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# Using Risk Factor Weighting to Target and Create Effective Public Health Policy for Campylobacteriosis Prevention in Ontario, Canada

**Andrew Papadopoulos*, Emily Vellekoop, Mai Pham, Ian Young, Nicole Britten**

Department of Population Medicine, University of Guelph, Guelph, Canada
*Corresponding author: apapadop@uoguelph.ca

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**Abstract** Campylobacter is one of the major causes of foodborne illness globally, making prevention of Campylobacter infections a significant public health concern. Factors such as under-reporting and the low dose required to cause illness make surveillance and control of food-acquired campylobacteriosis challenging. A literature review was conducted to identify articles that included relevant information about the causes of foodborne illness, transmission of Campylobacter, specific risk factors associated with food-acquired Campylobacter infection and reported numbers of cases of Campylobacter. The majority of studies determine that specific demographic groups are at a higher risk for contracting foodborne illness, with age, gender, and location being the most significant factors. Food-acquired campylobacteriosis accounts for up to 74 to 85% of total cases, with poultry being the number one contributing vehicle. Location of food-acquired Campylobacter infection differs between countries. In Ontario, the majority of food-acquired campylobacteriosis cases are attributed to food prepared in the home. A risk factor diagram shows the source of Campylobacter organisms and the locations where people are exposed. It then shows causes of food-acquired Campylobacter infection, dividing them into human and non-human factors. Human factors are the major contributing causes of Campylobacter infection in people. Targeted policies should be developed which target these factors and address the specific groups that are at a higher risk for foodborne illness. Policy initiatives that focus on consumer level human factors will have the greatest impact on campylobacteriosis prevention. Further research needs to be conducted to determine the proportion of foodborne illness which can be attributed to specific risk factors and why consumers and food handlers do not follow proper procedures for minimizing exposure to Campylobacter organisms. Targeted policies can provide a more cost-effective way to help prevent further cases of Campylobacter infection as well as improve disease surveillance.

***Keywords:*** *Campylobacter infection, foodborne illness, targeted policy, campylobacteriosis, prevention, risk factor weighting, public health policy*

## 1. Introduction

*Campylobacter* is one of the major causes of foodborne illness world-wide and is considered to be the causative agent of 5 to 15% of the global incidence of diarrheal diseases [1,2,3,4]. Usual symptoms of campylobacteriosis include diarrhea, malaise, fever, and abdominal pain; however, serious sequelae can include reactive arthritis, inflammatory bowel disease, and Guillain-Barré syndrome [1,5,6,7]. The economic costs of campylobacteriosis in HALYs (health adjusted life-years) are determined to be approximately 146 HALY/year in Ontario [8]. There is a conservative estimated total prevalence of 88 566 cases of campylobacteriosis in Ontario per year and *Campylobacter* is the leading cause of foodborne illness in Canada making prevention of *Campylobacter* infections a significant public health concern [6,8,9].

*Campylobacter* infection has an incubation period between one and eleven days, averaging three days before the onset of symptoms [5]. Infections are usually self-limiting and persist for about one week [5]. As a result, under-reporting of *Campylobacter* infection occurs frequently with an estimated minimum rate of 23 cases per one reported case [10].A very low dose of *Campylobacter* organisms are required to cause infection in humans making surveillance systems designed to monitor the number of contracted *Campylobacter* infections difficult to implement. [5]. A better understanding of the causes and risk factors associated with food-acquired *Campylobacter* infection will allow for the development and implementation of targeted public health initiatives. Targeted policies can provide a more cost-effective way to help prevent further cases of *Campylobacter* infection as well as improve disease surveillance.

A risk factor diagram is a tool that can be used to weight the importance of various factors involved in a specific event. The sequence of factors and the number of intervening variables can help show the temporal sequence of cause and effect relationships within a transmissible disease [11]. A risk factor diagram is also a valuable tool in assessing areas where further research and data collection need to occur. In this case, a sequential risk factor diagram can illustrate the importance of factors

contributing to human campylobacteriosis, and identify specific areas for further investigation.

