cutting raw meat (Serecon Management Consulting Inc., 2004), 83% always washed items that had contact with raw meat, chicken or seafood and 93% always washed the plate used to hold raw meat, chicken or seafood before using them for cooked items (Fraser Health & Vancouver Coastal Health, 2010). Furthermore, a focus group study found that participants took precautions to keep kitchen counters and cooking utensils clean to avoid cross-contamination (Les Études de Marché Créatec, 2007).

Soap and water were commonly reported (59–96%) as a method to clean kitchen surfaces and utensils in two POR studies (EKOS Research Associates Inc., 2010; Léger Marketing, 2011) and in one peer-reviewed study, respondents reported using detergent and water to clean cutting utensils (35%), cutting board (41%), kitchen counter (26%), kitchen sink (39%) and dishcloth/sponge (41%) (Wyne, 2001). Methods of cleaning the kitchen/sink or cutting board after preparing raw meat were reported from a peer-reviewed study with soap and water (65%) being the most common followed by bleach and water (17%), dishwasher (12%), antibacterial cleaner/disinfectant (7%), plain water (4%) and other methods (<1%) such as vinegar or lemon juice, salt, baking soda and rubbing alcohol (Nesbitt et al., 2009). Similar results were found from a single POR study where other methods identified included disinfectant (41%), water only (7%), bleach (6%) and vinegar (6%) (EKOS Research Associates Inc., 2010).

From a single peer-reviewed study, 59–71% of respondents reported using an appropriate method for treating the cutting board, kitchen counter or kitchen sink (Wyne, 2001); furthermore detergent and soap were identified by 41% of respondents as how they clean their dishcloth or sponge (Wyne, 2001). From a focus group study, participants were unsure of how often to clean or about specific cleaning practices (Patterson, 2007). One POR study found that the majority of consumers changed the sponge, cloth, or rag to clean their kitchen every day (21%) or several times a week (36%) (Serecon Management Consulting Inc., 2004).

From a single POR study, few Canadians (7%) reported always washing reusable grocery bags, with the largest proportion (38%) stating that they never wash their reusable grocery bags (EKOS Research Associates Inc., 2010).

3.5.5. Separation of raw meats from other food items ('Separate')

Four POR studies (EKOS Research Associates Inc., 2010; Ipsos-Reid Corporation, 2004; Les Études de Marché Créatec, 2007; Serecon Management Consulting Inc., 2004) reported on self-reported behaviours related to separating raw meats from other food items (Table 4). To prevent seepage of raw meat juices to other foods in the refrigerator, 81% always and 12% sometimes took precautions (Serecon Management Consulting Inc., 2004). Methods of separation in another study included putting meat, poultry and seafood on the bottom shelf of the refrigerator (40%), and never putting meat or poultry and fresh produce in the same shopping bag (48%) (EKOS Research Associates Inc., 2010).

One study reported separation practices for discarding marinade used for meats, poultry, fish and seafood (72%) or boiling the marinade for a full minute (13%), and always switching to a clean plate for cooked meat after barbecuing or cooking (92%) (Serecon Management Consulting Inc., 2004). Another study showed that 61% agreed or strongly agreed with the statement, 'I have separate cutting boards for raw meats and vegetables' (Ipsos-Reid Corporation, 2004). Results from focus groups also showed that some participants used separate cutting surfaces and storage shelves for different foods (Les Études de Marché Créatec, 2007).

3.5.6. Refrigerator temperatures ('Chill')

Five POR studies (EKOS Research Associates Inc., 2010; Fraser Health & Vancouver Coastal Health, 2010; Léger Marketing, 2011; Patterson, 2007; Serecon Management Consulting Inc., 2004) and one peer-reviewed study (Nesbitt et al., 2009) asked questions related to refrigerator thermometer use and temperature (Table 4). Some surveys explored whether consumers reported having a thermometer in their refrigerator, and knowledge around the recommended refrigerator temperature. From one POR study, 30% of participants reported having a thermometer in their fridge (EKOS Research Associates Inc., 2010) and when worded differently in another study 80% responded 'no' to using a thermometer to determine if the refrigerator is cold enough (Fraser Health & Vancouver Coastal Health, 2010). One peer-reviewed study found that 60% of respondents did not know the recommended refrigerator temperature (Nesbitt et al., 2009). Similarly, two POR studies found that 41–67% of respondents were unable to provide a response when asked what the recommended refrigerator temperature should be, with only 22–24% responding with the correct recommended temperature (EKOS Research Associates Inc., 2010; Serecon Management Consulting Inc., 2004). Furthermore, when asked in a focus group setting, it was unclear to participants whether 4 °C was meant to be a minimum, maximum or ideal refrigerator temperature (Patterson, 2007).

Awareness of the actual refrigerator temperature was assessed in two studies, with one POR study showing that nearly all (94–95%) consumers reported keeping their refrigerator clean and set to a temperature below 4 °C on a regular basis (Léger Marketing, 2011) and one peer-reviewed study, showing that 93% of respondents that were aware of their refrigerator temperature had it set to the correct recommended temperature (Nesbitt et al., 2009).

