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Understanding the Knowledge Translation Practices of Environmental Health Officers in Canada: A Mixed Methods Study

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A thesis submitted in partial fulfillment of the requirements for the Doctor of Philosophy degree in Health and Rehabilitation Sciences

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Abstract

Though important to Environmental Health Officer (EHO) practice, few research articles explore what evidence-informed practice looks like in environmental health or the factors that influence it. This study set out to understand the barriers to, and facilitators of, research utilization (RU) experienced by EHOs by asking: how do EHO practitioner perceptions of the barriers to RU change during an emergency; what factors influence evidence use during an emergency; and what can be done to ensure access to evidence and support effective and appropriate practice decision-making?

These questions were answered through three studies that used quantitative and qualitative methods. The Barriers to Research Utilization Scale was used to collect data during a typical practice year (2012) and again during the COVID-19 pandemic (2020).

Study one, asked EHOs to rate the barriers to RU experienced in practice. The data were analyzed to identify if findings changed during the pandemic. Lack of authority, lack of time to review research, and lack of time to implement findings, were the top three barriers to RU experienced by EHOs at both times.

Study two, considered the relationships between variables to reduce findings into simplified factors representing the barriers influencing EHO practice. Four factors were found to influence RU in EHO practice. These factors aligned with two of the six Active Implementation Frameworks (AIFs): the Implementation Drivers Framework and the Useful Innovations Framework.

Study three assessed the other barriers to RU experienced by EHOs in 2012 and 2020. The top three themes from the open-ended responses included: Legislative policy, programs, and services; Political and structural barriers; and EHO practitioners in sufficient numbers to enable practice delivery while exploring the evidence. The top barriers aligned with the following AIFs: Implementation Drivers Framework; Systemic Change Framework, and Usable Innovations Framework. The final finding was that during emergencies, EHOs require: Processes to engage the impacted community; Strong

leaders to support change; Emerging evidence that is relevant and applicable; A culture that enables organizational innovation; and Project, change, and implementation management.

Overall, these studies show the pervasive nature of the barriers to RU for EHOs in every day and emergency conditions. In emergencies, EHOs require access to emergent evidence, implementation pathways, opportunities to engage with impacted communities, and strong leadership support. Targeting interventions at the systemic and organizational levels will help increase RU by EHOs.

Keywords

Environmental health officer, environmental public health, public health, barriers to research utilization, knowledge translation, practice, implementation science, evidence-informed decision-making, research utilization, Active Implementation Frameworks

Summary for Lay Audience

This study sought to understand the barriers to, and facilitators of, evidence use by Environmental Health Officers (EHOs) in Canada in their everyday and emergency practice. Overarching findings include the fact that barriers are particularly embedded in the EHO work context, both in emergency and day-to-day work conditions. These barriers are heavily related to organizational factors (e.g., leadership, time, etc.), systemic issues (e.g., legislation, political influence, etc.), and conditions of the evidence (e.g., relevance, access, etc.). However, there are unique barriers that arise in emergencies including a lack of: strong leadership, a culture that supports change, embedded processes to support change, and human resources. It is important to identify ways to reduce the impact of these barriers to support evidence-informed decision-making and meet community needs.

Co-Authorship Statement

The three manuscripts that make up this dissertation were written with the intent to publish separately with myself, Shawna Bourne, as first author, Dr. Anita Kothari as second author, and Dr. Nadine Wathen and Dr. Jessica Polzer as third and fourth authors, depending on the manuscript.

As first author, I was primarily responsible for the design, recruitment, data collection and analysis, interpretation of the results, and writing of the manuscripts for this study. As second author, Dr. Anita Kothari provided research supervision to the primary author and was a trusted advisor in all aspects of the design and implementation of all stages the research process. She also provided critical review of the analysis and throughout the process of developing the manuscripts.

The third and fourth authors, Dr. Nadine Wathen and Dr. Jessica Polzer, contributed to the conception and design of the research project, engaged in critical review of the findings, and read and approved all three manuscripts.

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It is with enormous gratitude that I thank the environmental health officers (EHOs) who took the time to participate in this research project, lending their voice to an issue of importance to environmental public health practitioners and the people they serve across Canada. This is especially true, recognizing the additional burden to participants during the first year of the COVID-19 pandemic when the second set of data was collected. Without the participation of EHOs, this research would not have been possible. I hope that this body of work is informative and useful to practitioners and the people who employ them, making work easier and more impactful as we gain a better understanding of how to better support EHO practitioners in their every day and emergency efforts.

I would also like to thank my supervisor, Dr. Anita Kothari for openly and willingly sharing her wisdom, her compassion and guidance as I navigated personal, professional, and academic challenges throughout the period of this study. To my academic committee members, Dr. Nadine Wathen and Dr. Jessica Polzer, I thank you for your advice, perspective, and numerous hours spent guiding, supporting, reviewing drafts, and encouraging me through this process.

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and whom I admire and miss immensely, I dedicate this thesis and what it means to you,
gran.

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Chapter 1

1 The Barriers to Research Utilization Experienced by Environmental Health Officers in their Everyday and Emergency Practice in Canada

1.1 Introduction

The health care literature identifies Evidence-Informed Decision-Making (EIDM), Knowledge Translation (KT), and Implementation Science (IS) as distinct but related approaches for increasing evidence uptake to improve health care programs, services, and outcomes (Bick & Graham, 2010; Shelton et al., 2020; Straus et al., 2009). EIDM is the process of making decisions based on the best available evidence resources, including research, previous experience, client input, preference, expertise, and skill set (Rycroft-Malone et al., 2002). KT is defined as the process of moving knowledge into action, including both the creation and implementation of knowledge to aid the decision-making process (Graham et al., 2006). IS focuses on strategies to support the systematic uptake of evidence into healthcare practice that considers the quality of the evidence and the characteristics of the practitioner, the practice processes, and the health care setting (Shelton et al., 2020). These definitions show the inherent linkages that exist between these three approaches that all focus on the use of evidence in policy and practice and the importance of that evidence as a tool to improve healthcare outcomes.

The complexity of the healthcare environments in which practitioners work has meant that the definition of evidence has changed overtime (Brownson et al., 1999; Shelton et al., 2018). Evidence can be used to develop best practices with process steps that can be repeated over and over by the practitioner in a simple context. When applying evidence in a more complex situation, such as the application of a public health intervention in a community-based setting, the process of incorporating evidence into decision-making will be more complex, requiring relevant information, community engagement, political

momentum, and support to ensure effective implementation. Because public health problems are often more complex and socially integrated, the type of evidence needed for problem management in this setting is defined as a combination of research, expertise, contextual information, and stakeholder expectations; the evidence is applied to the design, development, delivery, and evaluation of health programs, services, interventions, and outcomes to achieve public health objectives (Patton, 1997; Rycroft-Malone et al., 2004).

Research utilization (RU) is the use of research findings in practice (Funk et al., 1995). RU occurs when healthcare professionals apply evidence in concert with practice knowledge, core competencies, and expert knowledge of the systems and context of application. A major concern in the fields of EIDM, KT, and IS is the gap that exists between the best research evidence and professional healthcare practice, known as the Evidence to Practice Gap (Straus et al., 2009). To understand the factors affecting the evidence to practice gap in environmental health, RU provides a tangible basis for assessing how processes within the knowledge to action cycle of KT (Graham et al., 2006) support EIDM, and then determine useful strategies to influence the systematic uptake of evidence in professional practice (Shelton et al., 2020)..

Prior research has demonstrated that RU is not accomplished simply by ensuring that a practitioner has access to research evidence; rather, the adoption of evidence into practice is influenced by many factors (Fixsen & Blase, 2020; Yost et al., 2014). Studies to date indicate that these influences vary based on structures and institutions, the context, and the practitioner. These influences are further complicated by the relationships that connect people, place, process, and systems (Fixsen et al., 2005). The goal of this research study is to develop an understanding of those factors that influence RU amongst Environmental Health Officers (EHOs) working at the frontlines of public health in Canada. Understanding the barriers to, and facilitators of, RU experienced in everyday and emergency EHO practice can be leveraged to increase EIDM through the use of strategic interventions. This is the focus of the three studies presented in this thesis and the integration of those findings that comprise this body of work.

1.2 Background

Public health services in Canada are delivered by a variety of public health professionals. However, health protection services, a subset of public health programs and services, are primarily delivered by EHOs. These services include, but are not limited to, the oversight of the safety of drinking water; conditions in recreational water; outbreak management; conditions of the built environment (e.g., indoor air quality in community buildings); emergency and disaster management (e.g., issuing and lifting boil water advisories); monitoring and mitigating health impacts due to biological and toxic exposures (e.g., environmental spills, etc.); through the application of risk assessments that balance community risk and population preferences (Dhesi & Stewart, 2015; Vanderlinden et al., 2012). The practical responsibilities of EHOs include the delivery of these and other services and programs critical to public health; environmental health is a discipline that involves the application of science, regulatory enforcement, management of risk, and community partnership and engagement (Mak & Ponto, 2013). An undesirable event, in any of these environmental health practice areas, has the potential to have a significant negative impact on the broad population and thus may affect morbidity and mortality rates (Gamboa-Maldonado et al., 2012; Rodrigues et al., 2021).

In Canada, the roles of public health practitioners are mandated at federal, provincial, and regional levels. This structure of governance provides unique opportunities for comparative, exploratory KT and IS research at both the organizational and system levels in the Canadian context (Diez-Roux, 2000). Studying EHO evidence use in environmental public health programs and services allows for a more complete understanding of the factors, context, and characteristics that affect the practical application of evidence in practice (Diez-Roux, 2008). EHO emergency practice also provides another contextual area of consideration as EHOs are critical public servants when decisions must be made with respect to emergencies of public health consequence.

At the local, provincial, and federal levels of emergency and disaster response, emergencies can be quite diverse. The term emergency typically refers to events or situations characterized by intense, rapid response, that are often differentiated based on

the scale of impact and the ability to manage or control outcomes (Forsting, 2004). Emergencies in environmental health exist along a continuum of differing degrees of magnitude, sometimes with deadly outcomes such as in a disaster that disrupts essential services (e.g., housing, communications, sanitation, water, or health care). The common denominator in all emergencies is that an emergency event gives rise to unanticipated, severe, and immediate threats to public health.

In emergencies, EHOs across Canada provide front-line public health assessments to identify and evaluate population health risks and determine the appropriate intervention and level of action required to minimize health impacts (Forsting, 2004; Kreuter et al., 2004; Sekercioglu et al., 2020). The importance of responding in a timely and appropriate manner in emergencies is critical to reducing risk and increasing stability as a population health measures (Khan et al., 2018).

1.3 Research Problem

In everyday work, EHOs focus on a combination of health promotion and health protection services, which include routine disease prevention and management through monitoring, surveillance, education, and enforcement of standards (Howze et al., 2004; Kreuter et al., 2004). EHOs also work on large- and small-scale emergencies such as outbreaks and disaster response (Sly, 2014). In an early report into the Severe Acute Respiratory Outbreak in Toronto of 2003, a post-emergency evaluation of the event noted that EHO work had been reduced to essential services only due to the demands of the community response (Basrur et al., 2004). This observation was repeated during H1N1 pandemic of 2009 (Hall et al., 2012) and in the COVID-19 pandemic of 2019 (Sekercioglu et al., 2020). It is unknown how emergency work adds to or changes the factors affecting RU in EHO practice. However, it was anticipated that translation of knowledge into practice would be influenced by conditions of emergency practice. Uncovering the barriers to, and facilitators of, RU that influence the EIDM practices of Canadian EHOs in normal and emergency practice could contribute to continuous improvement in practices, processes, and outcomes in public health.

1.3.1 Research Gaps

While it is generally accepted that EIDM is important to environmental health practice and service delivery (Barratt et al., 2013; Dhesei & Stewart, 2015), there are only a small number of research articles that have explored what evidence-informed practice looks like in environmental health and the factors that influence it. General guidance to support RU in EHO practice has been developed based on what is known from other professional groups (Mackintosh et al., 2015); however, it is not clear how accurately the guidance reflects the reality of environmental health practice. More information is needed on the specific factors influencing RU in environmental health practice for appropriate interventions to be provided.

Gaps have also been shown to exist in the evidence available to guide environmental health practice. A review of the evidence available on the database health-evidence.ca, a repository of systematic reviews of relevance to public health decision-making, found a lack of rigorous evidence in environmental health, food safety, and inspection, indicating that the literature in those areas may be sparse or of low quality (Tirilis et al., 2011). These results demonstrate a particular challenge for EHOs who are seeking relevant evidence suitable to support evidence-informed decision-making in their practice, another potential barrier for EHOs in Canada but it is unknown if this finding is indicative of a larger barrier to EIDM in environmental health practice from the perspective of EHOs.

There has been significant federal funding allocated to developing tools to support access to relevant evidence for EHOs across Canada (Dubois & Lévesque, 2020); though laudable, it is unclear if having access to more information alone will effectively increase EHO evidence use. Unfortunately, it is largely unknown how or which innovations will support increased EIDM practices of EHOs. Furthermore, targeting the right underutilization problem is important to increasing the uptake of evidence in EHO policy and practice. In fact, a global review of public health risk factors shows that the increasing incidence and prevalence of environmental health risk requires more attention to exposure risks, but also to the “cocktail of interventions” that are needed to better address population risk and improve outcomes (Abbafati et al., 2020). As the complexity

of environmental health issues increases, access to better information about the contexts and conditions that support evidence uptake in EHO practice are needed.

A systematic review of decision-making frameworks was completed to identify an approach suitable for the development of environmental health practice and interventions (Norris et al., 2021). The study found that most frameworks for EIDM are unsuitable for environmental health as they are linear and do not adequately consider the context of the intervention and lack guidance to support the inclusion of complex relationships that are inherent in environmental health problems. Key issues effecting usefulness were identified as differences that exist between clinical and environmental health practice including: certainty within the body of evidence, translating the body of evidence to the context and conditions (e.g., human, animal, and mechanical evidence), paucity and inappropriateness of random-controlled trials to application in a population with many variables, and differences in the decision-making context (e.g., process of risk analysis is both technical and social). The study found the need for and importance of a rigorous decision-making framework to address the differences between the clinical and environmental health decision-making contexts and challenges; however, a fulsome description of those challenges have not yet been clearly articulated in the literature.

The complexity of problems in environmental health is another challenge to EIDM in environmental health practice. EHOs apply interventions that are often long-term in nature and have multiple, interacting components, so applying evidence that has removed the context from the solution can be problematic (Gielen & Green, 2015; Rehfuss & Bartram, 2014; E. A. Smith et al., 2021). Complexities present in decision-making include the social, economic, political, and cultural context. And across Canada, factors such as geography, the social determinants of health, Indigenous health, and other demographics such as race and ethnicity, influence the outcomes in environmental health. These factors are well documented and deeply embedded, affecting the delivery of equitable programs and services (Jack et al., 2010; Rehfuss & Bartram, 2014; Rideout & Oickle, 2016). The complex environment in which EHOs make decisions require that these issues be considered; however, it is not clear what factors influence the uptake of this well documented evidence in EHO practice.

A recent study was completed to understand the sources of evidence used by EHOs in their decisions and actions, how they identify the required information, and the level of trust in those sources (Tang et al., 2015). The study begins to answer some important questions about evidence use by EHOs in Canada, but more information is needed. Of particular importance, this study found that almost 90% of EHOs reported using evidence in their daily practice, and reliable sources for decision-making cited by EHOs included peer-reviewed literatures and information from government sources, colleagues, and professional organizations. The study also reported that time, cost, and relevant information were important factors constraining RU in EHO practice. These important findings are taken a step further in this study which set out to identify the factors influencing RU by EHOs in emergency and normal working conditions, providing additional building blocks to help address the knowledge to practice gaps influencing the impact of environmental health programs and services in Canada.

1.3.2 Research Objectives

This study set out to understand the barriers to, and facilitators of, RU experienced by EHOs in Canada by asking the following three questions:

- i. How do EHO practitioner perceptions of the barriers to RU change during an emergency?
- ii. What factors influence evidence use during an emergency?
- iii. What can be done to ensure access to evidence and support effective and appropriate practice decision-making?