This article will identify the causes and risk factors of food-acquired *Campylobacter* infection, and present them as a risk factor diagram to graphically portray the relationships and importance of each variable. This visual representation will allow for the isolation of areas where targeted public policy initiatives can help prevent the spread of food-acquired campylobacteriosis.

## 2. Materials and Methods

A literature review was completed in July 2011, with a follow-up search conducted in August 2011 to ensure completeness. Databases searched include PubMed (MEDLINE), Agricola, bioOne, Scholar's Portal, CIHI and CBCA. See Table 1 for key words used in search query.

**Table 1. Key words used in search query**

| | | | |
|---|---|---|---|
| foodborne | food related | food associated | contaminated food |
| Disease | illness | sickness | |
| Bacteria | *Campylobacter* | *Campylobacter jejuni* | *Campylobacter coli* |
| Factor | risk factor | causes | |
| Canada | Ontario | | |
| Comparison | investigation | | |

Terms within rows were combined with "OR" and terms from all the rows were combined with "AND". Various combinations of search terms were used to narrow and broaden search results. Further articles were located by manually reviewing the reference lists of relevant articles. Articles citing other relevant studies are included in our bibliography. A few relevant reference books were also included.

All papers identified by the search were initially screened for relevance using the title and/or abstract. Literature was restricted to only those written in the English-language. Abstracts were then reviewed by a member of the research team and were included in the study if the abstract contained information about the cause(s) of foodborne-related *Campylobacter* infection, specific risk factors associated with foodborne-related *Campylobacter* infection, and the reported numbers of cases of *Campylobacter* infection in a particular jurisdiction. Any epidemiological studies relating to *Campylobacter* infection or general foodborne illness in Canada were also included.

The literature search was confined to countries with similar food regulatory and socioeconomic status to Canada such as the United States, the United Kingdom and Europe, Australia, and New Zealand. Other exclusion criteria included any articles published before 1991 (20 years), articles discussing non-food related *Campylobacter* infection, and articles that described the physiological characteristics of the *Campylobacter* micro-organism.

## 3. Results

There are several species of *Campylobacter* which cause diarrheal disease in humans but the most prevalent in foodborne illness are *Campylobacter jejuni* and *Campylobacter coli* [4]. In Canada, *C. jejuni* is about six times more prevalent than *C. coli* and it is responsible for 85% of human campylobacteriosis cases [2,12]. This finding is similar to a Danish study showing that *C. jejuni* is responsible for 89% of human infections and *C. coli* for 10% [5]. Other *Campylobacter* species contribute to approximately 1% of human cases [5]. The studies cited in this article refer to infections caused by all *Campylobacter* species.

Specific demographic groups are at higher risk for contracting a foodborne illness. A study based in England and Wales indicates that age, gender, ethnicity, and socioeconomic class are all significant demographic determinants for contracting a foodborne illness; however, most studies determine the significant demographic factors to be age, gender, and location. [1,8,13,14,15]. Most studies indicate a higher percentage of foodborne illness in males than females; however, a report by the Ontario Burden of Infectious Disease Advisory Group states that there is an equal distribution of *Campylobacter* infections between males and females [6,8,16,17]. A Canadian study indicates that individuals in a rural setting living in close proximity to high density farming are more likely to contract foodborne illness, specifically *Campylobacter* [18]. As with most foodborne illnesses, age distribution for *Campylobacter* follows a bimodal distribution [17,19]. The Public Health Agency of Canada reports that infants and young children are the most at risk, followed by young adults [2]. Australian, US, and Finish data confirm these age groups, specifically children from ages zero to four, and adults ages 20 through 29 [6,13,17,19,20].

The *Campylobacter* organism enters the food chain through its presence in several reservoirs including manure pits filled with animal fecal matter on farms, on contaminated equipment and in water tanks within slaughter plants, and in drinking water supplies [9,21]. Studies are available which show variables influencing infection of live birds with *Campylobacter* species and Hazard Analysis Critical Control Points (HACCP) studies of the slaughter process show specific areas where contamination occurs [5,9,12,21,22,23]. However, complete elimination of *Campylobacter* from food items cannot be accomplished and therefore the presence of *Campylobacter* in the human food supply will always be a serious public health concern.

