Knowledge Translation and Exchange in the Canadian Microbial Food Safety Sector

by

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ABSTRACT

KNOWLEDGE TRANSLATION AND EXCHANGE IN THE CANADIAN MICROBIAL FOOD SAFETY SECTOR: RESEARCHER-LEVEL ANALYSIS OF AWARENESS, ATTITUDES, ACTIVITIES, BARRIERS, AND DISCONNECTS WITH POLICY NEEDS

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Knowledge translation and exchange (KTE) is integral to the formation of evidence-informed policy. Prior to the work presented in this dissertation, a significant body of literature existed in the healthcare field regarding research-to-policy KTE; however, little was known about KTE between researchers and policymakers in the Canadian food safety system or the context-specific barriers that influence KTE. A mixed-methods approach was used, grounded in concepts from the healthcare literature, to explore Canadian food safety researchers’ KTE awareness and activities with policymakers, the barriers hindering KTE engagement and success, and timing and informational disparities between research and policy needs that may hinder KTE success. Canadian food safety researcher awareness of and engagement in KTE activities with policymakers was high. However engagement in activities identified as having the greatest potential for KTE success—i.e., collaboration with policymakers at all stages of the research process, provision of syntheses such as systematic reviews, and provision of a searchable database of research findings—was low relative to end-of-research dissemination of findings to policymakers. Several barriers were identified that limited
KTE engagement and success from the researcher’s perspective, including an inability to identify relevant policymakers, high policymaker turnover, a lack of resources and support in the research organization, a perceived lack of KTE skills on the part of researchers, and an inability to break free from traditional publish-or-perish research roles. Apparent informational disconnects (i.e., research output not meeting policymakers’ apparent informational needs) were identified that may further hinder KTE and evidence-informed policymaking. While new methodologies, such as systematic review, have been adapted for food safety research, boosting researchers’ potential ability to produce policy-relevant evidence, a cultural shift must occur in research and policymaking organizations, if sustained KTE is to be successful. As well, significant future investment must be made on the part of research organizations and policymakers, if KTE barriers are to be mitigated. Future research should evaluate KTE tools (e.g., sustained linkages between researchers and policymakers, provision of syntheses, provision of access to a database of research findings) to identify specific methods that may facilitate research use in food safety policymaking.
DEDICATION

~ Alfred Franklin Davis (1911–2010) ~

In memory of my grandfather,
   a dairy farmer and
   a believer in the merits of higher education,
   despite limited formal education
   of his own.

“But why don’t you just stay on as a vitnery?!”
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CHAPTER 1

Introduction, literature review, and study rationale

BACKGROUND

*There is nothing a government hates more than to be well-informed, for it makes the process of arriving at decisions much more complicated and difficult.*—John Maynard Keynes (1883–1946)

As the world progressed from the industrial age to the information age, the production of knowledge through scientific research increased exponentially. A simple query of annual numbers of citations for each of the last 58 years in the popular PubMed database (National Center for Biotechnology Information, [http://www.ncbi.nlm.nih.gov/sites/entrez?db=pubmed](http://www.ncbi.nlm.nih.gov/sites/entrez?db=pubmed)) demonstrates this trend. But to what end is the development of this deep pool of knowledge if the knowledge is not used? How can the findings of research, produced through the investment of millions of dollars of public money, best be used to benefit society and the natural world around us? As society increasingly demands transparency in policy decision making and evidence-informed decisions from public policymakers, by what means can policymakers more easily navigate the ever-deepening knowledge pool rather than simply drowning in it?

In the healthcare field, promotion of the use of research evidence (i.e., the findings of scientific research) to inform practice and policy decision making has intensified over the last few decades [1] as a means of ultimately improving health outcomes through the use of the most up-to-date health technologies and practices [2]. This mechanism has been termed “knowledge translation and exchange” (KTE) [2].
In the Canadian microbial food safety sector, interest exists in the researcher and policy communities regarding KTE as a means to promote evidence-informed policymaking [3]. Because little published evidence is available regarding KTE in food safety, KTE evidence must be extrapolated from the expansive literature in the healthcare field. The objectives of this literature review are as follows:

1. To define KTE and summarize the differences between practice and policy decision-making contexts that influence approaches to KTE
2. To discuss the concept of research use, describing theoretical models of research use in policymaking and discussing issues with measurement
3. To summarize selected policymaking concepts that may influence KTE and to describe a linear policymaking process and pertinent policymaking models
4. To present and discuss a conceptual framework for KTE strategies in policy contexts
5. To discuss barriers to KTE between researchers and policymakers

LITERATURE REVIEW

Knowledge translation and exchange

As defined by the Canadian Institutes of Health Research, knowledge translation and exchange (KTE), is “a dynamic and iterative process that includes the synthesis, dissemination, exchange and ethically sound application of knowledge to improve the health of Canadians, provide more effective health services and products, and strengthen the health care system” [2]. While this definition pertains to knowledge translation in the healthcare field, many other areas of society have adopted and adapted the relevant theories of healthcare KTE for their own purposes [4], including education, social work,
and criminal justice [5]; environmental policy [6]; and waste resource management [7].

Specifically, many players within the microbial food safety (MFS) sector in Canada have become interested in KTE (e.g., the recent evolution of the Science to Policy Division at the Laboratory for Foodborne Zoonoses, within the Public Health Agency of Canada), and the food safety sector is the focus of this dissertation.

**Differences between practice and policy contexts**

Knowledge can be used at any of the three levels of the decision-making hierarchy—at the practice, organizational, or government level—with distinctions between practice and organizational decision making potentially being blurred within organizations [4]. Within the healthcare system, primary caregivers (e.g., physicians, nurses, therapists) make decisions at the practice level, directors and managers (e.g., hospital directors, public health unit directors) make decisions at the organizational level, and public policymakers (i.e., municipal, provincial, and federal policymakers) make decisions at the government level. Within the food safety system, the practice and organizational levels can be considered individuals and organizations, respectively, that are involved in the production, manufacture, storage, handling, display, distribution, sale, preparation, or service of food [8], while a MFS policymaker is any person making federal, provincial, or local MFS policy decisions. In the KTE literature, the middle “organizational” level is often collapsed into the upper “government” level, with organizational decision making being considered “little p” policymaking and government decision making being “big P” policymaking [4]. In the research presented in this dissertation, only “big P” policy will be included (i.e., government policy) in the definition of “policy;” however, for discussion purposes below, a broader definition
including both organizational and government policy can be considered, as it is in the healthcare field.

The KTE literature is distinctly divided between research-to-practice and research-to-policy KTE, with organizational KTE being a context-dependent adaptation of either research-to-practice or research-to-policy models [4]. In healthcare, the validity of extending KTE concepts from clinical practice to the policy arena is questionable [9]: unlike clinical decisions, most policy decisions do not fall into “neat little boxes” that can be informed by technical inputs [10]. Nutley et al. [4] suggest that because the decision making process varies between practice and policy contexts, the models representing KTE in the practice and policy settings differ. Thus, the effectiveness of different KTE interventions also varies [11]—what works in one context may not work in another.

The different practice and policy decision making processes also dictate how research evidence may be used in the two contexts. Black [12] emphasizes, “Evidence based policy is not simply an extension of evidence based medicine: it is qualitatively different.” In the policy arena, research evidence may be used less as a problem-solving tool and more as a means of creating awareness and setting an agenda [9, 12]. As well, different types of uncertainty underlie decisions made by practitioners and policymakers [13]. Specifically, the uncertainty facing medical practitioners is largely of a factual nature, while the uncertainty facing policymakers is related more to societal values [13]. For example, when a practitioner must decide if a heart transplant is a suitable option for a specific patient, informational uncertainty regarding the intervention (e.g., will it work with this patient?) may predominate over value uncertainty (e.g., religious considerations, affordability) in many situations. However, when a policymaker must decide to fund or not to fund heart transplants, value uncertainties such as affordability, social inequities,
and religious considerations may play a greater role in the decision-making process than the efficacy of the intervention, assuming proof of efficacy already exists [13]. Thus, while research evidence may factor extensively into individual practice-related decisions, it may play a minor role in final “big P” policy decisions.

**Research use**

The use of research evidence to inform practice or policy is one of the central features of KTE; however, issues surrounding the lack of ability to define [14] and measure “research use” adequately can raise questions regarding claims of its importance, as well as claims in the literature of its apparent causes and effects [15]. These issues are discussed below.

**When is research considered to have been “used” in policymaking?**

In the broad sense, there are two forms of research use in policymaking—instrumental and conceptual use [16, 17, 18, 19, 20]. In general, *instrumental* use occurs when research has a specific, documentable impact on the policy decision-making process [21] and potentially on the final policy itself. *Conceptual* use is less easily defined and includes any way in which research findings may have altered or clarified the values, attitudes, and understanding of policymakers with regard to a policy issue, without having specific, documentable evidence of use [21]. Rich [22] (cited in Pelz [21]) referred to instrumental use as “knowledge for action” and conceptual use as “knowledge for understanding.” In many contexts, instrumental use of research by policymakers is rare [23], with conceptual use predominating [4, 24]. A third type of research use, *symbolic* use, was identified by Knorr [17] and has been defined as the use of research evidence to justify a political position or the use of the act of research to justify political inaction in an
area (e.g., policy change cannot occur because research is in process and the required
information is not yet available) [25]. Recent evidence has emerged demonstrating that
different predictors can be associated with the different types of research use [26, 27].

Weiss [14] proposed seven general conceptual models meant to clarify the
different meanings of “research use” encountered in the literature. Weiss’s seven models
[14] are summarized below.

**The knowledge-driven model**

In this model, research findings “push” policymakers to consider new ideas [14].
Basic research identifies novel technologies, practices, or concepts that may have a
beneficial influence on society or the natural world. Applied research then tests these
concepts and, if the tests prove successful, appropriate technologies are developed and
implemented. This model is a rational, linear process, perhaps more applicable in the
natural sciences than the social sciences [14].

**The problem-solving model**

In this model, policymakers “pull” knowledge from the knowledge pool to find
solutions to a specific problem [14]. Research findings are actively sought by
policymakers in an effort to resolve an issue. In this model, the goals of both the
policymakers and the researchers must be in agreement or KTE efforts may fail [28]. The
research findings may be pre-existing or the research may be commissioned by the
policymakers. This is also a rational, linear model, with policy need driving the process
[14].

**The interaction model**
In this model, policymakers search for knowledge from multiple sources to help in the decision making process [14]. The talents and beliefs of various players surrounding an issue are pooled to gain as much understanding of the issue as possible. The process is iterative, complicated, and messy, with many people involved and many back-and-forth interactions. Scientific evidence is often not the only influence on the policy decision, with colloquial evidence [29], experience, political views, pressure, and judgement also involved. While researchers may be present in the process, they may not have concrete data to directly guide the decision, sometimes because there is no relevant data on the issue and sometimes because the decision must be made before research can be completed. The process underlying the interaction model is not linear [14].

The political model

Resistance to change is the mainstay of this model [14]. After sometimes years of debate, policymakers’ opinions may have hardened and they may be unreceptive to new evidence. Instead of using research in an open-minded way, policymakers may use new research evidence to bolster their arguments, taking research findings out of their intended context and extrapolating to issues where the findings are not relevant [14]. In this way, research may be used, properly or improperly, by the partisan group to whose position it is most beneficial. Weiss [14] suggests that researchers view this type of research use suspiciously, “generally see[ing] it as an illegitimate attempt to "use" research (in the pejorative sense) for self-serving purposes of agency justification and personal aggrandizement.” That said, if research evidence is interpreted properly and equally available to all parties, its use is legitimate. In these instances, the probability of
research evidence ultimately influencing policy may be higher, because there is a group within the policy community to champion it [14].

*The tactical model*

In this model, the actual research findings are irrelevant; however, the act of doing the research is important [14]. Policymakers may commission research as a stall tactic to delay the decision-making process, or as “proof” of the policymakers’ high prioritization of the issue (i.e., symbolic research use). At times, policymakers may use research to position the researcher as a scapegoat should the policy inevitably fail [14]. In this instance, responsibility for policy decisions is shirked and criticism is deflected to the researchers who provided evidence in favour of the policy. At other times, policymaking organizations may align themselves with researchers and research groups as a means of legitimizing themselves [14]. Support of a research program may not only boost the prestige of an agency, but may also ensure the unwavering support of the researchers to whom support is provided [14].

*The enlightenment model*

The enlightenment model describes the slow, gradual, cumulative influence of research on policy [14], with conceptual use of evidence predominating instrumental or symbolic use. Over time, research may ultimately lead to shifts in the policy paradigm as ideas, concepts, and theories permeate the policy arena through diverse and potentially indirect routes. The policymaker rarely seeks out research evidence in the enlightenment model; instead, multiple sources of information, including professional journals and conversations with colleagues, subtly influence the grounds upon which the policymaker’s beliefs are based [14]. Consequent to the circuitous route that research
evidence takes to reach its target audience, the “enlightened” policymaker may be unable to identify the specific study that altered his or her way of thinking [14]. In this model, evidence from individual studies (or groups of studies) rarely directly influences policymakers; instead, theories and perspectives derived from a growing body of literature indirectly transform the policy arena as they diffuse through it [14]. It is assumed that all research evidence, regardless of quality, has the potential to diffuse into the policy arena in an unfiltered state and be used [14]. This diffusion is inefficient and takes time, with research findings sometimes becoming out of date before they have been recognized [14]. Generalizations and misinterpretations may be made, and the media may sensationalize an inaccurate or incomplete study, stealing the focus from more valid or relevant research findings [14]. In the end, policymakers may be “endarkened” by knowledge rather than “enlightened” as they are overwhelmed with both relevant and irrelevant information from various credible and non-credible sources. Thus, without a filter, knowledge can be as much an impediment to policymakers as it is an asset [14].

**Theoretical models of research use**

Many theoretical models of research use by policymakers have been developed [30-35]. In a seminal paper, Knott and Wildavsky [35] described research use in policymaking as a process, not an event, with seven distinct stages, each building upon the previous one. At any stage in the process, research may be considered used, although each successive stage is weighted more heavily than the previous one. Notions of both conceptual and instrumental use are incorporated into the scale. The seven stages are as follows:
1) Reception – The simple act of a policymaker receiving research results may be considered research use.

2) Cognition – Research may be considered used if the policymaker has read and comprehended the document.

3) Reference – Research may be considered used if changes occur to a policymaker’s frame of reference or the way he or she looks at the world (conceptual use).

4) Effort – If the policymaker acts in favour of policy changes recommended by research evidence, even if unsuccessful, research may be considered used.

5) Adoption – Research may be considered used if research findings directly influence policy development (instrumental use).

6) Implementation – If an evidence-informed policy is put into practice, research may be considered used.

7) Impact – Research may be considered fully used if the outcomes of the implemented policy have been evaluated against policy goals and the policy was determined to be successful.

This scale has been validated in the KTE literature [36] and has been used to underpin KTE research [36, 37]. However, the rational, linear process presented in the scale may not accurately depict research use in many policy contexts, where “complex and often messy conditions replete with competitive interests and influences prevail…” [15].

Interactive models of research use [33, 34, 38, 39] (not to be confused with Weiss’s [14] “interaction model”), may more accurately capture the complexity of
research use in policymaking and are regarded internationally as the dominant explanatory models [4, 25]. The premise of interactive models is that “sustained interactivity”—ongoing, two-way interpersonal links between researchers and policymakers that continue through the duration of the research process and beyond [4, 33, 40]—may be the best predictor of research use by target audiences [11, 24, 38, 41, 42]. The Canadian Health Services Research Foundation has labeled these processes “linkage and exchange” [43], while the Canadian Institutes of Health Research [44] has coined the term “integrated KTE” to discriminate between interactive KTE activities embedded throughout the research process and traditional practices of dissemination of research findings, termed end-of-grant KTE. Sustained links between researchers and policymakers support dialogue and exchange, encourage a shared understanding of the policy problem, resolve conflict more readily, promote interpretation of research findings within the policy context, and may act as the most efficient mechanism of research transfer [4, 42, 45]. Exposure of policymakers to research early in the research process allows time for policymakers to “find their niche and their voice,” as well as learn what the study is about and the ways in which it may affect them [33]. As Huberman [33] puts forward, “If it takes the research team two years to get hold of its study, …why should we assume that the reading of a single research report in a few days by a…layperson will bring enlightenment?”

While the benefits of integrated KTE appear to be numerous, many challenges to “linkage and exchange” between researchers and policymakers have also been identified [43, 45]. These issues include a lack of time for both researchers and policymakers; temporal disconnects between research and policy (i.e., research timelines are inherently
long, while policymaking timelines are relatively short); difficulties with tailoring research to multiple target audiences; an inability on the part of researchers to identify relevant and influential policymakers; high policymaker turnover and restructuring; lack of rewards for engagement in integrated KTE; a poor understanding of the research process and difficulties understanding research communications, on the part of policymakers; and incompatibility between policymakers’ perceived need to control the release of potentially volatile research findings versus researchers’ need to publish [43, 45]. Long-term, sustained interaction, with formal delineation of roles and boundaries may reduce these issues [45].

Rogers’ Diffusion of Innovations Theory

Although not a model of research use, Rogers’ Diffusion of Innovations Theory [46] has been used to underpin many KTE studies [47-49] and tools [15, 50]. In the social sciences, Rogers’ Diffusion of Innovations Theory is a widely used classical action theory [51] that describes the natural process of change in a population, from the time of exposure to an innovation (e.g., research evidence) to the ultimate maximal use of the innovation within the population. Rogers’ theory also identifies key barriers and facilitators to the adoption of innovations.

Rogers’ theory [46] outlines the various stages involved in the process of innovation adoption: awareness, persuasion, adoption, implementation, and confirmation. Potential adopters initially pass through the awareness stage in which they first identify an innovation (e.g., research evidence) and learn how it can be used. In the persuasion stage, potential adopters develop a favourable or unfavourable attitude toward the innovation, based largely on the attributes of the innovation. It is at this stage that the
potential adopter actively seeks information about the innovation. Adoption (or rejection) is predominately guided by attitudes developed in the persuasion stage, and is followed by implementation. During the final stage, confirmation, the adopter seeks further information about the innovation to reinforce his or her decision to adopt. If conflicting information is discovered, the innovation may still ultimately be rejected, despite its earlier implementation [46].

The rate of adoption of an innovation within a population is substantially influenced by factors related to the individual adopters (e.g., age, gender, education level), the adopters’ environments (e.g., characteristics of the organization in which they work, the general political environment), and the innovation itself [46]. Attributes of the innovation that may increase uptake include (1) perceived relative advantage to what is currently in use; (2) compatibility with the values, beliefs, and needs of the potential adopter and with previously introduced ideas; (3) low complexity of use; (4) how readily it can be tested before being formally adopted (trialability); and (5) the degree to which the results of an innovation are visible to others (observability). These attributes influence the development of a favourable or unfavourable attitude by the potential adopter at the persuasion stage of the innovation-decision process [46].

Rogers’ innovation-adoption process has contributed to KTE study design [47, 52, 53], research-use framework development [54, 55], research-use measurement tools [56], KTE process evaluation [57], and the identification of barriers to research use in practice and policymaking contexts [54].
**Measurement of research use**

In the past, evidence of instrumental use of research evidence was often sought as proof of successful KTE [23]; however, measurements of conceptual use predominate in more recent KTE impact studies [58]. Many tools to measure research use have been proposed (see Estabrooks [15], Squires [37], Van Eerd [58], and Sudsawad [59] for summaries). Evaluation of these tools has demonstrated many common deficiencies, including poor conceptualization of the type of research use being measured; inappropriate level of analysis (e.g., individual or organizational level); reliance on retrospective surveys, self-reporting, and recall; lack of experimental design; and basis on the assumptions that research use is always good, that all research is applicable, that research use is a linear process (i.e., acquisition, then critical appraisal, then implementation), and that decision makers are rational actors in rational environments [15]. Most measurement instruments have been developed, validated, and used to assess research use or KTE impact in practice settings, not policy settings [58].

Because of the complexity and indirect pathways of the policy decision making process [30], assessment of research use in policymaking has generally been through qualitative methods, with retrospective collection of data by document analysis and/or in-depth interviews of policymakers [24, 30]. Where the decision making process is more linear, quantitative survey instruments to measure research use may be appropriate [47-49]. Designs of studies measuring research use by policymakers can either follow specific research evidence forward in time (e.g., Dobbins et al. [47]) or retrospectively trace backwards from an obvious policy change to determine what impact research evidence had on the policy change (e.g., Waters et al. [60]). These retrospective “episode studies” allow for a more realistic understanding of the role that research evidence plays amongst
the other competing factors in policy change, whereas tracking research forward in time may overemphasize that role [61].

**Policymaking concepts**

*Bottom-up and top-down decision making*

Decision making can generally be considered to be either “bottom up,” in which government action can be influenced by the practice of non-government groups, or “top down,” in which practice is shaped by government policy decisions. Historically, with agricultural reconstruction in Western nations post-World War II, the role of science in the food production system was considered to be an input-output model: increased scientific research and capital within the agricultural industry would lead to increased food production and consequently improved human health [62]. With the rising need to feed the burgeoning urban masses of the industrial revolution, the input-output model has dominated Western cultures, generally leading to intensified agriculture and the promotion of globalization, monoculture, food quantity, and the use of agrochemicals at the expense of localization, biodiversity, food quality, and environmental health [62]. A generally top-down approach to food policy has followed—the production and distribution of large quantities of inexpensive, fast food for the masses is generally an upper-level government issue, with global and national policy decisions filtering down to local levels [62]. Within the MFS sector at the international level, decision making follows a top-down approach, with international standards set within the Sanitary and Phytosanitary (SPS) Agreement of the World Trade Association and national standards conforming to or going beyond those of the SPS Agreement [63]. In Canada, generally, a top-down approach exists, with the federal government’s basic responsibility being to set
standards for safe food, to monitor compliance, and to hold industry accountable when it fails to produce safe products [64]. The introduction of mandatory Hazard and Critical Control Point (HACCP) programs for food processors, with mandatory reporting of test results to the Canadian Food Inspection Agency (CFIA), is one example of top-down food safety policy [64]. Examples of bottom-up policy development exist, including the establishment by various commodity groups of voluntary, HACCP-based on-farm-food-safety programs that are recognized by the CFIA (e.g., Canadian On-farm Food Safety Programs for milk (Canadian Quality Milk Program), beef (Verified Beef Production program), pork (Canadian Quality Assurance program), and egg producers (Start Clean-Stay Clean)) [65]. As well, for Canadian commodities governed by supply management (e.g., milk and eggs), marketing groups may impose mandatory policies on producers (e.g., somatic cell count regulatory standards for dairy farmers [66]) and may be responsible for administering and enforcing provincially legislated on-farm food safety regulations developed parallel to the marketing group policies [67]. Thus, bottom-up approaches to foodborne pathogen control may co-exist with top-down measures.

*Policy context—Interests, ideologies, information, and institutions*

Inherent in the decision making process in government but not as distinct in practice environments are the influences of interests, ideologies, information, and institutions [9, 20, 38, 68, 69]. *Interests* represent how one would like the world to work, are context specific, and may change with each policy decision [38]. The self-interests of policymakers may be personal (e.g., career advancement, winning support of constituents for re-election) or political (e.g., advancement of the scope of their office, advancement of a cause) [4, 69]. Other interests may compete, such as the interests of the political party
or stakeholders within the policy community [69]. Within the food safety policy community, interested stakeholders may include food industry groups (e.g., livestock organizations, the processing industry, the retail industry, marketing agencies, farm pressure groups, alternative farming groups), consumer advocacy and educational groups (e.g., the Consumers’ Association of Canada), public health organizations, and food safety researchers employed outside of government. Ideologies are the systems of beliefs, moral and ethical values, and political orientations that influence policymakers’ decisions [4]. Ideologies can be considered long-standing, hardened opinions about how the world ought to be [38], and are unlikely to change with context or each policy decision.

Ideology can prevent consensus between public health proponents and policymakers on a shared problem definition [28], without which, KTE will fail. The information available to policymakers helps to define their interests and ideologies and may change institutional culture [4, 69]. Information can come from multiple sources and previous knowledge can influence how new information is perceived or used [69]. Institutions are the organizations within which policymakers make decisions. Institutional culture, history, rules, budgets, and other constraints influence the interests and ideologies of individual policymakers, thereby shaping how decisions are made [4, 69].

When research findings uphold policymakers’ and agencies’ interests, and are aligned with the current ideological environment, they are more likely to be used [24, 70]. Because of the fixed nature of interests and ideologies, when research evidence is to the contrary, it must be very convincing to effect change [70]. Failing this, Black [12] advises that research should target challenging and changing policymakers’ beliefs. Under repeated exposure, policymakers’ beliefs—opinions or convictions based upon previously digested knowledge [4]—can be influenced by research evidence; however, competition
with other potentially conflicting information and the prolonged effort required may reduce the impact of isolated KTE efforts [12]. Thus, sustained interaction between researchers and policymakers may be necessary to alter beliefs, supporting the theory behind interactive models [33, 34, 38, 39] and integrated KTE [44].

**The policymaking process**

Understanding the use of evidence in the policymaking process requires a basic understanding of the policymaking process itself. While policy development is rarely a rational, linear process [71], researchers often suppose it to be so [72], and the linear process is a useful starting point for discussion. A linear policy development framework has four stages including agenda setting, policy formulation, policy implementation, and policy evaluation [30, 73, 74].

*Agenda setting* – Agenda setting is comprised of problem definition and value and goal clarification [73]. At this stage, problems are recognized, analyzed, and priorities defined. The values of stakeholders and society are considered and understood so they can either be reflected in policy or respected by the policy process [73]. As well, the desired goals of the policy are defined and, if possible, baseline criteria and indicators are established to provide a means of policy evaluation post-implementation. Research can directly inform this stage by providing evidence that a problem exists; by defining the extent of the problem, the perceived risk, and societal values surrounding the problem; and by enlightening policymakers about the importance of the issue and contributing information toward policy evaluation methods [30, 59]. In food safety, the impact of foodborne illness on a population may be quantitatively expressed in terms of incidence of illness, disability adjusted life years (DALY), and quality adjusted life years (QALY)
Studies on the attribution of foodborne illness, risk assessment, analytic epidemiology, and outbreak investigations can aid in problem definition [74]. At the end of the agenda-setting stage, a decision is made to act or not act on the problem.

**Policy formulation** – Policy formulation encompasses two steps: option generation and selection [73]. At this stage, policy alternatives are brainstormed, preferably outside of the existing policy paradigm, and tools such as cost-benefit analyses, social impact assessments, risk assessments, and environmental assessments are used to evaluate the policy options identified. Research use at this stage can be either instrumental, by contributing directly to potential policy alternatives or by providing evidence or the alternatives’ pros and cons to aid in selection; conceptual, by broadening the perspectives of policymakers, thereby potentially altering their frames of reference to accommodate new policy solutions; or symbolic, by informing or supporting previously determined views [4, 30, 74]. In food safety, risk assessment, epidemiology, and economic analysis are all useful aids to evaluate the effectiveness, the efficiency, and the equity of the various policy alternatives [74]. At the selection stage, stakeholders’ views are considered, as well as public interest and societal values [73]. The alternatives are debated and bargains are struck, ideally in a collaborative manner. If stakeholder interests cannot be accommodated in the final policy selection, the stakeholder loop is closed [73].

**Policy implementation** – At this stage, policy is put into action: responsibility for delivery is assigned, capacity is assessed, instruments are chosen, and alignment with existing legislation is ensured [73]. Research can play valuable roles by providing quantitative evidence for guideline development [74] and by determining the most appropriate mechanism of implementation [4, 30]. Research evidence can also be used
symbolically at the implementation stage to build public support for the policy [30]. In food safety, research can aid risk management guideline development by setting targets for HACCP-based systems (Hazard and Critical Control Points) and by defining the Appropriate Level of Protection (ALOP) for national authorities (i.e., the level of public health protection in relation to food safety achieved at a point in time for a country) [74].

*Policy evaluation* – In the final stage of the policy process, the implemented policy is evaluated against desired outcomes, using the criteria and indicators identified in the agenda setting stage [73]. Evaluation should occur regularly at predetermined times [74] and policy modifications can be suggested by the evaluation outcomes [4, 73]. Research may help to modify policy at this stage, if agenda setting goals have not been reached. In food safety, monitoring or surveillance of human illness or pathogens at the farm, slaughterhouse, or retail level can aid policy evaluation efforts, by comparing post-implementation data with predetermined goals for performance indicators [74].

*Policymaking models*

Various policymaking models have been suggested in the literature and these can be grouped into several categories as suggested by Hanney et al. [30]. These categories include rational models, incrementalist models, networks, and the garbage can model. The groups of policymaking models may overlap, forming a continuum wherein a specific policy process may fall into more than one group.

*Rational models*

Rational policymaking models represent policymaking as the linear process previously outlined [30, 73, 74]. Policy decisions are labeled as “rational” when they are
calculated choices between clearly formulated alternatives to achieve desired ends [75]. The rational model concept has been generally criticized for its overly simplistic, linear, logical view of policymaking, with its orderly sequence failing to capture the “messy complexity” of real-life policy decision making [4, 75]. At the extreme, in the quest for full rationality (i.e., selecting an option after weighing all possible information), decisions can become irrational, if the costs of obtaining the information, in the form of time, energy, and money, outweigh the benefits of the rational approach [76].

**Incrementalist models and policy networks**

Incrementalist models are defined by the notion that policy decisions are not made in a readily-observable, clear-cut manner [76, 4], but are still based on a rational assessment of self-interest [39]. Decisions “accrete” [23] in a prolonged, muddled process of dissociated small steps toward a vague, often poorly conceptualized goal. The incrementalist models emphasize the many diverse sources of knowledge available to inform policymakers, as well as the roles of the interests, ideologies, and institutions of the various actors in the decision making process [30]. The basis of the model is the pluralist and democratic American political structure, in which political power is fragmented across institutions, and parties must “bargain their way to results,” resulting in progress in small, discontinuous steps [75, 76].