3.5.7. Reported handling of leftovers and defrosting ('Chill')

Six POR (Enviro-nics Research Group, 1998; EKOS Research Associates Inc., 2010; Ipsos-Reid Corporation, 2004; Léger Marketing, 2011; Patterson, 2007; Serecon Management Consulting Inc., 2004) and two peer-reviewed studies (Nesbitt et al., 2008, 2009; Wyne, 2001) reported on consumers' handling of leftovers and defrosting of foods (Table 4). In general, when respondents were asked if they refrigerated or froze perishable or leftover food within 2 h of cooking 65–89% responded that they did so always (EKOS Research Associates Inc., 2010; Léger Marketing, 2011). Likewise in a similarly worded, open-ended question 95% of respondents refrigerated or froze leftovers within 2 h of cooking (Serecon Management Consulting Inc., 2004). When specifically asked about meat or poultry leftovers, one POR study (Enviro-nics Research Group, 1998) and one peer-reviewed study (Wyne, 2001) found that 73% and 93% of respondents respectively, refrigerated or froze leftovers within 2 h of cooking. Just over half (58%) of respondents in a POR study, reported never dating leftover food that they refrigerated (EKOS Research Associates Inc., 2010).

When specifically asked about methods used to defrost frozen meat or frozen fish and seafood one peer-reviewed study (Nesbitt et al., 2009) found that respondents used the refrigerator (51%),

followed by microwave (31%), at room temp (26%) and in water (8%). Two POR studies looked specifically at thawing at room temperature and found that 43–45% of respondents sometimes to always thawed frozen meat or poultry on the counter (EKOS Research Associates Inc., 2010; Serecon Management Consulting Inc., 2004). When provided with several methods for defrosting a turkey, defrosting in the refrigerator was considered to be a safe practice by 87% of respondents; followed by in water at room temperature (45%); in a microwave (41%); and at room temperature (29%) (Envionics Research Group, 1998). Similarly, when respondents were asked about the main method used to defrost a whole chicken or turkey, 57% used the refrigerator followed by cold water (22%), on the counter (14%) and in the microwave (7%) (Serecon Management Consulting Inc., 2004). Results from focus groups found that consumers knew that it is best to defrost food in the fridge; however, most would continue to defrost partially on counter tops, as thawing in the refrigerator required planning and foresight (Patterson, 2007). From a peer-reviewed study, the most common surface used to thaw or defrost frozen meat was on a plate (47%), followed by in the packaged container (37%), in another container (19%) or on a cutting board (2%) (Nesbitt et al., 2009).

From a peer-reviewed study, respondents consumed approximately 2.4 meals or snacks consisting of leftover food items in the previous 7 days (Nesbitt et al., 2008). In addition, 96% of respondents reported consuming leftovers within four days of cooking (Nesbitt et al., 2008). Furthermore, results from a POR study showed that nearly half (40%) never kept leftover food after reheating it once and 79% never refroze food after being completely defrosted (EKOS Research Associates Inc., 2010). Finally, based on a single POR study, the majority (76%) of respondents disagreed or strongly disagreed with the statement, 'as long as I reheat them thoroughly it doesn't matter how long I store leftovers in the fridge' (Ipsos-Reid Corporation, 2004).

3.5.8. Reported use of food thermometers during cooking ('Cook')

Seven POR (EKOS Research Associates Inc., 2010; Fraser Health & Vancouver Coastal Health, 2010; Ipsos-Reid Corporation, 2007b; Léger Marketing, 2011; Les Études de Marché Créatec, 2007; Patterson, 2007; Serecon Management Consulting Inc., 2004) and two peer-reviewed studies (Nesbitt et al., 2009; Wyne, 2001) provided information related to the use of food thermometers for cooking (Table 4). Food thermometer use among Canadians is limited. From a peer-reviewed study, 14% of respondents reported using a thermometer to assess when meat is cooked enough to eat; other reported methods included, visual cues (64%), time (33%), taste (10%), another tool (3%) or other methods (<1%) (Nesbitt et al., 2009). Furthermore, another peer-reviewed study found that when respondents were specifically asked about specific meat products (i.e. whole poultry, large or small pieces of poultry, and beef patties) and a set list of options of how to decide when their food was cooked enough to eat was provided, less than 80% used an appropriate method to determine whether whole poultry, large and small pieces of poultry and beef patties were cooked enough to prevent food-borne illness; methods considered appropriate in this study included making sure juices run clear and/or the meat is not pink and/or use of a meat thermometer (Wyne, 2001).

Similar results were found from two POR studies, where 42–51% of respondents reported never using a food thermometer when cooking food or to determine if meat, poultry or leftovers are cooked to the correct temperature (EKOS Research Associates Inc., 2010; Léger Marketing, 2011). In two additional POR studies, respondents were asked about thermometer use when cooking specific foods and it was found that 81% and 66% never used a food thermometer when cooking ground beef or when roasting whole chickens or turkeys, respectively (Serecon Management Consulting Inc., 2004); while 95%, 86% and 82% never used a thermometer to

check if leftovers were reheated enough, when cooking hamburgers or when cooking chicken breast, respectively (Fraser Health & Vancouver Coastal Health, 2010).

From two POR studies, of those that reported using a food thermometer, a digital one was used by 32–40% (EKOS Research Associates Inc., 2010; Léger Marketing, 2011). Not owning a digital thermometer was cited by 33% (in 2010) and 32% (in 2011) of respondents as the reason why they did not use a digital thermometer (Léger Marketing, 2011).

From three focus group studies, most participants did not use a food thermometer except to verify that food is not overcooked (Patterson, 2007), while others reported being more careful with regard to cooking and cooking temperatures, with a tendency to cook meat longer (Les Études de Marché Créatec, 2007) and in general when it came to safe food handling methods, Canadians were least likely to use a meat thermometer (Ipsos-Reid Corporation, 2007b).