1.4 Methodology

As the primary researcher in this study, my selection of the three research questions arose from my experience as an EHO in Canada, and ongoing work in policy and program work as a leader in the provincial government. My work has focused on the application of environmental health principals and programs to the design, delivery, and continuous improvement of provincial programming including: the monitoring of small and large

drinking water systems in the province, measuring the impact of inequity in the modernization of the justice system, and issues of equity and housing in the agriculture sector. My roles after having worked as an EHO, included working with EHOs who provide programs and services at the municipal, provincial, and federal levels across Canada. My transformation and implementation pursuits, along with my passion for issues in the areas of environmental health, equity, and continuous improvement, have continued to influence my professional and academic pursuits, including this research study. My understanding of the work of EHOs and how knowledge is applied in everyday and emergency environmental health practice has informed my approach to identifying the barriers and facilitators of RU. My approach applies utilization focused methodologies that can be leveraged to inform EHO practice improvements through EIDM in a very practical way (Patton, 1997). It is my contention that this approach is required to ensure that the very traditional tenants of EHO practice of protection and promotion, are retained even as the profession pivots to address modern issues. To continue to be effective, environmental health must evolve to incorporate the very real population level concerns of racial and social equity that effect outcomes at the population level through the adoption of relevant evidence and new ways of knowing (Bourne & Rihal, 2019; Kreuter et al., 2004; Rideout & Oickle, 2016)

1.4.1 Constructionism and Pragmatism

In line with these views, social constructionism and pragmatism form the epistemological foundation, or the theory of the nature of knowledge, that guide this research. Social constructionism is the perspective that individuals construct their reality through social interactions within and across groups, and as a result, groups of individuals communicate and negotiate their views and perspectives of individual and shared reality together (Berger & Luckmann, 1967). This view holds that reality is constructed socially, through discourse, investigation, and deliberation and as a result, there are as many views of reality as there are individuals, and no particular view is privileged over another or considered “the one true reality”. Social constructionism purports that our knowledge and understanding of reality is highly contextualized and situation dependent.

Pragmatism is rooted in social philosophy and asserts that the interactions that occur between individuals result in individual experience and these individual experiences are critical to understanding phenomena like professional practice and the work environment (Hickman, 2009). Pragmatic approaches to knowing and understanding affirm that it is possible to draw inferences from these individual experiences and the connections and meanings that are drawn from them, and in so doing, learn about ways to inform “intelligent practice” rather than continuing to deliver “uninformed practice”. The findings based on the perceptions of EHOs in this study can thus provide evidence to inform decision-making and improve impacts and outcomes. Ultimately, the best pragmatic approach is the approach or approaches that best answer the research question (Teddlie et al., 2008). These philosophical underpinnings guide this research from the development of the associated research questions, and the collection, analysis, and interpretation of data, through to the resultant conclusions and recommendations that were made. Based on these beliefs, this research leverages the EHO perceptions of the barriers to, and facilitators, of RU expressed by the EHOs themselves about the social world and social systems within which they work.

1.4.2 Employing Mixed Methods

To understand the factors influencing RU by Canadian EHOs, a mixed methods approach was used. Mixed methods permit a broad evaluation of the phenomenon of RU in practice and a holistic understanding of the dynamic and complex practices of EHOs as individuals operating within teams, organizations, and larger systems, when trying to apply evidence (Clark et al., 2008; Teddlie et al., 2008). A carefully constructed mixed methods design brings together the strengths of both qualitative and quantitative research thereby increasing the credibility of the study findings. Mixed methods are both constructionist and pragmatic in design. Social constructionists consider individuals (practitioners) to be participants in a common cultural system of understanding (the work environment). To gain insight into this cultural system, the actions and behaviours of a practitioner should be explored through a combination of methods to provide additional evidence particularly in situations involving a new study population (Gergen, 1994), in this case EHOs. In new populations, mixed methods studies validate and illustrate results

through the collection and analysis of complex information that is gathered using multiple methods (Creswell & Plano Clark, 2011). Pragmatically speaking, the best approach to collect data was to employ a method that uncovered the individual's perspective, as the expert in their own experience. This way it is possible to uncover information about the barriers that have had the most important impact on RU in EHO practice in Canada. Through this approach, the research design provided a means to identify generalizable knowledge about the barriers and facilitators to RU through the quantitative methods while the qualitative analysis of the data provided opportunities to understand the more specific experiences of EHOs and hear the real stories about the barriers to RU that EHOs experience in their practice. The data collected through the online survey in this study included both closed-ended survey items which were used in the quantitative analysis and open-ended survey items which were used for qualitative analysis. Each chapter in the study employed a different method to answer the three questions about EIDM that drove this study. Descriptive statistics were the focus of the reporting in chapter two, dimensional analysis was employed in chapter three interpreted through the lens of theory, and in chapter four thematic analysis was used to gain insight into the open text responses. In chapter five, the results of the three prior chapters were integrated through the mixed methods process of between methods triangulation (Creswell & Plano Clark, 2011; Flick, 2020). Between methods triangulation in this study leverages statistical analysis and thematic analysis in a systematic manner to inform our understanding of RU in environmental health practice (Flick, 2020).

1.4.3 Ethics and Confidentiality

The BARRIERS Scale, used as the method of data collection in this thesis, required a non-medical review of ethical risks and accountability to ensure that participants were treated with respect and dignity throughout the research process. As such, issues of confidentiality, informed consent, and anonymity were considered in the methodological design. A consent page was included in the survey and participants were informed of the nature of the survey. Researcher interests and any biases, of which there were none, were also disclosed. Contact information for the research team as well as the [Western University's Research Ethics Boards](#) were included in the consent and disclosure

documents, this provided information to all participants in the event that had any questions or concerns that were not addressed in the online documentation.

Ethics approval for this study was obtained from the Western University's Research Ethics Boards and is documented under Research Ethics Approval Project Identification numbers: 102798 and 115466.

1.5 Methods

The Barriers to Research Utilization Scale (BARRIERS Scale) (Funk et al., 1991) was used to collect the data for each study reported in this thesis. The BARRIERS Scale is an established tool and was originally created for, and used extensively, in nursing research. It has been shown to be useful for obtaining foundational information about the barriers to, and facilitators of, RU (Athanasakis, 2013; Carlson & Plonczynski, 2008; Kajermo et al., 2010; Tuppal et al., 2019). EHOs were eligible to participate if they: (i) were an EHO, (ii) had been granted a Certificate in Public Health Inspection, or the CPHI(C) designation, and (iii) had at least one year of experience working within the Canadian context at the point in time when they completed the survey.

As the goal of this research study is to develop an understanding of those factors that influence RU amongst EHOs working at the frontlines of public health in Canada, the survey tool seemed appropriate. To answer questions about differences between the experiences of EHOs in everyday and emergency practice, the survey was administered to Canadian EHOs at two points in time. First in 2012, during a period of normal practice across Canada, and once again in 2020, during the COVID-19 pandemic, an emergency period when EHOs were directed to respond to the global pandemic emergency. Demographic information was also collected to allow for comparisons in responses across time.

1.5.1 Integrated Article Format

In this study, the EHO responses to the BARRIERS Scale formed the basis of the three studies that comprise chapters two through four. The integrated article format was used to

report each of the study findings, one per chapter, followed by an integration of the results in the last chapter of the thesis. Each chapter uses a practical approach to understanding the context in which research is being used in Canada by EHOs, supporting the pragmatic goals of this paper. The following provides a high-level overview of the purpose and analysis completed in each chapter of this thesis to answer the research questions.

In chapter two, the closed-ended BARRIERS Scale questions were analyzed using descriptive statistical analysis. The following two questions were the focus of chapter two: (i) what are the barriers to research utilization experienced by Canadian EHOs in their everyday work and (ii.) how do these barriers change in the context of emergency practice? To address these questions the responses were analyzed using SPSS for measuring central tendency, and the Mann–Whitney U-test to determine if there was a statistically significant difference between the responses to the BARRIERS Scale in 2012 and 2020.

In chapter three, the research aim was to develop a more holistic understanding of the EHO responses by (i) simplifying the data into new comprehensive constructs to determine the relationships amongst variables and (ii) interpreting and visualizing the data in a simplified format. Dimensional reduction was used to the gain additional knowledge about the factors influencing research utilization by EHOs in Canada. Principal Component analysis (PCA) was run on the 2012 data using SPSS to identify the factors which explained the related clusters of barriers which were then assessed using the Active Implementation Frameworks (AIFs). The AIFs are an evidence-based set of six frameworks which comprise a mid-range theory for predicting and testing the outcomes of interventions designed to support practice innovation arising from the best evidence. AIFs focus on conditions that improve the implementation processes and systems that set the context of implementation (Fixsen & Blase, 2020). Confirmatory Factor Analysis (CFA) was completed in Stata and the results were used to determine goodness of fit of the PCA model against the data collected in 2020.

In chapter four, the EHO responses to the three open-ended items in the BARRIERS Scale were analyzed using thematic analysis to (i) understand the other barriers to RU experienced by Canadian EHOs in their everyday work not captured in the BARRIERS Scale and (ii.) to determine how these other barriers to RU change in the context of emergency practice. The open-ended survey question data were analyzed in NVivo using inductive and deductive approaches and tools within NVivo.

In the final or fifth chapter of this thesis, the results of the findings across the three studies are triangulated using a pragmatic mixed methods approach to assemble the data into a comprehensive whole and present the overarching findings.

1.6 Significance

This study has the potential to expand knowledge in the field of KT to include an underrepresented subpopulation in public health, the EHO. This is of additional relevance because of the need for strong and reliable decision-making by EHOs to protect and promote public health outcomes across Canada effectively and efficiently.

Furthermore, methodologically, this research approached the study questions by using a well-recognized quantitative tool within a mixed methods design. In this research, the quantitative BARRIERS Scale was adapted to a new and unique study population. The resultant findings provide a baseline of information that can be used as a reference point for future practical KT studies in environmental health.

This study also led to the identification of useful information for decision-makers in the development of strategies to aid EIDM in environmental health. The multiple levels of social interaction that occur within the decision-making process of EHOs warrants scrutiny prior to the implementation of KT interventions. EIDM in environmental health also needs to be informed by the evidence. A study such as this one provides additional clarity and direction to those seeking to increase EIDM in public health. The results of this study identified patterns within the contexts of EHO work that have an important influence on their EIDM behaviours. Understanding and identifying the variables that affect those EIDM behaviours is important to ensure the right interventions and supports

are in place to support RU by EHOs. By capturing the issues, challenges, and problems identified by the research participants, an informed analysis of the KT practices and patterns of EHOs and their workplaces can be established and utilized by researchers, employers, and practitioners for improved environmental health outcomes in Canada. The tools and techniques of IS can then be leveraged to create the conditions for effective RU.

Previous research indicated that EIDM is the norm for EHOs in their daily practice (Tang et al., 2015), and this study brings increasing clarity to how those practices are affected beyond the individual level of assessment. This work also explored how those barriers change in normal and emergency work. The literature on EIDM practice is increasing with respect to how EHOs acquire knowledge and apply it to public health practice and this study adds to that knowledge base. Understanding the barriers experienced by EHOs in Canada provides useful information that can help: (i) organizations support the KT processes that are needed in environmental health, (ii) researchers and organizations to gain insight into the appropriate interventions to increase RU, and (iii) practitioners to receive information to support decision-making and better advocate for working conditions that facilitate RU in the field of environmental health.

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Chapter 2

2 Canadian Environmental Health Officer Perceptions of Barriers to Research Utilization in Everyday and Emergency Practice¹

2.1 Abstract

Background: Environmental health can maximize its benefits to the public by incorporating evidence-informed research findings into Environmental Health Officer (EHO) practice. Organizations, practitioners, and environmental health researchers need to understand the barriers to Research Utilization (RU) experienced by EHOs to ensure that programs and services are delivered in a way that provides the best outcomes and impacts for the public, in both normal and emergency practice.

Purpose: To report the quantitative findings from the analysis of the EHO responses to the 29 closed-ended questions in the BARRIERS Scale to (i) understand the barriers to research utilization experienced by Canadian EHOs in their everyday work and (ii) determine how these barriers change in the context of emergency practice.

Methods: EHOs were invited to respond to the items in the Barriers to Research Utilization (BARRIERS) Scale and their responses were analyzed using descriptive statistics. Data were collected in 2012 (311 respondents), which was a typical work period, and again in 2020 (82 respondents), during the Covid-19 pandemic. Responses were analyzed using measures of central tendency. The Mann–Whitney U-test was then used to determine if there was a statistically significant difference between the responses to the BARRIERS Scale in 2012 and 2020.

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Results: The three greatest barriers to RU identified by EHOs at both points in time were a: (i) lack of authority to implement changes in practice, (ii) lack of time to review research, and (iii) lack of time to implement research findings. The mean ratings of each of the 29-survey item responses to the BARRIERS Scale were not statistically different in 2012 and in 2020. This suggests that the barriers to RU in normal work and emergency periods are similar and particularly embedded in EHO practice.

Discussion: The three top barriers to RU, lack of authority, lack of time to read research, and lack of time to implement research, should be addressed to improve the uptake and utilization of research in environmental health practice. This study demonstrates that the reported barriers to RU for EHOs were consistent at the two points of data collection. From these two findings, it can be inferred that employers, practitioners, and researchers who wish to continuously improve environmental health programs and services should take advantage of periods of relative calm (non-emergency) to take stock of the barriers to RU and apply intervention strategies to improve the adoption of evidence. These improvements will have an ongoing impact and influence on practice behaviours during both every-day and emergency conditions. More studies are needed to understand the embedded structural and organizational barriers to RU in environmental health practice; however, this study provides a useful starting point, or baseline, to understand the nature of the barriers to RU in EHO practice. Areas for future investigation are suggested, including (i) identifying the underlying factors influencing RU in EHO practice using methodologies like factor analysis to support the development of strategies to increase RU, and (ii) increasing practice-based research in environmental health, including piloting the use of strategic interventions that address the lack of time and authority experienced by EHOs across Canada.

2.2 Introduction

The role of Environmental Health Officers (EHOs), also referred to as Public Health Inspectors in Canada, is complex and varied across the Canadian landscape. EHOs investigate, evaluate, and mitigate health-related hazards that are connected to the natural and built environment. EHOs apply environmental health risk assessment methodology to understand the scale and scope of identified threats and concerns impacting upon public health outcomes in the community (Portier, 2011; World Health Organization, 2021). The work of EHOs is structured through policy and legislation at the federal, provincial, and municipal levels across the country. The application of these varied regulations enables the programs and services delivered by EHOs within the local contexts of diverse communities. EHOs across Canada educate communities and partners about environmental health risks and remedies, and enforce various regulations in communities to mitigate risks. EHOs employ several tools to protect community health, including collaboration and education, issuing tickets or orders, and summoning individuals to court to address environmental health concerns.

The areas of focus of Canadian EHOs include the promotion, prevention, and control of contamination in air, food or water quality; infection control, particularly in communal settings like schools or nursing homes; and many other sources of health-related risks arising in the environment (Canadian Institute of Public Health Inspectors, 2020b). As subject matter experts in risk assessment and environmental health strategies, EHOs in Canada are also involved in building healthy policy, supporting and educating the public on healthier practices, amplifying community action through public engagement and reorienting health services, and interventions to meet community needs (Campbell et al., 2011). These environmental health objectives align with global EHO mandates to manage and mitigate environmental health risks and improve community health (Prüss-Ustün et al., 2017).

The importance of using the best evidence to inform practice decisions in environmental health is clear when considering the fact that the environment touches every person in every aspect of their daily life (Hancock, 1993). The impacts of decisions made when risk

is identified can be acute and immediate or lead to negative, chronic outcomes, including increased morbidity and mortality (Prüss-Ustün et al., 2017). Daily exposures to pathogens, chemicals, and other contaminants occur through key physiological conduits such as the air we breathe, the water we drink, the food we eat, our options around shelter, and ongoing risk exposures (Campbell et al., 2011; Koehler et al., 2018; Kuiper et al., 2012). EHOs use evidence to design, develop, and deliver environmental public health interventions as a part of their day-to-day and emergency work. For this reason, grounding environmental health interventions in rigorous research is essential to well-designed environmental public health practice (Weed & Mckeown, 2003). In the community, the relevance or contextual fit of that evidence is also important. Known gaps in the environmental health knowledge base include a lack of evidence about the application of evidence in the natural settings where environmental health risks occur (Portier, 2011); these gaps exist because of a historical focus on the hard environmental sciences rather than the application of hard science to practice (World Health Organization, 2017b). EHO practice depends on a combination of best evidence and community context to deliver effective environmental health services (Gamboa-Maldonado et al., 2012; Koehler et al., 2018).