Weiss [23] describes the incrementalist policy process as lacking a clearly defined path:

No problem (or opportunity) is identified as an explicit issue, no identifiable set of authorized decision makers meets, no list of options is generated, no assessment is made of relative advantages and
disadvantages, no crisp choice is made. Yet the onrushing flow of events shape [sic] an accommodation—and a pattern of behavior—that has widespread ramifications. It may in time be ratified by conscious policy action, but in the crucial formative stages, it just seems to happen. [23]

Thus, without a clear decision-making path, identifying the critical points where research knowledge could be injected into the process can be difficult [4]. Decisions are often substantially informed by non-research “evidence” such as experience, interests, values, established positions, and personal ambitions [30, 75, 76], and because of the greater role of negotiation, maneuvering, and bargaining in the decision-making process, research evidence may be mainly used for political or tactical purposes [4, 75] (see sections 1.1.2.1.5 and 1.1.2.1.6).

The garbage can model and adaptations

The garbage can model, originally introduced by Cohen et al. [77], frames organizational decision making as a chaotic, opportunistic process found within organized anarchies. Pre-existing solutions are randomly mixed with current organizational problems in a figurative garbage can [77]. If the availability of a suitable previously proposed solution coincides with the emergence of an organizational problem and the requisite time and capacity to deal with it, the existing proposal may be passed off as a solution to the new problem [77,78]. As Cohen et al. summarize,
It is clear that the garbage can process does not resolve problems well. But it does enable choices to be made and problems resolved, even when the organization is plagued with goal ambiguity and conflict, with poorly understood problems that wander in and out of the system, with a variable environment, and with decision makers who may have other things on their minds [77].

Choices made within the garbage can model do not fulfill the definition of “rational” in that all potential alternatives are not identified and evaluated before a choice is made. Choices are made in a haphazard fashion, dependent upon timing and capacity, with little direction toward an organizational goal, and perhaps little opportunity for research use by decision makers working under time and budgetary constraints [4, 77].

Whereas the garbage can model was intended as a depiction of organizational decision making, Kingdon [79] proposed the multiple-streams model, an adaptation of the garbage can model, to represent the policy agenda-setting process in government. As its name suggests, the multiple-streams model consists of three separate theoretical entities: a problem stream, a policy stream, and a political stream. Although the three streams operate in isolation, Kingdon [79] suggests patterns exist in their flow, unlike within the garbage can model, in which solutions and problems occur randomly [4]. Where the three streams merge, a problem may become a policy priority and a policy decision may be made [4, 79].

Within the problem stream flow “conditions” and “problems,” with conditions becoming problems when they are perceived as being contrary to societal or political values [80]. Brehaut and Juzwishin [80] explain this concept within the context of
American health insurance. Forty million Americans live without health insurance, an everyday condition of American existence. However, if American societal values evolved to embrace universal healthcare (or if the ideology of a newly elected governing party was aligned with universal healthcare), 40 million Americans without health coverage would be viewed as a problem [80].

Within the policy or solutions stream flow policy options and alternatives that could potentially solve the issues within the problem stream [4, 79]. Amongst other criteria, the policy options must be politically aligned and technically feasible to be adopted [79]. The final stream, the political stream, is influenced by national mood, organized political interests, and changes in government [4, 79]. If the three streams merge—a policy problem is identified, a policy solution is available, and the political context is favourable—a policy window will open [79]. At these times, policy decision makers become receptive to information regarding the policy problem and solution, and policy entrepreneurs (i.e., individuals advocating a policy idea or proposal [4]) may have success in championing research evidence [81, 4].

Models of evidence-informed policy decision making

Evidence-based policy decision making has been defined as people making “well-informed decisions about policies, programmes and projects by putting the best available evidence from research at the heart of policy development and implementation” [82]. This is in contrast to “ideology-based” policy decision making [4] and “opinion-based” policy decision making [82], in which scientific evidence plays a lesser role than ideology or beliefs. Recognizing that there are many factors other than evidence that influence the decision-making process, the term “evidence-informed policy decision making” was
adopted, with the aim of promoting the use of evidence in the policymaking process, while still acknowledging ideology, politics, personal experience, and the media as influential [83]. The multifactorial basis of policy decision making has been recognized in the Canadian food safety system [84, 85]. As Justice Haines comments in his 2004 report on meat safety in Ontario, “While science is an important element in developing food safety policy it is not the only consideration. Social values, ethics, consumer demands, economic and political considerations and other factors will impact these policy decisions.” [84, 85].

Critics of evidence-informed policy theory suggest that it is too strongly based on a rational model of policymaking; whereas actual policy decision making is more often irrational, resembling the incrementalist or garbage can models [12, 23, 87]. Nonetheless, evidence-informed-policy-decision-making models have been developed (e.g., the Canadian Health Services Research Foundation (CHRSF) [13] and Bowen [86]). Figure 2 illustrates the CHSRF framework of evidence-informed policymaking, adapted to include actors in the Canadian food safety system.

The CHSRF framework is supported by Weiss’s “interaction model” of evidence use [14], by including multiple actors—researchers and other knowledge purveyors—in the accrual of knowledge to inform the decision-making process. The rationale of the framework is that the impact of potentially non-science-based anecdotes and stories from knowledge purveyors may be reduced, through the provision of ideas with a more substantial component of research evidence [13]. As stated by the CHSRF, “Perhaps all that is being sought through evidence-based decision-making is a status for science in decisions that is at least equivalent to the current status of public or interest group opinion” [13].
The CHSRF framework also embodies the concept of “linkage and exchange” between researchers and policymakers [43], demonstrated by the reciprocal arrows between these two groups (Figure 2). As the strength of the relationship between researchers and policymakers grows, evidence-informed decision making should improve, a concept based upon the interactive models of research use (see section 1.1.2.2) [33, 34, 38, 39]. However, as previously noted (section 1.1.1), the uncertainty faced by policymakers is often “value uncertainty” [13]. Hence, increasing the balance of factual evidence in the policymaking process may not necessarily ensure that the final decision will be any different than one made with a limited amount of scientific evidence [13]. In recognizing this, the CHSRF acknowledges that the goal of knowledge translation is perhaps not to expect policymakers to comply with all research evidence, even when it removes all informational uncertainty, but to ensure that there is “accountability to evidence in policy decision making” [13]. Increasing policymakers’ awareness of research evidence and improving their attitude toward it may achieve this goal.

In the CHSRF framework adapted to the Canadian food safety system (Figure 2), stakeholder groups appear in all four categories of the framework—researchers, research funders, knowledge purveyors, and policymakers. Some stakeholder groups, such as commodity representative organizations, may carry out their own research; have the capacity to fund academic research; may act as advocacy groups, using non-scientific information; and may develop policy within their commodity sector, as part of bottom-up policymaking. Thus, stakeholder groups likely play an important role in KTE within the MFS system.
KTE models and conceptual frameworks

Many frameworks and models for KTE in policy have evolved in the literature [42, 88-92], suggesting that theory development may be outpacing the use of theory in KTE research [1]. Ward [92] distilled the elements of 28 KTE models into 5 common components:

1) Problem identification and communication.
2) Knowledge/research development and selection.
3) Analysis of context.
4) Knowledge transfer activities or interventions.
5) Knowledge/research utilization.

As a guide to the development of KTE strategies, Lavis et al. [90] introduced a conceptual framework of KTE that was recently revisited by Grimshaw et al. [11]. Within this framework, the core components of a KTE strategy with policymakers were presented as five questions:

1) What should be transferred to decision makers?—the message
2) To whom should research knowledge be transferred?—the target audience
3) By whom should research knowledge be transferred?—the messenger
4) How should research knowledge be transferred?—the KTE intervention
5) With what effect should research knowledge be transferred?—evaluation

The message

Synthesized research evidence in the form of up-to-date systematic reviews or meta-analyses should be presented to policymakers, not the results of individual research
studies [11, 48, 90, 93]. Evidence has shown that the conclusions of individual studies may differ greatly from those of meta-analyses, which provide a more objective appraisal of the evidence [94]. “Actionable messages” and “ideas” influence decision making more than data and numbers [68, 90, 95, 96], which may be seen by policymakers as too “complicated” or “boring” [68]. Thus, researchers should provide concise executive summaries of synthesized research [93], with clear, resonating take-home messages [31] communicated in a jargon-free narrative [20, 31, 95, 97].

**The target audience**

The primary target audience for a KTE strategy should be clearly identified and understood, as different audiences have different informational needs [11, 90, 98]. Selection of the target audience should be guided by who has the most power to act on the research evidence, who can influence the people with power, and from which of these target audiences can the greatest KTE success be expected [90]. In the food safety system, target audiences may include decision makers in federal, provincial, or regional government (i.e., those with power to act), as well as interested stakeholder groups (i.e., those who can influence). Significant time and financial resources are necessary to engage a target audience, develop a sustained professional relationship with them, and fully understand the decision-making environment [90, 95, 99]. The decision-making environment—including the organizational culture and leadership of the decision-making organization and the greater political context—can influence policymakers’ receptivity to research evidence and evidence-informed decision making [38, 68, 99, 100], and may inhibit KTE success [38].
The messenger

Messenger credibility with the target audience is of primary importance to KTE success [11, 90, 101, 102]. Jacobson and Goering [101] identified four dimensions of credibility: scientific credibility, expertise, authority, and stance. Credibility can be enhanced when researchers are perceived to be objective and impartial (scientific credibility) [101, 103] or it can be undermined when researchers are perceived to engage in advocacy against the prevailing position of policymakers (stance) [104]. The accrual of knowledge, experience, and skill (expertise) in building credibility can be time consuming [90, 103]. Confidence and communication ability may lend perceived credibility (authority) [101]; thus, selection of an appropriate messenger should also be guided by potential messengers’ interpersonal skills [99, 103]. Knowledge brokers—intermediaries between researchers and policymakers [105]—may represent a valuable alternative to traditional researcher-policymaker KTE, where researchers interact with policymakers [90, 105].

The KTE intervention

Selection of an appropriate KTE intervention should be guided by a context-specific assessment of the barriers and facilitators expected to influence KTE success, the ability of the various interventions to overcome the identified barriers, the target-audience environment, and the available resources [11, 106]. Rogers’ Diffusion of Innovations theory has been used to categorized barriers to policymakers’ use of research evidence into four groups: barriers related to (1) the innovation (i.e., the message), (2) the policymaker (i.e., the target audience), (3) the policymaking organization, and (4) the system external to the policymaking organization (e.g., the political environment) [47,
Adapted from this, barriers to KTE engagement at the researcher level should include two additional categories: barriers related to the researcher and the research organization. KTE barriers will be summarized in a subsequent section.

The evidence supporting the use of specific research-to-policy KTE interventions remains incomplete [10, 11], with few systematic reviews evaluating the success of KTE strategies [11]. In a recent review of the literature [11], two systematic reviews of KTE interventions with policymakers were identified. The first systematic review evaluated factors that influence the use of research evidence in policymaking [108]. Little consistency was found across the findings of the 16 included studies; thus, intervention success is likely highly context specific. Two potential facilitators of research use by policymakers appeared regularly in the 16 included studies: interactions between researchers and policymakers, and research that was aligned with the beliefs, values, interests, or political goals of members of the policy community [108]. In a systematic review of interventions to increase the use of systematic reviews by policymakers, Perrier et al. [109] identified only one study with an experimental design in the available literature [100]. This randomized controlled trial found that a combination of providing tailored messages and access to an online registry of systematic reviews had a significant effect on the number of associated strategies and policies implemented by a health department, although there was no effect on global evidence-informed policymaking [100]. As well, knowledge brokering was less effective in contexts where evidence-informed decision making was already espoused [100]. Because only one study was available for systematic review and the success of KTE interventions is context specific, the generalizability of the findings may be low.
Evaluation

Evaluation of KTE activities is advocated by many KTE models and theories as a means to iteratively adapt the KTE process to the context in which it is implemented [30, 51, 90, 92, 106, 110]. However, the difficulties associated with formal evaluation of KTE interventions with policymakers are many-fold, as can be inferred by the paucity of well-designed studies mentioned above [11]. One of the main challenges in formally evaluating KTE with policymakers is determining what endpoint to assess—when is research considered to have been “used”? [14, 21, 35]—and how to measure it [15, 20, 30]. A framework for the evaluation of research use has been developed [59, 111]. Informal methods, such as target-audience feedback on the perceived usefulness of research products, have been used to ensure user needs are being met [112]. Establishment of a user feedback system should be incorporated into all KTE strategies, preferably with at least self-reported documentation of research evidence being a component of agenda setting or decision making [11].

Barriers to KTE

A context-specific evaluation of the barriers expected to hinder KTE with policymakers should be conducted to guide KTE intervention selection and implementation [11]. Although empirical research on KTE barriers is limited [113], many barriers to KTE with policymakers have been identified in KTE-theory and KTE-practice literature in healthcare. As mentioned above, barriers to KTE engagement by researchers and to research use by policymakers can occur at many levels, including those related to the research or message, the researcher or messenger, the policymaker or target audience, the research organization, the policymaking organization, and the general political
environment or system. The boundaries between these levels may blur as barriers may cut across levels; however, the levels provide a useful framework to summarize the major barriers to KTE found in the literature.

**Barriers related to the research or message**

Generally, research-related KTE barriers can be categorized as either associated with the research process or with the research product.

The research process can influence KTE engagement by researchers and research use by policymakers via limitations of the questions answerable by research and long research timelines. The questions posed by policymakers may be unanswerable, either because of limitations to the data available to researchers [96] or because policymakers pose questions that are unanswerable within the confines of the research process [114]. If existing research findings are not easily adaptable to the complex, multi-component problems of interest to policymakers, the evidence may not be used [115]. As well, the inherent length of the research process—from problem definition, through funding acquisition, graduate student training, data collection, analysis, and report writing and dissemination—may be incompatible with the short policy timelines within which policymakers require information [24, 68, 114, 115]. The tendency of researchers to “get lost in minutiae” to maintain scientific rigour may also result in short deadlines not being met [96]. In extreme cases, reports may be out of date by the time they are available to policymakers [96].

The research products provided to policymakers should be a synthesis of a body of work, not an individual study [68, 90, 103, 116]. That said, a paucity of relevant systematic reviews has been identified as a barrier to evidence-informed policymaking.
and issues with the scientific rigour of primary food safety intervention studies have been recognized as a hindrance to systematic review in food safety [117]. Policy applicable research is more likely to be used by policymakers if it is unambiguous, simple to apply, is perceived as useful, is aligned with policymaker values, demonstrates visible benefits, permits flexible application, and has acceptable risks [103]. The timeliness of the research findings with respect to current policy priorities [24, 96, 99], the accessibility of the research products [68, 95, 115], and the policy relevance and relevance of the findings specifically to the local policymaking context [68, 103, 115, 118] influence the uptake and use of the evidence by policymakers. Where policymakers have the skills to critique research evidence, poor quality research [24, 68] is also less likely to be used.

The presentation of the research findings also influences research use by policymakers. Lavis [90] advises that research “ideas” enlighten but “data” has less influence. Recognition that research evidence is competing with other information sources for policymakers’ attention is essential, as research findings that are presented in a manner that will capture policymakers’ attention will be more likely to be used [96]. Research findings should be distilled down to a clear and unambiguous message for policymakers [95, 96, 103, 112, 119], using stories in lay-person language to illustrate points [95, 96, 118]. When the presentation of research findings is perceived to be aimed at an academic audience, policymakers will be less likely to use the evidence [115].

**Barriers related to the researcher or messenger**

KTE barriers related to the researcher or messenger may be categorized as either challenges facing researchers that negatively impact their engagement in KTE activities or attributes of the messenger that influence research use by policymakers.
Researcher engagement in KTE activities can be significantly influenced by time constraints, whether actual or perceived [90, 95, 96, 99, 103, 115, 120]. Integrated KTE (inclusion of policymakers in the research process) requires extensive time to build and maintain relationships between researchers and policymakers [95], and the process of translating research findings can be perceived by researchers as being complex and time consuming [103]. Competing priorities for researchers’ time, such as teaching, graduate student training, peer-reviewed publication, and service on institutional boards and committees, also reduce the likelihood of KTE engagement [90, 95, 96, 99, 103, 113, 115, 120].

Researchers’ perceptions of the effects of KTE can also inhibit engagement. Perceived loss of control of the research process as policymakers become involved in research question design [99] and the perception that research findings may become meaningless when reported in lay-person language [114] can reduce the likelihood of researcher engagement in KTE. As well, the likelihood of future KTE engagement may be reduced if researchers perceive a lack of impact of their KTE activities, either due to a lack of feedback from policymakers or a lack of understanding of the ways policymakers may use research (i.e., researchers desire instrumental use by policymakers and either are unaware of or do not recognize the value of conceptual use of research findings) [95, 99]. Finally, misperceptions of the policymaking process as an event and not a process can negatively impact KTE success. Lomas [38] advises that in general, researchers do not understand the policy decision-making process, meaning a researcher may arrive on a policymaker’s doorstep “brandishing his or her study” after the initial main policy-forming steps have occurred [38]. In the struggle to prevent the forced closure of safe injection sites for drug users in Canada, Fafard [28] demonstrated how researchers’ KTE
efforts were undermined by a misunderstanding of the policy process as a science-based, linear, problem-solving event and a misplaced assumption of a shared problem definition that was based on harm reduction and an egalitarian conception of social justice. In reality, the newly elected Conservative government held a competing view of what was required to achieve a just and fair society, with a differing definition and approach to public safety that did not include harm reduction for injection drug users [28]. Because public policy decisions—especially those in highly contested areas—are not simple, linear problem-solving exercises made in a political vacuum, science-based evidence played a minor role in the decision-making process, while politics (e.g., coalition building, the mobilization of public opinion, lobbying, and political and ideational struggle) contributed greatly to the outcome [28].

Attributes of the researcher or messenger can influence research use by policymakers. Specifically, as previously mentioned, the credibility of the researcher and messenger [90, 96, 101] and the interpersonal skills of the messenger (e.g., skills at facilitation, adult education, networking, and communication) [90, 99, 103, 114], are essential in the establishment of linkage and exchange mechanisms and for policymakers to perceive research evidence as beneficial.

**Barriers related to the policymaker**

Similar to researchers, policymakers’ ability to use research evidence may be limited by time constraints [68, 90, 95, 96, 99, 103, 115, 120, 121]. Policy decision making is often fast paced, and as policymaker mandates and the complexity of policies increase, the time available to collect, appraise, and adapt research evidence to local
contexts decreases [68]. As well, competing priorities limit policymakers’ time to engage in integrated KTE [68, 90, 95, 96, 99, 103, 120, 121].

Policymaker receptivity to research evidence is influenced by both organizational culture toward the use of research evidence (see below) [68, 99, 103, 105, 115] and individual policymaker-level factors, including intellectual capacity, tolerance for uncertainty, and learning and decision-making styles [103]. Individual interests, values, and political agendas may also influence openness to using research evidence [68, 115]. Lack of awareness of evidence-informed policymaking [121] and an overload of information that is not directly related to current national priorities can further reduce policymaker receptivity to research evidence [112].

Different sources of information—personal experience, common sense, expert opinion, the media, and community views—and pressures can compete with research evidence for policymakers’ attention during the decision-making process [68, 115]. Jewell [68] describes “the power of the anecdote” compared to abstract, “boring” research reports, further underlining the importance of the presentation of the message, described earlier. Stakeholder and public pressure and, in some political systems, lobbyists and money, may act upon or, at worst, coerce policymakers to disregard research evidence [68, 115].

Many policymakers lack a scientific background and, consequently, may not understand the research process [24, 38, 68, 103, 114]. A limited understanding of research and the research process can negatively impact policymakers’ ability to critically appraise and understand research evidence and, ultimately, to use it appropriately [68, 122]. Lomas [38] depicts the policymaker view of research as a retail store, where researchers are storekeepers proffering already existing research evidence. Because of
this misperception of research as a product and not a process, policymakers may contact researchers with complex questions and urgent deadlines [38, 116]. Policymakers who understand research as a process may more readily influence research priorities and questions, thereby facilitating the production of more policy-relevant research evidence.

“Two communities”—differences between researchers and policymakers

Within the KTE literature, KTE failure has been attributed to the “two-communities” issue—a theory that fundamental cultural differences between researchers and policymakers act as barriers to research use [123]. Lack of a common background or language between researchers and policymakers is thought to hinder research uptake [103], while temporal and priority disconnects between researchers and policymakers can also threaten KTE success [30, 116]. Other cultural differences between researchers and policymakers that may reduce KTE effectiveness include differing values and interests [30], different needs for complexity—researchers often rely on complex methods to attain scientific rigour, while policymakers prefer simplicity and may be suspicious of complex analyses [96]—and different tolerances of uncertainty in evidence—researchers are reluctant to claim results of statistical analyses are “100% certain,” while policymakers may be reluctant to accept anything less than 100% proof [114-116].

The “two-communities” issue may challenge the initial establishment of linkages between researchers and policymakers [99]. Naïveté on the part of researchers with respect to the policy process and on the part of policymakers with respect to the research process can lead to mutual distrust between the parties [24] and undermine KTE success [90, 96, 99, 103]. Mutual trust and respectful professional relationships are critical to effective information exchange in integrated KTE [118]; however, extensive time and
resources are required to overcome researcher-policymaker cultural differences in establishing such relationships [90, 95, 99].

**Barriers related to the research organization**

The culture and leadership of the research organization toward KTE significantly impact KTE engagement by researchers [103, 113, 119]. “Engaged institutions” in academia are characterized by responsiveness (to collaborative relationships and real-world problems), respect for partners, academic neutrality, accessibility, integration of engagement into the institutional mission, coordination, and adequate resources for KTE [113, 124, 125]. Acknowledgement by organizations of the important role that promotion and incentive policies play in employee prioritization of KTE over other work activities (e.g., traditional publication) is essential [113]. Traditional incentive systems that value within-group activity furnish no motivation for researchers to diverge from conventional practices such as peer-reviewed publication [99, 103, 113, 126]. Instead, a lack of KTE incentives coupled with a finite number of hours in a work week force researchers to prioritize KTE low relative to other work activities [113]. Low KTE prioritization means few researchers have KTE experience, few receive KTE training, and few resources are available to defray KTE costs [113]. Significant resource allocation is necessary to learn the policymaking environment and policy process, to gain credibility with the target audience, and to sustain the exchange of ideas [90, 95, 113], and a lack of resources has been linked to a lack of KTE success [103, 114, 127]. Power and budget struggles internal to research organizations can further limit researcher opportunities for KTE [24].

Jacobson [113] advises that research organizations wishing to manifest a KTE-forward culture in their employees should include KTE activities as viable components in
promotion and tenure processes and other internal policies; make KTE documentation standard practice; provide KTE training, funding, and administrative support; provide structured and informal opportunities for linkage with target audiences; develop dedicated units, administrative positions, or knowledge brokers with mandates to engage specific target audiences; recruit employees with KTE skills; and emphasize KTE in operational plans and mission statements.

**Barriers related to the policymaking organization**

Organizational culture and leadership also influence policymaker use of research [68, 99, 103, 105, 115, 128]. In policymaking organizations with limited KTE cultures, individual policymaker receptivity to research evidence can be low [103], collection and appraisal of research can be viewed as non-work activities [115], and policymakers may be more likely to use web-search techniques to find information or go with their “gut feelings” to make decisions [68]. A lack of organizational support for use of research evidence in decision making can mean policymakers are untrained in the critical appraisal and adaptation of research [115], and there may be no incentive for policymakers to engage in higher scientific training [114]. As well, senior managers may not include research use in their expectations of decision makers [115], documents used to inform decisions may not be structured to include research evidence [115], and compensation may not be provided to decision makers for the effort required to acquire and use research evidence [114]. Institutional constraints can limit resources for KTE and research use [68, 99, 128], and budget cuts can further restrict policymaker KTE capacity [115]. Strong leadership and a receptive organizational culture have been cited as critical factors.
necessary to develop organizational capacity for evidence-informed decision making [121].

The structure and processes of the policymaking organization can also influence research use by policymakers [99, 103]. High turnover of staff, especially in decision-making positions, challenges the establishment of long-term linkages between researchers and policymakers [24, 68, 95] and the retention of knowledge within policymaking organizations [68]. The development of a knowledge management strategy within a policymaking organization may improve access to research evidence [121, 128] and result in improved “institutional memory” [11, 68]. The structure of the policymaking organization, including its size and maturity, formalization, differentiation, decentralization, and presence of “slack” resources (i.e., extra financial or human resources not defined for a specific use) [103] also influences the uptake, absorption, and use of new knowledge [103]. Mature, differentiated organizations made up of relatively autonomously acting units, with adequate resources, capacity and external links facilitate the acquisition, diffusion, and use of knowledge [103]. The role of the policymaking organization in the larger political system influences the type of decision being made: some organizations may make mainly “content-driven” technical decisions (e.g., selection of the appropriate field-level test to measure pathogen presence in food), while others may make mainly “large-scale” political decisions (e.g., whether to implement pathogen reduction strategies for \textit{E. coli} O157 in ground beef) [30, 129]. Groups developing content-driven technical policy may make greater instrumental use of research evidence, while conceptual use may prevail in large-scale policy development [129].
Barriers external to research and policymaking organizations

External to researcher and policymaker organizations, funding agencies and the general political environment can influence KTE success [28, 99, 103, 104, 114]. The prioritization of primary research over syntheses by funding agencies can restrict the output and ultimate availability of systematic reviews and other syntheses for policymaking [103, 114]. Similarly, limited external funding for KTE activities that promote dialogue between researchers and policymakers may reduce KTE engagement and the sustainability of integrated KTE strategies [114].

In policy decision making, the role of the larger political context and the power of the coalition of actors external to the decision-making organization cannot be overemphasized [28, 99, 104]. KTE success may be undermined when research use is simply conceptualized as the technical implementation of scientific evidence by individual decision makers, who can be targeted in a context that is void of political interests [28, 104]. Because policy decision making occurs in a political environment, government interests, values, and ideology compete with both colloquial and scientific evidence in the decision-making process [30, 129], and political instability [24] and power struggles between committees and lobbies [68] can further limit the use of research [99, 103]. Long-held politically based beliefs and entrenched ideas can be impervious to new research evidence, while competing interests and philosophies, outside of those of the ruling party, may constrain the use of research evidence by policymakers [103, 115, 130]. As well, when policy decisions occur in a field in which social, economic, or political power is unequally distributed, the presentation of controversial evidence not aligned with prevailing opinion may be labeled advocacy and conflict may occur between researchers and powerful interest groups or governments resistant to change [104, 131]. In these
circumstances, the interests of the powerful social groups may trump research evidence in policy decision making, irrespective of the strength and rigour of the scientific evidence [104]. Thus, research findings may have a limited role to play when policy change must come about through diverse, non-linear negotiations within an array of actors in a political environment charged with interests, ideals, and ideologies [104].

**STUDY RATIONALE AND RESEARCH OBJECTIVES**

In March 2005, a 2-day workshop was held in Canada for interested national and international researchers and policymakers in microbial food safety, to begin development of a framework for microbial food safety policy research [3]. Interest in KTE and evidence-informed policy has grown in the Canadian food safety system since that time, as demonstrated locally by the evolution of a KTE community of practice between researchers at the University of Guelph, the Public Health Agency of Canada, and the Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA); as well as the establishment of KTE funding initiatives within the University of Guelph-OMAFRA Partnership. While much activity and interest exist surrounding KTE in food safety, little formal research has been conducted in the field. As such, a series of researcher-level studies was proposed to broaden the evidence base of KTE in the Canadian microbial food safety system. The major objectives of these studies, which are described in this dissertation, are as follows:

1. To quantitatively evaluate Canadian microbial food safety researchers’ awareness of and attitudes toward KTE, as well as their engagement in selected KTE activities (Chapter 2),
2. To quantitatively evaluate the presence of selected potential barriers to KTE, from the perspective of researchers, in the Canadian microbial food safety system (Chapter 3),

3. To qualitatively explore researchers’ attitudes toward KTE and perceived barriers to KTE, in the Canadian microbial food safety system (Chapter 4), and

4. To quantitatively and descriptively evaluate changes in research output over time, and to identify potential disparities in timing and information between research output and apparent policy needs, for three major foodborne pathogens in Canada (Chapter 5).
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Figure 1.1. Total annual citations indexed in PubMed, 1950–2007
Figure 1.2. The CHSRF framework of evidence-informed policymaking in the Canadian food safety system.

Adapted from [13] Canadian Health Services Research Foundation: Health services research and...evidence-based decision-making. 2000.
CHAPTER 2

Knowledge translation and exchange in the Canadian microbial food safety system: A quantitative assessment of researcher awareness, attitude, and activities with government policymakers

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ABSTRACT

Knowledge translation and exchange (KTE) is a process through which research evidence can more effectively inform decision making in policy and practice environments. A telephone survey of Canadian microbial food safety researchers was conducted in 2009 to examine aspects of researcher KTE activities with government policymakers. Overall, researcher awareness of and engagement in KTE activities was high, although engagement was mainly through end-of-research dissemination activities rather than throughout the research process (integrated knowledge translation) and engagement in some high-quality KTE activities was low. Government researchers were significantly more likely to engage in KTE activities with federal policymakers and did so with greater frequency than non-government researchers.
INTRODUCTION

Promotion of the use of research evidence has intensified in the medical field over the last few decades, as a means of ultimately improving health outcomes through the use of the most up-to-date health technologies and practices available. Concurrently, there has been increased focus on determining the ideal mechanisms that encourage the uptake of research evidence in healthcare practice and policymaking (Mitton et al., 2007). Initial assumptions were that decision makers would use evidence, if it was communicated to them. Thus, it was believed that the use of evidence depended largely on effective communication, and that improvement of the distribution of research findings would yield increased evidence-informed decision making (Nutley et al., 2008). However, research has demonstrated that while the distribution of evidence in the form of educational materials may raise awareness of evidence and may initiate an attitude change in a target audience, rarely does dissemination alone provoke behaviour change (e.g., lead to a different policy decision) (Grimshaw et al., 2001; Lomas, 1991). Many studies have elucidated key factors facilitating the uptake of research evidence by health policymakers (summarized in a systematic review by Innvaer et al. (2002)). With knowledge of the potential facilitators of research evidence uptake by policymakers and with recognition of the complexity of the policymaking process, models and conceptual frameworks have been developed to aid in the promotion of the use of research evidence within the government policy process (Canadian Health Services Research Foundation, 2000; Ebener et al., 2006; Elliott and Popay, 2000; Graham et al., 2006; Hanney et al., 2003; Jacobson et al., 2003; Lavis et al., 2003; Lomas, 2000; Weiss, 1979). A key concept
found in most of these frameworks is the integration of research-policymaker engagement into the various stages of the research process, as well as the dissemination of end-of-research products. Several studies have demonstrated that interaction of researchers and their target audiences throughout the research process increases the use of research evidence by the end-user (Elliott and Popay, 2000; Innvaer et al., 2002; Ross et al., 2003; Walter et al., 2003). This interactive mechanism of promoting the use of research evidence by target audiences has been termed “knowledge translation and exchange” (KTE) (Canadian Institutes of Health Research, 2010).