3.5.9. Reported attention to best before date and safe food handling labels

One peer-reviewed (Nesbitt et al., 2009) and seven POR studies (COMPAS Inc., 2003; Decima Research, 2010; EKOS Research Associates Inc., 2010; Ipsos-Reid Corporation, 2004; Léger Marketing, 2011; Les Études de Marché Créatec, 2007; Phoenix Strategic Perspectives Inc., 2006) queried consumers on their use of best before dates and safe food handling labels. From a single peer-reviewed study, 40% of respondents were aware that the meat package they purchased had a label on it that gives instructions for safe cooking and handling (Nesbitt et al., 2009).

From two POR studies, 84–85% of respondents claimed to read labels and followed cooking and storage instructions for all foods (Léger Marketing, 2011); and when asked in a slightly different way the majority of Canadians (85%) read the label the first time they purchased a product but only 39% read the label on subsequent purchases (Decima Research, 2010). One POR study found that 79% of respondents always read best before dates (Ipsos-Reid Corporation, 2004); however, in another study when asked for the main reason for reading a label or package information, the product expiry date was only reported by 2% of respondents (COMPAS Inc., 2003). From focus group research, it was reported that Canadians looked at or read labels on at least some of the grocery products they purchase (Phoenix Strategic Perspectives Inc., 2006). In addition to expiry and best before dates, participants looked for storage instructions, cooking or preparation instructions and contents or ingredients on food labels (Phoenix Strategic Perspectives Inc., 2006). Furthermore, participants expressed interest in information on safe duration and temperature for storage of food, warning about possible contamination from handling, cooking instructions for raw meat, freezing life or period, packaging date, consistency with regard to expiry or best before dates and labels showing the date of last government inspection (Les Études de Marché Créatec, 2007).

Four POR studies (Decima Research, 2010; EKOS Research Associates Inc., 2010; Ipsos-Reid Corporation, 2004; Les Études de Marché Créatec, 2007) assessed behaviours and feelings towards abiding by best before and expiry dates for foods. From one study, 52% felt that 'best before dates indicate when a product is freshest and foods kept past this date are still safe to consume for a while' matched closest to their understanding of best before dates (EKOS Research Associates Inc., 2010), however, from a different study, 72% agreed or strongly agreed to the statement, 'I throw food out if it is past the expiry date' (Ipsos-Reid Corporation, 2004). Quantitative results from a POR study found that 70% of respondents reported that they always checked the best before date before preparing food (EKOS Research Associates Inc., 2010). From focus group discussions, participants stated that they paid attention to

best before and expiry dates on foods (Decima Research, 2010) and that there was uncertainty in using foods past their expiry date (Les Études de Marché Créatec, 2007).

4. Discussion

A number of government agencies and other researchers have investigated Canadian consumer's food safety perceptions, knowledge and behaviours over the past 15 years, however, this is the first publication to bring all of the results together. The intent of the study was to gather all available information on Canadian consumer food safety practices. A total of 26 publications from peer-reviewed and POR studies were included. These studies employed different methods, study designs, sample sizes and study scopes creating difficulties in making comparisons and drawing robust conclusions. The limitations recognized in combining literature from different publication types is that POR studies have not undergone the same rigorous peer-review process and could potentially have biases not present in peer-reviewed literature. Therefore, results should be interpreted with some caution. However, this approach ensures that all related information has been incorporated and allows us to generate the most comprehensive baseline possible; especially given the paucity of peer-reviewed published literature on this topic. Furthermore, results from both peer-reviewed and POR studies substantially overlapped suggesting consistency in their findings regardless of publication type. Finally, the POR literature provided depth and breadth to our understanding of the findings reported in the peer-reviewed literature. Thus, the strengths outweigh the limitations and it is warranted to incorporate both peer-reviewed and POR literature.

Consumers' confidence in the safety of the Canadian food supply is relatively high in Canada. However, there was variability in confidence levels between the surveys which may in part be due to the fact that some surveys took place after the 2008 *Listeria* outbreak. In fact, in one study (Ipsos-Reid Corporation, 2010) the 2008 listeriosis crisis, and too many food recalls were cited among the main reasons for lower confidence. Consumers felt that the government is most responsible for food safety but there were variations in terms of which specific group. There is an opportunity to educate Canadians on which departments and agencies are responsible for food safety.

Measuring consumer knowledge has been used to evaluate the effectiveness of health promotion initiatives after they have been implemented (MacDonald, 1998). Results from studies evaluating food safety interventions (e.g. psychosocial and educational) on consumer food safety behaviour have shown that food safety interventions can be effective at eliciting food safety changes in terms of behaviour, knowledge and attitudes (Milton & Mullan, 2010). Therefore, understanding consumers' preferred sources of food safety information and topics of interest are important to ensure that the most effective sources and messages are used. Results from the review suggest that the internet, television, radio, or other media are preferred sources of information, and messaging could include safe food handling practices, agricultural production and processing, and food recalls and contaminations.

Many Canadians felt that food contamination occurs before food reaches their kitchen. Furthermore, of those who self-reported experiencing food-borne illness, the majority felt that it was caused by food prepared outside the home. The majority of Canadian consumers reported taking precautions in their home to keep food safe, reporting washing their hands, proper refrigeration, careful storage and preparation of food in their home. In general, there was a high level of awareness of food safety-related subjects; however, there remains some lack of awareness of the potential role food preparation in the home may have in causing food-borne illnesses. The principal causes of cross-contamination in the

domestic kitchen have been identified to include faulty food-handling techniques, poor personal hygiene, inadequate cleaning methods, and lack of facilities for the separation of raw and cooked foods (Restaino & Wind, 1990). All of these factors lead to opportunities for direct and indirect cross-contamination of foods (Jay, Govenlock, & Comar, 1999). Given that Canadians prepared and consumed most of their meals at home, continuing education emphasizing the role of the consumer in food safety and protecting themselves from food-borne illness is warranted.