2.3 Understanding Evidence Use in Environmental Health Practice

To date, little is known about how EHOs in Canada use evidence to shape their public health practice, and conversely, how these practice gaps inform research. To this end, a study to understand the sources of evidence used by EHOs in their decision-making was completed and it found that approximately 90% of EHOs reported using evidence in their daily practice and that they consider peer-reviewed literature, government reports and resources, colleagues, and professional organizations to be reliable sources of information (Tang et al., 2015). EHOs also reported that time, cost, and relevance, were limitations to the application of evidence in practice. These findings begin the process of unravelling the evidence-informed decision-making (EIDM) practices of EHOs in their work to

which this study will contribute additional information about both every day and emergency practice.

A rigorous analysis of the barriers to the use of evidence in EHO practice has been recommended in the literature in order to ensure a strong and effective environmental public health workforce (Halverson, 2019; Smith et al., 2007; World Health Organization, 2017b). In this effort, practice reviews are important to population health because the poor application of evidence can cause community harm (Prüss-Ustün et al., 2017). To avoid poor practice outcomes for communities, EHOs require access to high-quality evidence to effectively and efficiently perform both day-to-day and emergency work (Barratt et al., 2013; Brownson et al., 2009). The gap that exists in our understanding of how EHOs use evidence in practice is important to study because of the potential community-wide impacts should evidence not be used rigorously.

Evidence gaps present a particular challenge for EHOs in emergencies. Emergencies, like outbreaks in facilities or natural disasters, are often unexpected, dangerous situations that require immediate action to resolve, and require the rapid mobilization of both government and the community (World Health Organization, 2017a). In environmental health emergencies, the failure of an EHO to respond quickly and appropriately may result in unnecessary injury or death (Eldridge & Tenkate, 2006; Fielding, 1999; Forsting, 2004). This means EHOs need rapid access to high-quality and up-to-date information in emergencies. Moreover, EHOs must be able to adapt to emergent information in these situations, for example during the 2020 Covid-19 Pandemic, as more information was learned about the virus, its variants and its means of transmission, EHOs had to stay abreast of these changes to provide accurate advice and protect community health (Rodrigues et al., 2021; Sekercioglu et al., 2020). In constantly changing situations like pandemics, decisions about how to approach risk include how best to apply protocols and practice by encouraging risk-reducing behaviours (e.g., through education) or implementing mandatory mitigation strategies (e.g., through directives and orders) in various contexts such as schools, workplaces, and grocery stores.

Although environmental health practitioners are not new to emergency response, the lack of research into EHOs' everyday practices limits the full integration of these practices into emergency response efforts in concert with other public health professionals (Forsting, 2004; Freudenberg, 2004). For example, a lack of data on practice and outcomes of interventions has meant that there has been variation in the utilization of EHO competencies in Canada, dependent on jurisdiction, throughout the pandemic. The risk factors directly impacting public health outcomes in COVID-19 of environmental health concern, such as indoor air quality, the use of disinfectants, and an increase in waste from masks, gloves and medical procedures, are shared almost universally across the provinces (Haas et al., 2021; Sekercioglu et al., 2020). Research that documents the outcomes of strategic environmental health interventions in emergencies will help to maximize the impact of environmental health practitioners in communities in coordination with other public health professionals every day and in emergencies. Further study of EHO practice impacts will help to clarify tangible opportunities for environmental health risk and mitigation strategies in synchrony with the other important health partners in the population health landscape (Gamboa-Maldonado et al., 2012). Additionally, complex, "wicked problems" like climate change, require a deeper understanding of the constantly developing evidence, as well as the outcomes and influence of preventive actions on communities (Kreuter et al., 2004).

Like many other health professionals, EHOs experienced dramatic changes in their professional practice in 2020 due to the Covid-19 pandemic. The global pandemic presented a unique opportunity to consider how practitioner perceptions of the barriers to RU and related practices might have changed due to pandemic-related demands. Understanding how emergencies impact evidence use is important to EHOs who deliver critical emergency services during large-scale public health emergencies. It is also important to the public, who rely on EHOs to make effective and appropriate decisions using current and reliable information in their practice decisions. Understanding the potential impact of emergencies on EHO evidence use will help to reduce the risk that EHOs are misinformed, or practices are poorly executed in an emergency because environmental health interventions have the potential to impact positively or negatively on health outcomes at the population level.

This paper reports the findings of a study designed to increase understanding of the barriers that EHOs face when using evidence in their everyday work and how these barriers might change in the context of an emergency. These findings provide important insights into EHO identified barriers to using research evidence in two different scenarios, the everyday practice context and in an environmental health emergency, by using the Barriers to Research Utilization (BARRIERS) Scale where data was collected at two points in time.

2.4 The BARRIERS Scale as a Tool to Understand the Factors Influencing Research Utilization in Environmental Health Practice

The BARRIERS Scale was developed in 1991 to identify the principal factors that nurses perceive as barriers to RU in their practice (Funk et al., 1991). The Scale is comprised of 29 statements on a Likert Scale that each respondent rates as having no impact to a great impact on their ability to use research to inform their professional practice. The items in the BARRIERS Scale were developed by applying concepts from the healthcare literature related to evidence-based practice to the work environment of clinical nursing (Funk et al., 1991).

The BARRIERS Scale has been used effectively in over 60 research studies since its inception and has been the subject of several systematic reviews (Athanasakis, 2013; Carlson & Plonczynski, 2008; Hutchinson & Johnston, 2006; Kajermo et al., 2010; Lau et al., 2015; Middlebrooks et al., 2016; Sanjari et al., 2015; Tuppal et al., 2019; B. Williams, Perillo, et al., 2015). These reviews integrate the findings of studies that have focused on the barriers to research utilization in nursing practice in various countries including the Americas, Europe, Asia, and Africa. The Scale has been translated into several languages such as Korean, Turkish, Spanish, and Swedish. It has also been used successfully in multiple nursing environments, including nursing homes, teaching hospitals, and primary care facilities.

Although most studies using the BARRIERS Scale have focused on nursing behaviours and practices, the BARRIERS Scale has also been used successfully to understand the perceptions of barriers to RU in the context of other allied health professionals, including social workers (Lee, 2016), music therapists (Waldon, 2015), occupational therapists (Williams, Brown, et al., 2015), healthcare workers in corrections (Visher et al., 2014), and other health care practitioners and educators (Boer, 2012; Nedjat et al., 2014; Ntaganira, 2012; Stichler et al., 2011). The tool has also been used to correlate and compare perceptions of RU to other characteristics (e.g., demographics) of study participants (Williams, Perillo, et al., 2015). This demonstrates the flexibility, sensitivity, and usefulness of the BARRIERS Scale in various contexts and with diverse types of health care professionals.

Several studies have been conducted to measure nurse perceptions of barriers influencing their use of research and the most commonly used survey tool has been the BARRIERS Scale (Athanasakis, 2013). There are, as a result, many recommendations about the ongoing use of the Scale. The reviews confirm that there is ample evidence that the BARRIERS Scale is a reliable and valid tool (Athanasakis, 2013; Kajermo et al., 2010). The BARRIERS Scale was developed on the premise that understanding the barriers to RU would lead to the development of interventions to eliminate or reduce those barriers (Funk et al., 1991). Although, there has been a significant number of academic studies using the BARRIERS Scale in nursing and other allied health professions, systematic reviews identified limited application of those findings to design interventions that increase RU (Athanasakis, 2013; Carlson & Plonczynski, 2008; Kajermo et al., 2010). Reviewer recommendations have included that the BARRIERS Scale is no longer used in nursing research because it has not had an impact on nursing practice (Kajermo et al., 2010). However, the lack of impact of the BARRIERS Scale in practice may be rooted in the lack of collaboration between researchers and practitioners, as collaboration enables cooperation in the implementation of interventions that go beyond completing a single study (Rycroft-Malone et al., 2015). One systematic review highlights the importance of relationships between healthcare professionals and commissioning organizations to address the complexity of “fit” when designing strategic interventions to increase RU when barriers are identified (Lau et al., 2015) and this is the premise of implementation

science as tool for advancing the use of evidence in practice decision-making (Fixsen et al., 2005; Fixsen & Blase, 2020). Hence, one can infer that meaningful change to support EIDM in practice is contingent on relationship building and collaboration, understanding the context and active efforts regardless of the tool used to identify the barriers to RU.

Systematic reviews have also been used to identify common barriers to RU reported by nurses in multiple studies conducted across the globe. The most common and consistent barriers to RU include a lack of time to implement new ideas, time to read research, lack of authority, inadequate facilities for implementation, inability to understand statistical analysis, the relevant data being unavailable in one place, and a lack of awareness of the research (Carlson & Plonczynski, 2008; Hutchinson & Johnston, 2006; Kajermo et al., 2010). This is also reflected in the findings that EHOs similarly find it difficult to use the best available information due to time constraints, cost, and relevance of the information (Tang et al., 2015). These findings are consistent with nurses in the United States of America where most studies have been completed. It is important to note that the barriers to RU utilization vary based on the country and professional group being studied (Athanasakis, 2013; Kajermo et al., 2010; Middlebrooks et al., 2016; Tuppal et al., 2019).

Several reviews, also recommend that the BARRIERS Scale be used primarily for developing and testing interventions to address the most commonly identified issues or barriers that obstruct RU in nursing practice, (Athanasakis, 2013; Carlson & Plonczynski, 2008; Hutchinson & Johnston, 2006; Middlebrooks et al., 2016; Tuppal et al., 2019). Three studies have been identified that used the Scale as a pre-and-post test to determine the success of interventions. Two of these studies reported that the Scale successfully detected a change in participant perception of barriers to RU following the implementation of the intervention (Bobo, 1997; Fink et al., 2005). Bobo identified a statistically significant change in the perceived barriers to RU in the treatment group of his study to improve access to relevant research and in Fink's cross-sectional study, a pre-and-post survey design was used to measure the impact of several organization-level interventions (e.g., the implementation of an evidence-based practice council) focused on culture change. Fink found an improvement in BARRIERS Scale results at the study's end. In the third study, the BARRIERS Scale was one of two survey tools used to

determine if a training intervention to improve nursing attitudes towards RU was effective in reducing barriers by using pre and post intervention surveys (Çetinkaya et al., 2020). The results of this study showed an improvement in attitude towards research; however, the participants' perceptions of the barriers to RU remained unchanged as no efforts were made to address the barriers identified by participants in the study. These findings suggest that the BARRIERS Scale is both a useful and sensitive diagnostic tool for measuring changes to perceived barriers to RU in a sample population, when data is collected at two points in time (Kajermo et al., 2010; Wang et al., 2013).

Based on the findings of individual studies and systematic reviews of the BARRIERS Scale, it is clear that this scale has been successfully adapted to and applied in various professional settings with many different allied health professionals. It is also evident that the BARRIERS Scale is sufficiently sensitive to detect changes, or lack of changes, in a study population at two or more points in time.

These specific properties of the BARRIERS Scale are leveraged in this study to understand the barriers to RU experienced by EHOs delivering environmental health services in Canada. This understanding is an important first step towards gathering the evidence needed to support evidence-informed practice interventions that can address identified barriers to research utilization in the field of environmental health. This study establishes a baseline of evidence that is lacking in environmental health practice. The findings generated by this research will continue to build our understanding of the EIDM practices of EHOs for future studies that aim to increase and improve the application of research to environmental health practice in Canada.

This research forms part of a larger study that considers the use of evidence by EHOs, which is recognized as critical to the increasingly complex practices in the fields of public and environmental health both in Canada and abroad (Barratt et al., 2013; Dhesi & Stewart, 2015; Eyles & Furgal, 2002; Shelton et al., 2018; World Health Organization, 2017b). By applying the BARRIERS Scale to better understand the factors that influence the uptake and adoption of research in the everyday and emergency practices of Canadian EHOs, we can begin to consider an evidence-informed approach which is needed to

support the uptake of evidence in this important area of public health practice. In this study, the BARRIERS Scale was disseminated to Canadian EHOs to provide insight into (i) the barriers to RU in the everyday work of EHOs; and (ii) how those barriers change in an emergency.

2.5 Methods

The BARRIERS Scale (Funk et al., 1991) is a survey comprised of 29 closed-ended and three open-ended questions, that can be answered or skipped based on the participant's choice. Each closed-ended survey item has five response options ranging from 1 to 5: 1 = to no extent; 2 = to a little extent; 3 = to a moderate extent; 4 = to a great extent; and 5 = no opinion. Non-responses and no-opinion responses (i.e., a BARRIERS Scale response = 5) were treated as missing data in 2012 and 2020 as per the methodology used in the original study (Funk et al., 1991). The Scale closes with three open-ended questions to gather additional information about other perceived barriers and facilitators to RU. SurveyMonkey, a cloud-based survey authoring platform, was used to create the online survey.

The Scale was originally designed for use with nurses in a clinical context (Funk et al., 1991) and was adapted for use with Canadian EHOs in this study. The contextual revisions to the Scale were pilot tested with twenty EHOs working at two local health units in Ontario to: (i) assess whether or not the EHO contextual revisions to item wording was clear to participants; (ii) ensure that instructions for completing the survey were easy to understand; and (iii) confirm that there were no unexpected technical issues related to the online mode of survey delivery (Dillman, 2007). Based on the feedback, minor changes were made to the survey to improve clarity for respondents. No logistical or technical problems were reported from participants concerning completing the items in the instrument. The pilot test confirmed face validity.

Participants in this study were recruited via the Canadian Institute of Public Health Inspectors (CIPHI) national listserv in both 2012 and 2020 (Canadian Institute of Public Health Inspectors, 2011). The link to the electronic survey was included as part of an

email message sent via listserv to EHOs in both years. A number of Listserv subscribers were consistent in both years at just over 1700 voluntary recipients, which includes both CIPHI members and non-members (office@ciphi.ca, personal communication, May 12, 2021).

Respondents confirmed their consent to participate in the survey by choosing to complete the survey questions. Dillman's (2007) techniques for online surveys were used in the layout and design of the survey and to optimize response rates (e.g., follow-up emails to participants). To be included in this study, participants were required to complete three initial, mandatory questions to confirm that they: (i) they were an EHO; (ii) that they had been granted the CPHI(C) designation; and (iii) had at least one year of experience working within the Canadian context at the point in time when they completed the survey. Outside of these three mandatory questions, participants had the option to respond to or skip any of the remaining questions in the survey. The data was not available to confirm the proportion of listserv recipients who met the inclusion criteria (office@ciphi.ca, personal communication, May 12, 2021).

The data were collected anonymously and included both the BARRIERS Scale and demographic data (e.g., gender, year of birth and levels of educational attainment) which respondents also had the option of skipping. The study tools and methods were reviewed and approved by Western's Non-Medical Research Ethics Board (NMREB# 102798 and REB# 115466). The statistical design, analysis, and interpretation of the data employed in this study were reviewed by the Western Data Science Solutions service.

2.5.1 Data Analysis

The survey data collected in 2012 and 2020 were analyzed using Statistical Package for Social Sciences (SPSS) v.27.0 and G*Power 3.1 (Erdfelder et al., 2009; Faul et al., 2007). Both datasets were determined to be non-parametric using the Shapiro-Wilks and Kolmogorov-Smirnov tests for normality. Imputation was not used in the analysis of the data, in alignment with the guidance provided by the Scale developers (University of North Carolina at Chapel Hill, 2018). The significance threshold, or p-value for interpretation, was set at 0.01. It was also determined that in both years, the responses to

the BARRIERS Scale demonstrated high internal consistency (Cronbach's Alpha for all 29 items was 0.910 in both years).

The two key analytical processes used to identify the top three barriers to RU identified by EHOs were Measures of Central Tendency and the percentage of participants who ranked scale items as a barrier to RU from a moderate to great extent. Measures of Central Tendency were used to describe the rank and order of the barriers identified by EHOs in order of importance in 2012 and 2020. The Mann-Whitney U-test was used to determine whether there was a statistically significant difference between the responses to the BARRIERS Scale in 2012 and 2020.