Although KTE was conceptualized in the healthcare field, many other areas have adopted and adapted the relevant KTE theories (Nutley et al., 2008). To date, however, no research has been conducted to determine the extent to which KTE has been integrated into food safety research and policy in Canada. In Canada, food safety policy is a shared responsibility between federal, provincial/territorial (hereafter “provincial”), and local governments. Within this partnership, the federal government develops national strategies for food safety, while identifying and assessing health risks within the food chain. Provincial mandates include surveillance, investigations, and compliance (Health Canada and The Canadian Food Inspection Agency, 2005). Local food safety programs focus mainly upon enforcing provincial policies regulating food retail establishments (e.g., restaurant inspection). Public awareness of microbial food safety (MFS) has heightened over the past few years following several high-profile food- and water-borne disease outbreaks (Ali, 2004; Attaran et al., 2008; Canadian Broadcasting Corporation, 2009). As a result, MFS policy decision making has come under scrutiny (Attaran et al., 2008).
Presumably, an evidence-informed approach to policymaking should improve food safety regulations, leading to greater food safety for Canadians and a reduction in the incidence of food-borne disease. Vast bodies of MFS research evidence exist, produced by both government and non-government researchers; however, it is unclear to what extent researchers attempt to inform policymaking. To address this knowledge gap, a survey of MFS researchers in Canada was undertaken. The objectives of this survey were (1) to evaluate Canadian MFS researcher awareness of and attitude toward KTE with government policymakers, (2) to investigate the types of KTE activities conducted by researchers, (3) to assess the frequency at which MFS researchers engaged in KTE activities with government policymakers in the previous 5 years, (4) to determine if government researchers engage in KTE activities at different frequencies than non-government researchers, and (5) to determine if end-of-research dissemination activities occur more frequently than integrated KTE.

MATERIALS AND METHODS

A telephone survey of Canadian researchers who had conducted MFS research on foods of animal origin was conducted. For the purposes of this study, the definition of “MFS research of foods of animal origin” included studies of foodborne pathogens anywhere along the farm-to-fork continuum; foodborne-pathogen surveillance; pathogen test-development research; and human or animal population or public health research. Studies purely evaluating human enteric-pathogen prevalence data were excluded as was antimicrobial resistance research.
Researchers were included in the study sampling frame if they were based in Canada and had conducted MFS research on foods of animal origin in Canada in the previous 5 years. A sampling frame of researchers was populated using a combination of web-search methods followed by a snowball approach. Initially, Canadian authors’ names were extracted from articles pertaining to MFS in the Journal of Foodborne Pathogens and the Journal of Food Protection from January 2004 to January 2009. Second, Canadian authors’ names were extracted from articles found using search terms “food” and “Canada”, “food safety” and “Canada”, “Salmonella” and “Canada”, “E. coli” and “Canada”, and “Campylobacter” and “Canada” (the three most prevalent foodborne pathogens in Canada) between January 2004 and January 2009 in the search engine Entrez Pubmed (http://www.ncbi.nlm.nih.gov/sites/entrez?db=pubmed). Finally, using a snowball approach, additional researchers were identified in publicly-accessible directories of the organizations of previously-identified researchers. Graduate students and post-doctoral students were excluded, as were researchers for whom no contact information was available.

A survey instrument was developed to collect information on researcher demographics (Table 1), researcher awareness and attitude toward KTE, and the frequency at which researchers had engaged in various KTE activities with policymakers in the previous 5 years. Respondent awareness of KTE was assessed using 3 questions modified from Michel and Sneed (1995): (1) “Prior to this survey, had you heard about KTE?”; (2) “Prior to this survey, had you read any literature about KTE?”; and (3) “Are you aware of any researchers who have conducted KTE activities with local, provincial,
or federal policymakers?” A positive response to any of these questions indicated awareness of KTE. A positive or negative attitude toward KTE was determined by asking respondents, “Do you believe that MFS researchers should alter the research process to conduct KTE with policymakers, where it is applicable and feasible to do so?” Respondents were asked with which government level(s) they had conducted KTE activities in the previous 5 years (i.e., federal, provincial, or local/regional), and for each government level identified positively by the respondent, questions were asked to assess the frequency at which the respondent had engaged in KTE activities. KTE activities were categorized into the following groups: (1) types of written research products provided (e.g., reports of primary research, syntheses, or systematic reviews), (2) media in which the products were provided (e.g., hard copy, email, website, list serve, orally), (3) other KTE activities (e.g., providing a searchable database of research results to policymakers), (4) interactions with policymakers at different stages of the research process, (5) venues of interactions outside of the research process, and (6) respondent evaluation of his or her KTE activities with policymakers (Figures 1–10). Respondents were asked to consider the frequency at which they engaged in each activity in relation to how often it was feasible to do that activity, not the number of times an activity was performed in the previous 5 years. Respondents were left to interpret the concept of “feasibility” as it would be context specific and dependent on numerous factors. A frequency scale was provided, as follows:

1) **Never**: a particular KTE activity was never undertaken when it was feasible to do so (or it was never feasible).
2) **Rarely**: fewer than half the times that it was feasible to do so

3) **Occasionally**: approximately half the times that it was feasible to do so

4) **Frequently**: more than 50% of the time that it was feasible to do so

5) **Almost always**: almost every time that it was feasible to do so

All MFS researchers in the sampling frame were contacted initially by email in January 2009, with a follow-up email to non-respondents 6 weeks later. Respondents were contacted by telephone at a mutually agreed upon time to complete the survey. Prior to completing the survey, respondents were emailed the criteria for the frequency scale described above, and definitions of “KTE activities”, “policymaker,” “primary research,” “syntheses,” “systematic reviews,” and “actionable messages.”

Surveys were conducted between January and May 2009 by DW and took 1–2 hours to complete. A data collection interface was developed within Microsoft Access (Microsoft Corp, 2007) to ensure consistency in question order and phrasing between respondents and to minimize transcription errors. Data were imported into Stata 9 (Stata Corp, College Station, TX) for analysis.

Descriptive statistics were determined for demographic variables. Data from KTE awareness and attitude questions were evaluated to determine the proportion of respondents with previous KTE awareness and with positive attitudes toward KTE. Unless noted otherwise, all associations between researcher type (i.e., government or non-government) and KTE awareness, attitude, and dichotomous activity engagement responses were evaluated using Fisher’s exact tests due to sparse data. Pearson $\chi^2$ tests of association were used otherwise, where the data allowed.
Separate analyses of the KTE activity frequency data were conducted for federal and provincial policymaker levels. KTE with local policymakers could not be evaluated due to a paucity of data. Frequency distributions of the responses for each KTE activity were evaluated visually for respondents as a whole and for government and non-government groups separately. Wilcoxon rank sum tests (Agresti, 2002) were used to test for statistically significant differences in the frequency distributions for government and non-government researchers. Frequency distributions demonstrated to be significantly different were evaluated visually and mean frequencies (determined on a latent continuous scale described below) were compared to determine how the response distributions of the government and non-government groups differed. A latent continuous scale (Powers and Xie, 2008) was assumed to underlie the categorical response scale measuring the frequency of engagement in the various KTE activities. Mean frequencies of engagement were calculated for each KTE activity for all researchers and for government and non-government researcher groups separately on the assumed continuous scale. Using the latent scale, mean frequency of engagement values could assume non-whole numbers and could range from 1 (Never) to 5 (Always), with a value \( \geq 3 \) indicating the activity was engaged in 50% or more of the times it was feasible to do so.

Fisher’s exact tests were used to compare the proportion of researchers engaging in any end-of-grant activities (KTE activities after the main research process) with the proportion engaging in KTE activities at each of the first five stages in the research process: (1) when developing the research question, (2) when establishing the research design and methods, (3) when executing the research, (4) when analyzing or interpreting
the research findings, and (5) when developing the research products. These tests were conducted at both the federal and provincial levels for researchers as a whole.

RESULTS

Of the 115 researchers in the sampling frame, 66 surveys were completed (response rate of 57%). Government researchers comprised 61% of the respondents (n = 40), while 39% of the respondents were non-government researchers (n = 26) employed in academia (n = 24) or private organizations (n = 2). The response rate was similar in both the government and non-government researcher categories at 56% and 58%, respectively. Of the 49 non-respondents, 12 indicated they could not participate because they were not working (i.e., on maternity leave, sabbatical, etc.), 8 initially agreed to participate but could not be reached in follow-up communications, and 29 did not respond to either recruitment email.

Demographic data

Demographic variables are summarized in Table 1. No respondents had been conducting MFS research for less than 2 years.

Researcher awareness of and attitude toward KTE

Most researchers (83%, n = 55) had heard of the concept of KTE (technology transfer was included in the definition of KTE), while 47% (n = 31) had read literature about KTE, and 86% (n = 57) knew someone who had engaged in KTE activities. Only 6% of participants (n = 4) had no awareness of KTE, indicated by negative responses to all three of the above questions. For each of the three awareness questions, there were no
significant differences between the responses of government and non-government researchers (heard of KTE: \( p = 0.505 \); read about KTE: \( p = 0.056 \) (\( \chi^2 \) test); aware of others doing KTE: \( p = 0.301 \)).

Only those respondents who had awareness of KTE as determined by the previous questions were asked about their attitude toward KTE (\( n = 62 \)). These respondents were asked whether they believed that the research process should be altered to include KTE with policymakers, where it was applicable and feasible to do so. Most respondents (92%, \( n = 57 \)) agreed, and this belief was consistent across government and non-government researchers (\( p = 0.640 \)).

**Proportion of researchers conducting KTE and frequency of engagement**

Eight of the 66 respondents (12%) had not conducted KTE with any government policymakers while 50 researchers (75.8%) had engaged in KTE activities with federal policymakers, 42 (63.6%) with provincial, and 9 (13.6%) with local policymakers. More than half of the respondents had engaged in KTE activities with more than one government level of policymaker (\( n = 37 \)). Government researchers were significantly more likely to have engaged in KTE activities with policymakers at the federal level than non-government researchers (85% of government researchers compared to 62% of non-government researchers; \( p = 0.030 \)). Otherwise, there were no significant differences between government and non-government researchers with respect to the policymakers with whom they had engaged in KTE activities. The combination of government levels of policymakers with whom researchers had engaged in KTE activities most frequently was
federal and provincial but not local policymakers (48.3% of all researchers conducting KTE; n = 28).

The proportion and frequency data presented below are for the subset of respondents who had engaged in KTE activities with either federal or provincial policymakers, not all respondents. Only significant frequency data are shown (e.g., distributions of frequency of engagement that were significantly different on Wilcoxon rank sum tests). Where these data are presented, both the Wilcoxon rank sum p-value as well as the mean frequency of engagement (denoted as $\bar{x}$) of the government and non-government groups are shown, to indicate which group had engaged in the activity at a greater frequency. The proportions of researchers that had engaged in each KTE activity are presented in Figures 1 through 10.

Regarding the provision of various written documents to policymakers (Figures 1 and 2), less than a quarter of researchers had conducted a systematic review of a MFS topic. Government researchers had provided reprints (Wilcoxon rank sum $p = 0.030$; mean frequency ($\bar{x}$) = 3.1 vs. 2.3, on the latent scale), full reports of primary research ($p = 0.046$; $\bar{x} = 3.3$ vs. 2.4), and full reports of syntheses ($p = 0.048$; $\bar{x} = 3.0$ vs. 2.7) to federal policymakers at significantly greater frequency than non-government researchers. There were no significant differences between researcher types in the frequency of provision of documents to provincial policymakers.

Regarding various media used in KTE activities (Figures 3 and 4), less than 25% of researchers had provided a searchable database of research evidence for policymakers. The media used by the greatest proportion of respondents to provide research products to
federal and provincial policymakers were mail or email and in verbal form. There were no significant differences in the reported frequencies at which government and non-government researchers had engaged in these activities with either federal or provincial policymakers.

Regarding engagement with policymakers at various stages of the research process (Figures 5 and 6), a significantly greater proportion of all researchers had engaged in end-of-grant activities (i.e., dissemination of research products) with federal policymakers than had collaborated with policymakers at the following early stages of the research process: developing the research question \( (p = 0.031) \), establishing the research design and methods \( (p = 0.008) \), executing the research \( (p = 0.016) \), analyzing or interpreting the research findings \( (p = 0.008) \), and developing research products \( (p = 0.031) \). Government researchers collaborated with federal policymakers at a significantly greater frequency than non-government researchers to develop research questions \( (p = 0.005, \bar{x} = 3.4 \text{ vs. } 2.1) \). No significant differences in frequency of engagement were seen at the provincial level.

Regarding venues used outside of the formal research process to interact with policymakers, (Figures 7 and 8), formal networks had been used by fewer participants than other venues such as government meetings, expert committees, conferences, and researcher organized events to interact with federal and provincial policymakers. Government researchers had engaged federal and provincial policymakers significantly more frequently at researcher organized events than had non-government researchers (Federal: \( p = 0.007, \bar{x} = 3.2 \text{ vs. } 2.3 \); Provincial: \( p = 0.048, \bar{x} = 3.0 \text{ vs. } 2.2 \)). Government
researchers also had engaged provincial policymakers more frequently on expert committees than had non-government researchers ($p = 0.014, \bar{x} = 2.8$ vs. $2.2$).

Compared to the other KTE activities assessed in this survey, evaluations of KTE activities had been conducted by relatively fewer researchers (Figures 9 and 10). Less than a third of researchers had formally assessed changes in policymakers’ actual behavior that could have been attributed to their KTE activities, and the very low frequency of engagement in that evaluation activity ($\bar{x}$ range = 1.1 to 1.5) indicates that those who had engaged in the activity did so very rarely.

**DISCUSSION**

By definition, applied research is directed toward a specific practical aim and is more than the creation of new knowledge (Organization for Economic Co-operation and Development, 2002). As a consequence, applied research generally has one or more end-users, with KTE activities facilitating the exchange of knowledge between researcher and end-user. Government policymakers are just one of many potential end-users of MFS research. The high proportion of participants in this survey that agreed that policymakers should be included in the research process and the high proportion that had engaged in KTE activities with policymakers indicate high awareness of KTE with policymakers, beyond traditional KTE with industry partners. In part, this high awareness may be due to major Canadian funding agencies recently beginning to require descriptions of KTE deliverables in research proposals (Ross et al., 2007). As well, some Canadian government organizations employing researchers have added a commitment to KTE with policymakers to their mission statements (e.g., Canadian Food Inspection Agency...
Thus, funding agencies and government organizations may help to drive KTE awareness amongst MFS researchers in Canada.

While awareness of KTE was high amongst survey participants, engagement in activities considered promising to bridge the research-policy gap (Lavis et al., 2010) was low. KTE activities can be divided broadly into three categories: producer-push activities (researcher efforts to disseminate evidence to target audiences), user-pull activities (procurement of evidence from researchers initiated by target audiences), and exchange activities (involvement of target audiences in the research process). Providing systematic reviews and offering access to a searchable database of research findings have been described as promising producer-push and user-pull activities, respectively (Lavis et al., 2010). Systematic reviews and meta-analyses facilitate the uptake of research evidence by reducing the bias and uncertainty inherent in individual research studies and by reducing the time required by target audiences to find, appraise, and synthesize the available literature (Ciliska et al., 1999). Similarly, offering access to searchable databases of research findings facilitates the procurement of relevant evidence from researchers by target audiences. Less than a quarter of participants in this study had engaged in either of these producer-push or user-pull activities, similar to an international survey of health researchers in low-to-middle-income countries (Lavis et al. 2010). If MFS researchers and policymakers in Canada and other countries wish to engage more effectively in KTE, participation in bridging activities by both producers and users should be considered.

KTE research in the medical field has typically focused on determining the most effective practices to increase the uptake and use of research evidence by either health-
care practitioners or policymakers (Nutley et al., 2008). In both practitioner and policymaking areas, similarities exist in the effectiveness of KTE interventions. Specifically, passive interventions (i.e., distribution of evidence in written form) are generally considered ineffective in altering a target audience’s decision-making behaviour but may be useful to increase awareness of research evidence (Bero et al., 1998; Freemantle et al., 2007; Grimshaw et al., 2001; Lomas, 2000; Matowe et al., 2002). Multifaceted or active approaches to knowledge transfer—e.g., inclusion of policymakers in the research process, termed “integrated KTE” (Canadian Institutes of Health Research, 2010)—are considered to be more efficacious in increasing the use of evidence in decision making (Cranney et al., 2008; Freemantle et al., 2007; Gagnon, 2011; Gibbons et al., 1994; Grimshaw et al., 2004; Grol, 2001; Jack et al., 2010; Lane and Flagg, 2010; Lomas, 2000; McGrath et al., 2009; O’Brien et al., 2007; Osterling and Austin, 2008). In light of the evidence supporting integrated KTE, the Canadian Institutes of Health Research (CIHR), a health-care funding body of the Canadian government, require knowledge-users to be co-investigators for some funding opportunities (Graham et al., 2009). In our survey, researchers generally appeared to have a desire to have their messages heard, indicated by >75% overall prevalence of passive dissemination; however, considerably less involvement in integrated KTE activities was reported, suggesting that, in the past, researchers’ efforts may have served more to raise awareness of MFS issues than to influence policy decision-making. Some respondents who had engaged in integrated KTE were likely researchers working in Canadian government regulatory agencies, where KTE is formally integrated within the research process.
Although integrated KTE exists within government regulatory groups, researchers elsewhere should not refrain from engagement in KTE with policymakers. Different groups of researchers have differing capacities to conduct different types of research, and KTE engagement by various groups may contribute a greater scope of evidence relevant to the policy area.

As illustrated within Canadian government regulatory agencies, a research group’s capacity to engage in effective KTE with policymakers may be affected by its location within the policy community. A policy community is “that part of a political system that…acquires a dominant voice in determining government decisions in a specific field of public activity...” (Pross, 1986). The community can be depicted diagrammatically as a circle, with groups actively involved in the policy process lying centrally (the sub-government) and groups with interest in but less influence over the process lying more peripherally (the interested public). Government agencies, pressure groups, media, and individuals—including non-government researchers—could be part of the policy community. Forbes (1985) modeled the Canadian farm and food policy community, placing government agencies and their researchers centrally and non-government researchers more peripherally. While changes in the Canadian government structure have caused the policy community to be altered considerably in the ensuing 25 years, there is no reason to believe that the relative locations of government and non-government researchers within the community have changed. In this survey, government researchers consistently reported engaging more frequently in most of the KTE activities than non-government researchers, although not all differences were statistically significant. Central
placement within the policy community may have contributed to this apparent trend, as well as other potential factors, such as a greater capacity to conduct KTE or a greater value placed on KTE with policymakers in government versus academic organizations.

Promotion of a culture of KTE and research-evidence use within policy decision-making systems may be enhanced through the creation of formal researcher-policymaker networks (Jbilou et al., 2007). Within the educational research literature, network analysts suggest that strong linkages between practitioners and researchers may promote more numerous and meaningful exchanges of information (Huberman, 1990). Similarly, Kiefer et al. (2005) suggest that the development of a Canada-wide network of population and public health practitioners and research experts could potentially identify knowledge gaps, improve methods of conducting research, and increase the uptake and utilization of evidence by policymakers. The development of researcher-policymaker networks was also determined to be a strategy to promote research-based decision making in Canadian health organizations (Jbilou et al., 2007). In this survey of MFS researchers, formal networks to interact with policymakers were used less frequently than other means such as meetings, conferences, and expert committees or groups. In Canada, there is a tendency for MFS research groups to be small and scattered across a broad geographic area, potentially leading to a lack of cohesion in the MFS research sector. This lack of cohesion may limit policymakers’ ability to identify experts. Strong formal MFS researcher-policymaker networks—inclusive of academics and researchers beyond a single government department—and similar to those proposed in the public health and health-care sectors above, could provide a cohesive system of support.
Awareness of KTE with policymakers appears to be high amongst Canadian MFS researchers; however, the survey findings suggest a dearth of high-quality KTE activities, evidenced by low participation in integrated KTE and promising bridging activities and little use of formal researcher-policymaker networks. Elsewhere in the world, food safety systems are developing innovative strategies that address these issues (e.g., the development of the European Food Safety Authority (EFSA) and Biosecurity New Zealand). The creation of EFSA in 2002 established an independent authority to provide timely, impartial evidence-based advice upon request from the European Commission, European Parliament, or European Union Member States regarding emerging and ongoing food safety risks (European Food Safety Authority, 2012; Silano and Silano, 2008). To this end, EFSA engages in integrated KTE, through the exchange of knowledge with policymakers to aid in identification of food safety issues of political concern (Silano and Silano, 2008). Among other duties, EFSA coordinates targeted risk assessments to be completed by its scientific staff and Member States, and has recently committed to adopting systematic review methodology, where appropriate beyond the risk assessment process (a promising producer-push bridging activity) (European Food Safety Authority, 2010). Knowledge exchange is facilitated by the EFSA website, where scientific opinions adopted by EFSA are available for both specialist and non-specialist audiences (Silano and Silano, 2008), and by the Information Exchange Platform, a digital forum to share information on risk assessment activities and completed reports, accessible by Member States and nominated individuals (a promising user-pull bridging activity) (European Food Safety Authority, 2011). To aid information exchange further, several
formal networks have been developed and are supported by EFSA: issue-based networks to facilitate scientific cooperation between Member States (European Food Safety Authority, 2011); networks of European organizations capable of collaborating to assist EFSA through grant and procurement schemes (European Food Safety Authority, 2011); and the EFSA Database, a roster of external scientific experts, including academics and other individuals, that can be sourced for participation—sometimes at short notice—in the work of Scientific Panels or the Scientific Committee (European Food Safety Authority, 2011; Silano and Silano, 2008). Through integrated KTE, promising producer-push and user-pull bridging activities, and formal networks, EFSA strives to provide rigorous evidence-based advice to European political bodies. Continually morphing to more effectively meet its goals (European Food Safety Authority, 2012; Silano and Silano, 2008), EFSA represents a useful model, internationally, for food safety KTE in a challenging geopolitical landscape.

Despite having a good response rate, the survey’s small sample size may have reduced the power of the analysis to detect significant differences in some comparisons. As well, the low prevalence of KTE with local policymakers amongst respondents prevented analysis of the data at the local level. Two other issues may have influenced the study findings. First, some non-government researchers may have included funding agencies in the definition of “policymaker.” When asked at the end of the survey to provide names of important Canadian food safety policymakers, approximately 5 non-government researchers who had previously reported to have engaged in KTE activities indicated that they had not interacted directly with policymakers (and, thus, could not
name one). Instead, they had provided their research products to the government funding agency that had funded their research, with the assumption that the agency would pass the information to the relevant policymakers. While this revelation occurred infrequently, the true overall proportion of researchers engaging in KTE activities with policymakers should be less than the reported 88%. Because only non-government researchers appeared to misinterpret the “policymaker” definition, the apparent proportion of researchers in this group engaging with federal policymakers was inflated and the true difference in the proportions of government and non-government researchers engaging in federal KTE should be more profound than reported. A second issue that may have influenced the study’s findings was a lack of heterogeneity in the government researcher group. Government researchers were naturally clustered according to the government level in which they were employed (primarily federal or provincial), their government organization (federal researchers), and their province (provincial researchers). Of the 40 government researchers surveyed, the majority were employed at the federal level, reflecting the distribution of researchers in the sampling frame. Thus, the findings of this study, where they relate to government researchers, reflect mainly the experiences of federal-level researchers. The data could not be analyzed by government or organizational level due to the small sample size.

Although the findings of this study are specific to Canada, they indicate an awareness of KTE in the researcher community that we hope crosses geographic boundaries. Internationally, EFSA represents one possible model that incorporates promising KTE strategies. In Canada, the apparent low prevalence of integrated KTE and
promising bridging activities are areas where improvement could be made. Focus group studies may illuminate the background mechanisms that are driving the findings of this study. Greater understanding of the MFS sector, from both a researcher and a policymaker perspective, will aid in the development of effective KTE resources, ultimately promoting a culture of evidence-informed policy decision making.
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Table 2.1. Descriptive statistics of the demographics of participants in a survey of microbial food safety (MFS) researchers in Canada in 2009.

<table>
<thead>
<tr>
<th>Categorical variables</th>
<th>Categories</th>
<th>Number of respondents</th>
<th>Proportion of all respondents (%)</th>
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<tbody>
<tr>
<td>Number of years conducting MFS research, excluding graduate work</td>
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<td>12</td>
<td>18.2</td>
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<td></td>
<td>&gt;5 years</td>
<td>54</td>
<td>81.8</td>
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<tr>
<td>Type of employment while conducting MFS research on foods of animal origin, in the last 5 years (If more than one, the most recent organization was used and further questions were based on this organization.)</td>
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<td>60.6</td>
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<tr>
<td>Topic area of MFS research</td>
<td>Non-government</td>
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<td>39.4</td>
</tr>
<tr>
<td></td>
<td>Veterinary biomedical</td>
<td>10</td>
<td>15.2</td>
</tr>
<tr>
<td></td>
<td>Human biomedical</td>
<td>4</td>
<td>6.1</td>
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<tr>
<td></td>
<td>Food quality</td>
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<tr>
<td></td>
<td>Veterinary population/public health</td>
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<td>33.3</td>
</tr>
<tr>
<td></td>
<td>Human population/public health</td>
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<td>22.7</td>
</tr>
<tr>
<td>Type of research</td>
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<td>---------------------------</td>
<td>-----------------</td>
<td>-----</td>
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</tr>
<tr>
<td>Primarily applied</td>
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<td>59.1</td>
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<td>Equal mix</td>
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<tr>
<td>Highest level of post-secondary education</td>
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<td>Other graduate degree</td>
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<td>Graduate degrees obtained outside of Canada</td>
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<td>39.4</td>
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<td>No</td>
<td>40</td>
<td>60.6</td>
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<tr>
<td>Sex</td>
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<td>Number of years since completion of highest level of post-secondary education</td>
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<td>18</td>
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<td>Number of researchers employed at workplace</td>
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<tr>
<td>Number of these researchers conducting MFS research</td>
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<td>Number of days spent at conferences or interacting with external colleagues, in the past year</td>
<td>Days</td>
<td>22.3</td>
<td>20</td>
</tr>
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</table>
Figure 2.1. Proportions of respondents who had provided various written documents to federal policymakers, of those respondents who had engaged in KTE activities with federal policymakers, in a survey of Canadian microbial food safety researchers in 2009.
Figure 2.2. Proportions of respondents who had provided various written documents to provincial policymakers, of those respondents who had engaged in KTE activities with provincial policymakers, in a survey of Canadian microbial food safety researchers in 2009.

- All researchers who conducted KTE with provincial policymakers (n = 42)
- Non-government researchers who conducted KTE with provincial policymakers (n = 17)
- Government researchers who conducted KTE with provincial policymakers (n = 25)
Figure 2.3. Proportions of respondents that had used various media in their KTE activities with federal policymakers, of those respondents who had engaged in KTE activities with federal policymakers, in a survey of Canadian microbial food safety researchers in 2009.
Figure 2.4. Proportions of respondents that had used various media in their KTE activities with provincial policymakers, of those respondents who had engaged in KTE activities with provincial policymakers, in a survey of Canadian microbial food safety researchers in 2009.
Figure 2.5. Proportions of respondents that had interacted with federal policymakers at various stages of the research process, of those respondents who had engaged in KTE activities with federal policymakers, in a survey of Canadian microbial food safety researchers in 2009.
Figure 2.6. Proportions of respondents that had interacted with provincial policymakers at various stages of the research process, of those respondents who had engaged in KTE activities with provincial policymakers, in a survey of Canadian microbial food safety researchers in 2009.
Figure 2.7. Proportions of respondents that had interacted with federal policymakers at various venues outside of the formal research process, of those respondents who had engaged in KTE activities with federal policymakers, in a survey of Canadian microbial food safety researchers in 2009.
Figure 2.8. Proportions of respondents that had interacted with provincial policymakers at various venues outside of the formal research process, of those respondents who had engaged in KTE activities with provincial policymakers, in a survey of Canadian microbial food safety researchers in 2009.
Figure 2.9. Proportions of respondents that had used various methods to evaluate their KTE activities with federal policymakers, of those respondents who had engaged in KTE activities with federal policymakers, in a survey of Canadian microbial food safety researchers in 2009.
Figure 2.10. Proportions of respondents that had used various methods to evaluate their KTE activities with provincial policymakers, of those respondents who had engaged in KTE activities with provincial policymakers, in a survey of Canadian microbial food safety researchers in 2009.

- Assessed policymakers' perceptions of the usefulness of KTE
- Noticed any changes in policymakers' awareness of microbial food safety research that may be attributed to KTE activities
- Assessed changes in policymakers' actual behaviour that may be attributed to KTE activities (e.g., through policymaker interviews or policy document analysis)

All researchers who conducted KTE with provincial policymakers (n = 42)
Non-government researchers who conducted KTE with provincial policymakers (n = 17)
Government researchers who conducted KTE with provincial policymakers (n = 25)
CHAPTER 3

A quantitative assessment of researchers’ perceptions of the presence of selected barriers to knowledge translation and exchange in the Canadian food safety system

(Presented in the style of the journal *BMC Public Health.*

ABSTRACT

**Background:** In the Canadian food safety system, interest is evolving in knowledge translation and exchange (KTE) between researchers and policymakers to promote the use of research evidence in policy decision making. Little evidence is available regarding the barriers to KTE success from the researcher perspective. An evaluation of context-specific KTE barriers is necessary for the development of KTE strategies in the food safety sector.

**Methods:** A quantitative telephone survey of Canadian microbial food safety (MFS) researchers employed in government and non-government positions assessed the perceived presence of selected potential barriers to knowledge translation and exchange (KTE) with government policymakers. Potential barriers selected from the healthcare literature were categorized as researcher-, research-, research organization-, or system-related.