Food-borne illnesses can pose a problem to all individuals but are especially important for infants, the elderly, pregnant women, and individuals with compromised immune systems (Scott & Herbold, 2010). Consumers are aware that there are specific groups that are at a higher risk for food-borne illness complications; however, individuals within these groups did not tend to recognize their own group as high-risk. Therefore, educating persons who fall within high-risk groups (and their care-givers) about their increased risk for food-borne illness is also warranted.

Data on consumption of high-risk foods can help inform interventions to address the commonly eaten high-risk foods, and help tailor food safety messaging to the demographic groups most likely to be eating them. Consumption of high-risk foods continues to be common among Canadians. Among all surveys that assessed knowledge of high-risk foods, consumers were consistently able to identify them. They were most likely to rank meats as carrying an increased risk of food-borne illness and less likely to identify unpasteurized juices and cheeses. The survey conducted in 2010 (EKOS Research Associates Inc., 2010) post the *Listeria* outbreak, found that deli meats were ranked as the most high-risk food, illustrating the potential impact an outbreak, food recall, and associated media coverage can have on public awareness of food safety concerns. A recent study (Fein, Lando, Levy, Teisl, & Noblet, 2011) supports these findings, showing that increased media attention to food safety issues can improve consumer awareness of food safety hazards and increase safe food handling practices.

Knowledge and compliance with the FightBAC® Program key principles of 'clean', 'separate', 'chill' and 'cook' varied depending on the specific practice. In general, good cleaning practices were often reported. Canadians reported washing hands regularly and considered this an important safety precaution. However, not all reported always washing hands before and after handling food and did not always use soap and water nor always wash for the recommended 20 s. Likewise, Canadians commonly reported washing fruits and vegetables before eating; however, approximately half of Canadians reported washing poultry before cooking, which is not recommended since bacteria can be easily washed off and splashed onto surrounding kitchen surfaces (USDA, 2011b). In general, Canadians reported taking precautions to keep their kitchen surfaces and utensils clean and typically reported appropriate cleaning methods, though some still reported washing with water only. Few Canadians reported regularly washing reusable grocery bags. According to a survey conducted in the U.S., few Americans (15%) also reported regularly washing reusable grocery bags (Academy of Nutrition and Dietetics, 2012). This may be of importance for prevention of cross-contamination since a peer-reviewed study on the microbial safety of reusable bags has shown that if not properly washed on a regular basis, they can play a role in the cross-contamination of foods (Williams, Gerba, Maxwell, & Sinclair, 2011).

Reported behaviours of separating raw meat and juices are in-line with recommended good practices. Using separate cutting boards and designating certain shelves in the refrigerator and grocery bags for raw meat only are consistent with the FightBAC® Program key principles and the majority of Canadians reported taking such precautions to prevent seepage of raw meat juices to other foods.

Appropriately refrigerating food, using a thermometer to know the temperature of the refrigerator and appropriate handling of leftovers and defrosting are all part of the 'chill' key principle. The majority of Canadians were aware and reported compliance with refrigerating or freezing cooked food within 2 h; however, dating food was not a common practice. This food safety practice might be helpful to ensure food is consumed within the appropriate amount of time (USDA, 2011a). An additional area for improvement would be promotion of thermometer use in the refrigerator and education on the recommended refrigerator temperature to inhibit growth of organisms. Finally, further education on proper methods of thawing frozen meat is recommended since approximately one quarter of Canadians reported thawing frozen meat at room temperature and believed that this is a safe practice.

Proper food safety practices under the key principle of 'cook' focus on cooking food to the appropriate temperature and using a food thermometer to ensure this. The majority of Canadians did not use a food thermometer when cooking and reported subjective methods such as visual cues, or time or taste to determine when food was cooked enough. These practices present a potential food safety challenge since these cues are unreliable indicators of final temperature to ensure pathogens have been killed (Lyon, Berry, Soderberg, & Clinch, 2000). Education and strategies to improve this food safety step are recommended.

There were few surveys that inquired about food labels, which may be due to the fact that they have not been a major focus in terms of food safety. However, results showed that best before dates and food labels were typically read by Canadians although not necessarily every time they purchased a food. Safe food handling labels have been shown to have limited influence on consumer practices, but were somewhat effective in discouraging cross-contamination rather than promoting thorough cooking practices (Yang, Angulo, & Altekruze, 2000). Results from the literature review showed that consumers did express some interest in labels with information related to proper cooking, preparation and storage instructions, shelf-life, warnings about possible contamination, and date of last government inspection. Therefore, food handling labels could be useful in promoting proper food handling and preparation practices, but may be one component among many other food safety education messages that target behavioural changes.