Vehicles which contribute to *Campylobacter* infection include contact or consumption of contaminated meat (usually poultry and in particular poultry purchased raw), consumption of raw milk, consumption of contaminated drinking water, transmission from other animal species including young dogs and cats, and travel to locations where *Campylobacter* infection is highly prevalent such as farms and other rural locations both inside and outside of Canada [1,10,24,25,26]. The most significant source of human infection with *Campylobacter* spp is contaminated food items [27]. Food-acquired campylobacteriosis makes up to 74 to 85% of total disease cases [10,12,28,29]. Other factors collectively represent approximately 20 to 30% of campylobacteriosis cases [5,22,25,26,30]. Poultry, especially when purchased and handled raw or served undercooked is the main contributing food item and is responsible for about 35 – 40% of food-acquired *Campylobacter* infections, making it the number one contributing vehicle [5,22,25,26,29,31,32]. In Ontario, meat items (including poultry) and foods of animal origin

are responsible for approximately 65% of all food-acquired illness [10,33].

Data showing the location where the highest risk of food-acquired *Campylobacter* infection occurs differ depending on the country where the data was collected. Some international studies show commercial food establishments have a higher risk. A study from the United States determined that poultry served in restaurants had the highest attributable fraction of cases and an Australian study determined that 55% of cases result from food served in a commercial establishment [24,29]. However, in Ontario, the majority of food-acquired illness occurs in private homes, with approximately 50% of food-acquired illness attributed to food prepared in the home [5,10]. Dutch and UK studies also show that the home is a high risk setting for acquiring foodborne illness [33,34].

A US study breaks the causes of food-acquired illness into two categories: human and non-human factors [35]. Non-human factors or environmental factors are the result of the facilities used and are generally more of a concern in commercial food establishments. However, even in commercial settings, human factors contribute to the majority (63%) of food-safety violations [35]. In a private home setting, the only alterable explanatory variables of foodborne campylobacteriosis are human factors. The causes of campylobacteriosis are the same as most foodborne infectious agents, time-temperature abuse (maintaining food at a temperature that allows bacterial growth for a sufficient length of time), cross-contamination (transferring pathogenic organisms from surfaces, fomites, or other food) and poor hygiene practices [36]. Improper consumer hygiene practices can account for 40 to 60% of foodborne illness acquired in a home setting [34]. In a Dutch study, 4 to 43% of consumers reported improperly cleaning cutting boards, 7 to 74% reported not washing hands properly, and 3 to 48% reported improperly cleaning cutlery [34]. However, a follow-up observational study found much higher proportions of improper cleaning with values of 91%, 100%, and 61% respectively [34]. There is no direct quantitative data showing which of these general causes contributes the most to *Campylobacter* infection; however, cross-contamination is usually cited as the largest cause [5,25,34]. An estimate can be made based on a US study focusing on food safety violations in restaurants in the Las Vegas area, which indicated that 35% of violations are due to cross-contamination compared to 18% for time-temperature abuse, and 10% due to personal hygiene [35]. Please refer to Figure 1 for a graphical representation of the results.