The quantitative results from the BARRIERS Scale are the focus of this paper, while the text-based qualitative data generated by the three open-ended questions included in the BARRIERS Scale are reported elsewhere.

2.6 Results

Three hundred and eleven (311) participants completed the online survey in 2012 and 82 respondents completed the survey in 2020. Of the 311 respondents in 2012, 36 were excluded because they: (i) lacked the CIPHI Designation (n=13); (ii) had the CIPHI designation for a period of less than 1 year (n=7); or (iii) had worked as an EHO in Canada for less than one year (n=16). As a result, 275 participants met the selection criteria and had the option to complete the remaining items in the BARRIERS Scale and associated demographic questions. Of the 82 respondents who completed this survey in 2020, three were excluded because they had worked as an EHO in Canada for less than one year, leaving 79 participants who met the inclusion criteria and who had the option to complete the remaining items in the BARRIERS Scale and associated demographic questions.

Some demographic differences were identified between participants in 2012 and 2020 that reflected workforce changes across Canada, including a larger number of female-identifying study participants in 2020, which aligns with increasing numbers of females in the Canadian workforce (Moyser, 2017) and a greater number of people who identify

as visible minorities, which reflects greater ethnic diversity in the workforce in Canada in 2020 (Martel, 2019). The median age of participants also showed a slight increase between 2012 and 2020. In addition, fewer EHOs worked full-time in 2020 as compared to 2012 and that reflects an increase in flexible work arrangements which were more common during the Covid-19 Pandemic of 2020, with the many retired EHOs being recalled to support pandemic-related work and the public health response (Worth & Karaagac, 2020). Table 1 includes a summary of the demographic characteristics of the participants in 2012 and 2020. Also of note, there was representation from EHOs across Canada in both surveys, reflecting the number of active, regular memberships identified by CIPHI by province (office@ciphi.ca, personal communication, May 12, 2021). Appendices A through E provide additional details about the demographic characteristics of the respondents).

Demographic Information	2012	2020
Male	52% (n=142)	35% (n=28)
Female	48% (n=129)	62.0% (n=49)
Other gender	1% (n=3)	0% (n=0)
Indigenous Canadian	2% (n=4)	1% (n=1)
Visible Minority	14% (n=37)	19% (n=15)
Caucasian	85% (n=217)	80% (n=62)
Self-Identified Disability	2% (5)	1% (n=1)
Median Age	42 years (n=255)	44 years (n=74)
Bachelor's degree	67% (n=183)	73% (n=57)
Graduate degree	17% (n=47)	23% (n=18)

Full-time (35 hours or more per week)	97% (n=266)	90% (n=71)
Other Employment (e.g., part-time, consulting, etc.)	1% (n=2)	5% (n=4)

Table 1: Summary of the Demographic Characteristics of Participants in 2012 and 2020

The data collected from EHOs in 2012 and 2020 were analyzed to identify the most important and least important barriers to RU in the EHO work context by calculating the mean (\bar{x}) response for each item on the BARRIERS Scale. Table 2 shows the top three barriers to RU in 2012 and 2020 based on their means and the percentage of respondents who agreed or strongly agreed with the statements, while Table 3 shows the bottom three barriers to RU during the same period. The full ranking of results can be found in Appendix F: Table Ranking of the 2012 BARRIERS Scale Results (n=311) and Appendix G: Table Ranking of the 2020 BARRIERS Scale Results (n=82).

Top three barriers in 2012	Top three barriers in 2020
Item #13 - The Environmental Health Officer does not feel she/he has enough authority to change environmental health practices, policies and/or procedures. (\bar{x} = 3.43; 83.5% agree or strongly agree)	Item #13 - The Environmental Health Officer does not feel she/he has enough authority to change environmental health practices, policies and/or procedures. (\bar{x} = 3.50; 85.9% agree or strongly agree)
Item #7 - The Environmental Health Officer does not have time to read research. (\bar{x} = 3.29; 81.3% agree or strongly agree)	Item #29 - There is insufficient time on the job to implement new ideas. (\bar{x} = 3.24; 75.0% agree or strongly agree)

Item #29 - There is insufficient time on the job to implement new ideas. ($x = 3.20$; 77.0% agree or strongly agree)	Item #7 - The Environmental Health Officer does not have time to read research. ($x = 3.19$; 78.5% agree or strongly agree)
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Table 2: The Top Three (3) Barriers to Research Utilization in 2012 and 2020

Bottom three barriers in 2012	Bottom three barriers in 2020
Item #20 - The Environmental Health Officer does not see the value of research for practice. ($x = 1.82$; 22.3% agree or strongly agree)	Item #20 - The Environmental Health Officer does not see the value of research for practice. ($x = 1.82$; 12.9% agree or strongly agree)
Item #26 - The Environmental Health Officer is unwilling to change/try new ideas. ($x = 1.99$; 27.4% agree or strongly agree)	Item #22 - The conclusions drawn from the research are not justified. ($x = 1.99$; 25.0% agree or strongly agree)
Item #22 - The conclusions drawn from the research are not justified. ($x = 2.08$; 27.2% agree or strongly agree)	Item #26 - The Environmental Health Officer is unwilling to change/try new ideas. ($x = 2.08$; 21.1% agree or strongly agree)

Table 3: The Bottom Three (3) Barriers to Research Utilization in 2012 and 2020

The majority of the barriers cited by EHOs as important by virtue of their making up the top 14 of the 29 items, were related to organizational factors such as the support and cooperation provided by administration (Item #19), Medical Officers of Health (Item #18) and other staff (Item #25). Other high-ranking barriers included how the research results are compiled (Item #12), the lack of practice relevant research (Item #4), unclear implications of the research for practice (Item #2), and the overall availability of the research to the EHO (Item #1). At the other end of the rankings, EHOs found issues with

the research itself, including statistical analyses (Item #3), unclear reporting (Item #24), and methodological inadequacies (Item #11), of lesser concern than having access to research that is relevant to practice at both points of data collection.

A post hoc power analysis using G*Power 3.1 (Erdfelder et al., 2009; Faul et al., 2007) revealed that the statistical power for this study was 0.875 in 2012 and 2020, and that the findings of group differences had statistical significance at the 0.01 level (Cohen, 1992, 2013). Thus, there was sufficient statistical power to support the reported findings.

2.6.1 Descriptive Analysis

The top three barriers of significance reported by EHOs in 2012 and 2020 were identical. The top reported barriers to RU were: “The Environmental Health Officer does not feel she/he has enough authority to change environmental health practices, policies and/or procedures” (Item #13); “The Environmental Health Officer does not have time to read research” (Item #7); and “There is insufficient time on the job to implement new ideas” (Item #29). The greatest barrier to RU in both 2012 and 2020, was Item #13; however, the other top two barriers, exchanged second and third rank at the two points in time when data was collected. In 2012, Item #7 was ranked as the second greatest barrier to RU, and third greatest barrier in 2020, whereas Item #29 was ranked second greatest barrier in 2012, and third greatest barrier in 2020 (see Table 1).

Similarly, the bottom three barriers to RU reported by EHOs in 2012 and 2020 were identical; they were: “The Environmental Health Officer does not see the value of research for practice” (Item #20); “The Environmental Health Officer is unwilling to change/try new ideas (Item #26); and “The conclusions drawn from the research are not justified” (Item #22). These items were consistently identified as having the least influence on RU by EHO participants. The least important barriers to RU were Item #20 in both 2012 and 2020, and much like the greatest barriers to RU, the second and third least important barriers to RU were transposed at the two points of data collection. In 2012, Item #26 was ranked as the second to the least important barrier in 2012, and third least in 2020, whereas Item #22 was ranked the second to the least important barrier in 2012, and third least in 2020 (see Table 2).

While the top three barrier rankings differed slightly at the two collection points, the Mann-Whitney U-test demonstrated the differences were not statistically significant. Thus, the difference in rankings between each item response to the BARRIERS Scale in 2012 and 2020 were not statistically different ($p \geq 0.01$). The barriers to RU reported by EHOs in the normal practice period of 2012, were not statistically different from the barriers reported by EHOs during the 2020 global pandemic.

2.7 Discussion

By asking EHOs to respond to the BARRIERS Scale at two distinct points in time, in 2012 and again in 2020 during the emergent Covid-19 pandemic, the following two research questions were answered: (i) what factors affect evidence use by EHOs in their everyday work, and (ii) how these factors change in emergency situations.

This study found that the three greatest barriers to RU in EHO practice, in both 2012 and 2020, were a lack of authority to change practice, and insufficient time to read and implement research into practice. This aligns with the findings that time was an obstacle to the application of knowledge in EHO practice in a study seeking to understand the knowledge translation practices of EHOs in Canada (Tang et al., 2015). Through statistical analysis, it was also confirmed that the mean ratings of the responses to the BARRIERS Scale remained stable between these two points of data collection. This finding indicates that the barriers identified by the study participants did not differ in a statistically significant way in 2012 as compared to 2020, and most importantly, that the barriers identified as most significant during periods of normal work activities (2012) remained stable during the second period of data collection when EHO practice was dominated by emergency response activities due to the global Covid-19 Pandemic (2020).

2.7.1 The Factors Influencing Evidence Use by EHOs

These novel research findings provide important insights into the barriers that prevent EHOs from incorporating research evidence into practice. These findings demonstrate how the structures that EHOs work within, and the organizations that employ EHOs,

influence the uptake of evidence into the practice of its employees. These findings are important because in Canada, evidence informed environmental health practice is a priority of the Public Health Agency of Canada; and the agency has mandated the National Collaborating Centre for Environmental Health to support this priority (Dubois & Lévesque, 2020). These research findings are useful for identifying priorities to achieve the mandate of increasing evidence use by EHOs in Canada.

These findings inform practitioners and employers that increasing EIDM behaviours requires efforts that go beyond developing resources or training focused on how to effectively assess and apply research evidence because these main barriers have little influence on RU according to EHOs in both 2012 and 2020. In fact, EHOs indicated that their ability to understand (Item #10), trust (Item #23), and assess (Item #28) research, and to justify its application to practice (Item#22) were all low-ranking barriers to RU. These barriers were amongst the bottom 10 barriers to RU in both years.

Furthermore, EHOs indicated that practitioners valuing research for practice (item #20) was the least important barrier RU in both years, demonstrating that EHOs value RU which has been previously documented when EHOs indicated that they regularly use evidence in their decision-making processes (Tang et al., 2015). This may relate to the fact that EHO practice requires the application of risk analysis to make assessments about risk and outcomes, and as a result, EHOs interpret complex data and information as a core competency in their work, including performing complex sampling in the environment and assessing complicated reports to determine exposure risk as a part of their skillsets (Canadian Institute of Public Health Inspectors, 2020a). Complex data and interpreting that data is not an important barrier to RU identified by EHOs in this study.

However, issues related to EHO perceptions of their own authority to implement practice changes based on the evidence (Item #13), and the allocation of EHO practice time to reading and applying evidence in practice (Items #7 and #29) are more important barriers to evidence use and should be the focus of meaningful interventions. These three barriers, lack of authority, time to read research, and sufficient time to implement innovations in practice, have the greatest impact on RU according to EHOs. The current findings

suggest that EHOs are willing to apply evidence in practice but lack organizational support. Identifying ways to target and implement interventions that address these three specific barriers to RU in the EHO work environment are tied to the organizational structure. These barriers present areas for further study to improve the use of evidence in EHO practice.

The benefits of amalgamating relevant environmental health research to increase uptake in EHO practice is another vital area requiring further research as a large amount of Canadian funding currently targets this particular barrier (Dubois & Lévesque, 2020). Although not in the top three barriers, EHOs report challenges in locating information because the evidence is not compiled in a centralized location (Item #12) and due to a lack of awareness of the research (Item #5). These two barriers were amongst the top ten barriers to research utilization in both 2012 and 2020.

For EHOs, the type of research evidence available to them is a significant barrier to evidence-informed practice. Features of the evidence include qualities related to the way the research is contextualized (Item # 2) and its relevance to EHO practice (Item # 4). These barriers are also amongst the top ten barriers according to EHOs. Canada has made investments to research availability and relevance for practicing EHOs through the National Collaborating Centre for Environmental Health (Dubois & Lévesque, 2020). The National Collaborating Centre for Environmental Health develops meaningful resources for environmental health practitioners through regular gap assessments (Chociolko et al., 2006, 2010) and releases systematic reviews and training materials in partnership with the Canadian Institute of Public Health Inspectors and local health units. Their focus is on providing access to relevant, practice-based evidence. In addition, the *Environmental Health Review*, which is the professional journal for EHOs in Canada, transitioned to an online format in 2012, making it easier for EHOs to access free, online practice focused research, opinions, and commentary with an emphasis on Canadian environmental health practice issues.

Although these two interventions make relevant research materials more readily available to EHOs, they do not fundamentally change the conditions within which these practice

behaviours occur. The top three barriers, which are all at the organizational level, remain unaddressed despite the prioritization of evidence informed practice at the national level. Limited time to review and implement research, and a lack of authority to make change, are the primary opportunities for intervention that have the potential to achieve the desired outcomes. Applied research into EHO practice, organizational-level interventions, and other strategies to improve RU are needed. And based on these research findings, strategies targeting individual-level beliefs, attitudes or general competencies around research utilization are unlikely to produce substantive changes in how research is utilized in this practice group. Additional research is needed to confirm this finding, as it differs to some degree from findings in studies completed with other health practitioner groups that saw value in targeting individual-level barriers to increase research uptake in professional practice (Carroll et al., 1997; Duncombe, 2018; Hutchinson & Johnston, 2004; Parahoo, 2000; Uysal et al., 2010). Based on the results of this study, interventions at the organizational level are more likely to achieve an increase in RU by EHOs, through the creation of a culture that supports evidence use and provides a clear system of accountability for practice decisions and outcomes, leading to an increased adoption of evidence.

These findings echo other research on strategies to increase RU in public health that indicate that organizations are an important target for interventions to support EIDM (Armstrong et al., 2013; Ellen et al., 2013; Kitson et al., 1998). Research indicates that by creating an organizational culture that values the use of evidence, providing resources to support the implementation of practice change, and establishing environments where evidence-based solutions to policy and practice problems are endorsed and supported, the application of evidence can be improved (Lobb & Colditz, 2013; Masood et al., 2018). Focusing on the outcomes of the interventions already in place, is also a key area of future research (Bick & Graham, 2010; Wilkinson et al., 2010).

2.7.2 Perceived Barriers to Research Utilization in Normal and Emergency Situations

The second, and the most surprising finding in this study, is that the mean values of the EHO responses to the BARRIERS Scale in 2012 did not differ statistically from the data collected in 2020. This means that the barriers identified at the two points in time remained constant, even though the data were collected under extremely different conditions. The first during normal conditions and the second during a pandemic emergency. As hypothesized, there were fewer respondents during the pandemic which was anticipated due to the increased pressure experienced by EHOs to respond to the pandemic, while continuing to deliver critical programs and services (Sekercioglu et al., 2020). The lower response rate did not affect the statistical power of this study; thus, it can be said that the barriers to RU in EHO practice, remained constant when EHOs responded to the scale in a normal period (2012) and during a pandemic emergency (2020). This finding indicates that the barriers experienced by EHOs in their normal and emergency practice are stable and deeply rooted in the Canadian public health context, systems, and structures wherein EHOs practice. Because previous studies have demonstrated that changes in perceived barriers to RU can be detected by the BARRIERS Scale (Bobo, 1997; Fink et al., 2005), one can infer that investments made between 2012 and 2020 to improve RU for EHOs, have not had a statistically significant impact on the perceived barriers to RU as identified by EHO practitioners. Nationally, efforts have focused on making relevant research more easily available; however, EHOs have indicated at both points of data collection, that organizational issues are their greatest barriers to RU. Because these barriers are not the focus of interventions at the national level, these barriers to RU remain deep-seated, persistent, and strong. This finding should be further explored in future research.

The stability of the findings from the two points in time when the data were collected in this study, provide some reassurance to practitioners, organizations, and researchers, that if effective interventions are designed to address the key structural and organizational barriers identified as persistent are addressed during periods of calm, the resulting changes should also result in improvements to RU by EHOs during emergencies.