A number of gaps in research and recommendations regarding future research have been identified. The literature search revealed that there have been no studies in Canadian populations that examined actual safe food handling behaviours in the home, either by direct observation or video-recording of home behaviours. The search located 35 international publications describing observed consumer food-handling behaviour that were conducted in the United States, Europe, Australia, and New Zealand and all suggested that the rate of observed behaviours is lower than that of self-reported studies (Abbot, Byrd-Bredbenner, Schaffner, Bruhn, & Blalock, 2009; Albrecht, 1995; Anderson, Shuster, Hansen, Levy, & Volk, 2004; Azevedo et al., 2005; Breen et al., 2006; Byrd-Bredbenner, Maurer, Wheatley, Cottone, & Clancy, 2007a, 2007b; Clayton, Griffith, Peters, & Price, 2000; Clayton, Griffith, & Price, 2003; DeDonder et al., 2009; Dharod et al., 2007a, 2007b; Fischer et al., 2007; Ghebrehewet & Stevenson, 2003; Godwin, Chen, & Coppings, 2006; Gorman, Bloomfield, & Adley, 2002; Griffith, Worsfold, & Mitchell, 1998; James & Evans, 1992; Jay et al., 1999; Johnson et al., 1998; Kendall et al., 2004; Kennedy et al., 2005; Kilonzo-Nthenge, Chen, & Godwin, 2008; Marklinder, Lindblad, Eriksson, Finnson, & Lindqvist, 2004; McCurdy, Hillers, & Cann, 2005; O'Brien, 1997; Phang, 2010; Redmond & Griffith, 2004, 2006; Redmond, Griffith, & Peters, 2000a, 2000b; Scott & Herbold, 2010; Worsfold, 1994; Worsfold & Griffith, 1995, 1997). Research methods that rely on self-reported data can be biased towards people

reporting responses considered to be socially acceptable or desirable (respondents reporting what they believe to be correct or what they believe the interviewer would like to hear) (Redmond & Griffith, 2003). Observational studies in Canada on consumer food safety practices would add to the current body of knowledge on consumer food safety behaviours and would also allow validation of the results of surveys assessing self-reported behaviours.

There are differences in the results between studies, which may in part be due to variations in study designs, study populations (age, sex, location, and socio-economic status), survey questions and definitions of correct behaviour. Few studies used consistent wording thus hampering comparability between studies. In order to facilitate comparison between studies and to determine changing trends over time, it is necessary to establish a set of standard survey questions. Facilitating comparison between surveys has the potential to enhance the understanding of changes that food safety education campaigns and messaging are having on consumer knowledge and behaviours.

Future work to investigate difference among cultural and socio-demographic groups could help to inform more targeted interventions. Also, ensuring national representation would be necessary to have a complete picture of food safety behaviours among Canadians.

5. Conclusions

In conclusion, there is a breadth of research investigating consumer food safety practices in Canada. Despite variations in study designs, methods, scope and publication types among the studies, a summary of all the knowledge to date has provided insight into common perceptions, knowledge and behaviours of Canadian consumers. Overall, there is good general awareness of food safety among Canadian consumers indicating that there remain areas that need improvements and further education. Food safety education campaigns should raise knowledge of high-risk foods and educate persons who fall within high-risk groups about their increased risk for food-borne illness. The internet and social media appear to be the best method to reach audiences for food safety education. Consumers possessed a significant amount of confidence in the safety of the Canadian food supply and generally held the government most responsible for ensuring safety. Consumers' understanding of their role and importance in the safety of foods prepared at home should therefore be reiterated and emphasized in food safety messaging. A limitation of the study methodologies is that all studies relied on self-reported behaviours, a method known to be subject to reporting bias, therefore implementing observational studies would allow for validation of these results and a more accurate representation of consumer behaviour. Finally, future studies should develop questions and methods based on these surveys in order to benefit from this existing baseline knowledge and to allow comparisons over time to assess the effectiveness of food safety interventions on the reduction of food-borne illness. Together with government, industry and academia, critical review of questions and recommendations for standardized wording would support higher quality and more meaningful results from such research.