**Results:** Sixty-six researchers participated in the survey, 40 employed in government and 26 in non-government positions, for a response rate of 57%. Descriptively, two system-
related barriers were perceived most negatively by participants and were identified to likely be present in the Canadian MFS system: high policymaker turnover and lack of policymaker-driven collaborative initiatives. A lack of organizational support in the form of human and financial resources was perceived to be present by respondents, suggesting a scarcity of resources to mitigate system-related barriers.

**Conclusions:** Canadian food safety researchers perceive that food safety policymakers change job positions frequently. This may limit researchers’ ability to maintain policymaker contacts necessary for KTE. The human and financial resources necessary for KTE engagement and success may be lacking for many researchers. Shifts in organizational culture to include KTE are necessary for sustained KTE success between researchers and policymakers. Further qualitative analyses may elucidate the barriers most influencing researcher KTE with policymakers in the Canadian food safety system.
BACKGROUND

In Canada, foodborne pathogens are estimated to cause millions of cases of disease each year [1]. Sound government food safety policy decisions informed by current research evidence may aid in reducing this burden of illness. Efforts to increase the level of evidence-informed decision making in policy and practice through increased exchange of information and ideas between researchers and policymakers has been a focus of the Canadian healthcare system for several years [2, 3]. This process of information exchange has been termed knowledge translation and exchange (KTE).

Although the concept of KTE originated within the healthcare sector, it has been embraced by other fields including education, social work, and criminal justice [4], environmental policy [5], and waste and resource management [6]. There is a paucity of research focused on KTE in the food safety sector. As a result, there is little understanding of the flow of information between microbial food safety (MFS) researchers and policymakers or the factors perceived to be barriers to information exchange.

Evaluation of the context-specific barriers to and facilitators of KTE is necessary for the development of a KTE strategy by an organization or research group [7], thus much research has been conducted to identify barriers to the exchange of knowledge in the healthcare fields. Most studies have focused on the barriers experienced by policymakers throughout the KTE process that ultimately hinder the utilization of research in policy decision making (see systematic reviews by Innvaer and colleagues [8] and Orton and colleagues [9] for the main perceived facilitators of and barriers to
research utilization by policymakers). Factors at the researcher level can ultimately act as barriers to research utilization in policy because the KTE process either is never initiated or falters early in the process; however, little work has focused specifically on barriers to researcher engagement in or successful execution of KTE activities. Previously identified barriers to policymaker research utilization that could also be considered potential barriers to researcher KTE engagement include a lack of policymaker time or interest [9, 10], policymaker turnover [8, 10, 11], lack of researcher visibility [12], and lack of researcher credibility, as perceived by policymakers [7, 12-15]. Some potential barriers to researcher KTE engagement or execution have been identified in the literature but have not been empirically tested for actual impact. These potential barriers include a lack of researcher interest in KTE [16], researcher reward structures that do not recognize KTE activities [12, 17], lack of knowledge of the KTE process [18], poor researcher communication skills [7, 12, 14, 16], lack of researcher time or resources [7, 12-14, 16, 19], an inability to identify the target audience [12], and lack of policy-relevant research [13]. In an international survey of researchers, Lavis and colleagues [20] determined that stability of target audience contacts and the presence of formal structures or processes linking researchers to their target audiences were predictors of researcher engagement in selected KTE activities.

In the literature, barriers to research utilization by policymakers have been presented in four categories based upon Rogers’ Theory of Innovation Diffusion [21]: factors related to (1) the individual (i.e., the policymaker), (2) the individual’s organization, (3) the system (i.e., external to the individual’s organization), and (4) the
innovation (i.e., the research finding that has the potential to be used) [22]. Lavis and colleagues [20] modified the framework to categorize barriers to engagement in KTE activities by researchers, organizing the potential barriers into individual (i.e., the researcher and the research), organizational (i.e., the researcher’s organization), and system-related (i.e., the environment external to the researcher’s organization) factors. Categorized as such, potential barriers can be considered in terms of their ease of mitigation, with individual and organizational barriers being potentially easier to overcome than system-related factors [23]. Viewing barriers with respect to their ease of mitigation may aid in the development of KTE strategies by research organizations.

While the list of barriers to effective KTE between researchers and policymakers is extensive, little is known about the specific barriers to researcher engagement in and execution of KTE activities within the Canadian MFS sector. If KTE strategies are to be developed in food safety, an assessment of the expected potential barriers to KTE must be conducted. As such, a mixed-methods approach was proposed to investigate potential barriers to KTE engagement and execution, as perceived by MFS researchers, with this survey as the initial, quantitative, exploratory study. The specific objectives of the survey were to identify potential KTE barriers that (1) were perceived to be present in the Canadian MFS sector or (2) may have influenced KTE engagement.

METHODS

A telephone survey of Canadian researchers employed in government and non-government positions, who had conducted MFS research on foods of animal origin was completed between January and May, 2009. An in-depth description of the survey
method has been reported elsewhere [24]. Using web-based techniques, a sampling frame was populated of researchers that were employed in Canada and had conducted MFS research on foods of animal origin, outside of graduate work, in the previous 5 years [24]. The definition of “MFS research on foods of animal origin” included research along the farm-to-fork continuum on pathogens that cause human foodborne disease that are found in animals or meat products. MFS research on foods of animal origin may include foodborne pathogen surveillance, pathogen test development, intervention and risk factor analyses, human or animal population or public health research. Researchers in the sampling frame were contacted by email, with a follow-up email to non-respondents 6 weeks later. Prior to being contacted by telephone to complete the survey, respondents were emailed a survey package, including a form of relevant definitions (e.g., definitions of “KTE activities” and “policymaker”). Verbal consent was obtained on the day of the survey.

The survey instrument was developed based upon barriers identified to hinder KTE with policymakers in the healthcare field [8, 10, 13, 14, 16, 17, 25-29]. As proposed in the literature [20, 22], four categories of KTE barriers were explored: those related to (1) the researcher, (2) the research, (3) the researcher’s organization, and (4) the system external to the researcher’s organization. Demographic data were collected and used as researcher-related and some research-related factors in analyses. Perceptions of the presence of the remaining research-related, organizational, and system-related factors in the Canadian MFS system were evaluated by assessing the participant’s level of agreement with survey statements representing each potential barrier, on a 5-point Likert
scale: (1) Strongly disagree, (2) Disagree, (3) Agree, (4) Strongly agree, and (5) Don’t know. Survey statements were worded such that agreement indicated the participant perceived that the potential barrier was not present in the Canadian MFS system (e.g., “There was low turnover amongst MFS policymakers.”).

“KTE engagement” was defined as having participated in any of a broad range of KTE activities with policymakers at the federal, provincial, or municipal level in the previous 5 years. Allowable KTE activities included but were not limited to collaboration with policymakers at any stage of the research process; dissemination of reports or publications to policymakers; participation in events such as workshops or symposia, with policymakers; and verbal interaction with policymakers, over the telephone or in person. Those who had engaged in KTE activities in the previous 5 years were subsequently termed “Engagers,” while those who had not were termed “Non-engagers.” “Policymakers” were defined as anyone responsible for setting policy related to delivering MFS services and programs in either the veterinary or human public health sectors.

Due to the small sampling frame of potential participants, a pretest of the survey could not be done with members of the population of interest. Instead, the survey was pretested with 5 graduate students in fields related to MFS. All pretest surveys and researcher surveys were conducted by telephone by DW and data were entered in Microsoft Access (Microsoft Corp, 2007) and analyzed in Stata 9 (Stata Corp, College Station, TX).
Analyses

The overall response rate and response rates for government and non-government researchers were calculated. Descriptive statistics of the respondents were also tabulated. For analysis, data collected on the Likert scale were collapsed into “Negative” (i.e., the amalgamation of “Disagree” and “Strongly disagree”) and “Positive” (i.e., the amalgamation of “Agree” and “Strongly agree”) responses, due to a paucity of data in the extreme categories [30]. Consequently, 3 response categories remained: “Positive,” “Negative,” and “Don’t know.” Statistical analysis of the response data was hampered by the inclusion of the “Don’t know” response because (1) the data were not ordinal and (2) “Don’t know” would have had to have been considered a non-response in some statistical analyses. When considered as a non-response, the sample of respondents providing responses would have varied with each survey statement and the “Don’t know” responses may not have occurred at random, potentially biasing results. Analyses consisted of two types: (1) those evaluating whether a potential barrier was perceived to be present in the Canadian food safety system and (2) those evaluating whether the potential barriers may have influenced KTE engagement.

Analyses of potential-barrier presence

Descriptive evaluations of the data included determination of the mode response (i.e., the response most frequently selected by respondents) of each statement and ranking of statements by the proportion of negative responses amongst all participants who had an opinion (i.e., amongst those who did not respond “Don’t know”). If a statement had a negative mode response or it was in the top quartile of statements with respect to the
proportion of its responses that were negative, it was considered to represent a potential KTE barrier that may be present in the Canadian food safety system.

**Analyses of potential-barrier influence on KTE engagement**

Statistical analyses of the associations between the potential barriers and KTE engagement were used to identify potential barriers that may have influenced KTE engagement. The analyses varied by data type. First, to evaluate associations between demographic variables and KTE engagement, univariable logistic regression models were fit to continuous demographic data and Fisher’s exact test was used for categorical demographic variables. Variables with significant associations with the outcome represented factors that may have influenced KTE engagement.

For the non-ordinal response data (i.e., survey statement responses), a descriptive analysis and a statistical analysis were conducted to identify potential barriers that may have influenced KTE engagement. For the descriptive analysis, statements were identified that had “Positive” as the mode response for Engagers and “Negative” as the mode response for Non-engagers. These statements may have been perceived differently by Engagers and Non-engagers, suggesting the potential barriers they represented may have influenced KTE engagement. For the statistical analysis, Fisher’s exact test was used to identify statements for which the distribution of responses between the “Positive,” “Negative,” and “Don’t know” categories was significantly different for Engagers and Non-engagers. For survey statements with significant associations between KTE engagement and response distribution, the $\chi^2$ statistic was partitioned to determine how the response distributions differed [31]. With partitioning, there were three types of
significantly different response distributions from which inferences could be made regarding KTE barriers (Table 1). A potential barrier was inferred possibly to have negatively influenced KTE engagement if it demonstrated the first distribution (“Negative/Positive”), because a greater than expected proportion of Non-engagers responded negatively. The second distribution (“Don’t know/Positive”) was the distribution expected to occur most frequently, given that Non-engagers, due to their lack of KTE engagement, would likely have a general lack of awareness of many organizational and system-related KTE factors, while the same organizational and system-related KTE factors may have acted as facilitators of KTE engagement for Engagers, promoting a favourable response. The final distribution type (“Don’t know/Negative”) suggested that the potential barrier was likely present in the MFS system and may have negatively influenced the KTE process for Engagers, given that those who had actual experience with KTE had a negative perception of the survey statement.

RESULTS

In total, 66 surveys were completed, providing an overall response rate of 57%. The response rate was similar amongst government and non-government researchers at 56% and 58%, respectively. Descriptive statistics of the respondents are found in Tables 2 and 3. Forty of the respondents were government researchers, while 26 were non-government researchers (24 in academia and 2 in private research organizations).
Analyses of KTE barrier presence

All survey statements, ranked by the proportion of negative responses amongst participants who provided a response, are presented in Table 4. The five survey statements comprising the top quartile in Table 4 were identified as potential KTE barriers perceived to be present in the Canadian MFS system (Table 5). The two highest ranked barriers (both System-related barriers) were the only two potential barriers that also had negative mode categories—(1) high policymaker turnover and (2) lack of policymaker initiative to develop joint research opportunities (Tables 4 and 5). The final three potential barriers in the top quartile were a lack of organizational support in the form of human (3rd ranked) and financial (5th ranked) resources, and a perceived lack of KTE support for policymakers (4th ranked).

Analyses of potential barrier influence on KTE engagement

Eighty-eight percent of respondents had conducted some form of KTE with policymakers at least once in the previous 5 years (n = 58 of 66; of the 8 Non-engagers, 3 were government researchers and 5 were in non-government positions). Approximately 40% of Engagers disagreed with statements claiming that they could identify or access policymakers for whom their research was relevant, suggesting that (1) they had not actually engaged a policymaker in KTE, (2) they had engaged policymakers for whom their research was not relevant, or (3) they had engaged a policymaker in KTE in the previous 5 years, but they had found identification of and access to relevant policymakers difficult. This finding suggests misclassification of KTE engagement may have occurred.
Statistically, two demographic variables were significantly associated with KTE engagement (Tables 2 and 3). As the number of years increased since researchers completed their highest university degree, the odds of KTE engagement decreased (OR = 0.90; 95% C.I. = 0.83–0.98; p-value = 0.019). Also, respondents who had been conducting MFS research for > 5 years were significantly more likely to engage in KTE activities than respondents who had conducted MFS research for 2–5 years (p = 0.031). Thus, older and early-stage researchers were less likely to engage in KTE than mid-career researchers. Four of the 8 Non-engagers in the study had graduated > 14 years previous but had been conducting MFS research for only 2–5 years.

Descriptively, four survey statements had a “Positive” mode response for Engagers and a “Negative” mode response for Non-engagers (Table 4), suggesting the potential barriers they represent may have influenced KTE engagement. Three of these statements represented organizational barriers—lack of human and financial resources and KTE incentives—while one represented a system barrier, the inability to access policymakers for whom the research was relevant. Most survey statements that required more in-depth knowledge of policymakers (e.g., “There was low turnover amongst MFS policymakers”) evoked, numerically, a high proportion of “Don’t know” responses, relative to other statements. “Don’t know” was a mode response only for Non-engagers.

Many of the survey statements demonstrated statistically significantly different response distributions for Engagers and Non-engagers (Table 4). However, when their $\chi^2$ statistics were partitioned, no survey statements were demonstrated to represent a potential barrier that may have hindered KTE engagement (Table 1). However, statistical
power to detect a difference was low. Most differences in response distributions were of
the second “expected” type in Table 1 (“Don’t know/Positive”). Two survey statements
fell into the third distribution type (“Don’t know/Negative”), suggesting the potential
barriers they represented may have hindered the KTE process for Engagers. These two
potential barriers included high policymaker turnover and lack of expertise or technical
support for policymakers.

DISCUSSION

This survey evaluated Canadian MFS researchers’ perceptions of selected
potential barriers to KTE from the literature related to the researcher, the research, the
organization, and the system external to the research environment. While many barriers
to KTE have been identified in the health-care literature, not all KTE barriers are present
in every context. Similarly, while many models of KTE have been developed [11, 13, 32-
38], these generalized models do not provide context-specific guidance for KTE program
development. Context-specific barriers must be identified and plans for their mitigation
incorporated into local KTE program design. However, organizational KTE resources are
finite and should be allocated preferentially to mitigate those barriers that most influence
KTE success. This paper provides an initial analysis of the potential KTE barriers present
in the Canadian MFS sector, providing information pertinent to MFS research
organizations and researchers interested in KTE and rationale for the allocation of
organizational KTE resources. As this was a preliminary study, descriptive tests that had
higher sensitivity than statistical tests were used to capture more of the potential barriers
that were present or influencing KTE. Statistical tests lacked power due to the small
sample size and the low number of Non-engagers; therefore, they were not very sensitive. The potential barriers are discussed below within researcher, research-related, organizational, and system-related groups.

**Researcher-related factors**

Individual researchers should not necessarily act as KTE messengers, unless they possess credibility with their target audience, KTE skills and experience, and sufficient time and resources [7]. Within this study, demographic variables were analyzed as researcher-related potential barriers, not researcher attributes such as credibility, communication skills, or policy knowledge. Significantly fewer early-career MFS researchers (2–5 years MFS research experience) engaged in KTE activities with policymakers than mid-to-later-career researchers (>5 years MFS research experience), possibly suggesting lack of a body of research at a reportable stage, lack of contacts or networks with policymakers, or lack of time, credibility, incentives, role models, or knowledge of KTE or policy processes. While some of these issues will likely diminish over time as early-career researchers progress in their professions (e.g., as volume of research evidence and credibility increase), organizational investment may be necessary to increase researcher knowledge of KTE and policy processes as this information may not be provided within graduate curricula [18]. Respondents who had graduated >14 years previously were significantly less likely to engage in KTE activities than more recent graduates. The reason for this association is unknown. Recent involvement in a degree program may have exposed respondents to more contemporary concepts such as KTE, thereby engendering greater KTE involvement, or those graduating >14 years...
previously may have been in more management or administrative positions, with less of a research mandate and consequently a lower likelihood of KTE engagement.

Not every researcher should interact with policymakers [7], one reason being that research organizations could risk overwhelming policymakers with vast amounts of potentially conflicting evidence if all researchers sought to engage policymakers [39]. Ideally, a few credible individuals should act as research liaisons with policymakers and strive to present evidence synthesized from a body of research, not the results of multiple individual primary research studies (see Research-related factors below) [7, 40]. When selecting researchers to interact with policymakers, organizations may benefit from careful consideration of researchers’ career stages as well as other researcher-related attributes: appropriate interpersonal and communication skills [7, 12, 13, 16, 25], an understanding of the KTE process [7, 12-14, 25], an understanding of the policy process [29, 40], and available time [7, 12-14, 25, 29].

**Research-related factors**

Although none of the research-related factors selected for this study were perceived negatively by researchers, several research-related barriers to KTE have been identified in the health-care literature, including a lack of policy relevance of research [10, 12, 16, 25, 29], poor quality research [8, 10, 40], non-synthesized or inconclusive research [13, 41] and research complexity [10, 29, 40]. As well, not all research can or should have an impact on policy [13]. For example, basic or discovery research may identify opportunities potentially of interest to public policy, temporally preceding the applied research that defines and tests the findings and may directly inform policy [39].
Poor reporting of intervention research and a lack of high-quality syntheses have been identified as issues in the MFS system [42, 43]. In healthcare, high-quality syntheses such as systematic reviews amalgamate the findings of entire bodies of research, using explicit methods to reduce bias and increase the reliability and accuracy of conclusions above that of individual primary research studies. Thus, they are ideal tools for KTE with policymakers [7, 39, 44]. Historically in the MFS system, the poor methodological quality of published syntheses of pre-harvest intervention research [43] was seen to be partly due to a scarcity of rigorously conducted, primary MFS intervention studies [42] and partly due to a lack of an accepted protocol to synthesize primary research [45]. To address these issues, guidelines for the reporting of randomized clinical trials (RCTs) for livestock and food safety were published [46, 47] and systematic review methodology from healthcare was adapted to food safety intervention research [45]. Beyond systematic review, alternative tools to synthesize evidence and aid food safety decision making, such as multi-criteria decision analysis, have been developed [48]. Thus, while published high-quality synthesized research products may not have been available in the past, with the aforementioned advancements, KTE success should be enhanced through the provision of more rigorous, synthesized evidence in the future.

Research complexity may also hinder KTE [10, 29, 40] because the “transaction costs” for policymakers are too high, when research is challenging to understand. Landry et al. [23] suggest that transaction costs can affect the use of research evidence by policymakers: the greater the difficulty that policymakers have in reading or understanding research evidence, the greater their transaction costs and the lower the
likelihood that they will engage in KTE activities. Key to overcoming the challenges of communicating complex research is to have a meaningful, tailored message for policymakers [10, 12-14, 29, 40, 41, 49]. As well, ongoing interaction between researchers and policymakers aids in the setting of locally-relevant research priorities, resulting in more locally-meaningful findings and actionable messages that may be of greater interest to policymakers.

**Organizational factors**

The presence of organizational support for KTE in this study was not high—just over half of respondents with opinions indicated their organizations provided them with human or financial KTE resources or incentives for KTE. The presence of organizational support does not necessarily indicate that support was sufficient for KTE success.

Substantial time and resources must be committed on the part of a research organization to increase researchers’ capacity to identify their target audience, learn about them, and gain credibility with them [7, 13, 19, 23]. Buy-in at all levels of the research organization is critical to minimize power and budget struggles [8] and to increase the likelihood of a long-term, sustainable KTE program. It is possible that because KTE with government policymakers is a new concept within the MFS sector, organizational buy-in may not yet have reached a level sufficient to provide support for ongoing, sustainable KTE. If ongoing, sustainable KTE programs are to be maintained, organizations must have buy-in at all levels [50, 51] and be prepared to invest the necessary human and financial resources—resources for KTE itself as well as resources to overcome researcher-, research-, and system-related barriers [19]. Further investigation of organizational KTE
support is necessary to explore its true extent within Canadian MFS research organizations.

**System-related factors**

Factors related to the system external to the researcher’s organization can generally be considered difficult and costly to mitigate [23]. Thus, context-specific system barriers should be identified as they may require substantial allocation of time and resources to overcome. Of the system-related potential barriers included in the survey, three were identified as potentially being present in the Canadian food safety sector: (1) high policymaker turnover, (2) lack of policymaker-driven collaborative initiatives, and (3) lack of KTE support for policymakers. As well, one system-related barrier—an inability to access relevant policymakers—was identified numerically as potentially hindering KTE engagement, as it was perceived negatively by Non-engagers and positively by Engagers. All of these potential barriers were policymaker related. (Other non-policymaker-related system-related potential barriers may have also been present but were not included in the survey.) In some contexts, policymaker-related barriers can be reduced through the development of linkages—formal, ongoing, organizational-level relationships between evidence producers and evidence users [12, 14, 37]. Linkages between research organizations and policymaking bodies can create continuity despite staff turnover and changes in the governing political party, continuity that is necessary for researchers to identify and access relevant policymakers. Linkage may also encourage knowledge management within the policymaking organization, improving “institutional memory,” which would otherwise be lost with policymaker turnover [10, 14]. While not
without potential issues (e.g., misunderstandings, overstepping of boundaries, the perception that researchers are agents of the government and no longer autonomous) [26, 52], linkages may also help to overcome potential barriers related to government structure. Canadian MFS policy is a shared effort between agriculture, health, and environment ministries at federal, provincial, and local government levels [53]. Because of the heterogeneity of the Canadian MFS regulatory and policymaking bodies and the potential for geographically regionalized and institutionally isolated policy decision making, KTE from the MFS researcher perspective can be daunting, especially with respect to identification of and access to relevant policymakers. Organizational linkages may aid KTE activities through the development of formal mechanisms for knowledge exchange between researchers and policymakers.

In this study, the two highest-ranked barriers were system-related factors, indicating that they may have high impact on KTE engagement and success. Mitigation of these system-related barriers may then have a greater positive impact on KTE success than mitigation of other barriers. That said, system-related factors require a high degree of investment to overcome, investment that necessitate a high level of buy-in on the part of the research organization and policymakers. Thus, prior to attempting to mitigate system-related barriers, initial focus should be placed upon building organizational buy-in through increasing the perceived value of KTE activities in both research and policy settings.

The limitations of this study can be categorized into two groups: limitations of the data collected and limitations due to study design. Regarding the data collected, the
response rate of the survey was relatively high; however, because the sampling frame was small, the final sample size was also small. The data were also highly unbalanced (i.e., there was a low proportion of Non-engagers). Coupled together, the small sample size and unbalanced dataset substantially reduced the power of the statistical analyses and precluded statistical comparisons between government and non-government respondents. As this was a preliminary study, descriptive assessments that had higher sensitivity than statistical tests were used to identify potential barriers present and influencing KTE. It should be noted that because the proportion of Non-engagers was low, a response of any Non-engager had the potential to be highly influential in both statistical and descriptive analyses.

Study design limitations were related to the design of the survey instrument. The dichotomous nature and low cutoff of the “years conducting MFS research” variable prevented ideal analysis; a continuous variable would have tested the association with the outcome along the variable’s entire range, better defining the nature of the association for higher values of the variable. As well, because of the preliminary nature of the study, participants’ familiarity with KTE and MFS policymaking in Canada was unknown. As a result, “Don’t know” was included as a response option to the survey statements. While inclusion of “Don’t know” provided a more realistic evaluation of participant opinion in that respondents were not forced into a positive or negative response, it also meant that the data collected were no longer ordinal in nature. The non-ordinal nature of the data made it impossible to rank the survey statements by overall perceived negativity; instead, they were ranked by perceived negativity amongst respondents who had an opinion.
Fitting of regression models to the response data was precluded as “Don’t know” data did not occur at random (i.e., the “Don’t know” responses were associated with the type of survey statement—results not shown). A potential bias also may have occurred in the form of misclassification of KTE engagement. Although steps were taken to ensure every respondent was informed of the study definitions of “KTE activities” and “policymakers” before participation, misclassification of Engagers may have occurred, as evidenced by the high proportion of Engagers who responded that they could not identify or access relevant policymakers. This misclassification may have biased the results, although the direction of any bias is unknown. The cause of this potential misclassification was likely a too broad definition of “KTE activity”—any degree of interaction with policymakers was allowed, not just sustained activity—and possibly a misinterpretation of the definition of “policymaker” by some respondents to include funding organizations (who were assumed to provide research reports up to policymakers). Finally, closed questions forced participants to respond within the bounds of the survey and did not allow for elaboration. Open-ended questions may have allowed a greater understanding of the issues influencing the participants’ responses.

CONCLUSIONS

Within the Canadian MFS system, awareness of the concept of KTE amongst researchers appears to be high [24], an encouraging sign that KTE partnerships with policymakers may be developing. Researchers and research organizations wishing to extend the influence of their research to the policy sphere by developing a KTE partnership should be guided by a KTE framework (e.g., Lavis et al. [13]) and should
have a general knowledge of the context-specific potential barriers to KTE that they may anticipate encountering. This paper provides a quantitative summary of the presence of selected potential barriers to researcher KTE engagement related to the researcher, the research, the research organization, and the system in the Canadian MFS sector, as perceived by researchers. The two highest-ranked barriers in this study were system related, and organizational support for KTE appeared to be available to only half of respondents. Without organizational support, system-related barriers are difficult to overcome. Thus, achievement of organizational buy-in for KTE should be considered a priority in KTE strategy development.
REFERENCES


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32. Canadian Health Services Research Foundation: Health services research and...evidence-based decision-making. 2000.


Table 3.1. Expected types of response distributions demonstrated on Fisher’s exact test to have significant differences between KTE Engagers and Non-engagers, in a 2009 telephone survey of Canadian MFS researchers.

<table>
<thead>
<tr>
<th>Non-engagers</th>
<th>Engagers</th>
<th>Inference drawn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significantly more negative responses than expected</td>
<td>Significantly more positive responses than expected</td>
<td>Potential barrier may have negatively influenced KTE engagement</td>
</tr>
<tr>
<td>Significantly more “Don’t know” responses than expected</td>
<td>Significantly more positive responses than expected</td>
<td>Expected response distribution</td>
</tr>
<tr>
<td>Significantly more “Don’t know” responses than expected</td>
<td>Significantly more negative responses than expected</td>
<td>Potential barrier likely present in the Canadian MFS system and may hinder the KTE process for those who engage</td>
</tr>
</tbody>
</table>
Table 3.2. Demographic data of respondents in a 2009 telephone survey of Canadian MFS researchers. P-values represent significance of associations between the demographic variable and KTE engagement using Fisher’s exact test (categorical data) and logistic regression (continuous data).

<table>
<thead>
<tr>
<th>Categorical variables</th>
<th>Categories</th>
<th>Number of Non-engagers</th>
<th>Number of Engagers</th>
<th>Total number of respondents (%)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of years conducting MFS research, excluding graduate work</td>
<td>2–5 years</td>
<td>4</td>
<td>8</td>
<td>12 (18.2)</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>&gt;5 years</td>
<td>4</td>
<td>50</td>
<td>54 (81.8)</td>
<td></td>
</tr>
<tr>
<td>Type of employment while conducting MFS research on foods of animal origin, in the past 5 years (If more than one, the most recent organization was used and further questions were based on this organization.)</td>
<td>Government</td>
<td>3</td>
<td>37</td>
<td>40 (60.6)</td>
<td>0.247</td>
</tr>
<tr>
<td>Topic area of MFS research</td>
<td>Non-government</td>
<td>Veterinary biomedical</td>
<td>Human biomedical</td>
<td>Food quality</td>
<td>Veterinary population/public health</td>
</tr>
<tr>
<td>------------------------------------------------</td>
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<td>--------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>21</td>
<td>26 (39.4)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>4</td>
<td>4 (6.1)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>20</td>
<td>22 (33.3)</td>
<td>2</td>
</tr>
<tr>
<td>Type of research</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>3 (4.5)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>35</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Percentage of total annual workload comprising research</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>5 (7.6)</td>
<td>0</td>
</tr>
<tr>
<td>Highest level of post-secondary education</td>
<td>10–49%</td>
<td>50–100%</td>
<td>PhD</td>
<td>MSc</td>
<td>DVM or MD</td>
</tr>
<tr>
<td>------------------------------------------</td>
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<tr>
<td></td>
<td>1</td>
<td>6</td>
<td>5</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>38</td>
<td>41</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>17 (25.8)</td>
<td>44 (66.7)</td>
<td>46 (69.7)</td>
<td>17 (25.8)</td>
<td>2 (3.0)</td>
</tr>
<tr>
<td>Graduate degrees obtained outside of Canada</td>
<td>Yes 6</td>
<td>No 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>38</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>26 (39.4)</td>
<td>40 (60.6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>Male 4</td>
<td>Female 4</td>
<td>38</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>42 (63.6)</td>
<td>24 (36.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>Median</td>
<td>Standard deviation</td>
<td>Range</td>
<td>Odds ratio (95% confidence interval)</td>
</tr>
<tr>
<td>Number of years since completion of</td>
<td>18.9</td>
<td>18</td>
<td>10.0</td>
<td>1–41</td>
<td>0.90</td>
</tr>
</tbody>
</table>

129
<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>highest level of post-secondary education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of researchers employed at workplace</td>
<td>25.4</td>
<td>20</td>
<td>29.3</td>
<td>1–180</td>
<td>1.00</td>
<td>0.612</td>
</tr>
<tr>
<td>Number of these researchers conducting MFS research</td>
<td>7.8</td>
<td>5</td>
<td>10.1</td>
<td>1–70</td>
<td>1.00</td>
<td>0.963</td>
</tr>
<tr>
<td>Number of days spent at conferences or interacting with external colleagues, in the past year</td>
<td>22.3</td>
<td>20</td>
<td>17.8</td>
<td>1–100</td>
<td>1.04</td>
<td>0.237</td>
</tr>
</tbody>
</table>

(0.83–0.98)

(0.98–1.04)

(0.93–1.07)

(0.97–1.11)
### Table 3.3. Continuous demographic data of respondents in a 2009 telephone survey of Canadian MFS researchers. P-values represent significance of associations between the demographic variable and KTE engagement in a univariable logistic regression model.