Intervention planning should be easier to implement, monitor, and strengthen in normal work cycles. Establishing organizational and structural improvements to support EHOs during normal periods of work may effectively support EHOs in emergencies as well. This is important because during emergencies RU becomes critical to the delivery of time-sensitive environmental health practice (Yost et al., 2014). This approach to strategic intervention planning will maximize the ability of researchers and organizations to spread and scale-up innovation, adoption, and continuous improvement in day-to-day and emergency practice.

For researchers who are interested in practice-based research and implementation science in the field of environmental health, these findings provide useful information to support the development of knowledge translation interventions that are likely to drive positive outcomes. According to the findings in this study, to achieve the greatest impact and sustainability from RU interventions, EHO practice researchers and employers should focus on addressing the following barriers: (i) lack of perceived authority to implement change, (ii) lack of time to read the evidence, and (iii) lack of time implement the research.

2.7.3 Strengths and Limitations

This study takes an innovative approach to looking at the barriers to research utilization in EHO practice by using the BARRIERS Scale. The Scale has been successfully used to identify barriers to RU experienced by allied health professionals for many years (Hutchinson & Johnston, 2006; Kajermo et al., 2010). By comparing data collected in 2012 and 2020, the study provides meaningful results that can be used to understand the evidence-informed practice behaviours of EHOs in both normal and emergency situations. This approach provides new insights to support evidence-informed practice behaviours in environmental health services in Canada.

Although the BARRIERS Scale has previously been used to measure changes in perceived barriers within a population following the application of an intervention (Bobo, 1997; Çetinkaya et al., 2020; Fink et al., 2005), this was the first time that the Scale has been used to collect data at two points in time and obtain a baseline of perceived barriers

in environmental health for future studies. Pilot testing ensured that the BARRIERS Scale was appropriately adapted to this new professional group. The study results have sufficient statistical power to be useful as a comparator for future studies focused on Canadian EHOs (Faul et al., 2007).

The data in this study was collected independently in 2012 and 2020; however, a longitudinal study would have provided information about change at the individual level over time. As this cross-sectional study provides a snapshot of how EHOs perspective changed (or not) at the national level at two distinct points in time, it is not able to provide information on how perceptions have changed over time.

There are limitations inherent to using any research tool that relies on participants to report on their own past experiences. These limitations include recall bias and social desirability bias (Althubaiti, 2016). Social desirability bias was minimized by collecting survey responses online. No identifiers were used in the collection of the data. Recall bias, or the misremembering or omission of key details in a retrospective study, may also have occurred. However, as this is a study about EHO perceptions of the practice environment by EHO practitioners at the point when the test was taken, the impacts of recall bias on the findings are limited, although EHOs may perceive their competencies in EIDM practice to be better than they are in reality. Finally, practitioners have not been asked to recall specific events but have been asked about their general perceptions about practice conditions at the point when they completed the survey.

This research seeks to understand the barriers perceived by EHOs across Canada and although the number of respondents were small, the number of respondents by province were proportional to the number of EHOs represented by CIPHI across Canada as compared to national membership numbers. However, there may be differences between the people who chose to participate in this study and those who did not. Nonetheless, this is a good starting point to better understand the factors affecting RU in EHO practice across Canada. Future studies will add to the general understanding of the factors influencing the evidence-informed practices of EHOs.

2.8 Conclusion: Supporting Evidence Uptake in Environmental Health

The environmental health needs of communities are changing and so must EHOs and their practices (Brooks et al., 2019). Evidence is important to environmental health decision-making and practitioners need that evidence to make sound decisions about community health risks. This becomes even more apparent as novel and wicked environmental health problems change the types of issues that are prioritized in the environmental health field. These issues require expertise not just in environmental health and risk management, but also in the social, economic, political, and demographic factors that have become increasingly important in the adoption of health advice in the community (Benmarhnia et al., 2021; Hancock, 2017). EHOs will have an ever-increasing need for high-quality information about risks, that includes relevant contextual information, to make evidence-informed decisions (Howze et al., 2004). However, no amount of information is helpful if practitioners do not perceive that they have the authority to apply that knowledge, or if they lack the time to review it or implement it in their practice. Some effort must be made to improve the structural and organizational barriers that negatively impact EHO evidence use.

By identifying the barriers that EHOs perceive as having the most (and least) impact on evidence use, this study provides insight into the strategies that are necessary to improve RU in EHO practice. By applying these findings to practice, primarily through the design and development of interventions that focus on organizational and structural barriers to RU, information useful to employers, practitioners, and interested bodies like the Public Health Agency of Canada; however, to achieve EIDM, further research is needed to uncover: (i) the types of practice barriers that are present in different organizations and contexts (e.g., federal and provincial); (ii) the underlying factors that drive the barriers to RU in EHO practice; and (iii) the best strategies and interventions for improving RU in EHO practice by addressing the persistent and deep-rooted barriers to RU that have been identified in the Canadian context. A thoughtful evidence-based strategy will increase the

likelihood of an improvement in RU by EHOs in Canada and achieve the mandate to increase evidence-informed environmental health practice in Canada.

2.9 References

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2.10 Appendices

2.10.1 Appendix A: Individual Level Characteristics of Respondents

Individual Level Characteristics	2012 (n=311)	2020 (n=82)
Personal Characteristics		
Male	52% (n=142)	35% (n=28)
Female	48% (n=129)	62.0% (n=49)
Other gender	1% (n=3)	0% (n=0)
Aboriginal	2% (n=4)	1% (n=1)
Visible Minority	14% (n=37)	19% (n=15)
Caucasian	85% (n=217)	80% (n=62)
Self-Identified Disability	2% (5)	1% (n=1)
Median Age	42 years (n=255)	44 years (n=74)
Minimum Age	25 years	27 years
Maximum Age	70 Years	75 Years
Educational Attainment		
Bachelor's degree	67% (n=183)	73% (n=57)
Graduate degree	17% (n=47)	23% (n=18)
Other (e.g., College Diploma)	15% (n=40)	4% (n=3)
Undertaking formal study (full or part-time)	10% (n=28)	1% (n=1)

CIPHI Membership Status		
Hold membership	78% (n=211)	78% (n=62)
Employment Status		
Full-time (35 hours or more per week)	97% (n=266)	90% (n=71)
Other Employment (e.g., part-time, consulting, etc.)	1% (n=2)	5% (n=4)
Not employed	1% (n=2)	5% (n=4)

2.10.2 Appendix B: Team Level Characteristics of Respondents

Team Level Characteristics	2012 (n=311)	2020 (n=82)
Types of Positions		
EHO (front-line prevention and promotion)	67% (n=182)	60% (n=48)
Consulting	2% (n=5)	6% (n=5)
Policy and Program Analysis	3% (n=7)	5% (n=4)
Environmental Health Education	1% (n=3)	5% (n=4)
Management	21% (n=58)	14% (n=11)
Other (e.g., surveillance, product safety, etc.)	7% (n=18)	9% (n=7)
Direct Supervision		
EHO supervisor in place	78% (n=210)	80% (n=16)
Team Size		
Median average number of people on a team	10 (n=232)	10 (n=69)
Minimum number of people	1	1
Maximum number of people	65	70
Interprofessional Collaboration		
Frequently or always collaborate with others	34% (n=92)	36% (n=28)
Occasionally collaborate with others	37% (n=100)	33% (n=26)
Rarely or never collaborate with others	29% (n=80)	31% (n=24)

2.10.3 Appendix C: Organization Level Characteristics of Respondents

Organizational Characteristics	2012 (n=311)	2020 (n=82)
Work Environment		
Local government (e.g., health unit)	72% (n=198)	60% (n=48)
Provincial government	16% (n=44)	26% (n=21)
Federal government	7% (n=19)	2% (n=3)
Other (e.g., healthcare setting, consulting, etc.)	4% (n=10)	10% (n=8)
Primary Service Population		
Urban rural mix (approx. 50% urban: 50% rural)	54% (n=143)	47% (n=36)
Mostly urban	26% (n=69)	25% (n=19)
Mostly rural	14% (n=38)	13% (n=10)
Mostly remote	2% (n=6)	5% (n=4)
Other (e.g., international, far north, etc.)	3% (n=8)	10% (n=8)
Completed CIPHI professional development hours	70% (n=188)	73% (n=58)

2.10.4 Appendix D: Geographical Characteristics of Respondents

System Level Characteristics	2012 (n=311)	2020 (n=82)
Province of Territory of Work		
Alberta	16% (n=43)	21% (n=16)
British Columbia	16% (n=44)	15% (n=12)
Manitoba	6% (n=16)	9% (n=7)
New Brunswick	3% (n=8)	3% (n=2)
Newfoundland and Labrador	1% (n=3)	1% (n=1)
Nova Scotia	1% (n=3)	4% (n=3)
Ontario	51% (n=138)	35% (n=27)
Prince Edward Island	1% (n=2)	0
Quebec	0	0
Saskatchewan	4% (n=10)	9% (n=7)
Northwest Territories	<1% (n=1)	1% (n=1)
Nunavut	<1% (n=1)	0
Yukon	<1% (n=1)	0
Other (e.g., Working outside of Ontario, retired, etc.)	1% (n=2)	3% (n=2)

2.10.5 Appendix E: Regular CIPHI Memberships by Province

Province	2012 (n=311)	2020 (n=82)	Change
Regular CIPHI Membership Numbers			
Alberta, Northwest Territories and Nunavut	279	314	↑ 12.5%
British Columbia and Yukon	156	154	↓ 1.3%
Saskatchewan	93	97	↑ 4.3%
Manitoba	60	55	↓ 8.5%
Ontario	553	462	↓ 16.5%
New Brunswick and Quebec	55	33	↓ 40.0%
Nova Scotia and Prince Edward Island	59	62	↑ 5.1%
Newfoundland and Labrador	22	16	↓ 28.3%
Total	1277	1193	↓ 6.6%

2.10.6 Appendix F: Table Ranking of the 2012 BARRIERS Scale Results (N=311)

Rank	Item No.	Item	N (311)	Mean	Standard Error	Rated as Moderate or Great % (n)	No Opinion % (n)	No Response % (n)
1	13	The Environmental Health Officer does not feel she/he has enough authority to change environmental health practices, policies and/or procedures.	267	3.43	0.05	83.5 (223)	1.3 (4)	12.9 (40)
2	7	The Environmental Health Officer does not have time to read research.	267	3.29	0.05	81.3 (217)	1.9 (6)	12.2 (38)
3	29	There is insufficient time on the job to implement new ideas.	265	3.20	0.05	77.0 (204)	2.3 (7)	12.5 (39)
4	12	The relevant literature is not compiled in one place.	243	3.19	0.06	78.2 (190)	8.4 (26)	13.5 (42)
5	6	The work environment is inadequate for implementation.	263	3.11	0.06	74.5 (196)	3.5 (11)	11.9 (37)
6	5	The Environmental Health Officer is unaware of the research.	261	3.08	0.06	73.9 (193)	1.6 (5)	14.5 (45)
7	2	Implications for practice are not made clear.	262	2.97	0.05	71.4 (187)	3.9 (12)	11.9 (37)

Rank	Item No.	Item	N (311)	Mean	Standard Error	Rated as Moderate or Great % (n)	No Opinion % (n)	No Response % (n)
8	1	Research reports/articles are not readily available.	270	2.87	0.05	79.9 (194)	1.3 (4)	11.9 (37)
9	14	The Environmental Health Officer feels results are not generalizable to his/her own setting.	253	2.86	0.06	65.2 (165)	5.5 (17)	13.2 (41)
10	8	The research has not been replicated.	200	2.77	0.07	62.0 (124)	21.9 (68)	13.8 (43)
11	19	Administration will not allow implementation.	240	2.75	0.07	58.3 (140)	10.6 (33)	12.2 (38)
12	4	The research is not relevant to the Environmental Health Officer's practice.	252	2.71	0.06	57.9 (146)	5.5 (17)	13.5 (42)
13	18	The Medical Officer of Health and senior managers within the organization will not cooperate with implementation.	239	2.64	0.07	52.7 (126)	11.3 (35)	11.9 (37)
14	25	Other staff are not supportive of implementation in general.	242	2.61	0.06	53.7 (130)	8.4 (26)	13.8 (43)
15	15	The Environmental Health Officer is isolated from knowledgeable colleagues with whom to discuss the research.	268	2.56	0.07	53.0 (142)	1.3 (4)	12.5 (39)

Rank	Item No.	Item	N (311)	Mean	Standard Error	Rated as Moderate or Great % (n)	No Opinion % (n)	No Response % (n)
16	3	Statistical analyses are not understandable.	261	2.56	0.06	50.0 (131)	3.9 (12)	12.2 (38)
17	28	The Environmental Health Officer does not feel capable of evaluating the quality of the research.	266	2.51	0.06	50.4 (134)	2.3 (7)	12.2 (38)
18	27	The amount of research information is overwhelming.	252	2.48	0.06	47.6 (120)	4.8 (15)	14.1 (44)
19	11	The research has methodological inadequacies.	190	2.39	0.06	39.5 (75)	26.7 (83)	12.2 (38)
20	10	The Environmental Health Officer is uncertain whether to believe the results of the research.	256	2.39	0.06	44.5 (114)	5.1 (16)	12.5 (39)
21	9	The Environmental Health Officer feels the benefits of changing practice will be minimal.	247	2.38	0.06	43.7 (108)	7.4 (23)	13.2 (41)
22	23	The literature reports conflicting results.	206	2.38	0.06	41.3 (85)	20.3 (63)	13.5 (42)
23	24	Research in general is not reported clearly, in that it is not easy to read or understand.	258	2.37	0.06	44.6 (115)	4.2 (13)	12.9 (40)

Rank	Item No.	Item	N (311)	Mean	Standard Error	Rated as Moderate or Great % (n)	No Opinion % (n)	No Response % (n)
24	21	There is not a documented need to change practice.	246	2.36	0.06	43.1 (106)	8.0 (25)	12.9 (40)
25	17	Research reports/articles are not published fast enough.	217	2.28	0.07	40.6 (88)	16.7 (52)	13.5 (42)
26	16	The Environmental Health Officer sees little benefit for self.	260	2.19	0.06	36.2 (94)	3.9 (12)	12.5 (39)
27	22	The conclusions drawn from the research are not justified.	213	2.08	0.05	27.2 (58)	18.0 (56)	13.5 (42)
28	26	The Environmental Health Officer is unwilling to change/try new ideas.	266	1.99	0.05	27.4 (73)	1.9 (6)	12.5 (39)
29	20	The Environmental Health Officer does not see the value of research for practice.	256	1.82	0.06	22.3 (57)	5.5 (17)	12.2 (38)

2.10.7 Appendix G: Table Ranking of the 2020 BARRIERS Scale Results (N=82)

Rank	Item No.	Item	N (82)	Mean	Standard Error	Moderate or Great % (n)	No Opinion % (n)	No Response % (n)
1	13	The Environmental Health Officer does not feel she/he has enough authority to change environmental health practices, policies and/or procedures.	78	3.5	0.09	85.9 (67)	1.2 (1)	4.9 (4)
2	29	There is insufficient time on the job to implement new ideas.	78	3.24	0.11	75.6 (59)	1.2 (1)	3.7 (3)
3	7	The Environmental Health Officer does not have time to read research.	79	3.19	0.11	78.5 (62)	0.0 (0)	3.7 (3)
4	5	The Environmental Health Officer is unaware of the research.	79	3.18	0.10	77.2 (61)	0.0 (0)	3.7 (3)
5	6	The work environment is inadequate for implementation.	79	3.14	0.10	79.7 (63)	0.0 (0)	3.7 (3)
6	12	The relevant literature is not compiled in one place.	73	3.04	0.10	68.3 (56)	6.1 (5)	4.9 (4)
7	2	Implications for practice are not made clear.	77	2.99	0.09	75.3 (58)	1.2 (1)	4.9 (4)
8	19	Administration will not allow implementation.	72	2.94	0.12	66.7 (48)	8.5 (7)	3.7 (3)