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References

- Abbot, J. M., Byrd-Bredbenner, C., Schaffner, D., Bruhn, C. M., & Blalock, L. (2009). Comparison of food safety cognitions and self-reported food-handling behaviors with observed food safety behaviors of young adults. *European Journal of Clinical Nutrition*, 63(4), 572–579.
- Academy of Nutrition and Dietetics. (April 2012). *Survey: Less than 1 in 6 Americans frequently washes grocery totes increasing risk for food poisoning*. <http://www.eatright.org/MEDIA/content.aspx?id=6442468957> Accessed 13.08.12.
- Adak, G. K., Long, S. M., & O'Brian, S. J. (2000). Trends in indigenous foodborne disease ad deaths, England and Wales: 1992 to 2000. *Gut*, 51, 832–841.
- Albrecht, J. A. (1995). Food safety knowledge and practices of consumers in the USA. *Journal of Consumer Studies & Home Economics*, 19, 119–134.
- Anderson, J. B., Shuster, T. A., Hansen, K. E., Levy, A. S., & Volk, A. (2004). A camera's view of consumer food-handling behaviors. *Journal of the American Dietetic Association*, 104(2), 186–191.
- Azevedo, I., Regalo, M., Mena, C., Almeida, G., Carneiro, L., Teixeira, P., et al. (2005). Incidence of *Listeria* spp. in domestic refrigerators in Portugal. *Food Control*, 16(2), 121–124.
- Breen, A., Brock, S., Crawford, K., Docherty, M., Drummond, G., Gill, L., et al. (2006). The refrigerator safari – an educational tool for undergraduate students learning about the microbiological safety of food. *British Food Journal*, 108(6), 487–494.
- Byrd-Bredbenner, C., Maurer, J., Wheatley, V., Cottone, E., & Clancy, M. (2007a). Observed food safety behaviours of young adults. *British Food Journal*, 109(7), 519–530.
- Byrd-Bredbenner, C., Maurer, J., Wheatley, V., Cottone, E., & Clancy, M. (2007b). Food safety hazards lurk in the kitchens of young adults. *Journal of Food Protection*, 70(4), 991–996.
- Canadian Partnership for Consumer Food Safety Education. (2011). *FightBact!*. <http://www.canfightbac.org/cpcfse/en/> Accessed 12.03.11.
- Clayton, D. A., Griffith, C. J., Peters, A. C., & Price, P. (2000). Attitudes, knowledge and food safety practices of UK consumers. In *Proceedings of the second NSF international conference on food safety: Preventing foodborne illness through science and education, 11 to 13 October 2000* (pp. 321–328). Savannah, Georgia, USA.
- Clayton, D. A., Griffith, C. J., & Price, P. (2003). An investigation of the factors underlying consumers' implementation of specific food safety practices. *British Food Journal*, 105(7), 434–453.
- COMPAS Inc. (29 April, 2004). *Food for thought: Canada's only syndicated study of attitudes and behaviour related to food health and safety*.
- COMPAS Inc. (2003). *Food for thought* (Vol. 1). No. 2 (Winter 2003).
- Decima Research. (2010). *Food safety: Canadians' awareness attitudes, and behaviours*. http://epe.lac-bac.gc.ca/003/008/099/003008-disclaimer.html?orig=100/200/301/pwgs-c-tpsgc/por-ef/canadian_food_inspection_agency/2010/088-09/report.pdf Accessed 29.09.11.
- DeDonder, S., Jacob, C. J., Surgeoner, B. V., Chapman, B., Phebus, R., & Powell, D. A. (2009). Self-reported and observed behavior of primary meal preparers and adolescents during preparation of frozen, uncooked, breaded chicken products. *British Food Journal*, 111(9), 915–929.
- Dharod, J. M., Perez-Escamilla, R., Paciello, S., Venkitanarayanan, K., Bermudez-Millan, A., & Damio, G. (2007a). Critical control points for home prepared 'Chicken and Salad' in Puerto Rican households. *Food Protection Trends*, 27(7), 544–552.
- Dharod, J. M., Perez-Escamilla, R., Paciello, S., Bermudez-Millan, A., Venkitanarayanan, K., & Damio, G. (2007b). Comparison between self-reported and observed food handling behaviors among Latinas. *Journal of Food Protection*, 70(8), 1927–1932.
- EKOS Research Associates Inc. (2010). *Survey of Canadians' knowledge & behaviour related to food safety*. HT372-090013/001/CY.
- EKOS Research Associates Inc. (2005). *Wave 8: Rising cosmopolitan outlook and resurgent privacy concerns in a risky world – Part of the security monitor 2004 study*.
- EnviroNics Research Group. (1998). *Safe food handling study*. PN 4242.
- Fein, S. B., Lando, A. M., Levy, A. S., Teisl, M. F., & Noblet, C. (2011). Trends in U.S. consumers' safe handling and consumption of food and their risk perceptions, 1988 through 2010. *Journal of Food Protection*, 74(9), 1513–1523.
- Fischer, A. R., De Jong, A. E., Van Asselt, E. D., De Jonge, R., Frewer, L. J., & Nauta, M. J. (2007). Food safety in the domestic environment: an interdisciplinary investigation of microbial hazards during food preparation. *Risk Analysis*, 27(4), 1065–1082.
- Fraser Health & Vancouver Coastal Health. (2010). *Food safety practices: Findings from a Fraser Health (FH) and Vancouver Coastal Health (VCH) Survey*. <http://www.fraserhealth.ca/media/Food%20Safety%20Practices.pdf> Accessed 14.03.11.
- Gebrehewet, S., & Stevenson, L. (2003). Effectiveness of home-based food storage training: a community development approach. *International Journal of Environmental Health Research*, 13(Suppl. 1), S169–S174.
- Godwin, S. L., Chen, F. C., & Coppings, R. J. (2006). Correlation of visual perceptions of cleanliness and reported cleaning practices with measures of microbial contamination in home refrigerators. *Food Protection Trends*, 26(7), 474–480.
- Gorman, R., Bloomfield, S., & Adley, C. C. (2002). A study of cross-contamination of food-borne pathogens in the domestic kitchen in the Republic of Ireland. *International Journal of Food Microbiology*, 76(1–2), 143–150.
- Government of Canada. (October 2007). *Public opinion research reports*. <http://amicus.collectionscanada.ca/porr-rrp-bin/Main/BasicSearch?coll=28&l=0&v=1> Accessed 03.12.11.
- Government of Canada. (January 2009). *What is public opinion research?*. <http://www.porr-rrp.gc.ca/009007-400-e.html> Accessed 03.12.11.