<table>
<thead>
<tr>
<th>Demographic Variable</th>
<th>Mean</th>
<th>Median</th>
<th>Standard Deviation</th>
<th>Range</th>
<th>Odds Ratio (95% confidence interval)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of years since completion of highest level of post-secondary education</td>
<td>18.9</td>
<td>18</td>
<td>10.0</td>
<td>1–41</td>
<td>0.90 (0.83–0.98)</td>
<td>0.019</td>
</tr>
<tr>
<td>Number of researchers employed at workplace</td>
<td>25.4</td>
<td>20</td>
<td>29.3</td>
<td>1–180</td>
<td>1.00 (0.98–1.04)</td>
<td>0.612</td>
</tr>
<tr>
<td>Number of these researchers conducting MFS research</td>
<td>7.8</td>
<td>5</td>
<td>10.1</td>
<td>1–70</td>
<td>1.00 (0.93–1.07)</td>
<td>0.963</td>
</tr>
<tr>
<td>Number of days spent at conferences or interacting with external colleagues, in the past year</td>
<td>22.3</td>
<td>20</td>
<td>17.8</td>
<td>1–100</td>
<td>1.04 (0.97–1.11)</td>
<td>0.237</td>
</tr>
</tbody>
</table>
Table 3.4. Survey statements representing potential KTE barriers in a 2009 survey of Canadian MFS researchers. Response distributions and the results of Fisher’s exact tests to identify significant differences in response distributions between Engagers and Non-engagers are shown. Statements are ordered by the proportion of Negative responses amongst respondents with an opinion.

<table>
<thead>
<tr>
<th>Survey statement</th>
<th>Barrier Type</th>
<th>Respondent type</th>
<th>Distribution of responses</th>
<th>P-value of Fisher’s exact test</th>
<th>Mode response</th>
<th>Proportion of Negative responses amongst respondents with an opinion (Rank)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Negative (%)</td>
<td>Positive (%)</td>
<td>Don’t know (%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
"There was low turnover amongst MFS policymakers."

<table>
<thead>
<tr>
<th>System</th>
<th>All</th>
<th>Engagers</th>
<th>Nonengagers</th>
<th>Chi-square</th>
<th>p-value</th>
<th>Response</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>Engagers</td>
<td>Nonengagers</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>28 (42.4)</td>
<td>14 (21.2)</td>
<td>24 (36.4)</td>
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<td></td>
<td>Negative</td>
<td>66.7 (1)</td>
</tr>
<tr>
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<td>Engagers</td>
<td>28 (48.3)</td>
<td>13 (22.4)</td>
<td>17 (29.3)</td>
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<td>Negative</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nonengagers</td>
<td>0 (0)</td>
<td>1 (12.5)</td>
<td>7 (87.5)</td>
<td></td>
<td>Don’t know</td>
<td></td>
</tr>
</tbody>
</table>

"Opportunities were created by policymakers to develop joint research initiatives with them."

<table>
<thead>
<tr>
<th>System</th>
<th>All</th>
<th>Engagers</th>
<th>Nonengagers</th>
<th>Chi-square</th>
<th>p-value</th>
<th>Response</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
<td>Engagers</td>
<td>Nonengagers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30 (45.5)</td>
<td>27 (40.9)</td>
<td>9 (13.6)</td>
<td>0.057</td>
<td></td>
<td>Negative</td>
<td>52.6 (2)</td>
</tr>
<tr>
<td></td>
<td>Engagers</td>
<td>26 (44.8)</td>
<td>26 (44.8)</td>
<td>6 (10.3)</td>
<td></td>
<td>Ambiguous</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nonengagers</td>
<td>4 (50.0)</td>
<td>1 (12.5)</td>
<td>3 (37.5)</td>
<td></td>
<td>Negative</td>
<td></td>
</tr>
</tbody>
</table>

---

a The observed frequency of response was significantly greater than expected, when the $\chi^2$ statistic was partitioned.

b The observed frequency of response was significantly less than expected, when the $\chi^2$ statistic was partitioned.
<table>
<thead>
<tr>
<th>Question</th>
<th>Category</th>
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<th>Nonengagers</th>
<th>p-value</th>
<th>Result</th>
<th>% (SD)</th>
</tr>
</thead>
<tbody>
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<td>“My organization made human resources available to me to assist with KTE.”</td>
<td>Organization</td>
<td>All</td>
<td>29 (43.9)</td>
<td>33 (50.0)</td>
<td>4 (6.1)</td>
<td>0.001</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>Engagers</td>
<td>25 (43.1)</td>
<td>32 (55.2)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1 (1.7)&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nonengagers</td>
<td>4 (50.0)</td>
<td>1 (12.5)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3 (37.5)&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Expertise or technical support was available to policymakers for translating research into action.”</td>
<td>System</td>
<td>All</td>
<td>21 (31.8)</td>
<td>25 (37.9)</td>
<td>20 (30.3)</td>
<td>0.046</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>Engagers</td>
<td>21 (36.2)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>22 (37.9)</td>
<td>15 (25.9)&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nonengagers</td>
<td>0 (0)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3 (37.5)</td>
<td>5 (62.5)&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“My organization made financial resources available to me to assist with KTE.”</td>
<td>Organization</td>
<td>All</td>
<td>27 (40.9)</td>
<td>35 (53.0)</td>
<td>4 (6.1)</td>
<td>0.002</td>
<td>Positive</td>
</tr>
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<td></td>
<td>Engagers</td>
<td>23 (39.7)</td>
<td>34 (58.6)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1 (1.7)&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nonengagers</td>
<td>4 (50.0)</td>
<td>1 (12.5)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3 (37.5)&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“I could access the policymakers for”</td>
<td>System</td>
<td>All</td>
<td>26 (39.4)</td>
<td>35 (53.0)</td>
<td>5 (7.6)</td>
<td>0.003</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>Engagers</td>
<td>22 (37.9)</td>
<td>34 (58.6)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2 (3.5)&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

134
<table>
<thead>
<tr>
<th>Statement</th>
<th>Source</th>
<th>Type</th>
<th>Group</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
<th>Significance</th>
<th>P-value</th>
<th>Weight</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;I could identify the policymakers for whom my research was relevant.&quot;</td>
<td>System</td>
<td>All</td>
<td>Engagers</td>
<td>23 (39.7)</td>
<td>35 (60.3)</td>
<td>0 (0)</td>
<td>Positive</td>
<td>0.012</td>
<td></td>
<td>40.6 (8)</td>
<td>Positive</td>
</tr>
<tr>
<td>&quot;The translation of research to action was aided by incentives for KTE within my organization&quot;</td>
<td>Organization</td>
<td>All</td>
<td>Engagers</td>
<td>20 (34.5)</td>
<td>34 (58.6)</td>
<td>4 (6.9)</td>
<td>Positive</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;The cost of translating research</td>
<td>System</td>
<td>All</td>
<td>Engagers</td>
<td>21 (36.2)</td>
<td>32 (55.2)</td>
<td>5 (8.6)</td>
<td>Positive</td>
<td></td>
<td></td>
<td>39.0 (10)</td>
<td>Positive</td>
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</table>
"Into action was low."

<table>
<thead>
<tr>
<th></th>
<th>System</th>
<th>All</th>
<th>Engagers</th>
<th>Nonengagers</th>
<th>P-value</th>
<th>Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;KTE activities could be paid for through research grants for which I was eligible.&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nonengagers</td>
<td>2 (25.0)</td>
<td>4 (50.0)</td>
<td>2 (25.0)</td>
<td>0.064</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>21 (31.9)</td>
<td>39 (59.1)</td>
<td>6 (9.1)</td>
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</tr>
</tbody>
</table>

"Over the past 5 years, my organization has become more supportive of individuals who conduct MFS KTE."

<table>
<thead>
<tr>
<th></th>
<th>Organization</th>
<th>All</th>
<th>Engagers</th>
<th>Nonengagers</th>
<th>P-value</th>
<th>Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nonengagers</td>
<td>3 (37.5)</td>
<td>1 (12.5)</td>
<td>4 (50.0)</td>
<td></td>
<td>Don’t know</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>19 (28.8)</td>
<td>38 (57.6)</td>
<td>9 (13.6)</td>
<td>0.002</td>
<td>Positive</td>
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<tr>
<td></td>
<td>Engagers</td>
<td>16 (27.6)</td>
<td>37 (63.8)</td>
<td>5 (8.6)</td>
<td></td>
<td>Positive</td>
</tr>
</tbody>
</table>

"Events were created by policymakers to bring together researchers and policymakers for discussion about MFS"

<table>
<thead>
<tr>
<th></th>
<th>System</th>
<th>All</th>
<th>Engagers</th>
<th>Nonengagers</th>
<th>P-value</th>
<th>Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nonengagers</td>
<td>3 (37.5)</td>
<td>3 (37.5)</td>
<td>2 (25.0)</td>
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<td>Ambiguous</td>
</tr>
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<td></td>
<td>All</td>
<td>18 (27.3)</td>
<td>44 (66.7)</td>
<td>4 (6.1)</td>
<td>0.036</td>
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<td>41 (70.7)</td>
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</table>

136
research.”

“Currently, my organization is supportive of individuals who conduct MFS KTE.”

<table>
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<th>Nonengagers</th>
</tr>
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<td>11 (16.7)</td>
<td>9 (15.5)</td>
<td>2 (25.0)</td>
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<td></td>
<td></td>
<td>52 (78.8)</td>
<td>48 (82.8)</td>
<td>4 (50.0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 (4.6)</td>
<td>1 (1.7)</td>
<td>2 (25.0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.017</td>
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<td>17.5 (14)</td>
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</table>

“Policymakers considered some or all of my research relevant to policy decision making.”

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<th>Nonengagers</th>
</tr>
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<tbody>
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<td></td>
<td>8 (12.1)</td>
<td>6 (10.3)</td>
<td>2 (25.0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>39 (59.1)</td>
<td>38 (65.5)</td>
<td>1 (12.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19 (28.8)</td>
<td>14 (24.1)</td>
<td>5 (62.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Don’t know</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.011</td>
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<td>17.0 (15)</td>
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</table>

“Some or all of my research coincided with the priorities of policymakers.”

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<th>Engagers</th>
<th>Nonengagers</th>
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<tbody>
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<td></td>
<td></td>
<td>2 (3.0)</td>
<td>2 (3.5)</td>
<td>0 (0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>58 (87.9)</td>
<td>52 (89.7)</td>
<td>6 (75.0)</td>
</tr>
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<td></td>
<td></td>
<td>6 (9.1)</td>
<td>4 (6.9)</td>
<td>2 (25.0)</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.352</td>
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<td>3.3 (16)</td>
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</table>

“I considered some or all of my research relevant to”

<table>
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<th>Engagers</th>
<th>Nonengagers</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>2 (3.0)</td>
<td>1 (1.7)</td>
<td>1 (12.5)</td>
</tr>
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<td></td>
<td></td>
<td>64 (97.0)</td>
<td>57 (98.3)</td>
<td>7 (87.5)</td>
</tr>
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<td>Positive</td>
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<td>Positive</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Positive</td>
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<td></td>
<td></td>
<td>0.229</td>
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<td>3.0 (17)</td>
</tr>
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</table>
**In general, policymakers viewed my research as credible.**

<table>
<thead>
<tr>
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<th>51 (77.3)</th>
<th>15 (22.8)</th>
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<th>Positive</th>
<th>0 (18)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Engagers</td>
<td>0 (0)</td>
<td>49 (84.5)(^a)</td>
<td>9 (15.5)(^b)</td>
<td></td>
<td>Positive</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nonengagers</td>
<td>0 (0)</td>
<td>2 (25.0)(^b)</td>
<td>6 (75.0)(^a)</td>
<td></td>
<td>Don’t know</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**My organization was seen as a credible source of MFS research by policymakers.**

<table>
<thead>
<tr>
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<th>Organization</th>
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<th>0 (0)</th>
<th>62 (93.9)</th>
<th>4 (6.1)</th>
<th>0.005</th>
<th>Positive</th>
<th>0 (19)</th>
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</thead>
<tbody>
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<td>Engagers</td>
<td>0 (0)</td>
<td>57 (98.3)(^a)</td>
<td>1 (1.7)(^b)</td>
<td></td>
<td>Positive</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nonengagers</td>
<td>0 (0)</td>
<td>5 (62.5)(^b)</td>
<td>3 (37.5)(^a)</td>
<td></td>
<td>Positive</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3.5. Potential KTE barriers identified as being present in the Canadian MFS system, as perceived by respondents to a 2009 survey of Canadian MFS researchers.

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Barrier type</th>
<th>Reason for identification as being present</th>
</tr>
</thead>
<tbody>
<tr>
<td>High policymaker turnover</td>
<td>System</td>
<td>Negative mode response overall Top quartile&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Lack of policymaker-driven collaborative initiatives</td>
<td>System</td>
<td>Negative mode response overall Top quartile&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Lack of human resources for KTE</td>
<td>Organizational</td>
<td>Top quartile&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Lack of KTE support for policymakers</td>
<td>System</td>
<td>Top quartile&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Lack of financial resources for KTE</td>
<td>Organizational</td>
<td>Top quartile&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup> Top quartile of all survey statements when ranked by the proportion of negative responses among participants who provided a response
CHAPTER 4

Canadian food safety researchers’ attitudes toward and perceived barriers to knowledge translation with policymakers: a qualitative assessment

(Presented in the style of the journal *BMC Public Health*.)

ABSTRACT

**Background:** Knowledge translation and exchange (KTE) between researchers and government policymakers is necessary to ensure policy decision making is evidence informed. Little is known about KTE in the food safety setting. Thus, a qualitative study was conducted to explore researchers’ attitudes toward KTE and the barriers perceived to hinder KTE with policymakers.

**Methods:** A focus group study of Canadian microbial food safety researchers was conducted in 2010. Four groups were enrolled—two of academic researchers and two of government researchers—with four participants each. A semi-structured interview guide was used to explore participants’ attitudes toward KTE and perceived barriers to KTE with policymakers. Transcripts of sessions were analyzed using content analysis to identify important concepts and emergent themes related to the research questions.

**Results:** Researcher attitudes toward KTE surrounded themes of current ineffectiveness, researcher responsibility, formal mechanisms, and increasing awareness. Barriers to KTE fell under four themes: (1) Research-related, including applicability of research to
policymaking; (2) Researcher-related, including an inability to break free from convention, a lack of knowledge of KTE and policy processes, doubts of personal KTE effectiveness, and a lack of time; (3) Organizational, including a lack of organizational buy-in for KTE that limited financial and human resources; and (4) System-related, including communication network issues with policymakers, temporal disconnects between policy and research timelines, policymaker limitations, and political issues. The barrier cited by the most participants to be their primary barrier to KTE was an inability to identify policymakers, which was linked to the complexity of the government structure, policymaker turnover, and insufficient financial resources.

**Conclusions:** Although researcher awareness of KTE is increasing, barriers pose significant obstacles to success. Research and policymaking organizational cultures and researchers’ values and beliefs about KTE need to be changed, if effective KTE is to occur in the food safety sector.
BACKGROUND

The burden of foodborne disease is high in Canada, with an estimated 11 million cases annually in a population of 30 million [1], at considerable economic cost [2, 3]. To reduce the burden and costs of foodborne disease, a science-based approach to food safety policymaking has been recommended, integrating epidemiologic research, risk analysis, and economic studies into the policy process to promote evidence-informed policy [4]. Within this integrated approach, the process in which researchers, stakeholders, and policymakers interact to synthesize, disseminate, exchange, and apply knowledge is termed knowledge translation and exchange (KTE) [5]. A lack of KTE was identified as a constraint to evidence-informed policymaking in the Canadian food safety sector [6].

In the public health sector, increasing emphasis is being placed on KTE strategies to facilitate the uptake of research evidence by policymakers [7]. KTE strategy should be informed by a context-specific assessment of the expected KTE barriers [8]. Various barriers to KTE success with policymakers have been identified in healthcare [7], with many studies focusing upon the policymaking level [9]. However, barriers related to both individual researchers and research organizations also occur. The barriers to KTE faced by healthcare researchers include competing priorities and time constraints for both researchers and policymakers [10-16], challenges in developing relationships with policymakers [9, 11, 15, 17], adapting the research process to meet short policy-priority timelines [9, 18], lack of understanding of KTE or policy processes [11, 19], an inability to identify appropriate target audiences [12], and a perceived potential loss of control of
the research process [10]. Barriers to KTE found within healthcare research organizations include a lack of resources [11, 20, 21], issues of organizational culture and leadership [11, 22], and conventional “publish-or-perish” incentive systems [23].

In the food safety sector, little primary KTE research has been conducted to identify barriers to KTE. To address this knowledge gap, a mixed-methods explanatory sequential design (i.e., a quantitative study followed by a qualitative study) was used [24]. Initially, a quantitative survey of Canadian microbial food safety (MFS) researchers was conducted, assessing to what degree respondents perceived selected barriers to KTE engagement to be present in the Canadian food safety system [25]. This focus group study was then completed to further clarify the findings, with the following objectives: (1) to describe the attitudes of Canadian MFS researchers toward KTE with policymakers and (2) to describe barriers perceived by researchers to hinder successful KTE with policymakers.

METHODS

A content analysis theoretical framework underpinned the study—comparisons of groups of individuals’ attitudes and perceptions were made through the analysis of recorded data [26, 27]. An inductive content analysis approach is used when no previous studies exist or when previous research is fragmented [28]. A focus group method was employed to encourage greater exploration and clarification of individual perspectives through group interaction [29].

Focus group participants were recruited by email from a subset of a sampling frame developed for the survey study [30]. The subset included individuals working in
academia or for non-regulatory federal government organizations. Because MFS researchers are located in small groups across Canada, purposive sampling was used to ensure a minimum of 4 participants per session [29]. Groups consisted of either all academic or all government researchers. Equal numbers of academic and government group sessions were conducted until limitations in the number of potential participants and geography prevented recruitment of further groups.

Ethical approval was obtained from the University of Guelph Research Ethics Board. A semi-structured interview guide was developed, ensuring consistency of wording between groups and standardized collection of the data [31]. The interview guide was pre-tested on a group of graduate students to ensure question clarity. Refreshments were served to encourage an informal atmosphere and freedom of speech [29]. After obtaining written, informed consent, participants were asked what “knowledge translation and exchange” meant to them, to ensure that all participants had a common understanding of KTE. All further questions were open-ended to address the following research questions: (1) What attitudes do MFS researchers have toward KTE with policymakers and why? and (2) What barriers do MFS researchers perceive to prevent or hinder them from engaging in effective KTE with policymakers? Participants were not provided with a formal definition of “policymaker”; however, they were guided to consider only government decision makers as policymakers, not those within industry. Pre-planned, non-structured probes were used, where necessary, to generate further discussion or to clarify responses. To conclude the session, participants were asked to
identify the primary barrier preventing or hindering the effectiveness of their KTE with policymakers.

Authors DW\textsuperscript{a} and MP\textsuperscript{b} acted as moderator and assistant moderator, respectively. A flipchart was used to summarize participants’ comments, thereby allowing participants to correct or approve the moderator’s interpretation. The assistant moderator took detailed field notes. All sessions were audio-taped and audio recordings were transcribed verbatim by a professional transcription service, with all identifying information removed. Transcript accuracy was verified using the original audio recordings and field notes. DW and MP met following each session to discuss important concepts that had emerged during the session and how those concepts may have differed from previous sessions. If necessary, to obtain clarification of specific comments, study participants were contacted after the session. To assess the validity of the data, participants of the first academic and government groups were contacted post-session to comment on the moderator’s interpretation of the data. Response to this member checking exercise was low and it was not repeated for the subsequent groups.

Thematic analysis was conducted by DW and MP. To reduce bias and increase reliability of the findings, a standardized data analysis procedure was used based on Krueger and Casey [32]. The multi-stage, systematic process of independent analysis followed by joint review and discussion ensured that reflexivity bias was reduced and that multiple passes were made through the data, increasing the sensitivity of the researchers.

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to identify emergent constructs. Briefly, for each research question, a codebook was developed of constructs emerging from the data of the first session. These codebooks were expanded and refined in an iterative manner as further constructs emerged during analysis of the following sessions. The final codebooks were condensed and emergent barrier concepts and, ultimately, barrier themes were identified. Analysis was aided by word-processing software (Word 2003; Microsoft Corp., Redmond, WA).

During analysis, participant comments identifying links between barrier constructs were extracted. Following development of the final codebook of barrier concepts, the data identifying links between constructs were reorganized to establish the links between the final barrier concepts, as perceived by the participants. To better visualize these rich data, they were portrayed in flowchart form (Figure 1). Because participants were not asked directly to identify associations between the barrier constructs that emerged during their sessions, these data may be incomplete.

At the time of the study, DW was a PhD student investigating knowledge translation in the food safety sector. DW had training in qualitative research methods and experience in KTE research in the Canadian food safety sector. MP held an MSc and was a university-based research assistant, with experience in qualitative research methods. DW was acquainted with some participants from the previous quantitative survey, and both DW and MP knew some participants through the university community. Neither DW nor MP held a position of authority over any participant.
RESULTS

Four focus groups of 4 participants each were conducted: 2 academic and 2 government sessions. Sessions lasted 1.5 hours and were held in Guelph, Ontario, Canada, in May and June, 2010, with one academic session occurring during a national conference, to obtain out-of-town participants. Forty-four researchers outside of the Guelph area were contacted to determine their conference attendance; one academic researcher attended the conference and agreed to participate. As well, 39 MFS researchers located within 100 km of Guelph were contacted and 15 participated in the study. Three academic institutions and 3 Guelph-based federal government groups were represented. All participants had conducted MFS research in the previous 5 years—15 were applied researchers and 1 academic researcher was involved exclusively in basic research. Six male and 10 female researchers participated, with research interests in both human and agricultural food safety research. Results for each research question are presented separately below. Where they occur, differences between academic and government participants relevant to the study objectives are described.

What attitudes do MFS researchers have toward KTE with policymakers and why?

Attitudes toward KTE with policymakers fell under 4 themes: Current ineffectiveness, Responsibility, Formal mechanisms, and Increasing awareness.

Current ineffectiveness

Participants in all sessions were concerned and at times frustrated that KTE activities were not as effective as they could be. Amongst many suggested causes of the
ineffectiveness were a lack of interest or involvement in KTE, either on the part of policymakers or both policymakers and researchers, and a lack of KTE training on recommended methods.

…I’m not sure that we’re (a) well aware of how to do knowledge translation and (b) even if we were, the exchange component is not at all clear—how to effectively exchange information up.

Overall, government participants commented more about policymaker causes of ineffectiveness and appeared to have more applied knowledge of KTE than academic researchers. Academic participants’ comments about KTE with policymakers often appeared arm’s length or speculative, employing words denoting uncertainty, such as “probably” and “maybe.” This suggested many academics may not have had extensive experience with policymakers upon which to base their comments.

**Responsibility**

All participants agreed that KTE was a responsibility of MFS researchers; however, some suggested that not all research was policy relevant and some commented that, logistically, it may not be possible for all researchers to engage policymakers. The Responsibility theme could be separated into two related constructs—scientific and social responsibility.

Participants suggested that researchers have a scientific responsibility to engage in KTE with policymakers because they are more competent to understand the import and meaning of their findings.
…most [policymakers] that I’ve dealt with are just coming from such entirely different backgrounds that…you’ve got to make sure your entire message is clear because they’re not going to go in the same direction.

Participants generally agreed that both academic and government research organizations have a scientific responsibility to engage policymakers because the two organizational types have differing capabilities to conduct different types of research as well as differing capacities to engage policymakers.

Comments about social responsibility focused on the concepts of providing as much information as possible to guide society’s public health policy (“better to over-inform [policymakers] than not”), the use of tax-payer money for research (“Federal science is more accountable [than academic science] and should be effectively used for questions of national, provincial, jurisdictional importance.”), and citizen engagement (“…as a citizen one has a responsibility, regardless of whether one is a scientist…to engage the [government] process”).

**Formal mechanisms**

The concept of a formal mechanism of knowledge exchange—a defined route of exchange with policymakers, formally laid out through coordination of the research organization and policymakers—was identified by participants in both government and academic sessions as a means to potentially improve KTE, but with differing attitudes. Government researchers implied that a formal mechanism outlining routes of information exchange could be beneficial (“I think you could be trained until you’re blue in the face
and still not be able to do it effectively, if there are not clear routes of specific exchange.”), while, when it was discussed, most academics felt that dictation of a formal mechanism of exchange by the university could be perceived as an inhibition of academic autonomy (“The notion of an institutional mechanism implies control of the message and this could be a problem.”).

**Increasing awareness**

Although participants in every session suggested that there is increasing awareness of KTE among researchers, government researchers discussed the theme more holistically and in more depth. Comments within government groups regarding government mandates and mission statements suggested that KTE awareness was being encouraged from within the organization, whereas some academic comments implied that KTE was being somewhat imposed upon researchers from external sources such as funding agencies (“…grant applications are requiring [KTE] and that’s what actually drives change…”)

**What barriers do MFS researchers perceive to prevent or hinder engagement in effective KTE with policymakers?**

Four barrier themes emerged from the data: (1) the Research, (2) the Researcher, (3) the Researcher’s Organization, and (4) the System. At the thematic level of analysis, much of the detail of the specific barriers to KTE was lost because the themes were broad. To gain greater insight into the factors hindering researcher KTE, the findings were explored at the barrier concept level, within each theme (Table 1). When asked to
name the primary barrier hindering effective KTE with policymakers, many researchers commented that the individual barriers were linked, making it difficult to select one primary barrier. The main barrier concept associations that were discussed by participants are illustrated in Figure 1.

**Theme: Research**

The Research theme was comprised of a single barrier concept—Applicability—that could not be grouped under another theme. Applicability was identified by one basic researcher participant as the primary barrier to effective KTE.

**Concept: Applicability**

Many participants commented that some MFS research is not applicable to policy, leading to a lack of researcher engagement in KTE. Non-applicability could result either from the research being basic (i.e., instead of applied) or from applied research findings occurring too early in a research program to have a policy-relevant take-home message.

**Theme: Researcher**

The Researcher theme encompassed four concepts related to researcher deficiencies leading to KTE ineffectiveness—Convention, Knowledge, Doubts, and Time. Both government and academic participants identified Knowledge as a primary barrier to KTE, specifically a lack of knowledge of policy and KTE processes. Convention and Time were identified only by academic participants as primary barriers. A lack of time was linked to other primary barriers (Figure 1).
**Concept: Convention**

Both academic and government researchers commented that convention favouring end-of-research publication hinders KTE. Some commented that integrating KTE into the research process requires effort, time, and resources, making the conventional process the easier path to follow.

…it’s my sense that our old way of doing things is fast and easy and KTE…takes a lot of time.

**Concept: Knowledge**

Knowledge deficits about KTE and policy processes were identified as hindering or preventing KTE. In general, comments within government groups appeared to reflect a greater base knowledge of what KTE is and how to do it. More than their academic counterparts, government participants expressed a need for KTE training and for two-way communication with policymakers. Some government researchers identified a link between their own lack of KTE expertise and their inability to obtain buy-in from their organization to engage in KTE. Other government researchers felt that they lacked KTE skills because KTE was a new job responsibility for which they were unprepared.

Comments from many academic researchers suggested they lacked knowledge of what KTE is and how to do it. While discussing the recent trend of KTE plans being required in research grant applications, one academic researcher commented,

It’s not necessarily useful at this phase; it’s just people writing because they know they have to put [down] something. So if we can
get…a common expectation or understanding of what [KTE] is, that might really help.

Both academic and government researchers cited a lack of understanding of the policy process and policymakers’ information needs as KTE barriers. Some suggested that a lack of sustained two-way communication with policymakers may result in either (1) development of non-policy-relevant research questions by researchers or (2) misinterpretation of research questions proposed by policymakers, because policymakers are not available to discuss the basis of their requests. One government researcher commented,

It wasn’t until I got into risk assessment work [that] I realized the communication part of the risk assessment was actually fundamentally more important than doing the work. You can do a very fancy, quantitative, probabilistic model, [but]…if we aren’t responding to [policymakers’] questions…we may as well not do the work.

One academic suggested that without feedback from policymakers regarding the utility of evidence provided to them, researchers do not know whether they had understood the policymaker’s initial needs or whether their KTE was effective.

**Concept: Doubts**

Researcher doubts that hindered KTE included doubting ones credibility as a messenger for policymakers and doubting the effectiveness of KTE, which reduced initiative to engage in KTE. These doubts were expressed most frequently in academic
sessions. Among government researchers, the main constructs of the Doubt theme were scientific uncertainty and partial evidence.

…we’re almost afraid to say something and [be] wrong as opposed to…[saying that] this is the best information we have at the moment and let’s do with it what we can.

Both academic and government researchers expressed worries that, in translation, their message may be oversimplified to the point that it has little meaning or, conversely, that removal of the uncertainty in research findings may render a message to be taken as an absolute, when it shouldn’t be. In general, doubts appeared to reduce researcher initiative to engage in KTE.

*Concept: Time*

The concept of time crossed multiple themes, emerging within the Researcher theme and the System theme, and being linked to the concept of organizational buy-in within the Researcher Organization theme. Within the Researcher theme, all groups discussed lack of time as a barrier to KTE engagement. Government researchers focused solely on the time required to conduct KTE, while academics also discussed the time required to understand what KTE is and how to do it. Many researchers felt that KTE required considerable time that was not available, given other responsibilities and priorities imposed by the research organization.

…the issue of conflicting responsibilities—there’s just too much else on your plate. Getting [policymakers] involved at square one in the research…my experience so far would be that it probably increases
the amount of time to get something up and running tenfold. It’s not double or triple—it’s huge.