Rank	Item No.	Item	N (82)	Mean	Standard Error	Moderate or Great % (n)	No Opinion % (n)	No Response % (n)
9	1	Research reports/articles are not readily available.	79	2.87	0.11	69.6 (55)	0.0 (0)	3.7 (3)
10	18	The Medical Officer of Health and senior managers within the organization will not cooperate with implementation.	72	2.76	0.12	58.3 (42)	8.5 (7)	3.7 (3)
11	15	The Environmental Health Officer is isolated from knowledgeable colleagues with whom to discuss the research.	78	2.74	0.12	56.4 (44)	1.2 (1)	3.7 (3)
12	4	The research is not relevant to the Environmental Health Officer's practice.	75	2.72	0.11	58.7 (44)	4.9 (4)	3.7 (3)
13	14	The Environmental Health Officer feels results are not generalizable to his/her own setting.	75	2.72	0.09	60.0 (45)	4.9 (4)	3.7 (3)
14	28	The Environmental Health Officer does not feel capable of evaluating the quality of the research.	77	2.61	0.11	57.1 (44)	2.4 (2)	3.7 (3)
15	25	Other staff are not supportive of implementation in general.	69	2.61	0.11	55.1 (38)	11.0 (9)	4.9 (4)
16	8	The research has not been replicated.	57	2.58	0.11	52.6 (30)	25.6 (21)	4.9 (4)

Rank	Item No.	Item	N (82)	Mean	Standard Error	Moderate or Great % (n)	No Opinion % (n)	No Response % (n)
17	27	The amount of research information is overwhelming.	75	2.51	0.12	49.3 (37)	1.2 (1)	7.3 (6)
18	3	Statistical analyses are not understandable.	74	2.49	0.11	48.6 (36)	6.1 (5)	3.7 (3)
19	21	There is not a documented need to change practice.	71	2.32	0.12	35.2 (25)	8.5 (7)	4.9 (4)
20	24	Research in general is not reported clearly, in that it is not easy to read or understand.	74	2.27	0.10	37.8 (28)	4.9 (4)	4.9 (4)
21	9	The Environmental Health Officer feels the benefits of changing practice will be minimal.	72	2.24	0.11	37.5 (27)	8.5 (7)	3.7 (3)
22	10	The Environmental Health Officer is uncertain whether to believe the results of the research.	75	2.2	0.10	33.3 (25)	4.9 (4)	3.7 (3)
23	11	The research has methodological inadequacies.	55	2.18	0.11	30.9 (17)	29.3 (24)	3.7 (3)
24	17	Research reports/articles are not published fast enough.	66	2.14	0.11	33.3 (22)	15.9 (13)	3.7 (3)
25	23	The literature reports conflicting results.	61	2.11	0.10	36.1 (22)	22.0 (18)	3.7 (3)

Rank	Item No.	Item	N (82)	Mean	Standard Error	Moderate or Great % (n)	No Opinion % (n)	No Response % (n)
26	16	The Environmental Health Officer sees little benefit for self.	73	2.04	0.11	31.5 (23)	7.3 (6)	3.7 (3)
27	26	The Environmental Health Officer is unwilling to change/try new ideas.	76	1.88	0.10	21.1 (16)	3.7 (3)	3.7 (3)
28	22	The conclusions drawn from the research are not justified.	64	1.59	0.10	25.0 (16)	17.1 (14)	4.9 (4)
29	20	The Environmental Health Officer does not see the value of research for practice.	74	1.59	0.09	12.2 (9)	6.1 (5)	3.7 (3)

Chapter 3

3 The Dimensional Structure of the BARRIERS Influencing EHO Evidence Informed Practice Decisions²

3.1 Abstract

Purpose: To investigate the dimensional structure of the responses of environmental health officers (EHOs) to the Barriers to Research Utilization Scale (BARRIERS Scale) in 2012 (n=311) and 2020 (n=82) in order to explain the factors influencing research utilization by EHOs in Canada.

Method: The cross-sectional data set used for this analysis were collected online. Principal Component Analysis (PCA) was used to reduce the number of observed variables from the EHO responses to the BARRIERS Scale in 2012 into a simple and actionable set of variables useful for understanding the barriers experienced by EHOs in their practice. The items in the components were analyzed for thematic fit with the Active Implementation Frameworks (AIFs). Confirmatory Factor Analysis (CFA) was then used to determine goodness of fit of the data collected in 2020 with the new Model based on the results of the PCA produced from the 2012 EHO responses.

Results: A four (4) factor PCA solution explained 52% of the loading variation in the 2012 Model. Sampling was determined to be adequate, and correlations were not found to form an identity matrix. The four components were labelled as follows: Competency Drivers, Useful Innovations, Leadership Drivers, and Organization Drivers based on the AIFs. All components had a Cronbach's Alpha greater than 0.7, which demonstrates an acceptable level of internal consistency. To complete the CFA, structural equation

² A version of this chapter has been accepted for publication as follows: Shawna Bourne, Anita Kothari, Nadine Wathen, and Jessica Polzer. (in press). The dimensional structure of the barriers to research utilization experienced by environmental health officers in Canada. Environmental Health Review. <https://pubs.ciphi.ca/loi/ehr>.

models were tested for goodness of fit using the Chi-Square Test of Model Fit, the Root Mean Square Error of Approximation, the Comparative Fit Index, and the Tucker-Lewis Fit Index against the data. The results showed that the new model provide a statistically sound but imperfect fit; however, the new model based on the 2012 EHO responses provided a significantly better fit than the one arising from the data created from nursing data when the model was developed.

Discussion: The four components identified provide a useful way of thinking about and approaching the development of interventions that could improve the uptake of research and innovation in EHO practice; however, there are gaps in the model specifically in the area of systems and processes, when analyzed against the AIFs. The CFA demonstrates that the new model, though not a perfect fit, provides a valuable way of thinking about the barriers that EHOs face in their practice. More research is needed to understand what missing information would improve our ability to understand and mitigate the barriers that EHOs face in applying research in their practice.

3.2 Introduction

Evidence-informed environmental health practice is an important aspect of public health policy and program delivery, and quality research is the basis for evidence informed practice. Environmental Health Officers (EHOs) are a vital part of the public health system in Canada and practitioners use evidence in the design and development of interventions for the purposes of health promotion and disease prevention in the areas of air quality, food and water safety, and communicable disease management (Barratt et al., 2013; Howze et al., 2004; Resnick et al., 2009; Valentine-Maher et al., 2018). The use of good quality evidence is particularly important in emergencies where decisions must be made quickly to mitigate risk for communities, for example, during the Covid-19 Pandemic (National Collaborating Centre on Environmental Health, 2020; Rodrigues et al., 2021).

Although it is well accepted that the application of research evidence in practice is the cornerstone of an effective public service, limited time and resources have been devoted to uncovering how evidence is applied and how to increase evidence uptake to address modern health issues (Bourne & Rihal, 2019; Chociolko et al., 2010; Hess et al., 2014; Lake, 2017; Sarigiannis & Hansen, 2012). However, the commitment of the Canadian government to support evidence-informed decision-making in public health was reaffirmed through its allocation of funds to the six National Collaborating Centres for Public Health through to 2028, one of which focuses on environmental health (Husson et al., 2021). Federal funding has been allocated to support environmental health practitioners and policy makers in the synthesis, translation, and exchange of knowledge to promote evidence informed decision-making in the field (National Collaborating Centre for Environmental Health, 2020). Despite these commitments, how to best achieve the goal of supporting EHOs in the application of evidence in their environmental health practice is still unknown (Brownson et al., 1999; Fielding, 1999; Salter et al., 2017). This study is designed to provide new evidence to identify areas of greatest importance to drive environmental health practice towards evidence-informed, innovative, and adaptive population health approaches in an evidence informed manner.

The importance of evidence-informed decision-making, or the use of the best evidence to inform practice decisions in environmental health, is clear when one considers the fact that the environment touches every person in every aspect of their daily life (Bourne & Rihal, 2019; Butterfield, 2017; Woolf et al., 2015). Conditions of the environment can have broad negative or positive impacts on human health and wellness if conditions are poor or excellent, respectively. Furthermore, the negative effects of environmental conditions on health can be acute or chronic, and can lead to increased incidence of morbidity and mortality (Antai & Moradi, 2010; Hajat, 2017; Jen et al., 2009).

Since environmental health risks account for a quarter of the global disease burden and are at the root of many of the “wicked problems” we face in Canada (and across the world) (Dhesi & Stewart, 2015; Howze et al., 2004; Kreuter et al., 2004; World Health Organization, 2010), it is of utmost importance that more time and resources are dedicated to exploring how to better support evidence-informed practice in environmental health to maximize outcomes, while recognizing that resources are limited (Glied & Teutsch, 2016). The application of evidence in environmental health becomes even more difficult because it is truly delivered at the population level, making interventions more complex, both politically and socially (Dhesi & Stewart, 2015; Hess et al., 2014). More effort is needed to understand the state of knowledge uptake in environmental health and dedicated research is required to find better ways of supporting the application of evidence in the day-to-day and emergency practice of EHOs.

3.2.1 The Barriers to Research Utilization Scale and the Active Implementation Frameworks

EHO practice behaviours, particularly as they relate to the use of knowledge for decision-making, are under-researched in Canada (Resnick et al., 2009; Stanbury et al., 2012; Whiley et al., 2019). In Canada, research into the use of evidence in EHO practice is nascent. A recent study focusing on the knowledge translation practices of EHOs in Canada found that the application of evidence is highly contingent on time and the availability of relevant information in their work, although EHOs reported high levels of evidence use in practice (Tang et al., 2015). A study to identify the barriers to research

utilization (RU) perceived by EHOs in their practice, that used the Barriers to Research Utilization (BARRIERS) Scale, found that the three top barriers to RU included having sufficient: (i) authority to implement research; (ii) time to implement research findings; and (iii) time to read research (Bourne, Kothari, Wathen, et al., 2022b). Data in the study were collected at two points in time, first in 2012 (311 respondents) and once again in 2020 (82 respondents) during the Covid-19 Pandemic. The study also found that despite the difference in work conditions at the two points of data collection, the barriers to RU remained consistent.

Although knowing the top three barriers to RU is a useful approach for pinpointing simple targets for designing tailored interventions, understanding the data in its totality can provide a more holistic way of designing comprehensive interventions and developing a more complete understanding of the barriers faced by EHOs. By developing a simpler interpretation of the complete, more complex data set, users of the research are able to consider the entirety of the data and its meaning, without being subjected to an overwhelming amount of detail. This approach to understanding complex data is achieved by using dimensionality reduction techniques (Jolliffe & Cadima, 2016). The dimensions that are uncovered provide a new way of looking at data that has a large number of variables and its associated patterns, without ignoring useful detail that can aid decision-making (Martinez et al., 2017). Thus, dimensionality reduction allows research users to focus their attention on the most relevant, bundles of information from the data to gain a deeper understanding of ways to improve RU in EHO practice.

Dimensionality reduction takes a large amount of data, identifies, and then organizes it based on the complex linear relationships that exist between observed variables. The technique then explains those relationships through interpretations that are meaningful for a target population within a particular context or condition (Finch, 2013). In summary, the statistical methods employed make the unseen dimensions apparent to the users of the research through statistical approaches (Alavi et al., 2020a; Finch, 2013; Williams et al., 2010). Dimensionality reduction is also frequently used in public health when identifying interventions for complex problems that involve multiple variables and to develop useful models to understand big data (Franke et al., 2016; Gao & Wang, 2022; Pfeiffer et al.,

2012). In this study, dimensionality reduction is applied to broaden our current understanding of the barriers to RU experienced by EHOs and to develop a simpler and more useful way of targeting and improving evidence-informed practice behaviours in the study population. Understanding the dimensionality within the data allows the research subject, in this case the barriers to RU, to be addressed at a higher conceptual level (Tabachnick & Fidell, 2019).

The items in the BARRIERS Scale were developed based on Rogers' Diffusion of Innovations Theory and other research related to evidence-informed practice in healthcare (Funk et al., 1991). The four Elements of Diffusion (Rogers, 2003) were used to interpret the four original principal components identified when the BARRIERS Scale was developed; the components were labeled based on the characteristics of the innovation, communication channels, time, and social systems; however, over the last three decades, advances have been made in the field of implementation science, including distilling earlier knowledge from multiple fields into more comprehensive theories, models, and frameworks (Nilsen, 2015). During that period, the National Implementation Research Network conducted a systemic review that informed the development of a new set of frameworks, the Active Implementation Frameworks (AIFs) (Fixsen et al., 2009). The research team identified the conditions that are most likely to produce intended implementation outcomes when evidence is applied in a particular context, given local conditions. In particular, when the goal is to improve the quality and effectiveness of practice in healthcare and education, the AIFs can be used to focus on conditions that improve the implementation processes and systems that set the context of implementation (Fixsen & Blase, 2020).

AIFs are described by the authors as a mid-range theory, made up of six guiding frameworks, that can be used to predict the outcomes of implementation efforts (Fixsen et al., 2018):

- **The Usable Innovations Framework** which focuses on the need to have well-defined, accessible, and practical innovations that are highly correlated to outcomes, in order to support implementation.

- **The Implementation Stages Framework** which focuses on the iterative steps required to achieve full implementation of an innovation.
- **The Implementation Drivers Framework** which focuses on the conditions that support behaviour change and drive innovation and adoption.
- **The Implementation Teams Framework** which recognizes the importance of practitioners who initiate and manage both organizational and system change as a speciality. These teams are experts in strategic and practical implementation and are key to identifying usable innovations and delivering successful implementations.
- **The Improvement Cycles Framework** which focuses on the continuous improvement cycles necessary for sustainment and the embeddedness of an innovation in an organization or system.
- **The Systemic Change Framework** which considers the systemic supports needed to transition from the status quo to the new normal.

The AIFs emphasize the conditions that promote and stabilize evidence informed practice within a system and the system's capacity to change (Fixsen & Blase, 2020). It is a useful, well-researched tool to support the analysis proposed in this study. The AIFs have been applied as a deductive analytical model to interpret the EHO responses to the BARRIERS Scale when dimension reduction techniques were applied in this study. To complete this analysis, the EHO responses to the Scale in 2012 were analyzed to create a new dimensional model. The new dimensional model and the original dimensional model developed by Funk et al. (1991) were then evaluated for goodness of fit against the EHO responses to the items in the BARRIERS Scale collected in 2020.

3.2.2 Dimensionality Reduction Techniques and Goodness of Fit Tests

Dimensionality reduction methods are intended to explore or establish correlational structures, or instrument constructs, amongst observed random variables, including the

data obtained from surveying a population (Finch, 2013). These techniques are grounded in the premise that measured variables can be correlated and that their correlations can be bundled in a way that represents a smaller set of defined features, most commonly known as factors or principal components (Tabachnick & Fidell, 2019). Those features represent an underlying structure that is more concise and simpler to interpret than the many survey items included in the survey instrument (Finch, 2013; Tabachnick & Fidell, 2019). These can be summarized as new interpretations that are both objective and subjective.

Objective because the statistical bundles are based on regressed correlations between the variables, and subjective due to the way in which meaning is interpreted from the data (Tabachnick & Fidell, 2019). There are two main types of dimension reduction techniques used to interpret data: Exploratory Factor Analysis (EFA) and Principal Component Analysis (PCA).

EFA is used in quantitative research to reduce a large set of variables into smaller sets, based on correlated consistencies in the data (Finch, 2013; Kieffer, 1999; Tabachnick & Fidell, 2019). PCA is used to reduce the data using techniques to capture maximum variation between the variables in the study (Alavi et al., 2020a). Though similar, PCA and EFA provide different statistical value to the researcher. PCA is used to identify formative structures where the components do not influence the cause indicators. EFA is used to identify reflective structures that explain an effect (Alavi et al., 2020a). In this study, the BARRIERS to RU are formative and accordingly, PCA is the dimensionality reduction method used to interpret the variation and relative importance of the observed variance in the observed outcomes (Finch, 2013; Tabachnick & Fidell, 2019).

Confirmatory Factor Analysis (CFA) is another statistical technique applied in this study. CFA is used to assess the alignment of items to an *a priori* theoretical expectation, for example the data extrapolated through dimensionality reduction techniques like EFA or PCA (Alavi et al., 2020b; Bandalos & Finney, 2018). In CFA, a rotation method is used to assess “goodness of fit” of the observed variables against a set of theoretical assumptions (Kieffer, 1999). CFA requires that a conceptual structure already exists and the variables, in this case the survey items, are mapped against that structure to determine whether the model aligns with expectations, using structural equation modeling. The goal

of CFA is to determine whether the proposed structure is a statistically “good fit” with the proposed model (Kieffer, 1999; Tabachnick & Fidell, 2019). If the factor coefficients fit, the model is said to be supported by the data (Bandalos & Finney, 2018; Tabachnick & Fidell, 2019).