- Griffith, C., Worsfold, D., & Mitchell, R. (1998). Food preparation, risk communication and the consumer. *Food Control*, 9(4), 225–232.
- Hoogenboom-Verdegaal, A. M., de Jong, J. C., During, M., Hoogenveen, R., & Hoekstra, J. A. (1994). Community-based study of the incidence of gastrointestinal diseases in The Netherlands. *Epidemiology and Infection*, 112, 481–487.
- IBM Business Consulting Services. (2003). *Health insider: An in-depth research report on consumer health issues*. Survey no.10 Fall/Winter 2003.
- Ipsos-Reid Corporation. (June, 2001). *Public views on matters relating to health protection*.
- Ipsos-Reid Corporation. (8 July, 2002). *New thoughts for food: Consumer component*.
- Ipsos-Reid Corporation. (2004). *Consumer perceptions of food safety and quality*. http://epe.lac-bac.gc.ca/100/200/301/pwgs-c-tpsgc/por-ef/agriculture_agri-food/2003/2003-1729-e.doc Accessed 30.09.11.
- Ipsos-Reid Corporation. (2007a). *Canadians' views and needs relative to consumer product safety survey*. <http://epe.lac-bac.gc.ca/100/200/301/pwgs-c-tpsgc/por-ef/health/2007/301-06/report.pdf> Accessed 29.09.11.
- Ipsos-Reid Corporation. (2007b). *Consumer perception survey – Food recalls and allergy alerts*. http://epe.lac-bac.gc.ca/100/200/301/pwgs-c-tpsgc/por-ef/canadian_food_inspection_agency/2007/307-06/report.doc Accessed 29.09.11.
- Ipsos-Reid Corporation. (2007c). *Health Canada performance survey*. <http://epe.lac-bac.gc.ca/100/200/301/pwgs-c-tpsgc/por-ef/health/2007/372-06-e/report.pdf> Accessed 30.09.11.
- Ipsos-Reid Corporation. (2010). *Consumer perceptions of food safety and quality – Wave 3 tracking 2010*. http://epe.lac-bac.gc.ca/100/200/301/pwgs-c-tpsgc/por-ef/agriculture_agri-food/2010/110-09/report.pdf Accessed 29.09.11.
- Jacob, C., Mathiasen, L., & Powell, D. (2010). Designing effective messages for microbial food safety hazards. *Food Control*, 21, 1–6.
- James, S. J., & Evans, J. (1992). Consumer handling of chilled foods – temperature performance. *International Journal of Refrigeration*, 15(5), 299–306.
- Jay, L. S., Govenlock, L. D., & Comar, D. (1999). A video study of Australian domestic food-handling practices. *Journal of Food Protection*, 62(11), 1285.
- Johnson, A. E., Donkin, A. J., Morgan, K., Lilley, J. M., Neale, R. J., Page, R. M., et al. (1998). Food safety knowledge and practice among elderly people living at home. *Journal of Epidemiology and Community Health*, 52(11), 745–748.
- Kaferstein, F. (2003). Actions to reverse the upward curve of foodborne illness. *Food Control*, 14(2), 101–109.
- Kendall, P. A., Elsbernd, A., Sinclair, K., Schroeder, M., Chen, G., Bergmann, V., et al. (2004). Observation versus self-report: validation of a consumer food behavior questionnaire. *Journal of Food Protection*, 67(11), 2578–2586.
- Kennedy, J., Cowan, C., Bolton, D. J., McDowell, D. A., Jackson, V., & Blair, I. S. (2005). Food safety knowledge of consumers and the microbiological and temperature status of their refrigerators. *Journal of Food Protection*, 68(7), 1421.
- Kilonzo-Nthenge, A., Chen, F. C., & Godwin, S. L. (2008). Occurrence of *Listeria* and Enterobacteriaceae in domestic refrigerators. *Journal of Food Protection*, 71(3), 608–612.
- Lee, M. B., & Middleton, D. (2003). Enteric illness in Ontario, Canada, from 1997 to 2001. *Journal of Food Protection*, 66, 953–961.
- Léger Marketing. (2011). *Food safety: Canadians' awareness, attitudes and behaviours*. http://epe.lac-bac.gc.ca/100/200/301/pwgs-c-tpsgc/por-ef/canadian_food_inspection_agency/2011/048-10/report.pdf Accessed 29.09.11.
- Les Études de Marché Créatec. (2007). *Canadians' perceptions of the safety of Canada's food supply*. http://epe.lac-bac.gc.ca/100/200/301/pwgs-c-tpsgc/por-ef/canadian_food_inspection_agency/2007/226-07/report.pdf Accessed 29.09.11.
- Lyon, B. G., Berry, B. W., Soderberg, D., & Clinch, N. (2000). Visual color and doneness indicators and the incidence of premature brown color in beef patties cooked to four end point temperatures. *Journal of Food Protection*, 63(10), 1389–1398.
- MacDonald, T. H. (1998). *Rethinking health promotion: A global approach* (1st ed.). London: Routledge.
- Majowicz, S. E., McNab, W. B., Sockett, P., Henson, T. S., Dore, K., Edge, V. L., et al. (2006). Burden and cost of gastroenteritis in a Canadian Community. *Journal of Food Protection*, 69, 651–659.
- Marklinder, I. M., Lindblad, M., Eriksson, L. M., Finnson, A. M., & Lindqvist, R. (2004). Home storage temperatures and consumer handling of refrigerated foods in Sweden. *Journal of Food Protection*, 67(11), 2570–2577.
- McCurdy, S. M., Hillers, V., & Cann, S. E. (2005). Consumer reaction and interest in using food thermometers when cooking small or thin meat items. *Food Protection Trends*, 25(11), 826–831.
- Mead, P. S., Slutsker, L., Dietz, V., McCaig, L. F., Bresee, J. S., Shapiro, C., et al. (1999). Food-related illness and death in the United States. *Emerging Infectious Diseases*, 5(5), 607–625.
- Medeiros, L., Hillers, V., Kendall, P., & Mason, A. (2001). Evaluation of food safety education for consumers. *Journal of Nutrition Education*, 33(Suppl. 1), S27–S34.
- Milton, A., & Mullan, B. (2010). Consumer food safety education for the domestic environment: a systematic review. *British Food Journal*, 112(8–9), 1003–1022.
- Nesbitt, A. (2007). *Food consumption patterns, home food safety practices and gastrointestinal health in a Canadian community*. University of Guelph. Master thesis.
- Nesbitt, A., Majowicz, S., Finley, R., Marshall, B., Pollari, F., Sargeant, J., et al. (2009). High-risk food consumption and food safety practices in a Canadian community. *Journal of Food Protection*, 72(12), 2575–2586.
- Nesbitt, A., Majowicz, S., Finley, R., Pollari, F., Pintar, K., Marshall, B., et al. (2008). Food consumption patterns in the Waterloo Region, Ontario, Canada: a cross-sectional telephone survey. *BMC Public Health*, 8, 370.