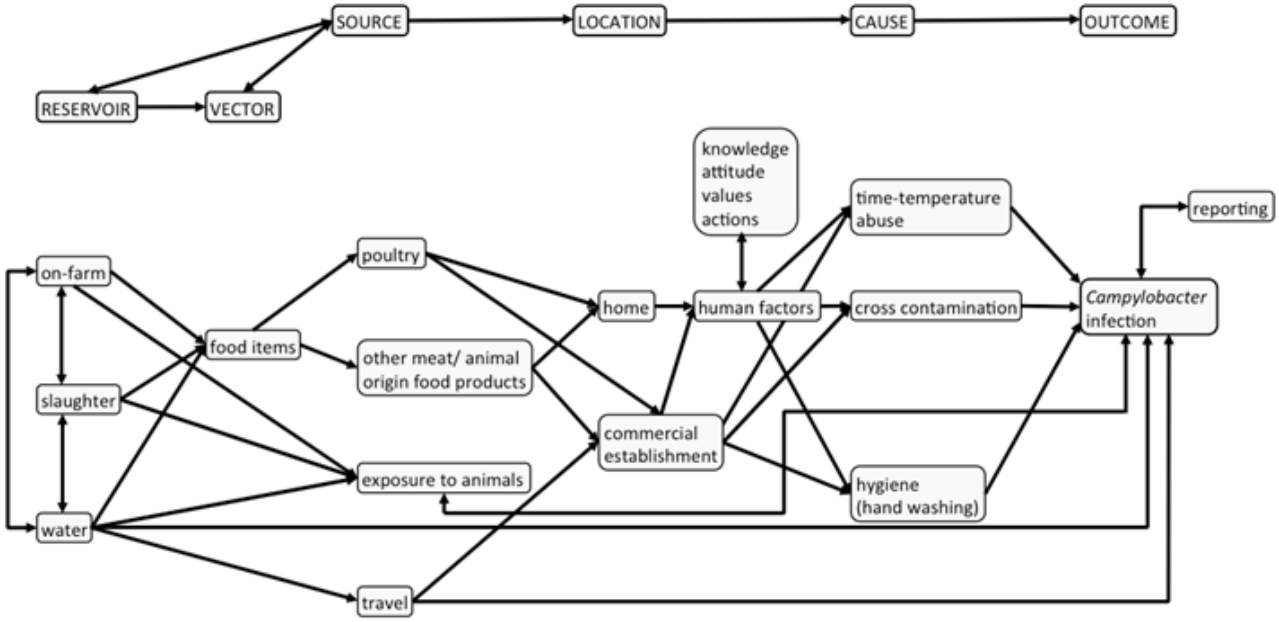


**Figure 1.** *Campylobacter* Risk Factor Diagram

This risk factor diagram shows the source of *Campylobacter* organisms and the locations where people are exposed. It then shows causes of food-acquired *Campylobacter* infection, dividing them into human and non-human factors. Human factors are the major contributing causes of *Campylobacter* infection in people.

## 4. Discussion

*Campylobacter* infections are a serious and expensive public health concern. The causes of *Campylobacter* infection are complex and often interrelated. Most foodborne *Campylobacter* infections are associated with poultry, in particular chicken. Although research has been conducted and policies and protocols are in place to reduce foodborne *Campylobacter* at the slaughter and farm levels, very little quantitative data on the infection and transmission of *Campylobacter* to humans from food sources is available. This data would be beneficial to any public health agency attempting to produce an effective policy aimed at reducing the number of human *Campylobacter* infections occurring in Ontario. An efficient public policy aimed at reducing the spread of foodborne *Campylobacter* could eliminate up to 80% of human *Campylobacter* infections [10,12,28,29].

As illustrated in the risk factor diagram for *Campylobacter* infections in Ontario, time-temperature abuse, cross-contamination, and personal hygiene (such as hand washing), defined as human factors, contribute significantly to risk of infection. Environmental factors (facility, level of contamination of raw food sources) do

not contribute as much as human factors to human cases of campylobacteriosis. This illustrates that policy initiatives with the greatest impact will focus on consumer level human factors.

Organisms that cause foodborne illness, such as *Campylobacter* are ubiquitous in the environment and can be introduced into the food supply at all stages of the farm-to-fork continuum [37]. All stakeholders in the food chain, including the food industry, governments and consumers, have a role to play in ensuring the safety of the food we eat. Consumers are the final line of defense against foodborne illness; what they do, or fail to do, can have major implications for the food safety at the point of consumption regardless of how well the other players in the food chain perform their roles [37,38].

While outbreaks of foodborne illness are often associated with food consumed at restaurants and public eating establishments (*e.g.*, cafeterias, delicatessens and hotels) [39,40], sporadic cases of foodborne illness have been shown to be more frequently associated with food consumed at home [10]. In a study analyzing sporadic cases of enteric illness reported in Ontario from 1997 to 2001, approximately 50% of cases were linked to a home setting [10]. Consumers tend to expect the foods they purchase to be safe and they believe that there is a low risk of becoming ill after preparing and consuming food in their home [39,41,42]. A survey of food safety behaviours among Canadians in Waterloo, Ontario, during 2005-2006 found that the prevalence of some high-risk food safety practices was very high (e.g. consuming undercooked eggs), and the authors suggested a need for additional food safety education for consumers [43].