3.2.3 The BARRIERS Scale Dimensionality and Goodness of Fit

Since its inception, the BARRIERS Scale has been used successfully in multiple studies to understand the barriers to RU experienced in the health care sector; these studies have been further analyzed in several systematic reviews (Athanasakis, 2013; Carlson & Plonczynski, 2008; Kajermo et al., 2010; Lau et al., 2015; Middlebrooks et al., 2016; Tuppal et al., 2019; B. Williams, Perillo, et al., 2015). The 29 closed-ended items in the BARRIERS Scale were first developed and tested in 1991 with a large group of nurses practicing in health care facilities across the United States. Using PCA, four factors were identified in the original study (Funk et al., 1991). Subsequent studies have been conducted using the BARRIERS Scale with different practitioners who work in multiple locations and professional contexts. In some cases, these studies demonstrated different dimensionalities as compared to the original BARRIERS Scale.

Fifteen relevant studies were identified where dimensionality reduction techniques, CFA, or both were used to assess of the BARRIERS Scale in a new context (a summary of the methods used and their unique characteristics, along with those of the original study, can be found in Appendix A). Dimensionality reduction techniques or CFA were applied in these specific studies, due to a number of reasons including: the translation of the BARRIERS Scale into to a new language (Ferreira et al., 2017; Song et al., 2016; Temel et al., 2010); use of the Scale with a new practitioner group, (Patel, 2010; Williams, Perillo, et al., 2015); or application of the Scale in a new context or setting with different work contexts and cultural norms (Closs & Bryar, 2001; Dunn et al., 1997; Hutchinson & Johnston, 2004; Kirshbaum et al., 2004; Marsh et al., 2001; Mehrdad et al., 2008; Retsas, 2000; Retsas & Nolan, 1999; Williams, Brown, et al., 2015). Two of these studies reported the use of factor analysis but no further information on the method or approach was provided (Shaffer, 1994; Sommer, 2003). The sensitivity in these dimensionality

reduction results, along with the difference in the item rankings and subscale scores, demonstrate that the BARRIERS Scale is capable of distinguishing between different organizational settings and populations of study (Marsh et al., 2001), supporting the objective of this study.

In 2012, the BARRIERS Scale was introduced to a new group of public health professionals, EHOs, who work in a different setting from that of the nurses who participated in the original study. In addition, this study took place in a different healthcare context, public health in Canada, rather than in clinical healthcare settings within the United States. These two unique characteristics provide the rationale for applying dimensionality reduction techniques in this study in order to gain a broader understanding of the specific dimensionality of the responses of EHOs to the BARRIERS Scale.

To understand the dimensional structure of the data collected as a part of this study, PCA was used to investigate the 2012 responses of EHOs to the BARRIERS Scale. The new 2012 EHO Model and the “Original Model” developed by Funk et al. (1991) were both compared against the 2020 responses. CFA is used as a method in this study to confirm fit of the new model and by virtue the BARRIERS Scale to assess the complex barriers impacting the evidence informed decision-making practices of EHOs in Canada in future studies. These results were then analyzed using the frameworks that make up the AIFs. This analysis provided a set of opportunities to target efforts to improve RU amongst EHOs and to identify gaps in the data that have been collected.

3.3 Methods

The data gathered from EHO participants across Canada in 2012 were analyzed using PCA in IBM SPSS v.27 for the purpose of dimensionality reduction. Two structural equation models were developed and analyzed in this study using Stata v.17. The first model was developed using the results of the PCA conducted as part of the original study reported by Funk et al. (1991) when the BARRIERS Scale was developed; this model was described as the “Original Model” in this study. The results of the PCA described in

this study was based on the EHO responses to the Scale in 2012, and it was also used to create a new model, henceforth called the “2012 EHO Model”. These two models were evaluated against four goodness of fit measures using the EHO responses to the BARRIERS Scale in 2020 (82 respondents) to determine which model provided the better fit with the 2020 item responses. Non-responses and no-opinion responses were treated as missing data in 2012 as per the methodology used in the original study (Funk et al., 1991). However, due to the low response rate in 2020, to complete the CFA, responses that included missing values were included in the goodness of fit analysis.

This research and its associated methods and tools were reviewed and approved by Western University’s Research Ethics Board (NMREB# 102798 and REB# 115466). Consultation services on statistical methods, analysis, and interpretation were provided by the Western Data Science Solutions services which are offered through the Department of Statistical and Actuarial Sciences at Western.

3.3.1 Principal Component Analysis

The data collected from 311 respondents in 2012 were analyzed using PCA with varimax (orthogonal) rotation in SPSS. This form of dimensionality reduction was selected because it reduces the number of variables associated with the item responses while retaining the greatest amount of information in the data in order to develop a formative or explanatory structure based on the item responses (Finch, 2013). The PCA model is not used to understand latent causation, but rather to identify patterns that can be interpreted to explain all the observed variance (Alavi et al., 2020a).

The following steps were taken to analyze the SPSS PCA output. First, the data were analyzed to determine whether PCA was an appropriate method to be used with the 2012 dataset. Two tests were used: (i) the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) to determine if the sample was large enough to identify correlations amongst the data, and (ii) the Bartlett’s Test of Sphericity (BTS) to confirm if there were statistically significant relationships between the variables and to determine their suitability for dimensionality reduction. The acceptable criterion for the KMO is 0.6 and the BTS must demonstrate a statistically significant p value of ≤ 0.05 .

Next the number of correlations were assessed through the development of a rotated correlation matrix and the analysis of the uncorrelated Eigenvalues and Eigenvectors (Finch, 2013) which was available as an output of SPSS. The Eigenvalues were assessed to determine the adequate number of components to retain based on the total variance explained (Nguyen & Holmes, 2019). A Scree Plot was used to visually identify the number of components to retain in order to maximize the explanatory capacity of the principal components identified. The cumulative percentage of variance explained was also analyzed. The interpretability of the resulting components is a critical decision point. As per Finch (2013), a good PCA makes sense whereas a bad PCA does not. The component names were based on an interpretation of the combination of observed variables of which the component was comprised (Finch, 2013; Humble, 2020); to provide additional rigour, the AIFs were used to guide the deductive analysis.

Once the resultant components were deemed to provide an acceptable level of interpretability of the overall data, each component was analyzed to determine its estimate of internal consistency by using the Cronbach's Alpha. This criterion was used to determine the reliability of the component by assessing the internal consistency among the items in each component (Tavakol & Dennick, 2011). Each item in the component is then assessed to determine if the overall internal consistency is changed through its elimination, in other words, to assess the extent to which altering the subsets of test items through an elimination process would result in similar results (Finch, 2013; Humble, 2020; Taber, 2018). Satisfactory internal consistency for the component is demonstrated by a Cronbach's Alpha of between 0.7 and 0.9 (Tavakol & Dennick, 2011). Also assessed was the grand mean of each component to determine its level of importance as a barrier to RU in relation to the other components identified in the study.

3.3.2 Confirmatory Factor Analysis

To complete the CFA for this study, two structural equation models were created to represent, estimate, and test the linear relationships between the variables using the 29-closed-ended items in the BARRIERS Scale. When developed, the original BARRIERS Scale applied PCA to assess the responses of the American nurses to the items in the

Scale and 28-items of the 29-item responses successfully mapped to the four factors identified in that study (Funk et al., 1991). Based on consultation and feedback from the research participants, the developers included Item #27 (The amount of research information is overwhelming) in what became the 29 closed-ended items of the BARRIERS Scale; however, item #27 did not map to the Original PCA Model. For the purposes of the CFA, the structural equation model based on the original model of the Scale was developed using only the 28-items that successfully mapped to the model developed in the original study. The 2012 EHO structural equation model was mapped using the PCA results from this study. The new 2012 EHO Model used all 29-items in the BARRIERS Scale to reflect the results of the PCA. CFA is a method used to test the structural models identified through dimension reduction, as it is used in this study (Bandalos & Finney, 2018).

To complete the CFA, the original model and the 2012 EHO model, were tested for goodness of fit with the 2020 data. The fit statistics were generated in Stata using maximum likelihood estimation (Kieffer, 1999). The models were based on the *a priori* expectations of the model where fixed parameters, or the principal components identified in the Original Model and in the 2012 EHO Model, as analyzed against the 2020 responses to determine their associated error values (Bandalos & Finney, 2018; Hu & Bentler, 1999). The CFA process generates multiple statistics to test the best relationships between the free and fixed parameters or “goodness of fit”. These data were used to accept or reject the models and identify the best simplified model that provided the most comprehensive explanation of the barriers to RU experienced by EHOs in Canada.

It is recommended that a combination of relative fit indices are used to determine if one model is a better fit than another and that no better alternatives are available (Hu & Bentler, 1999; Kieffer, 1999). For the purposes of estimating model fit, the following Goodness of Fit Indices were used: the Normed Chi-Square Goodness of Fit Test (χ^2/df), the Root Mean Square Error of Approximation (RMSEA), the Comparative Fit Index (CFI), and the Tucker-Lewis Index (TLI). The acceptable criterion for each index was: $\chi^2/df \leq 3.0$; $RMSEA \leq 0.08$; $CFI \geq 0.90$; and $TLI \geq 0.90$ (Hu & Bentler, 1998, 1999).

3.4 Results

3.4.1 Principal Component Analysis: 2012 Data

The KMO was found to be 0.848 when it was run on the data collected in 2012 ($n=311$), which showed that the sample was large enough to support PCA. The KMO was found to be larger than 0.8, providing confidence that the correlations between variables were adequate for analysis.

Eigenvalues were calculated in SPSS to determine if a four-component matrix would account for a substantial percentage of variance in the results (Finch, 2013; Tabachnick & Fidell, 2019; B. Williams et al., 2010). It was found that the model demonstrated 52% of the explained variance after four rotations with little increase in explanatory capacity with the addition of more components (see Appendix B: Total Variance 2012 Data Explained). Bartlett's Test of Sphericity (BTS) was also calculated, and it was determined that the 2012 EHO model is not an identity matrix ($p = 0.001$) and correlations exist between the eigenvalues. Eigenvalues were then loaded on a Scree Plot and the 2012 data showed a marked decrease in slope on the graph between component three and seven of the Scree Plot (see Appendix C: Scree Plot representing the 2012 Eigenvalues), signalling weaker associations and less meaningful explanatory capability in components seven and beyond (Finch, 2013; Tabachnick & Fidell, 2019; B. Williams et al., 2010). Components that include five or more strongly loading items are considered to be desirable and indicate a solid component for analysis (Costello & Osborne, 2005). The study results met this criterion with a four-component solution that was determined to have the best statistical strength and potential for meaningful explanatory value.

3.4.2 Four Principal Components Identified

The four extracted components were analyzed to determine the Cronbach's Alpha and to assess the items associated with each loaded component. The items associated with the components were interpreted using the Active Implementation Frameworks as a guiding mid-range theory (Fixsen & Blase, 2020). As previously described, there are six frameworks associated with the AIFs. The components identified in the PCA clustered

around two of these: (i) The Usable Innovations Framework which addresses the conditions of the innovation that make it acceptable for implementation, and (ii) the Implementation Drivers Framework which is further broken down into three sub-categories that make up the framework: Competency Drivers, Organization Drivers, and Leadership Drivers. These sub-categories work together in an integrated way to offset constraints and promote and support the use of evidence-informed innovation in a directed manner (Fixsen et al., 2018; Fixsen & Blase, 2020). These components represent two of the six AIFs that make up the mid-range theory.

The following provides a summary of the four principal components identified in this study, the number of items that loaded to each component, the grand mean for each component, the component name that was assigned, and the associated rationale (see appendices E through H for a chart summarizing this information).

Component One includes 11 items and has a Cronbach's Alpha of 0.84. Analysis shows that deleting any of the items that load to this component would decrease the overall reliability of the component. The items in this component deal with the attitude of the EHO towards innovations and their perceptions of the usefulness and relative advantage of the evidence in context (Rogers, 2003). The competency of the EHO to put innovations into practice is the focus of this component. The items found under this component deal with the EHO's confidence and competency in evaluating and applying the innovation in their own setting. Barriers include an inability to understand the research, being overwhelmed by the amount of information, and describing research as hard to read or understand. Also of importance is the EHO's resistance to change and inability to see the value of research for practice. This component includes the idea that the EHO sees little benefit for self as a result of implementing changes to improve practice as a barrier to utilization.

Barriers in this component are driven by individual level characteristics that inhibit proper assessment of innovations and are best addressed by activities focused on developing, improving, and supporting a practitioner's ability to adopt evidence-informed practices. This component was assigned the label **Competency Drivers** as competency

drivers relate to the skillset and attitude of the practitioner. This component has a grand mean of **2.35** and is the least important component affecting RU by EHOs according to the 2012 study data.

Component Two includes seven items and has a Cronbach's Alpha of 0.80. Analysis shows that deleting any of the items that load to this component would decrease the overall reliability of the component. The items in this component deal with the qualities of the innovation that help the practitioner decide the usefulness of the practice or program change. The AIFs define an innovation as something new that deviates from standard practice or more specifically, what is done every day (Fixsen et al., 2018). A successful implementation requires that the core components of the innovation be effectively operationalized, show fidelity with design or intent of the innovation, and become standard practice, to be considered a fully implemented change (Fixsen & Blase, 2020). For full implementation to occur, practitioners must understand the innovation, how to use it, and where it fits within their practice (Fixsen & Blase, 2020). Barriers to implementation associated with this component include items in the BARRIERS Scale that speak to the methodological inadequacy of the research, conflicting results in the literature, lack of evidence that the innovation works, and that the research findings have already been used successfully in EHO practice. Items indicate this barrier exists when there is general uncertainty about the innovation and EHOs are seeking more information to make decisions about implementation. Other items relate to the characteristics of the evidence including its clarity for the purposes of operationalization and application. The qualities of the innovation, and certainty around its usefulness, are the focus of this component. This component is assigned the label **Usable Innovations** and has a grand mean of **2.51**. It is the second least important barrier overall.

Component Three includes five items and has a Cronbach's Alpha of 0.84. Analysis shows that deleting any of the items that load to this component would decrease its overall reliability. This component considers the impact of the leadership climate in supporting the implementation of innovations that improve outcomes (Fixsen & Blase, 2020) and the items in this component deal with support for the innovation within the organization or system where the innovation is being applied. Items found in this

component include the perceived authority of the EHOs to make change, the support that administration, peers, and leadership provide EHOs who are implementing change, and the general leadership influences in the workplace that affect the adoption of changes. This component is assigned the label **Leadership Drivers** and has a grand mean of **2.92**. It is the second most important barrier to RU identified by EHOs.

Component Four includes six items and has a Cronbach's Alpha of 0.70. Analysis shows that deleting any of the items that load to this component would decrease the overall reliability of the factor to an unacceptable level. This component speaks to the supports and infrastructure needed to create an environment that supports implementation (Fixsen & Blase, 2020). The barriers found in this component are comprised of items that are systematic and inhospitable to active implementation. The items in this component deal with the application or process of executing innovations in the work environment (Rogers, 2003). Component four includes BARRIERS Scale items that relate to administrative barriers to implementation including a lack of needed resources, limited access to systems and information, and the use of policies, processes and procedures that are unaligned with supporting a culture of change and the delivery of innovation (Fixsen & Blase, 2020). Items associated with this component include a lack of time to review, time to implement the research, and lack of access to research that could inform practice decisions. Because of these barriers, EHOs experience a lack of awareness of the research and its implications to their practice. This component is assigned the label **Organization Drivers**. This component has a grand mean of **3.04** and this component has the greatest impact on the RU of EHOs.

The four components identified in this study have sufficient internal consistency as evidenced by the fact that the Cronbach's Alpha for each of the four factors was equal to or greater than 0.70, which is considered an acceptable result that shows high internal consistency. Each of the four factors identified in this study are considered highly significant ($p < .001$) using Hotelling's T-Squared Test of Significance.

These four components are explained using concepts from the AIFs (Fixsen et al., 2009; Fixsen & Blase, 2020). The constituent items are used to develop an action-oriented

conceptualization of the principal components. A summary of the component number, name, number of associated items, and grand mean can be found in Table 4. These themes provide a useful framework for understanding the overarching barriers to RU identified in this study and the AIFs provide definition, structure, useful direction to address the barriers, and identify gaps in the completeness of the data collected. These components reflect concepts found in two of the six frameworks in the AIFs (Fixsen et al., 2009; Fixsen & Blase, 2020).