- O'Brien, G. D. (1997). Domestic refrigerator air temperatures and the public's awareness of refrigerator use. *International Journal of Environmental Health Research*, 7(2), 141–148.
- Patterson, Langlois. Consultants. (2007). *Qualitative research on creatives for the CFIA's food safety and food recall campaigns*. http://epe.lac-bac.gc.ca/100/200/301/pwgsc-tpsgc/por-ef/canadian_food_inspection_agency/2007/200-07/report.pdf Accessed 29.09.11.
- Phang, H. (2010). *Consumer handling of hamburgers*. Davis: University of California. Master thesis.
- Phoenix Strategic Perspectives Inc. (2006). *Qualitative testing of educational statements for unpasteurized juice/cider products*. <http://epe.lac-bac.gc.ca/100/200/301/pwgsc-tpsgc/por-ef/health/2006/206-06/report.pdf> Accessed 04.12.11.
- Public Works and Government Services Canada. *Public opinion research reports on-line*. <http://www.tpsgc-pwgsc.gc.ca/rop-por/rappports-reports-eng.html>. Accessed 04.12.11.
- Redmond, E. C., & Griffith, C. J. (2006). A pilot study to evaluate the effectiveness of a social marketing-based consumer food safety initiative using observation. *British Food Journal*, 108(9), 753–770.
- Redmond, E. C., & Griffith, C. J. (2004). Consumer attitudes and perceptions towards microbial food safety in the domestic kitchen. *Journal of Food Safety*, 24(3), 169–194.
- Redmond, E. C., & Griffith, C. J. (2003). Consumer food handling in the home: a review of food safety studies. *Journal of Food Protection*, 66(1), 130–161.
- Redmond, E. C., Griffith, C. J., & Peters, A. C. (2000a). Risk based observational assessment of consumer food safety behavior and implications for food safety education. In *Proceedings of the second NSF international conference on food safety: Preventing foodborne illness through science and education, 11 to 13 October 2000* (pp. 113–119).
- Redmond, E. C., Griffith, C. J., & Peters, A. C. (2000b). Use of social marketing in the prevention of specific cross contamination actions in the domestic environment. In *Proceedings of the second NSF international conference on food safety: Preventing foodborne illness through science and education, 11 to 13 October 2000* (pp. 305–314).
- Restaino, L., & Wind, C. E. (1990). Antimicrobial effectiveness of hand washing for food establishments. *Dairy, Food, and Environmental Sanitation*, 10(3), 136–141.
- Scott, E., & Herbold, N. (2010). An in-home video study and questionnaire survey of food preparation, kitchen sanitation, and hand washing practices. *Journal of Environmental Health*, 72(10), 8–13.
- Serecon Management Consulting Inc. (10 May, 2004). *2004 National consumer food safety survey*.
- Simon Fraser University. (2011). *What is a scholarly journal?*. <http://www.lib.sfu.ca/help/publication-types/scholarly-journals> Accessed 03.12.11.
- The Strategic Counsel. (2009). *Food safety and food labelling: Canadians' awareness, attitudes and views*. http://epe.lac-bac.gc.ca/100/200/301/pwgsc-tpsgc/por-ef/canadian_food_inspection_agency/2009/097-08/report.pdf Accessed 29.09.11.
- The Strategic Counsel. (2007). *Health and wellness priorities: Findings from qualitative research*. <http://epe.lac-bac.gc.ca/100/200/301/pwgsc-tpsgc/por-ef/health/2007/124-07/report.pdf> Accessed 29.09.11.
- Thomas, M. K., Majowicz, S., Pollari, F., & Sockett, P. (2008). Burden of acute gastrointestinal illness in Canada, 1999–2007: interim summary of NSAGI activities. *Canadian Communicable Disease Report*, 34(5), 8–15.
- Thomas, M. K., Murray, R., Flockhart, L., Pintar, K., Pollari, F., Fazil, A., et al. (2013). Estimates of the burden of foodborne illness in Canada for 30 specified pathogens and unspecified agents, circa 2006. *Foodborne Pathogens and Disease*, 10(7), 639–648.
- USDA. (2011a). *Food labeling – Food product dating*. United States Department of Agriculture, Food Safety and Inspection Service. http://www.fsis.usda.gov/Factsheets/Food_Product_dating/#11 Accessed 18.06.12.
- USDA. (2011b). *Safe food handling – Washing food: Does it promote food safety?* United States Department of Agriculture, Food Safety and Inspection Service. http://www.fsis.usda.gov/Factsheets/Does_Washing_Food_Promote_Food_Safety/index.asp Accessed 18.06.12.
- Williams, D. L., Gerba, C. P., Maxwell, S., & Sinclair, R. G. (2011). Assessment of the potential for cross-contamination of food products by reusable shopping bags. *Food Protection Trends*, 31(8), 508–513.
- Worsfold, D., & Griffith, C. (1995). A generic model for evaluating consumer food safety behaviour. *Food Control*, 6(6), 357–363.
- Worsfold, D., & Griffith, C. J. (1997). Assessment of the standard of consumer food safety behavior. *Journal of Food Protection*, 60(4), 399–406.
- Worsfold, D. (1994). *An evaluation of domestic food hygiene and food preparation practices*. Open University United Kingdom. PhD thesis.
- Wyne, M. (2001). *Consumer knowledge and practice pertaining to safe food-handling in households*. University of British Columbia. Master thesis.
- Yang, S., Angulo, F. J., & Altekruse, S. F. (2000). Evaluation of safe food-handling instructions on raw meat and poultry products. *Journal of Food Protection*, 63(10), 1321–1325.