**Theme: Researcher Organization**

One dominating concept defined the Researcher Organization theme: Organizational buy-in. For one government participant, Organizational buy-in was the primary barrier to KTE, specifically a lack of funding and human resources, a lack of adherence to KTE mandates at all organizational levels, and an inappropriate reward system (Figure 1).

**Concept: Organizational buy-in**

Organizational buy-in was a multi-thematic concept, emerging in both the Researcher Organization theme and the System theme. It emerged in both government and academic sessions, incorporating such ideas as a lack of recognition of KTE in the promotion process for researchers, a lack of adherence to KTE mandates at all organizational levels, and a lack of financial or human resources for KTE.

Generally, academic researchers felt that while universities may consider KTE to be beneficial, most institutions do not recognize KTE activities in the promotion-and-tenure process. Many commented on the “publish-or-perish” phenomenon, …in the academic world, there’s a lot of emphasis on peer-reviewed articles, and there’s not a whole lot of emphasis on reaching the public. I don’t think that knowledge translation…is highly valued.

A similar reward system existed for at least one government researcher:
…if, for example, you are rewarded by being first author on the greatest number of publications you can possibly put out, then you’re not going to waste your time doing knowledge translation.

Publication-based rewards in government organizations were perceived to indicate a lack of adherence to the over-arching government mandate that promotes KTE activities with policymakers. As well, in some government research organizations, it was perceived that KTE mandates were not followed at all levels of management: senior managers often obstructed KTE because they did not believe networking activities (e.g., making connections with policymakers at events to increase opportunities for future communication and/or collaboration) were perceived by taxpayers to be valid activities for researchers.

…there is certainly this sense that we need to be accountable to the public in terms of how we spend our money…this lens that’s being put on our budget… if [KTE’s] not recognized as a valid use of our time…then we’re not going to get the funding.

**Theme: System**

The System theme incorporated all barrier concepts external to the researcher’s organization, including the concepts of Communication network issues, Temporal disconnects (i.e., long timelines for research evidence production not meeting short policy timelines), Policymaker limitations, and Political issues. Communication network issues were cited by more than half of both academic and government participants as their primary barrier to KTE with policymakers. Specifically, an inability to identify
relevant policymakers was named most frequently, cited by at least one participant in all but one group. Unclear communication structures inside and outside of government were also considered a primary barrier by at least one academic and one government participant.

**Concept: Communication network issues**

Communication network issues were related to both government structural complexity and turnover of policymaker contacts. Participants commented that compartmentalization of the Canadian food safety system within multiple government levels and jurisdictions exacerbated already unclear, lengthy communication structures and resulted in a reduced ability for researchers to identify and access policymakers. One government researcher lamented the lack of formal chains of communication.

But even when we want to communicate something up…the avenues for doing so effectively are not clear. …We have a pretty good idea who to provide the information to, but the official route isn’t necessarily there to do it…It is partially related to the fact that it’s a multi-departmental, horizontal thing rather than a single group that’s responsible for the whole thing…

Policymaker turnover was also blamed for researchers’ difficulties in identifying relevant policymakers and inabilitys to establish long-term relationships.

And there’s always, always, always, fluidity in that group. …You establish a relationship with somebody, and they’re gone…then all of a sudden there’s a new person in there.
In general, the government participants appeared to be able to identify their target audiences but were frustrated by unclear routes of information exchange, while academic participants appeared less able to identify relevant policymakers.

**Concept: Temporal disconnects**

Both academic and government participants identified temporal disconnects between research and policy as a hindrance to effective KTE. Researchers commented that the research process is lengthy and, in academia, is extended due to the need to train graduate students. In contrast, policy priorities were described with such words and phrases as “fire of the day,” “urgent,” “hot seat,” “reactive,” and “short-term thinking.” Many participants commented that policy priorities often are reactive to the latest foodborne disease crisis, driving research funding and priorities in one direction. However, by the time the research process is complete, policymakers are no longer receptive to research evidence because policy priorities have shifted to the next crisis.

There’s a disconnect in time and urgency…between policymakers and researchers. Policymakers want the…answer yesterday. And as researchers…by the time we’re given a question, we write a grant, get the research done…we’re talking months, at best, years more likely. In my experience, policymakers don’t want to talk to the people that are doing the research, they want to talk to people who have DONE the research.

**Concept: Policymaker limitations**

Participants could only speculate on policymaker limitations, thus, these perceived limitations may or may not be real. Perceived policymaker limitations formed
two categories: (1) perceived lack of knowledge or understanding and (2) perceived limitations of time or resources. Perceived knowledge and understanding gaps included lack of policymaker skills to critically appraise research evidence, lack of understanding of scientific language, inability to adapt research evidence to the policy context, lack of understanding of or tolerance for uncertainty in research results, and lack of understanding of the research process and its limitations. Both academic and government researchers had experience with policymakers asking unanswerable research questions because policymakers were uninformed about research limitations. Comments were made by both academic and government researchers that policymakers’ lack of understanding of scientific uncertainty may lead to unintentional misuse of research evidence, through over-simplification or over-interpretation of the evidence.

Our fear [is] of losing the content so that the implications are [removed], and then the policy that is enacted may be inappropriate for the information that was provided.

Researchers also commented that policymakers appeared to lack time and resources for KTE. Some felt that policymakers did not make time or use resources for KTE because they were not interested in KTE or did not value it. Government researchers linked high policymaker turnover and inappropriate promotion systems to policymaker disinterest in KTE. Both academic and government researchers perceived this lack of policymaker buy-in to be a barrier to KTE.

In general, comments made about policymakers in government groups appeared to be based more upon actual experience with policymakers than those made in academic
groups (i.e., academic participants’ comments about KTE with policymakers often employed words denoting uncertainty, such as “probably” and “maybe,” suggesting many academics may not have had extensive experience with policymakers upon which to base their comments).

**Concept: Political issues**

Participants suggested that both political disincentives and incentives may reduce KTE effectiveness, by reducing policymaker use of research evidence. Regarding political disincentives, policymakers may be disinclined to embrace an evidence-based policy direction that ostracizes the public or agri-food stakeholders because it could reduce their chances of re-election.

We’re…making the assumption that policymakers, if they just knew the information, would adopt the policy. But the case may be that policymakers don’t want to adopt the policy because it would be too controversial.

Conversely, political incentives (e.g., appealing to public opinion) may drive policymakers to adopt new policies against existing research evidence.

It [public opinion] also drives policy…sometimes the policy is developed, very little based on the work that we do but more on the fact that there was this big outbreak. And now all of a sudden we’re running around testing [for] Listeria on every single possible food product, even though we know that the risk is really, really low of getting listeriosis from packaged lettuce. So from an evidence
perspective…Why are we doing it? We’re doing it because we think the public wants us to do that.

While, at times, public will may drive reactionary policymaking forward, a lack of public will was also thought to reduce political incentive to develop long-term food safety priorities. Although participants viewed the Canadian public as being engaged in the political landscape during foodborne disease outbreaks, they suggested that, unlike Americans or Europeans, Canadians are more tolerant of foodborne disease issues outside of outbreaks and place little pressure on government to develop long-term solutions. This perceived lack of public will offers little political incentive to engage in KTE with researchers, and use research evidence to be proactive concerning foodborne disease. (“If there’s no public will, then there’s no political will.”)

Both academic and government researchers discussed political issues as potential KTE barriers; however, generally, academic comments appeared more speculative and government comments more grounded in experience (i.e., academic participants’ comments about KTE with policymakers often employed words denoting uncertainty, such as “probably” and “maybe,” suggesting many academics may not have had extensive experience with policymakers upon which to base their comments).

**DISCUSSION**

The focus group data were a source of rich, detailed information that allowed us to explore Canadian MFS researchers’ attitudes toward KTE and the barriers that hinder KTE with policymakers. Generally, value was placed upon the concept of KTE and participants appeared motivated to develop or improve their KTE strategies. However,
undertones of dissatisfaction were apparent surrounding the lack of perceived impact of their KTE efforts. KTE impact may be difficult to detect. Often, policymakers do not use research evidence directly in policy development (“instrumental” use) [9] but instead use it conceptually to clarify a problem, enlighten debate, frame an argument, or alter attitudes on an issue [33-36]. Over time, the cumulative effects of conceptual uses of research can be powerful [33]; however, these impacts are not easily identified or measured. Target-audience feedback is one method of measuring the conceptual use of research evidence and KTE impact [37]. Evaluation through feedback is integral to the iterative process of many KTE models [12, 38-42]; however, only half of Canadian MFS researchers engaging in KTE had obtained feedback from policymakers [30]. Without policymaker feedback, many researchers cannot infer the conceptual impact of their KTE efforts [43], potentially leading to speculations of KTE ineffectiveness. Perceived KTE ineffectiveness may lead to low outcome expectancy—a person’s estimate that a behaviour will lead to desired outcomes [44]—discouraging researchers from engaging in further KTE activities. Increasing policymaker feedback may raise outcome expectancy, and may encourage sustained KTE interactions over time [39].

Generally, government participants appeared to have more applied knowledge of KTE than their academic counterparts, as expected, given that Canadian government MFS researchers were significantly more likely to engage in KTE with federal policymakers than academic researchers [30]. Differences in KTE engagement may be associated with differing constructs of researcher responsibility. Whereas government participants focused on the inclusion of KTE in their organizational mandates and their
social responsibility to Canadian tax payers to produce policy-relevant evidence, concepts of competing priorities (e.g., the training of graduate students, peer-reviewed publication), research autonomy, and the pursuit of hypothesis-generating research arose amongst academics. Generally, most government participants considered KTE a part of their job description, despite not being rewarded for it, while most academics, although recognizing its value, considered KTE subordinate to their primary responsibilities.

Jacobson et al. [45] summarize similar findings, indicating that within academic reward systems, the high value placed upon traditional research products (i.e., peer-reviewed publication or receipt of research grants), coupled with limited time, forces academic researchers to rank KTE as a low-priority activity. Consequently, few academics receive KTE training or have KTE experience [45]. Changes to university reward systems need to occur to reduce the traditional “publish-or-perish” focus and free up time for KTE training and engagement on a sustained basis [43, 45, 46]. Funding bodies requiring integrated KTE for successful research grant proposals [47] may help to drive change in academic reward systems. With these changes in organizational culture, researchers’ beliefs and values surrounding KTE may be altered.

The barrier themes emerging from the focus group data were consistent with factors affecting the uptake of innovations by populations, initially identified in Roger’s Theory of Innovation Diffusion [48] and adapted by others to categorize KTE barriers [49, 50]. All of the barrier subcategories found in this study were previously identified in the health-care literature. The barrier subcategory cited by the most participants to be their primary barrier to KTE was an inability to identify policymakers, which was linked
to the complexity of the government structure, policymaker turnover, and insufficient financial resources (Figure 1). Government responsibility for food safety in Canada is multi-jurisdictional and multi-level; it involves many ministries and agencies at federal, provincial/territorial, and local levels of government [51]. A complex political structure was also found to hinder identification of and access to relevant target audiences in the Canadian children’s mental health system [46]. Policymaker turnover further exacerbates policymaker identification issues, forcing researchers to continuously redevelop relationships and gain credibility with new contacts. Two-thirds of Canadian MFS researchers perceive policymaker turnover to be high [25], indicating that turnover may affect policymaker identification on a widespread basis. Large resource investment is necessary on the part of research organizations to establish relationships with policymakers [12, 52] and this investment is multiplied when policymaker turnover occurs. However, for almost half of MFS researchers in Canada, their research organization did not provide human or financial resources for KTE [25]. Thus, KTE engagement for a high proportion of Canadian MFS researchers may be hindered by an inability to identify relevant policymakers, which is exacerbated by a paucity of human and financial resources, policymaker turnover, and compartmentalization of food safety policy within a complex political structure.

In a review of the KTE literature, Lavis et al. [12] advised that identification and knowledge of the target audience is critical to KTE success—multiple target audiences can influence policy decisions and researchers should engage the target audience with the greatest ability to effect change. For some academic researchers, engagement with
industry or producer groups influential in the policy community may result in greater policy impact than individual researcher KTE efforts. Also, contacts within these groups may be more easily identifiable and more stable over time than those within government, meaning fewer financial resources may be needed to maintain them. Government researchers may not have opportunities to bypass the political structure in which they work and other solutions may be needed to aid policymaker identification. Government participants in this study felt that formal routes of information exchange in government would identify relevant policymakers and enhance the KTE process. The presence of similar structures and processes linking researchers and their target audiences has been identified in the literature as a facilitator of researcher KTE engagement [50]. Linkage and information exchange between researchers and policymakers are necessary components of “integrated” KTE—inclusion of policymakers throughout the research process, from the development of the research question to final dissemination [5]. Through integrated KTE, the probability that research output will be of relevance to policymakers increases. As one government participant succinctly stated, “…if we aren’t responding to [policymakers’] questions…we may as well not do the work.” To develop formal information exchange structures, organizational buy-in and support must be high; however, lack of organizational buy-in was a commonly cited barrier to KTE amongst government participants. Organizational cultures that value research have been demonstrated to facilitate evidence-informed decision making [48, 53-57]. Thus, to enhance KTE within and across the myriad of government organizations responsible for
Canadian MFS policy, a stronger culture of KTE needs to evolve through all management levels, beyond the inclusion of KTE in organizational mandates.

The “Knowledge” and “Convention” themes were also commonly cited primary barriers to KTE for both government and academic participants. Although all participants appeared to have a general understanding of the concept of KTE, many perceived that they lacked skills of “how to do it.” Perhaps their uncertainty is not unfounded as beyond experiential accounts, little empirical evidence exists demonstrating which KTE strategies work [7, 8, 58, 59]. Amongst academics, confusion existed surrounding the various KTE-like terms used by funding agencies. Almost 100 different terms are used to identify KTE and related concepts within the literature [60], and often the terms are not explicitly defined [39, 61, 62]. Lack of clarity can result in unclear KTE expectations for both researchers and policymakers [10]. Many participants discussed Convention, describing a lack of initiative to break free from traditional research publication modes that are easier and take less time. Because the food safety sector is early in the adoption of KTE with policymakers, both researcher and organizational ties to traditional peer-reviewed publication conventions appear to remain strong and incentive for researchers to engage in integrated KTE with policymakers appears to be low. Researchers’ values and beliefs surrounding KTE will need to change, if effective KTE with policymakers is to occur. A trend of increasing organizational support for KTE activities over time has been demonstrated in the literature to be a facilitator of health researcher KTE engagement [50]. In 2009, more than half of MFS researchers in Canada reported that their organizations had become more supportive of individuals conducting KTE in the
previous 5 years [25], indicating that researchers may continue to have greater motivation to step beyond the conventions of publication. Changes in organizational culture may influence individuals’ attitudes toward KTE.

The focus group study was hampered by low numbers of potential participants scattered in disparate groups across a large geographic area. Although academic participants came from different cities, geographic variability was lacking in government participants (e.g., government researchers located in closer geographic proximity to policymakers may perceive the barriers to KTE differently). An in-depth interview method would have permitted inclusion of individuals from all areas of the country, increasing transferability; however, because participants’ applied knowledge of KTE was anticipated to be low, it was felt that a focus group design would generate a richer dataset through group discussion in an informal setting.

Limitations common to or inherent in qualitative studies may have influenced this study, including selection bias, social desirability bias, and lack of generalizability. Selection bias may have arisen due to the participatory nature of the study: those who volunteered for the study may have had stronger opinions about KTE than those who did not volunteer. Social desirability bias—participants conforming to a group member or to a prevailing attitude—was reduced by (1) not including research managers in the study as their presence may have influenced researcher responses; (2) informing participants that there were no “right” or “wrong” answers and encouraging participants to voice opinions, even in disagreement with others; and (3) asking participants to write down their responses to some questions prior to discussion, ensuring that initial, individual opinions
were obtained, as well as shared perspectives. Lack of external validity is inherent in all qualitative studies, due to a lack of randomization in the sampling process [32, 63]. However, although the inferences drawn in this study may not be generalizable to all MFS researchers in Canada, they may be transferable to other research groups in similar contexts (e.g., those based geographically distant from policymakers) [63].

**CONCLUSIONS**

The findings of this study demonstrate that within the Canadian MFS sector, there are researchers who value the concept of KTE and who are motivated to engage in KTE activities; however, lack of perceived impact may reduce sustained KTE engagement over time. An inability to identify policymakers was the barrier cited most frequently to hinder KTE. Engagement of influential stakeholders by academics or development of formal routes of knowledge exchange within government organizations may help mitigate policymaker identification issues. Organizational buy-in needs to evolve at all levels of both academic and government research organizations to validate KTE training and support for researchers. These shifts in organizational culture may encourage the changes in researchers’ values and beliefs regarding KTE, its perceived difficulty, and the time it takes, that are necessary for effective KTE to occur in the food safety sector.
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and promotion of knowledge translation: an international study. *Milbank Q* 
Table 4.1. Summary of thematic analysis of barriers perceived by Canadian MFS researchers to hinder or prevent effective KTE with policymakers.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Subcategories (“A” = emerged in academic groups, “G” = emerged in government groups)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concept</td>
<td></td>
</tr>
<tr>
<td>Research</td>
<td></td>
</tr>
<tr>
<td>Applicability</td>
<td>Basic or esoteric nature of research (A, G)</td>
</tr>
<tr>
<td>Researcher</td>
<td></td>
</tr>
<tr>
<td>Convention</td>
<td>Research process has not traditionally included KTE (A, G)</td>
</tr>
<tr>
<td></td>
<td>Researchers lack initiative to change traditional research process (A, G)</td>
</tr>
<tr>
<td>Knowledge</td>
<td>Lack of understanding of the KTE process (A, G)</td>
</tr>
<tr>
<td></td>
<td>Lack of understanding of policy or policymakers’ information needs (A, G)</td>
</tr>
<tr>
<td>Doubts</td>
<td>Perceived lack of credibility with policymakers (A, G)</td>
</tr>
<tr>
<td></td>
<td>Unwillingness to create messages for policymakers based on partial evidence (A, G)</td>
</tr>
<tr>
<td>Category</td>
<td>Issues</td>
</tr>
<tr>
<td>------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Time</strong></td>
<td>Low return on time and energy invested (A)</td>
</tr>
<tr>
<td></td>
<td>Lack of time (A, G)</td>
</tr>
<tr>
<td><strong>Organization</strong></td>
<td></td>
</tr>
<tr>
<td>Organizational buy-in</td>
<td>Lack of financial or human resources (A, G)</td>
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<td></td>
<td>Lack of recognition of KTE in promotion criteria (A, G)</td>
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<tr>
<td></td>
<td>Lack of adherence to government KTE mandates at all levels (G)</td>
</tr>
<tr>
<td><strong>System</strong></td>
<td></td>
</tr>
<tr>
<td>Communication network issues</td>
<td>Inability to identify policymakers (A, G)</td>
</tr>
<tr>
<td></td>
<td>Policymaker turnover (A, G)</td>
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<tr>
<td></td>
<td>No obvious communication structure outside or inside government (A, G)</td>
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<td></td>
<td>Compartmentalization of food safety within a complex political structure (A, G)</td>
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<tr>
<td></td>
<td>Inability to access policymakers (A)</td>
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<tr>
<td></td>
<td>Inability of policymakers to identify researchers (A)</td>
</tr>
<tr>
<td>Category</td>
<td>Description</td>
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<tr>
<td>--------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Temporal disconnects</td>
<td>Perceived disconnects between policy priorities and timelines and the research process (A, G)</td>
</tr>
<tr>
<td>Policymaker limitations</td>
<td>Perceived inability of policymakers to critique, understand, or adapt research evidence to context (A, G)</td>
</tr>
<tr>
<td></td>
<td>Perceived policymaker lack of understanding of research process or limitations (A, G)</td>
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<tr>
<td></td>
<td>Perceived policymaker lack of time or resources (A, G)</td>
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<tr>
<td></td>
<td>Lack of policymaker buy-in (A, G)</td>
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<tr>
<td>Political issues</td>
<td>Public opinion (A, G)</td>
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<td></td>
<td>Agri-food business pressure (A, G)</td>
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<tr>
<td></td>
<td>Political disincentives (A)</td>
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<td></td>
<td>Lack of public will to decrease foodborne disease (G)</td>
</tr>
</tbody>
</table>
Figure 4.1. Main associations between KTE barrier concepts discussed by participants in a focus group study of Canadian microbial food safety researchers.
CHAPTER 5

Canadian food safety research output relative to policymakers’ apparent informational needs: issues of timing and relevance

(Presented in the style of the journal *BMC Public Health.*)

ABSTRACT

**Background:** Research output that does not meet policymakers’ informational needs due to issues of relevance or timing (informational or temporal disconnects) can negatively influence knowledge translation. In Canada, food safety policy change is often reactive to foodborne disease outbreaks, and it was hypothesized that policy-relevant research output may occur after it is needed by policymakers.

**Methods:** Publications with a Canadian author were used as a proxy for Canadian research output (1999–2011 for Verotoxigenic *E. coli* (VTEC) and 2001–2011 for *Campylobacter* and non-typhoidal *Salmonella*). Policy-relevant publications were identified based on study design, research objective, and type of publication, and were categorized by commodity (e.g., beef, poultry, produce). Publicized outbreaks identified times when policymakers may have been receptive to policy-relevant research evidence. Outbreaks were categorized by source commodity. Poisson and logistic regression models identified associations between publication rates and time and publication policy relevance and time, respectively. Graphs of the probability of a policy-relevant publication and the probability of a publicized outbreak over time, by commodity,
illustrated potential informational and temporal disconnects. General linear mixed models identified significant differences between pathogens of mean monthly national disease incidence and mean monthly publication counts, controlling for trends over time.

**Results:** For each pathogen, monthly publication rates increased over time. The probability of policy-relevant research output increased over time for VTEC and *Salmonella*, but not for *Campylobacter*. Little produce-related policy-relevant research output occurred for *Salmonella* or VTEC, although the apparent probability of policymakers needing produce-related evidence was high (*Salmonella*) or increased over the study period (VTEC)—an informational disconnect. The apparent probability of policymakers needing meat-related VTEC dropped substantially over the study period; however, meat-related policy-relevant VTEC publications rose—a temporal disconnect. *Campylobacter* mean monthly national disease incidence was significantly higher than either VTEC (p < 0.001) or *Salmonella* (p < 0.001); however, *Campylobacter* mean monthly publication count was significantly lower than either of the other pathogens (p < 0.001)—an informational disconnect.

**Conclusions:** Informational and temporal disconnects between research output and policymakers’ apparent informational needs appear to exist in the Canadian food safety system, potentially hindering knowledge translation and evidence-informed decision making.
BACKGROUND

Foodborne and waterborne disease affect hundreds of thousands of Canadians annually [1]. In 2000 and 2001, the estimated average annual number of cases of *Campylobacter* was approximately 280,000–600,000 (rate 9.1–19.3/1000 population), verotoxigenic *Escherichia coli* (VTEC) was approximately 21,000–103,000 (rate 0.7–3.3/1000 population), and non-typhoidal *Salmonella* was approximately 75,000–215,000 (rate 2.5–6.9/1000 population) [2]. All three of these pathogens have been implicated in foodborne disease outbreaks in Canada [3], with *Salmonella* being the most commonly identified outbreak etiologic agent [3]. Although all three pathogens have been linked to all or almost all categories of potential sources of foodborne outbreaks (e.g., meat, dairy products, eggs, produce) [3], the most common source attributed to *Campylobacter* outbreaks is poultry, to VTEC outbreaks is beef, and to *Salmonella* outbreaks is produce [3].

Current Canadian food safety policy change is often reactive to foodborne disease emergencies [4], with policy priorities shifting as new disease outbreaks create media impact and subsequent public pressure on policymakers to act. At times of emergency, government decision making becomes time-compressed, with multiple authorities needing to make coordinated decisions across multiple jurisdictions [5]. Effective, large-scale response during an extreme event requires information to be exchanged and absorbed quickly within a network of multi-disciplinary and multi-jurisdictional organizations [6]. To accomplish a rapid, evidence-informed response, policy-relevant
research evidence must be produced proactively and, ideally, synthesized prior to emergencies.

Knowledge translation and exchange (KTE) strategies in government aim to promote the exchange of information between researchers and policymakers—information on policy priorities and knowledge needs from policymakers to researchers and research evidence from researchers to policymakers—to promote the output of policy-relevant research and to encourage decision making informed by the most up-to-date scientific evidence [7]. To optimize KTE, research and policy need to occur in sequence; however, this idealized, linear process of “rational decision making” is rarely seen in practice [8-10]. Specifically in the Canadian food safety system, reactive policy priorities are perceived to influence subsequent research funding [11], meaning policy-relevant research output may occur years after policymakers have need of the evidence. Proactive research evidence production is incorporated into Kingdon’s Agenda-setting Model of policy decision making [12], adapted from the “garbage can model” of organizational choice [13] to describe agenda setting in government. In this theoretical model, three streams flow independently through a policy arena: (1) a problem stream, composed of conditions of the state that have been perceived to need change; (2) a political stream that fluctuates with changes in government (ideology) and with public pressure; and (3) a policy or solutions stream, in which flows information (e.g., proactively produced research evidence) relevant to problems that may arise in the problem stream. When these three streams converge, “policy windows” open. At these times, policymakers become receptive to information—science-based or otherwise—to
aid decision making. In the food safety system, foodborne disease outbreaks act as “focusing events” [12], causing policy windows to open and policymakers to actively seek relevant information. However, policy windows remain open only for short periods, until policy priorities change or public pressure diminishes. If current, policy-relevant research evidence is not available in the solutions stream when policy windows are open, policymakers will tend to rely on colloquial evidence or out-of-date research evidence available in the solutions stream to inform their decisions [14-16]. In food safety, two general types of policy decisions occur: “content-driven” and “large-scale” decisions [10, 17]. Content-driven decisions require technical information [17] (e.g., what field-level test for a pathogen has the highest sensitivity?), must be justified by science [10], and may occur in the ongoing evolution of regulations, standards, or targets. Large-scale decisions are political in nature, and are justified by social values (e.g., should a national pathogen-control program be implemented?), with more diffuse input from science at the policy formulation stage [10]. At times of foodborne outbreaks, policy decisions may be more large scale than content driven, with policymakers requiring information on the efficacy of interventions for pathogen control to identify and evaluate policy options. For the purposes of this study, policy-relevant research evidence for foodborne pathogen control includes the findings of research on food safety interventions that, preferably, have been formally synthesized and are available in full format to allow critical evaluation.

Disparities between research and policy can reduce the likelihood of KTE success, because proactively produced, policy-relevant, issue-specific research evidence
is not available when policy windows open and policymakers are actively seeking information. It is hypothesized that these disparities (or disconnects) can be either temporal or informational in nature. Temporal disconnects occur if policy-relevant, issue-specific evidence is produced after policy windows close, and may be exacerbated if short-term policy priorities subsequently direct longer-term research priorities. Issues with the timing of research output relative to policymaking needs (temporal disconnects) have been identified as a key barrier to KTE in healthcare policy [14, 18-22], as well as a perceived barrier in the Canadian food safety system [11]. Informational disconnects may occur in food safety if policy-relevant research evidence is available for a pathogen when policy windows open, but the evidence is not specific to the policy issue. For example, if a *Salmonella* outbreak occurs attributable to produce (e.g., fruits, vegetables, nuts), an informational disconnect occurs if the available policy-relevant research findings for *Salmonella* are mainly related to meat and not produce. If they promote a change in research priorities, informational disconnects may cause temporal disconnects to occur relative to past outbreaks, as issue-specific research evidence production occurs after it is needed by policymakers. Thus, a temporal disconnect may be evidence of a past informational disconnect. Temporal disconnects may be beneficial as they can symbolize a change in research priorities in congruence with policymakers’ informational needs. However, temporal disconnects may be detrimental if policymakers’ informational needs change and research priorities remain entrenched in past domains that are no longer policy relevant. Accurate research prioritization in alignment with the anticipated future
informational needs of policymakers could reduce temporal and informational disconnects and improve KTE success.

The purpose of this study was to explore the historical timing of research output relative to the timing of the opening of policy windows that typically follow publicized foodborne disease outbreaks, thereby assessing the extent to which actual research-to-policy temporal and informational disconnects have occurred in the Canadian food safety system. Specifically, the research objectives were

1) to determine if food safety research output in Canada changed over time for three foodborne pathogens: Campylobacter sp., VTEC, and non-typhoidal pathogenic Salmonella sp.;

2) to determine if the policy relevance of food safety research output in Canada changed over time, for the same pathogens;

3) to descriptively evaluate if the amount of policy-relevant food safety research output available when policy windows open in Canada changed over time, for the same pathogens; and

4) to quantitatively compare the frequency of Canadian research output relative to national disease incidence among pathogens.

METHODS

For the purposes of this research, VTEC was defined as any verotoxin-producing E. coli, including both O157:H7 and non-O157 serotypes [23, 24].
Definition of proxy variables

Two proxy variables were used to estimate non-quantifiable variables: (1) “Research output” was quantified using bibliometric data (i.e., publication counts), a measure commonly used to operationalize research output [25, 26] and (2) the timing of the opening of policy windows (i.e., when policymakers actively seek relevant information) was estimated by the timing of the peak month of media-publicized foodborne disease outbreaks.

Procurement and categorization of bibliometric data

Bibliometric data collected included citations and abstracts of all publications having at least one Canadian author address, published between 1 January 1999 and 31 May 2011 for VTEC and between 1 January 2001 and 31 May 2011 for Campylobacter and Salmonella. VTEC bibliometric data were collected for 1999 and 2000 to include publications prior to Canada’s largest waterborne VTEC and Campylobacter outbreak, which occurred in Walkerton, Ontario, in May 2000 (hereafter, “Walkerton”) [27].

Search method

Publication searches for each pathogen were conducted in Web of Knowledge (http://wokinfo.com/) (which includes Web of Science) for articles with English abstracts published between the dates of interest, with “Canada” as an Address term and one of the following Topic terms for the pathogen of interest: (1) “Salmonell*”, (2) Campylobact*”, or (3) “VTEC” OR “Verotoxigenic E. coli” OR “Verocytotoxin producing E. coli” OR “STEC” OR “Shigella-toxin producing E. coli” OR “Shiga-toxin producing E. coli” OR
“O157” OR “Pathogenic E. coli” OR “Hemorrhagic Uremic Syndrome” OR “Haemorrhagic Uraemic Syndrome.” Search results were downloaded into EndNote X5 (Thomson Reuters, New York City, NY) into separate databases for each pathogen. Duplicate citations were removed using the EndNote duplicate tool and through manual sorting and identification. Publications identified as patents, books, or book chapters were removed.