Educational interventions and programs targeted toward consumers are necessary to increase their knowledge and awareness about food safety, to change their food handling and preparation behaviours, and ultimately, to decrease the incidence of foodborne illness in Canada [39].

People who prepare food for themselves and others do not do so with the intent to harm or cause illness; however, food continues to be a vehicle for many bacterial, viral, and fungal infections. There is a gap in understanding between food preparation actions and resulting foodborne illness [39]. Successful programs and policies must address the knowledge gap surrounding causes of foodborne illness and actions consumers can take to keep themselves and others safe.

In Canada, food safety is a shared responsibility between the federal, provincial, territorial, and municipal levels of government [44]. The federal government has the principal responsibility for setting food safety standards and policies, ensuring industry compliance with food safety regulations, initiating food recalls, and developing national strategies for managing food safety risks [37,38,44]. Each provincial and territorial government has a public health mandate that includes food safety surveillance, investigations, and compliance inspections [44].Within each province, it is the regional health authorities or local public health units that deliver these public health programs and services to the community within their geographic borders. This level of public health agency has been delivering food handler training to food establishments, but have largely neglected consumers. Targeted consumer education can have a profound effect on the prevalence of foodborne illness. However, it is critical to ensure the education programs are targeted with the consumer in mind and that the programs are tailored to the consumers segment's needs and preferences.

Policies must be developed which address the specific demographic groups associated with a higher risk for contracting a foodborne infection. Foodborne illness is highest in both females and males of 20 to 29 years, which an Australian study attributes to more travel in this age group [19]. The "second weaning effect" describes the high incidence of foodborne illness in males between the ages of 20 to 29. Generally, this is the age when males first start to prepare food for consumption; a possible lack of experience and knowledge relating to food handling allows for a higher risk of contamination and consumption of contaminated food items. Young children and infants under 4 years of age also have an increased risk of contracting a foodborne illness. This may be due to an increased symptom reporting on the part of care-givers however, there is also evidence of improper handling of bottles [14,19]. Policies must be accurately targeted at these specific demographic groups in order to make the greatest impact. It would be redundant and a poor utilization of resources to address the general population as some demographic groups already display adequate food handling behaviour.

Although cross-contamination can occur in restaurants and eating establishments, a significant amount of foodborne illness is acquired in a home setting. Further research needs to be conducted to determine the proportion of foodborne illness which can be attributed to specific risk factors and why consumers and food handlers do not follow proper procedures, including handwashing for minimizing exposure to *Campylobacter* organism. As well, research into the attitudes and beliefs of the public regarding foodborne illness must be conducted. Any data that will provide accurate weighting of infection rates is required. Further research is also needed to address the discrepancies between consumer reports and observational studies.

The limitations of this paper include the lack of information that is available to make a full assessment of the causes and risk factors of food-related *Campylobacter* infection. Furthermore, the information that is available is subject to detection bias due to the underreporting of foodborne illness, and information bias such as recall. Due to the lack of information, it is difficult to determine the generalizability of this work.

## 5. Conclusion

*Campylobacter* infections remain a major public health concern while a greater focus is being placed on the efficient use of scarce resources. A more focused and targeted approach to resolving public health issues within communities is required to ensure public health agencies have the greatest impact possible. Risk factor diagrams are an effective way to illustrate factors that contribute to campylobacteriosis and identify specific areas where further investigation is necessary. A risk factor diagram for *Campylobacter* infection shows that approximately 80% of these infections are caused by human factors, many occurring within the home. Targeting public policy and programs that would educate primary food handlers could have a significant impact on foodborne related illnesses within communities. Currently, few initiatives

exist that educate consumers regarding safe food handling, yet they are the last line of defense against food borne illness. Targeted programming has proven to be a more effective means of delivering a successful message when resources are limited.

## Competing Interests

Authors have no competing interests.

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