**Relevance screening**

Relevance screening was performed independently by two researchers, with identification and resolution of conflicts to improve validity. Prior to screening each pathogen database, 200 randomly selected publications were screened by both researchers to identify screening criteria issues. Titles and abstracts were used for screening purposes, with full publications used when abstracts were unavailable or lacking key information. Initially, publications were screened for the presence of indicator terms (Table 1). Publications with indicator terms present were further screened to exclude papers where the pathogen of interest appeared only in a secondary role (e.g., as a negative control).

**Date of publication**

For each publication, the month of publication was identified as the earliest of either the “hard-copy” or e-publication dates. For papers and abstracts presented at conferences, the month of publication was the earliest of hard-copy or e-publication dates and not the date of the conference, as many proceedings were not published until >12 months after the conference.
Identification of generally policy-relevant publications

All publications remaining after screening were scrutinized for policy relevance. Because a tool to measure the “policy relevance” of a publication was not available in the literature, a system to identify policy-relevant publications was developed, with three components: study design, study objective, and publication type (Table 2). Study design is an indicator of the strength of evidence of scientific findings, with respect to clinical decision making [34, 35], and consequently was included as an indicator of policy relevance. Study objective was included as an indicator of policy relevance for large-scale outbreak-related policy decisions because information regarding the efficacy of food safety interventions may be most likely to be sought by policymakers in the identification and evaluation of policy options. Evidence from research with other study objectives would likely also be sought by policymakers in efforts to frame the issue (e.g., pathogen frequency studies); however, well-designed evaluations of food safety interventions (Table 2) were selected as indicators of policy relevance because their findings were highly relevant to policy development for pathogen control. The type of publication (e.g., full paper versus abstract only) was included as an indicator of policy relevance because full publications would be necessary for policymakers to appropriately critique the evidence therein. Publications needed to satisfy all three components of the identification tool to be considered policy relevant.

Identification of <5-year-old, policy-relevant publications, specific to outbreak sources

All commodities of interest of all policy-relevant publications were identified (more than one could be identified per publication). Possible commodities of interest
included beef; dairy; pig/pork; poultry; egg; fruits, vegetables, and nuts (termed “produce”); wild game/fish; water; environment (e.g., soil, manure); and unspecified animal or food product. For each identified outbreak occurring during the study period (see below), the number of policy-relevant publications that had a commodity of interest the same as the source of the outbreak and that were published within 5 years prior to the outbreak was determined. These were termed “<5-year-old, policy-relevant publications, specific to the outbreak source” for each identified outbreak. The median survival time of the relevance of systematic reviews (SRs) of human medical interventions (i.e., the time before new conflicting evidence is published) has been estimated as 5.5 years [36]. Given the emergent nature of foodborne disease, food safety research is often of high priority, meaning food safety research output may be higher than human medical intervention research, reducing the median survival time of relevance. Thus a relevance cutoff of 5 years was chosen. For analysis, the outbreaks and the <5-year-old, policy-relevant publications associated with them were categorized into either “meat” or “produce” commodity groups.

Policy-relevance identification and identification of the commodities of interest was performed independently by two researchers using title and abstract and, if necessary, the full publication, with conflict resolution to improve validity. Where disagreements occurred, they were discussed until consensus was achieved, or if unresolvable, a third reviewer was consulted.
Procurement of outbreak data

The outbreak data collected for this study were not meant to include all outbreaks affecting Canadians over the study period, because numerous small unpublicized outbreaks occur across the country routinely and not all outbreaks act as focusing events for policymakers. Instead, the outbreak data collected were intended to be representative of open policy windows, times when policymakers were most receptive to research evidence to inform policy. Thus, only outbreaks that were publicized were of interest for this study. Food- and waterborne outbreaks having Canadian cases, a verified source, and impact in the Canadian news media or publicly available websites (i.e., they appeared in at least one print media article or on one publicly available website) were identified using Canadian Newsstand Complete (http://www.proquest.com/en-US/catalogs/databases/detail/canadian_newsstand.shtml) and Google (www.google.com). Searches were conducted in both interfaces for each pathogen of interest using the search term “(Foodborne OR Food-related OR "Food poisoning" OR Waterborne) AND (illness OR infection OR disease) AND outbreak AND (pathogen of interest).” Location limits were used in Google to limit search results to Canadian webpages. Date limits were used in both search engines to limit search results to single years between 2006 and May 2011 (2004 and May 2011 for VTEC). The first 100 Google search results for each year were inspected for reference to food- or waterborne outbreaks with Canadian cases. All Canadian Newsstand Complete search results were inspected as there were fewer than 100 results per year. Counts of search hits were tallied for each identified outbreak and outbreaks with the highest numbers of search hits were considered to have the highest
media impact. Descriptive information for each outbreak, including outbreak source, was collected from the information provided on the websites.

**Procurement of disease incidence data**

*Campylobacter, VTEC, and Salmonella* are reportable diseases in Canada [37], with the National Notifiable Disease Program of the Public Health Agency of Canada (PHAC) maintaining a database of all *Campylobacter* (untyped), non-typhoidal *Salmonella*, and VTEC cases reported to the national level. Nationally aggregated monthly disease incidence data were procured from PHAC for these three pathogens from January 1998 until the most recent data available (2008) [38].

**Analyses**

All statistical analyses and graphics were conducted in Stata 11 (Stata Corp, College Station, TX), except for time-series analyses and graphics, which were conducted in R 2.14.0 [39].

**Association between total publication counts and time**

To evaluate the association between publication counts and time, a Poisson regression model was fit for each pathogen. Each observation represented a month in the study period. The independent variable was the month in the study period (continuous; range: 1–149 for VTEC and 1–125 for *Campylobacter* and *Salmonella*), with the outcome being the number of publications published each month. The number of days in the month was forced into each model as an exposure. Abstracts presented at conferences were excluded as they tended to cluster in time relative to the conference date. Models
were fit in a forward stepwise method, using higher powers of the predictor of interest. Final model fit was tested using deviance and Pearson goodness-of-fit tests, while residuals were evaluated for normality and to identify potential outliers and influential covariate patterns.

**Association between probability of policy relevance and time**

Comparisons between pathogens were made of the proportions of all publications that were SRs, meta-analyses (MAs), or quantitative risk assessments (QRAs), using Fisher’s exact tests. The proportions of all publications that were policy relevant were also compared by pathogen, using Fisher’s exact test.

To evaluate the association between the probability of a publication being policy relevant and time, a logistic regression model was fit for each pathogen. Each observation represented a publication. The independent variable was the month of publication (continuous; range: 1–149 for VTEC and 1–125 for *Campylobacter* and *Salmonella*), with the outcome being the dichotomous base policy-relevance score of the publication. Abstracts were included because the base policy-relevance score was partially based upon whether a publication was an abstract. Models were fit in a forward stepwise method, using higher powers of the predictor. Final model fit was tested using Pearson and Hosmer-Lemeshow goodness-of-fit tests, and residuals were evaluated to identify potential outliers and influential covariate patterns.
Descriptive evaluation of trends in the publication of policy-relevant research specific to historical Canadian outbreaks

To assess trends in the publication of policy-relevant research specific to historical Canadian outbreaks, visual evaluations of graphs were conducted because limited numbers of outbreaks per pathogen by commodity precluded statistical analyses. Two graphics were prepared for each pathogen. First, the number of <5-year-old, policy-relevant publications, specific to the outbreak source was plotted for each identified outbreak by pathogen, with commodities of interest categorized into either “meat” or “produce” commodity groups. This plot illustrated the amount of <5-year-old, policy-relevant research, specific to an outbreak source that was available to policymakers at times when it was apparently needed. Secondly, the LOESS-smoothed [40] probability of (1) an outbreak and (2) publication of a commodity-specific policy-relevant paper were plotted over time by commodity group (“meat” and “produce”) for each pathogen. These plots illustrated how the probability of a publicized outbreak (i.e., a policy window opening) changed over time for each commodity group, and whether the output of commodity-specific policy-relevant research evidence was reflecting policymakers’ apparent informational needs. “Meat” referred to beef for VTEC, and pork and egg for Salmonella as these were the sources identified for non-produce-related outbreaks with media impact over the study period for the respective pathogens (no publicized poultry-related outbreaks were identified for Salmonella). Dairy-product data (i.e., milk, cheese, etc.) were excluded. “Produce” referred to vegetables, fruit, nuts, and products made from these commodities. For LOESS curves, the bandwidth of the locally weighted regression
algorithm was selected that would provide a smooth curve, minimizing monthly variability while capturing overall trends [40].

**Descriptive statistics and statistical comparison between pathogens of (1) mean monthly national disease incidence and (2) mean monthly publication counts**

Nationally aggregated, monthly disease incidence and monthly publication counts represented two concurrent time series for each pathogen from January 2001–December 2008. Descriptive statistics of each time series were calculated. To obtain statistical comparisons of overall mean monthly disease incidence between pathogens, while controlling for seasonality and trends over time, a general linear mixed model was fit, using a manual backward stepwise procedure. A second general linear mixed model was fit to compare mean monthly publication counts between pathogens, controlling for trends over time. For each model, the dependent variable (i.e., monthly disease incidence or monthly publication count) was transformed (natural log or square root transformation), if necessary, to achieve normally distributed, homoscedastic residuals. The fixed-effects portion of each full model was comprised of the main effects and interaction of a 3-level variable for pathogen and a 12-level variable for month of the year. The random-effects portion of each full model was comprised of an 8-level variable for year, and interactions between year and the fixed effects. Variables were retained in the fixed-effects portion of the model if they were significant at the 90% level (p < 0.10) and in the random-effects portion of the model if they were significant at the 80% level (p < 0.20). Main effects of significant interactions were retained, regardless of their significance. Residual analyses identified potential outliers, which were evaluated for
influence on the main effects of the pathogen variable. All linear mixed models were fit using SAS software, Version 9.2 (SAS Institute Inc., Cary, NC, USA).

RESULTS

Association between total publication counts and time

Flowcharts of publication counts for each pathogen from the initial bibliometric searches through relevance screening are presented in Figure 1. Numerically, fewer articles were published by Canadian authors for *Campylobacter* than *Salmonella*; VTEC publications were counted over a longer time and, therefore, are not comparable.

Time was significantly associated with publication counts for all three pathogens, as evidenced by regression curves (Figure 2). A positive, linear association was identified for *Salmonella* ($p < 0.001$), while a quadratic term (i.e., time squared) was significant for *Campylobacter* ($p = 0.001$), and a cubic term (i.e., time cubed) was significant in the final VTEC model ($p = 0.026$). The significance of the cubic term in the VTEC model was influenced by the first two years of the study period, in which publication rates demonstrated an initial downward curve (Figure 2). When the VTEC model was fit without the first two years of observations, the cubic term became non-significant ($p = 0.500$) and the quadratic term highly significant ($p < 0.001$).

Generally, goodness-of-fit tests demonstrated that the models fit the data well, except for the *Campylobacter* model. This is likely because the mean monthly publication count for *Campylobacter* was low ($\bar{x} = 3.2$), and the skewness and kurtosis of low-mean
count data cause tests based on normal theory to be inaccurate. Diagnostic tests of residuals were unremarkable.

**Association between probability of policy relevance and time**

Flowcharts of the policy-relevance scoring process for each pathogen are presented in Figure 3. Four publications (0.8%) were identified as SR/MA/QRAs for *Campylobacter*, 4 (0.5%) for VTEC, and 9 (1.1%) for *Salmonella*. These proportions were not significantly different between pathogens (p > 0.05). The proportion of all papers that were policy relevant was 1.1% for *Campylobacter*, 2.9% for VTEC, and 2.7% for *Salmonella*. The proportion of *Campylobacter* policy-relevant papers was significantly different than that for VTEC (p = 0.047), but there was no significant difference between the proportions of policy-relevant papers for *Campylobacter* and *Salmonella* (p = 0.076) or VTEC and *Salmonella* (p = 0.878).

There was no significant association between policy relevance and time for *Campylobacter* (p = 0.329) or VTEC (p = 0.291); however, time was significantly associated with policy relevance for *Salmonella* publications (OR = 1.02; 95% C.I. = 1.01–1.04; p < 0.001) (Figure 4). Higher powers (i.e., quadratic or cubic terms) of the time variable were not significant in the *Salmonella* model. Time was likely not the only predictor of policy relevance for *Salmonella* publications as the univariable model correctly classified only 77% of the data.
Descriptive evaluation of trends in the publication of policy-relevant research
specific to historical Canadian outbreaks

Forty-six foodborne outbreaks were identified that occurred between December 2005 and May 2011 (January 2004 and May 2011 for VTEC) and had Canadian cases, a verified source, and Canadian media impact (i.e., at least one search hit). For illustration purposes on graphs, the seven outbreaks with the highest number of search hits (the top 15% of the total) were identified as having high media impact (Table 3). All seven outbreaks had >15 hits, while the range of hits for the remaining outbreaks was 1–9 (mean 2.9 hits). All but one high-media impact outbreak had a produce-related source. The vehicle of the one meat-related outbreak with high-media impact (North Bay, Ontario; Harvey’s restaurant) was declared to be contaminated onions, but for the purposes of this study, this outbreak was categorized as a meat-related outbreak as the official outbreak report was suspicious of hamburger being the actual source [41]. Few Campylobacter outbreaks (4 outbreaks, none of high media impact) and no waterborne outbreaks were identified.

The paucity of publicized Campylobacter outbreaks prevented graphical analysis for this pathogen. For VTEC and Salmonella, plots of the number of <5-year-old, policy-relevant publications, available at times of identified outbreaks and specific to the outbreak source, are illustrated in Figures 5 and 6, respectively. Visually, Figures 5 and 6 suggest that, in general, there were more <5-year-old, policy-relevant publications specific to outbreak sources available to policymakers at times of VTEC outbreaks than at times of Salmonella outbreaks. A visual comparison of the hollow and solid circles in
Figure 5 demonstrates that, for VTEC, more policy-relevant publications were available at times of meat-related outbreaks compared to produce-related outbreaks: 4–10 <5-year-old policy-relevant publications were consistently available at times of meat-related outbreaks, while 0–1 were available at times of produce-related outbreaks. The last half of the study period was predominated by produce-related VTEC outbreaks (solid circles) for which there was little <5-year-old, policy-relevant research evidence available (Figure 5).

Visually, Figure 6 suggests that little <5-year-old, policy-relevant research, specific to outbreak sources was available to policymakers at times of Salmonella outbreaks prior to 2010. Before 2010, 0–1 <5-year-old, policy relevant publications were available at times of outbreaks. During 2010, two Salmonella outbreaks were identified, one pork related (hollow circle) and one produce related (solid circle), for which there were 4 and 2 publications, respectively, that were <5 years old, policy relevant, and specific to the outbreak source. For Salmonella, the entire study period was predominated by produce-related outbreaks (solid circles) (Figure 6).

Combined plots of (1) the smoothed probability of an outbreak with media impact occurring in a month and (2) the smoothed probability of a policy-relevant publication being published in a month are presented separately for meat and produce, for VTEC (Figure 7) and for Salmonella (Figure 8). For VTEC, the probability of a meat-related, policy-relevant publication being published in a month was high over the study period; however, for the last half of the study period, the probability of a meat-related outbreak with media impact occurring (i.e., the probability of a policy window opening) appeared
to decrease. Conversely, there was no produce-related, policy-relevant research output over the study period for VTEC, and yet the probability of a policy window opening was apparently high, as a result of multiple produce-related VTEC outbreaks occurring during the study period. The smoothing processes used to produce LOESS curves are somewhat inaccurate at the extreme ends of the x-axes and the first and last few data points can have high influence on the curve. Thus, the extreme ends of all smoothed curves should be interpreted with caution.

For *Salmonella*, the probability of a meat-related, policy-relevant publication being published in a month appeared to increase over time. However, the probability of a meat-related outbreak with media impact occurring in a month and a resultant policy window opening remained low. Conversely, the probability of a produce-related, policy-relevant publication being published was low for *Salmonella* throughout the study period, while the probability of a produce-related outbreak with media impact and a resultant policy window was apparently high, relative to meat-related policy windows.

**Descriptive statistics and statistical comparison between pathogens of (1) monthly national disease incidence and (2) monthly publication counts**

Visually, all disease incidence data plots demonstrated seasonality (Figures 9–11), with a noticeable spike in *Salmonella* incidence corresponding to the Ontario mung bean sprout outbreak in autumn 2005 (Figure 11). The descriptive statistics of the monthly disease incidence data (i.e., monthly total number of cases) from January 2001–December 2008 were the following: *Campylobacter* ($\bar{x} = 854$, range = 483–1641), VTEC ($\bar{x} = 88$, range = 20–240), *Salmonella* ($\bar{x} = 478$, range = 251–844). A general linear
mixed model demonstrated that the mean square-root-transformed monthly disease incidence differed significantly between pathogens \((p < 0.001)\), from January 2001 to December 2008. *Campylobacter* was significantly higher than both VTEC \((p < 0.001)\) and *Salmonella* \((p < 0.001)\), and *Salmonella* was significantly higher than VTEC \((p < 0.001)\). An outlier was identified in November 2005, corresponding to the *Salmonella* mung bean outbreak mentioned above; however, this outlier had no influence on the effects of the pathogen variable levels.

Visually, the publication count data plots demonstrated no overt seasonality, although trends of increasing means and unstable variance were evident (Figures 9–11). Monthly publication count descriptive statistics from January 2001–December 2008 were as follows: *Campylobacter* \((\bar{x} = 3.0, \text{range} = 0–8)\), VTEC \((\bar{x} = 4.5, \text{range} = 0–12)\), *Salmonella* \((\bar{x} = 5.3, \text{range} = 0–13)\). A general linear mixed model demonstrated that the mean monthly publication counts differed significantly between pathogens \((p < 0.001)\), from January 2001 to December 2008. *Campylobacter* was significantly lower than both VTEC \((p < 0.001)\) and *Salmonella* \((p < 0.001)\), and *Salmonella* was significantly higher than VTEC \((p = 0.013)\).

**DISCUSSION**

Internationally, rising scientific publication rates have been demonstrated in many healthcare fields [48-54], a trend also observed in this study, where publication counts per month increased over at least part of the study period for all three pathogens. In the literature, some bibliometric studies aim to identify whether a field of research is “keeping pace” with overall trends in increasing publication rates by analysing changes in
the proportion of publications in a bibliometric database (e.g., Medline) from a given field (e.g., Theander and Gustafson [48]). However, the intent of the current study was to evaluate the total amount of research evidence (policy-relevant and otherwise) available to policymakers for each pathogen for KTE purposes; thus, raw publication counts were analysed over time, without controlling for globally increasing publication rates. Therefore, factors affecting the changes in publication counts identified in the current study could include both factors specific to Canadian food safety research (e.g., changes in funding of research on certain foodborne pathogens) and general factors influencing global publication rates (e.g., increasing numbers of researchers, increasing numbers of journals, increasing numbers of articles published per month by online journals, wars, and economic recessions [55]).

Regardless of the cause, significant changes occurred in monthly publication rates over time for each of the pathogens. For *Salmonella*, research output increased linearly, and for *Campylobacter* and VTEC, following initial increases, significant downward trends in research output were identified over the last 1–2 years. These downward trends may be temporary—the growth of scientific literature shifts between periods of exponential growth, linear growth, and decreasing or no growth [55]—however, the exact cause of the identified downward trends is unknown. One possible cause is the influence of the Walkerton outbreak in May 2000 [27, 56]. Following the Walkerton outbreak, Canadian research may have been directed toward VTEC and *Campylobacter* (1) specifically, because the outbreak itself presented an ideal natural situation for scientific inquiry, and (2) generally, because food safety research funding priorities may have been
directed toward VTEC in reaction to the outbreak. Canadian food safety researchers perceive that policy and research funding priorities are reactive to foodborne disease crises [11], supporting the hypothesis that the Walkerton outbreak may have influenced VTEC and *Campylobacter* research output.

Trends in increasing probability of a publication being policy relevant were identifiable visually for VTEC and *Salmonella* (Figure 4); however, the trend was statistically significant only for *Salmonella*. The *Campylobacter* and VTEC data were limited by low numbers of policy-relevant publications, which reduced the effective sample sizes [57]. Increasing probability of a publication being policy relevant may have occurred for many reasons. KTE awareness is high among Canadian food safety researchers [58] and is perceived to be increasing [11]; therefore, opportunities for interaction between researchers and policymakers may also be increasing, resulting in a higher probability of policy relevance. Policy-relevant research output may also have been augmented by the recent implementation of synthesis methodologies for food safety research. Synthesis of research evidence by systematic review or meta-analysis for use in KTE efforts is encouraged by KTE researchers in healthcare [59-61]. Guidelines for systematic review methodology for food safety intervention research were first published in 2006 [62], increasing researchers’ arsenal to conduct policy-relevant research and, potentially, the probability of a policy-relevant publication later in the study period.

Although the overall probability of a policy-relevant publication for VTEC and *Salmonella* increased over the study period, Figures 5 and 6 visually demonstrated that except for meat-related VTEC outbreaks, there was little change in the number of <5-
year-old policy-relevant publications specific to the outbreak source available at times of publicized outbreaks during the study period. Underlying these seemingly conflicting findings were increasing probabilities of meat-related policy-relevant publications over time (with few produce-related policy-relevant publications) and low or decreasing probabilities of publicized meat-related outbreaks over time, relative to produce-related outbreaks (Figures 7 and 8). Thus, research-to-policy informational disconnects occurred: meat-related policy-relevant research output increased, but policymakers’ apparent need for these publications decreased. Similarly, policymaker need of <5-year-old produce-related policy-relevant evidence was apparently high, but little to none was produced. For VTEC, this disconnect may have been exacerbated by long research timelines, in that research prioritization in response to meat-related outbreaks prior to and early in the study period may have dictated research output later in the study period, when meat-related outbreaks were infrequent. Thus, a subsequent temporal disconnect also occurred, with meat-related evidence being produced after the policy window closed. Outbreak sources vary temporally [3, 63]. In a retrospective study of Canadian foodborne disease outbreaks from 1976–2005, Ravel et al. [3] identified an increase in the number of produce-related outbreaks in the last decade of the study, relative to the first two decades. Thus, produce-related outbreaks have been increasing in Canada, but policy-relevant research output has been disconnected from this, as evidenced by this study. Several reasons were hypothesized for the relative paucity of policy-relevant produce-related research output, including (1) the possibility that produce-related food safety research may not yet have reached a momentum, because many food safety researchers have
worked on foods of animal origin for years; (2) the possibility that established relationships may exist to a greater extent between researchers and actors within the meat industry, making it easier for new researchers to continue in that area than to establish new contacts in the perhaps less understood produce industry; (3) the possibility that, unlike the relatively powerful meat-related stakeholder groups, there is no major produce industry group to fund produce-related research; and (4) the possibility that the produce industry is more US- or international-based than the meat industry (40% of produce purchased by Canadians in 2007 was imported, while only 20% of meat purchases was imported) [64]. In light of the temporal trends in policymakers’ apparent need for produce-related research evidence, the almost-complete deficiency of policy-relevant produce-related research output by Canadian researchers is of concern. Facilitation of produce-related research through changes to research prioritization could encourage established food safety researchers as well as new researchers to engage more in produce-related research and develop contacts within the produce industry.

In addition to assessing outbreak-related research output, it was hypothesized that research output may be reactive to the national disease incidence (i.e., high disease incidence results in high research output). Time series analysis would allow evaluation of correlations between disease incidence and publication counts for individual pathogens; however, this method was not appropriate for our data because any correlation would likely occur at the annual level and time series analysis requires at least 60 time-sequenced observations to be valid [65]. This volume of data was unavailable for food safety at the annual level, given the relatively recent identification of the pathogenicity of
some organisms (e.g., VTEC was linked to hemorrhagic enteritis and hemolytic uremic syndrome in 1983 [66]). Instead of time-series analyses, separate general linear mixed models were fit to the disease incidence and publication count data to assess for significant differences between pathogens. If the hypothesis of research output being reactive to disease incidence were to be supported generally across pathogens, a pathogen with a significantly higher mean monthly disease incidence should also have a significantly higher mean monthly publication count. In the statistical modeling, the mean monthly incidence of *Campylobacter* cases was significantly higher than either VTEC or *Salmonella*; however, mean monthly research output for *Campylobacter* was significantly lower than either of the other pathogens. Thus, research output was unrelated to *Campylobacter* disease incidence and, if *Campylobacter* control had been a policy priority, a research-to-policy informational disconnect would have occurred.

*Campylobacter* control is considered a priority for public health inspectors in Canada [67]; however, there is little evidence that it is a priority for government policymakers [4]. The combination of relatively few outbreaks, poor outbreak detection [68] and the low severity of symptoms caused by *Campylobacter*, relative to VTEC and *Salmonella* [69], mean *Campylobacter* is usually not well captured in surveillance data [4] and *Campylobacter*-related policy windows likely rarely open. Should future policy priorities shift to *Campylobacter*, the lack of scientific evidence available would likely substantially hinder KTE.

KTE is hindered if informational or temporal disconnects between research and policy prevent relevant evidence from being available when policy windows open. The
findings of this study suggest both informational and temporal disconnects exist in the Canadian food safety system. The identified informational disconnects demonstrate that the policy-relevant evidence available to policymakers at times of open policy windows has become increasingly less pertinent to actual outbreak sources, as produce-related outbreaks become more common and meat-related evidence continues to be published more frequently than produce-related evidence. Temporal disconnects have exacerbated informational disconnects for VTEC, perhaps because previous short-term meat-related policy priorities have influenced long-term research priorities. Informational and temporal disconnects may be mitigated through accurate, continued prioritization of food safety risks. Prioritization of foodborne pathogens is a complex, data-driven process in which microbial foodborne hazards are identified that pose the greatest societal risk [63]. Prioritization assists decision makers in proactively allocating limited resources, including research funding, to areas where they will have the most impact in reducing morbidity and mortality. Tools have been proposed to aid in the prioritization of foodborne pathogens in Canada [70-72]. Ruzante et al. [72] recently proposed a multifactorial risk-prioritization framework, integrating public health, economic, and social factors (e.g., consumer risk perception and awareness, and social sensitivity). The public health factors in the framework capture the public health impact of both outbreak-related and sporadic disease, thereby potentially increasing the priority of high-incidence/low-outbreak pathogens (e.g., *Campylobacter*). The social dimension of the framework allows for some reactivity in response to changing public attitude (e.g., at
times of outbreaks); however, the prioritization process remains grounded by public health and economic evidence [72].

Food safety risk prioritization is integral to the recently passed Food Safety Modernization Act (FSMA) [72] in the United States (US), where fruits and vegetables have been increasingly recognized as important vehicles of foodborne disease [74-76]. At the heart of the FSMA’s target to reduce produce-related foodborne disease are the establishment of science-based standards for the safe production of fruits and vegetables [77, 78] and the ongoing re-evaluation of foodborne risks. Both of these activities will rely heavily upon ongoing policy-relevant research output from FDA, industry, and academic scientists [78]. The FSMA approach embraces several concepts integral to preventing research-to-policy disconnects, including (1) science-based prioritization of foodborne risk, (2) proactive and not reactive policy development, and (3) proactive research output. In contrast to a reactive approach to policymaking, the KTE benefits of a solutions-based, preventive approach are clear—timely, policy-relevant, and informationally relevant research evidence is available to policymakers for decision making on both disease prevention and outbreak control, when it is needed. In Canada, a proactive approach combined with a coordinated food safety regulatory framework have been proposed to improve communication between food safety agencies and the public, at times of food safety crises [79]. The negative impacts of reactive policy systems on evidence-informed policymaking have also been recognized in some sectors external to food safety [15, 80], and a shift toward a more proactive and solutions-based approach has been recommended [15].
Research-to-policy disconnects may also be mitigated through mechanisms complementary to a proactive approach. An exchange relationship exists between policymakers and publicly funded researchers, when policymakers obtain knowledge from researchers in return for resources and public legitimacy [10]. Power imbalances in the relationship, such as unilateral research agenda setting by either party, may reduce the value of evidence production [10], resulting in research-to-policy disconnects. Those who commission research or set research funding priorities should strive to balance highly focused research priorities that are potentially underpinned by policy questions unanswerable by research, with more broad research priorities, which may appeal to researchers’ sense of research autonomy but prove too generic to answer policy questions [10, 81]. Long-term relationships between researchers and policymakers may be key to avoiding unilateral research agenda setting, allowing researchers to interactively shape policymakers’ perceived informational needs and allowing policymakers to direct research toward questions of policy relevance [10]. Long-term linkages also encourage the establishment of “shared reservoirs of knowledge” available for future policy decisions [10]. Similarly, for recurrent policy priorities (e.g., foodborne disease outbreaks), researchers outside of linkages have been urged to store research evidence not of immediate use to policymakers in their “back pockets” (e.g., in a publicly accessible inventory of research findings, syntheses, and “pre-processed evidence” [60, 81, 82]), where it could easily be retrieved when policy priorities shift [83]. Because outbreaks occur repeatedly but unpredictably in time, knowledge management infrastructure, either
within government food safety organizations or as an off-site repository accessible by policymakers, is necessary for evidence-informed decision making [61].

One of the assumptions of this study was that the Canadian food safety policy process follows Kingdon’s Agenda-setting model [12]. The reactive nature of the food safety system suggests this premise is true; however, policy formation unrelated to outbreaks undoubtedly occurs outside of Kingdon’s policy windows and may be governed by another model (e.g., an interaction model [84]). Evidence is necessary to inform both time-sensitive decisions (e.g., in response to outbreaks) and long-term strategy and policy development [85]. The research-to-policy disconnects identified in this study are specific to time-sensitive policy processes, and may or may not be applicable to other less crisis-driven decision-making environments.

The forms of research evidence available to policymakers go beyond peer-reviewed publication, and inclusion of only peer-reviewed publications was a recognized limitation of the study. As well, the Web of Knowledge databases used for data collection are not inclusive of all peer-reviewed literature and may have preferentially selected peer-reviewed over other types of literature. However, with respect to topic and trend, the Web of Knowledge search results were likely representative of the topics and publication trends of evidence available to policymakers. The bibliometric data may also have been limited by constraints to the categorization process. For example, some meat-related research may have also been indirectly relevant to pathogen control in produce, because the reduction of pathogen loads in animals may reduce the risk of contamination of other products. However, because such publications would have been only indirectly related to
produce, they likely would not have been policy-relevant at times of produce-related outbreaks and should not have biased the findings. Although two reviewers screened and categorized all bibliometric data, some misclassification may have occurred. As well, a validated method of policy-relevance scoring was not available from the literature, and an identification tool was developed. Because the accuracy of the developed tool is unknown, misclassification may have occurred. Regarding the outbreak data, not all outbreaks identified in the media had a source attribution—potentially due to investigation or detection issues, or publication bias [3]—and were not used in analyses. Thus, biases in source attribution present in the media may have influenced the analyses.

**CONCLUSIONS**

The current study demonstrates that research evidence output may not be meeting the informational needs of policymakers in the Canadian food safety system. Recently published guidelines of systematic review methodologies for food safety interventions should increase the overall amount of policy-relevant research evidence available to policymakers. However, both informational and temporal disconnects hinder KTE, partially due to the reactive nature of the Canadian system influencing short-term policy priorities and long-term research priorities simultaneously. From an outbreak response perspective, history has demonstrated recurrent problems with the existing reactive approach—issues with government communication, roles and responsibilities, and information transfer [86] at times of outbreaks, and erosion of consumer confidence in the public health system [87]—thus, more proactive strategies need to be explored. Improved prioritization of food safety risks could help transition the Canadian food safety
to a more proactive system, where the focus is on disease prevention and research
evidence is produced prior to its need. In the words of one food safety researcher,
“Policymakers don’t want to talk to the people that are doing the research, they want to
talk to people who have DONE the research” [11].
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Table 5.1. Relevance screening criteria for publications about *Campylobacter*, VTEC, and *Salmonella*, published by Canadian authors, 1999–2011.

<table>
<thead>
<tr>
<th>Pathogen of interest</th>
<th>Publication retained if the title or abstract mentioned the following terms:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campylobacter</td>
<td>1) <em>Campylobacter spp.</em> (except <em>C. rectus</em>),</td>
</tr>
<tr>
<td></td>
<td>2) Walkerton.</td>
</tr>
<tr>
<td>VTEC</td>
<td>1) <em>E. coli</em> serotypes known to be zoonotic [28-32],</td>
</tr>
<tr>
<td></td>
<td>2) “Pathogenic <em>E. coli,</em>” “VTEC,” “STEC,” “EHEC,”</td>
</tr>
</tbody>
</table>
|                      | 3) “Shiga toxin,” “Stx,” “Stx-1,” or “Stx-2,” not produced by a *Shigella sp.*,
|                      | 4) Generic *E. coli* used as indicator bacteria for fecal contamination to address a food, food processing, or water quality question, |
|                      | 5) One of the following highly-publicized historical VTEC outbreaks: Jack-in-the-Box (hamburger, Washington, USA; 1993), Natural Selection Foods (spinach, California, USA; 2006), Walkerton (water, Walkerton, Ontario, Canada; 2000), Harvey’s Restaurant (contaminated onions, North Bay, Ontario, Canada; 2008). |
| Salmonella           | 1) *Salmonella* that was one of the following:                           |
|                      |   a. not subtyped,                                                     |
|                      |   b. Non-Typhi or Paratyphi *Salmonella* known to cause human disease [33],|
|                      |   c. not part of a mutagenicity test.                                   |
Table 5.2. Components of policy relevance, with examples of policy-relevant and non-policy-relevant publications, for publications about *Campylobacter*, VTEC, and *Salmonella*, published by Canadian authors, 1999–2011.

<table>
<thead>
<tr>
<th>Score component</th>
<th>Policy relevant</th>
<th>Not policy relevant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study design</td>
<td>Field trials, RCTs, systematic reviews, meta-analyses, quantitative risk assessments, quasi-experiments where a control group was not possible</td>
<td>Primary and secondary research designs other than those listed as policy relevant, narrative reviews, letters, comments, editorials</td>
</tr>
<tr>
<td>Study objective</td>
<td>Evaluation of an intervention to control foodborne or waterborne pathogens, using <em>in vivo</em> methods, natural challenge, and measuring a direct outcome.</td>
<td>Intervention studies with no control group or with a proxy outcome (e.g., for vaccine trials, an outcome of seroconversion instead of pathogen reduction), risk factor analyses, challenge trials, pathogen frequency evaluation, test development or evaluation, disease mechanism or case studies, laboratory-based studies at the cellular level or using lab animals as models for target species</td>
</tr>
<tr>
<td>Publication type</td>
<td>Journal articles, full government reports, and full proceedings papers</td>
<td>Abstracts presented at conferences</td>
</tr>
</tbody>
</table>
Table 5.3. Foodborne disease outbreaks with Canadian cases and a verified source, having high impact in the Canadian media, December 2005–May 2011 (*Salmonella*) and January 2004–May 2011 (VTEC).

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Outbreak source description</th>
<th>Year (start)</th>
<th>Year (end)</th>
<th>Month (start)</th>
<th>Month (end)</th>
<th>Month (peak)</th>
<th>Number of cases (from media, unverified)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. Enteritidis</td>
<td>Ontario, mung bean sprouts [41]</td>
<td>2005</td>
<td>2005</td>
<td>September</td>
<td>December</td>
<td>November</td>
<td>648</td>
</tr>
<tr>
<td><em>E. coli</em> O157</td>
<td>Imported Californian fresh bagged spinach [42]</td>
<td>2006</td>
<td>2006</td>
<td>August</td>
<td>September</td>
<td>August</td>
<td>205 (1 Canadian, 3 deaths)</td>
</tr>
<tr>
<td>S. Saintpaul</td>
<td>United States, tomatoes/Serrano peppers [43]</td>
<td>2008</td>
<td>2008</td>
<td>April</td>
<td>July</td>
<td>May</td>
<td>1442 (5 Canadians, 2 deaths)</td>
</tr>
<tr>
<td><em>E. coli</em> O157</td>
<td>North Bay, Ontario, Harvey’s restaurant (onions likely contaminated by beef) [40]</td>
<td>2008</td>
<td>2008</td>
<td>October</td>
<td>November</td>
<td>November</td>
<td>235</td>
</tr>
<tr>
<td>S. Typhimurium</td>
<td>Imported American peanut butter [44]</td>
<td>2008</td>
<td>2009</td>
<td>September</td>
<td>April</td>
<td>December</td>
<td>714 (1 Canadian, 9 deaths)</td>
</tr>
<tr>
<td><em>E. coli</em> O157</td>
<td>Multi-provincial, walnuts [45]</td>
<td>2011</td>
<td>2011</td>
<td>April</td>
<td>April</td>
<td>April</td>
<td>14 (1 death)</td>
</tr>
<tr>
<td><em>E. coli</em></td>
<td>Germany, fenugreek sprouts [46]</td>
<td>2011</td>
<td>2011</td>
<td>May</td>
<td>July</td>
<td>May</td>
<td>3910 (1 Canadian,</td>
</tr>
<tr>
<td>O104:H4</td>
<td>47 deaths</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 5.1. Flowcharts describing bibliometric data for Campylobacter, VTEC, and Salmonella, from initial searches through relevance screening.

Campylobacter publications identified in Web of Knowledge and Web of Science: 1488

640 duplicates removed: 818

26 patents removed: 792


1 removed because abstract lacked key screening information and full text unavailable: 766

206 publications removed due to lack of screening criteria indicator terms: 560

38 publications removed because pathogen appeared only in a secondary role. Available for analysis: 522

VTEC publications identified in Web of Knowledge and Web of Science: 2754

1583 duplicates removed: 1171

6 patents removed: 1165

17 book chapters removed. Available for relevance screening: 1148

1 removed because abstract lacked key screening information and full text unavailable: 1147

368 publications removed due to lack of screening criteria indicator terms: 779

45 publications removed because pathogen appeared only in a secondary role. Available for analysis: 734

Salmonella publications identified in Web of Knowledge and Web of Science: 3531

1587 duplicates removed: 1944

1 patent removed: 1943

41 book chapters removed. Available for relevance screening: 1902

7 removed because abstract lacked key screening information and full text unavailable: 1895

925 publications removed due to lack of screening criteria indicator terms: 970

151 publications removed because pathogen appeared only in a secondary role. Available for analysis: 819
Figure 5.2. LOESS-smoothed publication rates for *Campylobacter*, VTEC, and *Salmonella* research by Canadian authors, 2001–2011 (VTEC: 1999–2011), using a bandwidth of 80% of the data.
Figure 5.3. Flowcharts describing the policy-relevance scoring process for *Campylobacter*, VTEC, and *Salmonella* publications.
Figure 5.4. LOESS-smoothed probability of a publication being policy relevant for *Campylobacter*, VTEC, and *Salmonella* research by Canadian authors, 2001–2011 (VTEC: 1999–2011), using a bandwidth of 80% of the data.
Figure 5.5. Number of <5-year-old, policy-relevant publications, that were specific to the outbreak source, available at times of VTEC outbreaks with Canadian cases, a verified source, and Canadian media impact, from January 2004–May 2011. Times of outbreaks with high media impact are labeled and depicted with vertical lines.
Figure 5.6. Number of <5-year-old, policy-relevant publications, that were specific to the outbreak source, available at times of *Salmonella* outbreaks with Canadian cases, a verified source, and Canadian media impact, from December 2005–May 2011. Times of outbreaks with high media impact are labeled and depicted with vertical lines.
Figure 5.7. Plots of the LOESS smoothed probability of (1) an outbreak with media impact occurring in a month (bandwidth 60% of data) and (2) a policy-relevant publication being published in a month (bandwidth 80% of data), for meat and produce, for VTEC, January 2004–May 2011.
Figure 5.8. Plots of the LOESS smoothed probability of (1) an outbreak with media impact occurring in a month (bandwidth 60% of data) and (2) a policy-relevant publication being published in a month (bandwidth 80% of data), for meat and produce, for *Salmonella*, December 2005–May 2011.
Figure 5.9. Monthly incidence of *Campylobacter* cases in Canada reported to the national Notifiable Disease Surveillance System and monthly counts of papers about *Campylobacter* published by Canadian authors, 2001–2008.
Figure 5.10. Monthly incidence of VTEC cases in Canada reported to the national Notifiable Disease Surveillance System and monthly counts of papers about VTEC published by Canadian authors, 1999–2008.
Figure 5.11. Monthly incidence of non-typhoidal *Salmonella* cases in Canada reported to the national Notifiable Disease Surveillance System and monthly counts of papers about non-typhoidal *Salmonella* published by Canadian authors, 2001–2008.
CHAPTER 6

Summary Discussion and Conclusions

Drawing from the healthcare literature [1], knowledge translation and exchange (KTE) in food safety can be considered a means to reduce enteric disease in Canada, provide more effective food safety interventions and safer food products, and strengthen the food safety system, through the synthesis, dissemination, exchange, and ethically sound application of knowledge. In the last 10–15 years, considerable effort has been placed upon the identification of methods to improve the use of evidence in healthcare policy [2, 3] and, in recent years, KTE has garnered attention in the Canadian food safety sector [4]. Recognizing the sector’s interest in KTE, an evaluation of the current status of KTE between researchers and government policymakers was proposed.

This endeavour was timely in light of many recent food-related trends that are challenging current food safety policies and compelling the makers of future food safety policy to be evidence-informed. Emerging foodborne pathogens [5-7], novel vehicles for foodborne disease [7-9], changing patterns of food consumption and preferences [6, 7], and increased globalization of the food supply, with a widening retail distribution of food products [7] have altered the epidemiology of foodborne disease, suggesting the need for policy to evolve and for synthesized evidence to inform it [10]. Concurrently, frequent large-scale foodborne disease outbreaks [11-13] and deregulation within the food industry [12] have acted to erode consumer trust in food and the agencies that regulate its safety. Reclamation of consumer trust could be facilitated by a transparent policy
decision making process [12], requiring food safety policy decisions to be defendable and, therefore, evidence-informed [14].

Because no previous work had evaluated KTE in the food safety sector, the overall goal of the work presented in this dissertation was to characterize many of the facets of researcher-policymaker KTE, from the perspective of food safety researchers, and ultimately, to construct a more context-specific evidence base, within which Canadian food safety KTE strategies could be framed. Specifically, the objectives were as follows:

1. To quantitatively describe Canadian MFS researcher awareness of KTE with government policymakers (Chapter 2)
2. To describe researcher attitudes toward KTE with government policymakers, using a mixed-methods approach (Chapters 2 and 4)
3. To investigate the types of KTE activities engaged in by researchers (Chapter 2)
4. To assess the frequency at which MFS researchers engaged in KTE activities with government policymakers in the 5 years prior to 2009 and to compare frequency of activity between government and non-government researchers (Chapter 2)
5. To determine if end-of-research dissemination activities occur more frequently than integrated KTE (Chapter 2)
6. To identify and describe barriers perceived by researchers to hinder successful KTE with policymakers, using a mixed-methods approach (Chapters 3 and 4)

7. To determine if food safety research output in Canada changed over time for three foodborne pathogens: *Campylobacter* sp., non-typhoidal pathogenic *Salmonella* sp., and Verotoxigenic *E. coli* (VTEC) (Chapter 5)

8. To determine if the policy relevance of food safety research output in Canada changed over time, for the same pathogens (Chapter 5)

9. To evaluate whether the amount of recently-published policy-relevant food safety research evidence available when policy windows open in Canada has changed over time, for VTEC and Salmonella (Chapter 5)

10. To evaluate whether the probability of (a) meat-related and (b) produce-related policy-relevant research output has changed over time compared to the probability of publicized (a) meat-related and (b) produce-related outbreaks, for VTEC and Salmonella (Chapter 5)

11. To quantitatively compare (a) Canadian food safety research output and (b) nationally aggregated human disease incidence, between *Campylobacter*, VTEC, and *Salmonella* (Chapter 5)

To achieve these objectives, a mixed-methods methodology was used for the first two studies (Chapters 2–4): a quantitative survey was followed by a qualitative focus group study that evaluated similar constructs. The final bibliometric study (Chapter 5) extended the mixed-methods approach by quantitatively exploring a barrier to KTE that
was identified in the focus group study (i.e., temporal disconnects between the research and policy processes).

Within the survey and focus group studies, there was evidence of increasing researcher awareness of KTE and a generally positive attitude toward it. Most researchers agreed that KTE with policymakers should occur, where it was applicable and feasible to do so; however, some dissatisfaction was expressed regarding the perceived ineffectiveness of KTE efforts. KTE ineffectiveness may have been actual or perceived—however, researchers likely knew little about the actual success of their KTE efforts as formal evaluations had rarely been conducted (Chapter 2). Researchers linked their (possibly) ineffective KTE to a lack of KTE training and a lack of interest in KTE on the part of researchers and policymakers (Chapter 4). Without KTE training, researchers may have been unaware of the various ways policymakers may use research evidence (i.e., conceptual, instrumental, and symbolic research use [15-17]). Thus, perceptions of KTE ineffectiveness may have been erroneously based upon a lack of overt evidence of instrumental research use, and actual KTE success may have been higher than perceived, given that the most frequent form of research use by policymakers is conceptual and often indiscernible [15].

Ultimate KTE success is partly dependent upon the KTE intervention employed (i.e., the type of KTE activity used to engage researchers and policymakers). Although the body of KTE knowledge is growing, the challenges of KTE research (e.g., the wide range of settings in which KTE occurs, limiting the generalizability of findings; the difficulties in operationalizing randomized trials; the complications of measuring research...
use; the complexity of KTE interventions) mean little consistent, generalizable empirical evidence exists regarding the effectiveness of different KTE interventions, especially in the policymaking context [2, 3]. Two KTE interventions that have the potential to facilitate knowledge exchange have been termed “promising bridging activities” by Lavis et al. [18], and include the provision of systematic reviews or meta-analyses to policymakers and providing access to a searchable database of research findings. Also having the potential to facilitate research use in policymaking is “integrated” KTE—the meaningful engagement of decision makers in the research process—when compared to conventional end-of-research dissemination techniques [19]. Of the Canadian food safety researchers who had engaged in KTE with policymakers, less than a quarter had participated in the promising bridging activities identified above and, when compared to end-of-research evidence dissemination, significantly fewer researchers had engaged in integrated KTE (Chapter 2). These findings suggest that the quality of KTE activity in which Canadian food safety researchers engage is relatively low. However, expectations of researcher involvement in integrated KTE should be tempered with the recognition that integrated KTE is not appropriate for all researchers [19]. Those conducting research that would have significant beneficial effects if implemented in the real world are most appropriate to engage in integrated KTE, if they have the necessary skills, the target audience is amenable, and it is practical and feasible to do so.

Accountability of government research to tax-payers and, hence, the incumbent need to answer research questions of importance to policy decision making were discussed in the focus group study, suggesting that government researchers were likely to
engage in integrated KTE with a higher frequency than non-government researchers, at least when developing research questions. The survey findings confirmed this hypothesis. However, within the focus groups, issues were raised regarding challenges in the development of policy-relevant research questions with policymakers and misinterpretation of policymakers’ information needs, demonstrating that researcher-policymaker communication is not ideal. Specific to government researchers, for whom collaboration with policymakers is more incumbent, future context-specific research should explore the information-exchange relationship with policymakers to determine areas for improvement.

Communication issues between researchers and policymakers were identified as key barriers to successful KTE in the Canadian food safety system (Chapter 4). Specifically, the multi-jurisdictional, multi-agency complexity of the Canadian food safety system (see Papadopoulos et al. [12] for description) and high policymaker turnover (identified as present in the Canadian food safety system in Chapter 3) inhibited researchers’ abilities to identify relevant policymakers. A lack of provision of financial resources for KTE on the part of the researcher’s organization (identified in Chapter 3 as present in the Canadian food safety system) further hindered researchers’ abilities to identify policymakers (Chapter 4). The issue of insufficient organizational support for KTE cut through the sector, with almost half of researchers obtaining no financial resources for KTE through their organizations (Chapter 3). However, while increased KTE resources (e.g., human and financial resources and time) on the part of the researcher’s organization are necessary, they are unlikely to be sufficient to mitigate all
organizational and system-related KTE barriers [2]. Organizational cultures that do not fully embrace KTE—as described by some government focus group participants—may restrict researchers’ KTE efforts [20], regardless of financial support, while political context may preclude research evidence use by policymakers, regardless of the scientific evidence [21], unless the evidence is aligned and compatible with prevailing political interests, ideologies, and institutions [22].

Research evidence use by policymakers is also influenced by its relevance to policy priorities—evidence must be relevant to policymakers’ information needs [15]. Despite there being, generally, evidence of increasing monthly rates of research output and, for Salmonella, evidence of increasing likelihood of research output being policy relevant, at times of foodborne disease outbreaks in Canada, policymakers’ information needs may not be being met (Chapter 5). This information gap has developed over time as the source of high-profile foodborne disease outbreaks in Canada, generally, has changed from primarily meat to primarily produce, and policy-relevant research output, generally, has continued to be dominated by meat-related topics, with little to no produce-related research evidence output (Chapter 5). This discrepancy in policymakers’ information needs versus the policy-relevant research evidence available to them is an informational disconnect (Chapter 5). A potential informational disconnect was also identified for Campylobacter, unrelated to outbreaks, in that the mean monthly rate of Campylobacter-related research output was significantly lower than that for VTEC and Salmonella; however, mean monthly Campylobacter disease incidence was significantly greater (2–10 times greater) than that of either of the other pathogens. If Campylobacter
was a policy priority, this potential informational disconnect would be an actual informational disconnect. However, there is little evidence that *Campylobacter* is a policy priority for federal policymakers [10]. Public health inspectors at the local/regional level have identified *Campylobacter* as a pathogen of concern [23]. Thus, an actual informational disconnect exists for *Campylobacter*, which likely negatively impacts decision making by public health inspectors.

Outbreak-related informational disconnects are exacerbated by differences in policymaking and research timelines: policymakers’ information-seeking behaviour during outbreaks is crisis driven and follows short timelines, whereas the research timelines required to respond to policymakers’ outbreak-related questions are much longer (Chapter 4). This discrepancy in timelines was termed a temporal disconnect (Chapters 4 and 5). Originally, one of the objectives of the bibliometric study was to evaluate whether research output, measured by publication counts, was correlated in time with national disease incidence, using time series analysis. Data collection was at the monthly level; however, any correlation between research output and disease incidence would likely have occurred at the annual level (e.g., it was speculated that the Walkerton outbreak in May 2000 would cause research priorities to focus on VTEC, resulting in increased annual research output for this pathogen). A limitation to time series analysis is that >50 observations are required to fit models, meaning that >50 years of data were required for annual-level analyses, a volume that was not available. Visually, a temporal disconnect was identified for VTEC in that meat-related research output continued after the probability of a publicized meat-related outbreak (and policymakers’ need for meat-
related evidence) decreased (Chapter 5). One speculation is that after prioritization of meat-related VTEC research following meat-related outbreaks, long research timelines may have prolonged the duration of research output to a time when VTEC in meat was no longer a policy priority.

Because KTE had not previously been studied in the food safety sector, the research presented in this dissertation relied heavily upon KTE literature from the healthcare field, a potential limitation of the work. Specifically, survey development for Chapters 3 and 4 was wholly based upon the healthcare literature and discussion of all study findings was limited to comparisons with research in healthcare and other fields, not with research in food safety. Whether a foundation in healthcare biased the research findings is unknown; however, bias should only have occurred if KTE in food safety was significantly different from that in healthcare (e.g., a significant barrier to KTE was present in food safety that was not previously identified in the healthcare literature, leading to its inadvertent omission from the survey tool). A focus group study followed the initial survey study and although most of the main KTE barriers identified in the focus group study were also part of the survey tool, two were not: a perceived lack of KTE skills and an inability to break free from traditional publish-or-perish research models. The exclusion of these two potential barriers could have biased the survey findings in that their inclusion would have altered the ranking of the potential barriers in Chapter 4. The resulting bias on the overall survey findings would have been minimal, however, as the analyses were descriptive in nature and, therefore, somewhat robust to omitted barriers. The list of KTE barriers included in the survey tool was known a priori.

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not to be exhaustive (or even a random sample of all possible barriers) and, consequently, statistical analyses were not done (e.g., comparing Organizational to System-related barriers), as they would have been more susceptible to bias from omitted barriers.

Conducting the focus group study prior to the survey study, and basing the survey tool upon both the focus group findings and the healthcare literature, would have reduced the likelihood of bias occurring due to survey tool omissions. However, by conducting the survey before the focus group study—an explanatory sequential design [24]—an initial general picture of KTE barriers was developed through quantitative means, which was then refined and explained in detail, through qualitative inquiry. With this design, the qualitative phase was emphasized, prioritizing the questions “what are the primary KTE barriers?” and “why/how do they occur?”, over the question of how many researchers are affected by them. Considering that KTE success is not necessarily dictated by how many individual researchers are engaged, that many researchers engage in KTE with target audiences other than policymakers (e.g., industry), and that high engagement of individual researchers in KTE may overwhelm policymakers with conflicting, non-synthesized evidence sources [25], the quantitative questions surrounding KTE with policymakers at the researcher level in the Canadian food safety system are perhaps of lesser importance than the qualitative questions. The mixed-methods approach allowed evolution of a broader conceptualization of Canadian food safety KTE than if a quantitative or qualitative method alone had been used, strengthening the overall conclusions. As well, the mixed-methods approach increased the generalizability of some of the qualitative findings by drawing upon the quantitative inferences, while
qualitatively providing the context within which the quantitative findings could be interpreted [24]. The strengths of one approach mitigated the weaknesses of the other.

The work presented in this dissertation occurred at the researcher level. Through the progression of the studies, it became apparent that KTE engagement is partly dictated by organizational factors, to a greater or lesser degree, depending on the researcher’s organization. A quantitative researcher-level study was a useful starting point, given that previous work in the field had not been done. However, while the focus group study permitted an exploration of organizational factors from the perspective of the researcher, organizational-level studies would remove any bias in the exploration of organization-level issues that may be introduced by the researcher participants. In the future, identification of and evaluation of researcher organizations with mission statements that include KTE with policymakers would enhance the understanding of organizational cultures and KTE strategies at the organizational level, in the Canadian food safety system.

In 2003, Lavis et al. [26] identified 5 elements within an organizing framework for KTE strategies in healthcare, with details of the elements varying with respect to the target audience. Grimshaw et al. [2] recently revisited the framework, reviewing the elements and contributing to further discussion of the elements, where new evidence had become available. The five elements of the framework are the following:

1) What should be transferred to decision makers (the message)?
2) To whom should research knowledge be transferred (the target audience)?
3) By whom should research knowledge be transferred (the messenger)?
4) How should research knowledge be transferred (the knowledge-transfer processes and supporting communication infrastructure)?

5) With what effect should research knowledge be transferred (evaluation)?

When the findings of the work presented in this dissertation are considered in light of this organizational framework, several comments can be made with respect to general KTE processes in the Canadian food safety system. Regarding what should be transferred to policymakers, Lavis et al. advise that the unit of knowledge transfer should be up-to-date syntheses of evidence (i.e., systematic reviews or meta-analyses), preferably presented in the form of actionable messages or policy briefs [26]. Although few Canadian food safety researchers had conducted systematic reviews prior to 2009, the probability of research output being policy relevant (i.e., the proportion of research output that was considered to be high-quality evidence, which included systematic reviews and meta-analyses) had increased over time for two major pathogens. These findings are promising; however, evidence of informational disconnects suggests that research prioritization of policy-relevant research has not been focused on high-risk outbreak sources (e.g., produce) or pathogens with high burdens of disease (e.g., Campylobacter).

Regarding to whom research should be transferred, Grimshaw et al. emphasized that the target audience varies with the type of research and could include other researchers, industry, policymakers, consumers, etc. [2], while Lavis et al. advised that researchers should get to know their target audience (i.e., develop lasting professional relationships with them), a process that requires significant investment of time and
resources [26]. The proportion of Canadian food safety researchers who claimed to have engaged government policymakers in KTE activities was very high; however, the opinion that policymakers were unidentifiable or inaccessible permeated both academic and government researcher groups. Both groups also reported a lack of investment in KTE on the part of their research organizations, a paucity of time to pursue KTE activities, and high policymaker turnover. These findings suggest that a lack of time and resources may hinder the development of linkages between researchers and policymakers, while policymaker turnover threatens the sustainability of researcher-policymaker relationships, in the Canadian food safety system.

The work presented in this dissertation did not focus on the question of who was presenting research evidence to policymakers, and this could be a focus of future research. Both Lavis et al. [26] and Grimshaw et al. [2] advise that the credibility of the messenger is of high importance and that building credibility is a time-consuming and skill-intensive process, which makes it impossible to adopt a one-size-fits-all approach to identifying appropriate KTE messengers. To overcome this obstacle, Grimshaw et al. [2] suggest the establishment of research knowledge infrastructures, a concept that has been adopted by the European Food Safety Authority (EFSA), as discussed in Chapter 2. Research knowledge infrastructures consist of a technological component, which is comprised of searchable databases of research findings, and an organizational component, which includes human resources such as knowledge brokers, data analysts, document specialists, training programs, etc. Development of a food safety research knowledge infrastructure may be hindered in Canada because a central government
authority on food safety does not exist and food safety decision makers are dispersed across three government levels (i.e., federal, provincial, and municipal) and among multiple government ministries, agencies, departments, and units. At the individual level, few food safety researchers reported providing access to a searchable database of research findings to policymakers. Given the challenges faced by food safety researchers and policymakers to develop and maintain long-term linkages, establishment and maintenance of a research knowledge infrastructure, if initially just the technological component, may be a useful adjunct to linkage efforts.

Regarding how the research knowledge should be transferred, Grimshaw et al. [2] advise that an evaluation of context-specific barriers to KTE be conducted, prior to development of a KTE strategy. While the work presented in this dissertation identified many KTE barriers affecting the Canadian food safety system generally, KTE barrier identification must still be done, specific to the context of the research and government organizations where KTE strategy development is occurring. Furthermore, for sustainable, successful KTE strategies to develop, the culture within research organizations must continue to change, to be more supportive of researcher KTE engagement. Following KTE barrier identification, Grimshaw et al. [2] advise that selection of the KTE intervention (i.e., activity) should be guided by the barriers identified, the target audience environment, the mechanism of action of the various interventions to overcome the identified barriers, and the available resources. Two KTE interventions were discussed [2] that have shown promise in facilitating research use by policymakers: formal and informal interaction with researchers on the part of
policymakers; and research that was aligned with the beliefs, values, interests, political goals, etc., of policymakers or interest groups. A high proportion of Canadian food safety researchers who had engaged in KTE with policymakers reported interaction with policymakers at various venues, including expert committees and formal networks. This finding is promising; however, further work must be done to understand the impact of these interactions on food safety policy decision making.

Regarding to what effect research knowledge should be transferred, both Lavis et al. [26] and Grimshaw et al. [2] advise that evaluation of KTE activities should be conducted, with consideration of an appropriate measure of the ultimate research use by policymakers. Few food safety researchers who had engaged in KTE had evaluated the impact of their KTE activities with policymakers. Also, a lack of knowledge of KTE processes was identified as a barrier to KTE by researchers; thus, researchers may not have had the KTE skills necessary to conduct appropriate evaluations of KTE activities. Formal, rigorous evaluations of KTE are notoriously difficult due to challenges with the measurement of research use by the target audience [26]; thus, informal evaluations may be more useful and pertinent (e.g., simple follow-up with policymakers regarding the usefulness of a research product).

The work presented in this dissertation provides evidence that, generally, KTE in the Canadian food safety system incorporates many of the elements of the organizational framework of Lavis et al. [26], although it is unclear to what extent these elements may be coordinated within any given KTE strategy. Improvements can be made; but there is evidence that KTE in food safety is evolving to adopt many of the KTE concepts
suggested by research in the healthcare field. This body of work provides an initial
evidence base, specific to the Canadian food safety system, upon which KTE strategies
can be framed. Future work should be focused at the organizational level, to broaden the
existing evidence base of this dissertation.

REFERENCES