Factor No.	Factor Name	No. of Items	Grand Mean	Standard Deviation
1	Competency Drivers	11	2.35	0.29
2	Usable Innovations	7	2.51	0.33
3	Leadership Drivers	5	2.92	0.33
4	Organization Drivers	6	3.04	0.22

Table 4: Summary of Component Number, Name, Number of Related Items, and Grand Mean of the 2012 EHO Model derived from the PCA.

3.4.3 Confirmatory Factor Analysis: 2020 Data

CFA was used in this study to assess whether the original components developed by Funk et al. (1991) would better fit the EHO responses than the newly hypothesized EHO derived model based on the 2012 data. To complete this assessment, two structural equation models were created: the first according to the principal components identified in the development of the Original BARRIERS Scale based on the original study's findings (Funk et al., 1991). For the purpose of evaluating the model, the unmeasured variables, or the four constructs, were mapped to show their direct relationships to the measured variables associated with each construct in the *a priori* models. The paths demonstrate the regression of the unobserved component on the observed variable. The associated error, e_1 in the model, is associated with the measured variable, shown as V_1 ,

on the path diagram. All of the *a priori* relationships between the observed and unobserved variables in the study are mapped with each of the four components showing the existence of a covariance between each of the individual components. Appendix I shows the structural equation model of the 28-item BARRIERS Scale of the “Original Model” and Appendix J shows the structural equation model based on the “2012 EHO Model” developed from the EHO Specific Responses to the BARRIERS Scale collected in 2012. These two models were tested against the data collected from EHOs in 2020 for Goodness of Fit.

The following four tests were selected to assess relative fit: a Chi-Square Test of Model Fit (χ^2/df) where a result less than 3.0 indicated a satisfactory model fit; the Root Mean Square Error of Approximation (RMSEA) where values below 0.8 indicated a better model fit; the Comparative Fit Index (CFI) where values above 0.90 indicated an increasingly better fit; and the Tucker-Lewis Fit Index (TFI) where values above 0.90, also indicated an increasingly better fit.

3.4.4 Goodness of Fit Findings of the Original Model versus the 2012 Model

EHO responses to the BARRIERS Scale in 2020 were analyzed and assessed against a structural equation model of the original BARRIERS Scale components based on the clinical nurse responses in the United States (Funk et al., 1991). The Chi-Square Test of Model Fit showed a good fit between the 2020 EHO responses and the Original Model ($\chi^2/df=2.81$); however, the RMSEA (0.184), CFI (0.452), and TFI (0.397) showed that the fit was imperfect, with the results being particularly poor and unacceptable.

EHO responses to the BARRIERS Scale in 2020 were then mapped to the new 2012 EHO model based 2012 EHO responses to BARRIERS Scale. The results showed a significantly better Chi-Square Test of Model fit ($\chi^2/df=1.76$), RMSEA (0.098), CFI (0.695), and TFI (0.667) results as compared to the Original Model, showing improved alignment for all measures using the 2012 EHO Model. However, the 2012 EHO Model fit is still imperfect based on the data available; this could be due to the number and types

of items that make up the BARRIERS Scale as well as the small number of respondents to the survey due to the pandemic (see Table 5 Goodness of Fit of 2020 data with Funk's Original PCA Model and the new 2012 Model based on Canadian EHO input).

Model	χ^2/df (≤ 3.0)	RMSEA (≤ 0.8)	CFI (≥ 0.9)	TFI (≥ 0.9)
Original Model	2.181	0.184 (p = 0.001)	0.452	0.397
2012 Model	1.761	0.098 (p = 0.001)	0.695	0.667

Table 5: Goodness of Fit of 2020 Data with Funk's Original PCA Model and the New 2012 Model

3.5 Discussion

The findings from this study build on learnings to date about the top three barriers to RU identified by Canadian EHOs and the persistence of those barriers regardless of work conditions. EHOs identified that a lack of authority to make changes to practice, insufficient time to read research, and a lack of time to implement new ideas were the most important barriers to RU in both 2012 and 2020 (Bourne, Kothari, Wathen, et al., 2022b). The study also found no statistically significant difference in perceived barriers to RU in 2012, a normal year of work for EHOs, as compared to 2020, a year dominated by emergency response due to the Covid-19 pandemic. These findings show that barriers to RU remained stable for EHOs, even though the data was collected at two distinct and different points in time and working conditions, suggesting that the main barriers to RU are particularly embedded and structural, and that targeting interventions to improve RU during periods of calm can provide an effective way to better support EHO practitioners in both normal and emergency conditions.

Recognizing that these barriers have remained stable provides impetus to consider how all the EHO responses to the 29 closed-ended items in the BARRIERS Scale might inform practical and useful ways to increase RU in the complex practice environments in which EHOs work. As previously noted, dimension reduction techniques provide a way to simplify large amounts of data that are contained in a set of observed variables, in this case, all the data collected through the 2012 and 2020 surveys to understand the barriers to RU reported by EHOs in the Canadian context. In this study, PCA provided a parsimonious approach to understanding what the data tells, in its entirety, by retaining the data in fewer components that are easier to digest for practitioners and researchers (Tabachnick & Fidell, 2019). This resulted in a more complete, yet simpler and clearer summary of the data that is more likely to be reflective of the broader context. Combined with the top three barriers, this information has the potential to be more usable and actionable based on what has been learned. By using PCA, constructs were identified that have potential to lead to the development of comprehensive, targeted, and multi-faceted interventions that are applicable to the work context of EHOs and may mitigate the cluster of barriers they report as having the greatest impact on RU. These interventions can be actively used to advance evidence informed practice in environmental health based on the domains of concern identified. The results of the PCA were assessed using the AIFs, which not only describe or explain what is observed, they also provide information to guide specific strategies based on contextual factors that can be used to drive change and support successful implementations (Fixsen & Blase, 2020).

The approach used in this study incorporates learnings specific to the use of the BARRIERS Scale in health research and fortifies these learnings with the advances that have been made in implementation science in the intervening years. This approach also considers the unique work experiences, organizational contexts, and settings of EHOs. Most notably, the use of PCA in this study recognizes that EHOs are community-based public health professionals, operating within a distinct work environment and context, and that EHOs have their own professional culture and practice norms. Thus, EHO practice occurs within a very different system of healthcare policies, funding, access, and outcomes, from the context of the original study. Furthermore, these varied structures add to the complexity of interventions needed to increase RU and argue for a structural

approach to address RU for this professional group, rather than individual-level interventions, such as education and training, which are often adopted as quick solutions to address issues with uptake of research in practice (Ellen et al., 2014). PCA provided insight into the unique patterns of correlations arising from the Canadian EHO professional experience that hide within the rankings of observed variables collected as a part of this study (Alavi et al., 2020a).

3.5.1 The Active Implementation Frameworks and the Four Principal Components

The results of this study have been interpreted by applying the AIFs (Fixsen & Blase, 2020). The components, or clusters of items associated with the barriers to RU are interpreted as follows: (i) **Competency Drivers** or the general attitude and capability of the EHO towards assessing an innovation for application in context; (ii) **Usable Innovations** which are the qualities of the innovation that lend themselves to assessment for practice implementation; (iii) **Leadership Drivers** which influence, codify, and support the adoption of innovations through cultural norms and expectations, and lastly, (iv) **Organization Drivers** which focus on the organization's capacity to accommodate and support new ways of working through supportive administration, including proper resourcing, scheduling, and funding. The AIFs provided a means of approaching the adoption of an innovation as a voluntary choice by actors with the power to affect change at the appropriate levels, not simply as a descriptive endeavour, but with potential solutions in order to drive users towards evidence-informed action. This action-oriented approach also recognizes the structures within which EHO practice occurs. It aligns with behavioural science and focuses on creating the conditions that facilitate organizational and individual behavioural change (Harris et al., 2015; Novak et al., 2019; Spoth et al., 2021). Applying this lens offers a utilization focused, actionable, and practical approach to interpretation (Patton, 1997) and it provides a means to assess and address structural barriers to RU.

3.5.1.1 Competency Drivers

The concept of **Competency Drivers** focuses on the attitude and skillset of the adopter towards the innovation (Fixsen & Blase, 2020). The eleven items contained in this component relate to the EHO's perceptions about research, including perceived clarity, usefulness, and relative advantage in the work context. It also addresses issues of competency in making those assessments. This component recognizes that the practitioner acts as the proximate adopter of the innovation and needs to understand the relative advantage and disadvantage associated with the innovation. The attitude held towards an innovation, and innovations in general, will influence the likelihood (or unlikelihood) of adoption (Curtis et al., 2018). The EHO's attitude will also impact the speed at which the decision to adopt (or reject) an innovation will occur. Thus, competency is contingent on the sentiments of the EHO towards change and their capacity to understand what an innovation is and how it will be used.

Three broad themes influence adoption with respect to Competency Drivers in this component: relative advantage of the innovation in the practitioner's work context, the sentiments of the EHO and the level of influence of other colleagues' attitudes towards innovation or evidence (e.g., resistance to change). The EHO needs to sense that the innovation has relative advantages over other options, including continuing with the *status quo*. EHOs must have positive feelings about the innovation, including that it will benefit the EHO (e.g., time savings) or that there will be a practical benefit in their work (e.g., make work efforts faster or easier or result in better outcomes). This aligns with early ethnographic research into practice behaviours where practitioners were found to shape practice, not only based on the latest evidence, but also through assessments against past experience and the experiences of colleagues and other available data such as best practices, and what is known to work (Gabbay & le May, 2004). EHOs also need to have a sense of their competence to evaluate and apply the innovation. They may need to collaborate within their network about outcomes in other similar contexts to understand, share ideas, and develop solutions with respect to practice problems. Exploring how the research led to an innovation in other settings can sway that decision-making process. Practitioners seek information to help assess contextual differences that may influence

outcomes as a part of a fidelity assessment (Fixsen & Blase, 2020). Communities of practice, or groups of practitioners who share a practice concern, are important to social learning and provide an opportunity for EHOs to collaborate and find solutions to practice problems (Lave & Wenger, 1991). Overall, the EHO must have an interest in or motivation to act based on what is known about the innovation, and that is often derived from the research, their own experience, and the learning that comes from collaboration with colleagues. However, those attitudes and feelings about an innovation are not only intrinsic, but they are also influenced by the culture and context where the innovation is being implemented. Thus, although competencies are individual level drivers, competency drivers also have a cultural aspect, influencing how individuals value or resist change.

The items in the BARRIERS Scale associated with **Competency Drivers** were consistently the lowest scoring items related to barriers to RU selected by EHOs in this study, indicating that, in general, EHOs are confident in their ability to evaluate, manage, and find merit in the research innovations that may influence their practice. It also indicates there is a culture amongst EHOs of valuing RU which was previously noted in a study that sought to identify how EHOs incorporate research in their practice (Tang et al., 2015). Interventions that strengthen Competency Drivers would include actions that support a culture that values innovation through staff selection for competencies that support innovation adoption including in the hiring, promotion, or leadership of staff, as these three human resources tasks influence implementation culture in an organization (Fixsen & Blase, 2020). Selection for desired competencies can help organizations build and maintain a culture that supports innovation at the organization and team level. Competency modeling, or the use of knowledge, skills, abilities, and other characteristics, for hiring and selection, for the purpose of distinguishing proficiency, is a well-established practice in the fields of learning and development, human resources, and personnel psychology (Campion et al., 2011). The importance of training and development to build competencies and individual capacity has been demonstrated in the public health literature (Armstrong et al., 2013; Salter & Kothari, 2016). Beyond selection is the need for ongoing training and coaching to ensure that the right skills and attitudes are being supported by the institution with the goal of promoting skilful

evidence use in implementation processes across organizations. In Canada, EHOs must demonstrate discipline-specific competencies that are part of a framework for initial certification and ongoing professional development and practice hours (Canadian Institute of Public Health Inspectors, 2022b), which may explain why this is the least important barrier to RU in this study.

3.5.1.2 Usable Innovations

The seven items in the BARRIERS Scale associated with this component deal with the qualities of the innovation that facilitates assessment by an EHO, specifically, whether the research innovation can be made useful in the EHO's context (Fixsen & Blase, 2020). The AIFs define an *Innovation* as a deviation from standard practice and stipulates that true adoption of an innovation includes its incorporation into or replacement of a daily practice, not on occasion nor by some practitioners, but consistently and broadly across an organization. Rogers (2003) states that the newness of an innovation presents a certain degree of uncertainty and unpredictability and recognizes that information reduces that uncertainty. RU, in the context of evidence-informed decision-making, relies on an individual, or an organization, having access to review, comprehend, and apply research for appropriate application in the delivery of a program, service, or practice. For this to occur, the adopter of the innovation must be able to assess the usability of an innovation, and any related information, to determine the quality, reliability, and appropriateness for addressing the identified problem in the context of concern (Fixsen & Blase, 2020). Thus, for a practitioner who is competent and open to innovations, willing to apply something new in context, the innovation must be clearly and plainly articulated, and resource implications described. Finally, recommendations on how to apply the innovation, in context, must be included in the findings in plain language. Items in this principal component deal with general uncertainty about the results of the research including methodological inadequacy, conflicting results, and unjustified conclusions.

Mitigating strategies to counteract the barriers associated with the Usable Innovations component include ensuring that environmental health research is clearly written to reduce uncertainty (Fixsen & Blase, 2020). In one study that considered the spread and

diffusion of a novel research method, five innovation attributes were found to increase uptake: (i) a clear description of the foundational principles, (ii) simple comparisons to established approaches, (iii) provision of sample data and instructions, (iv) communication, support, and instructions, and (v) guidance to support application of the innovation (Cadarette et al., 2017). This aligns with Rogers five attributes that influence adoption of an innovation: (i) relative advantage over existing practices, (ii) compatibility with existing needs and practices, (iii) complexity of application, (iv) trialability for the purpose of testing, and (v) observability of the innovation's value for improving outcomes (Rogers, 2003). In other words, to increase RU in practice the methods, limitations, and rationale for approaches must be clearly articulated so relative advantage, complexity, and compatibility can be determined. Usable Innovations are also strengthened when the research focuses on application and includes a practice-based research component. The ability to review the results of tests or pilots of an innovation can increase the EHO's comfort in adopting the innovation in their public health practice and within their contexts and communities. This means that the evidence itself must contain enough information to assist in understanding an innovation's suitability for practice, and the ability to pilot the new approach, ultimately leading to further scale and spread (Harris et al., 2015; Scott et al., 2008). Thus, it can be inferred that by increasing the number of practice-focused studies in the environmental health field, researchers and research funders can increase the adoption of research in environmental health. The use of these proposed interventions require further study to determine their potential for reducing the barriers identified in the Usable Innovations principal component.

3.5.1.3 Leadership Drivers

The third principal component identified in this study is comprised of five items and is titled **Leadership Drivers**. This factor deals with support for the innovation within the social system (Rogers, 2003). In a work context, the system plays a vital role in facilitating or impeding RU due to system norms (Rusly et al., 2012, 2014), which define a range of tolerable behaviors for the members of the social system. Both formal and informal leaders in an organization have considerable influence on the norms that drive the level of receptiveness to change (Fixsen & Blase, 2020). The BARRIERS Scale items

that correlate to Leadership Drivers focus on collective decision-making and the employee's confidence that the organization will support their decision to implement an innovation. This factor links the social systems or networks that connect EHOs as subject matter experts who may have valuable insights to share about an innovation or practice problem, and authority figures in public health such as administrators, Medical Officers of Health, and other colleagues or peers within the public health system. In addition, Rogers (2003) presents the concept of *innovation gatekeeping*, where structures are set in place to control the diffusion and adoption of an innovation by managing the communication and general perception of support for the change. Leaders function as gatekeepers to change and their behaviours, and the consistency of those behaviours, help to create an environment that will facilitate implementation or stall it.

The organizational culture is driven by its leadership and leaders create the cultural conditions for change that facilitate the desired practice behaviours (Fixsen & Blase, 2020). Environmental health leaders in a local health department in California were found to have positively impacted the implementation of a new program by having a vision; cultivating a culture of innovation; supporting, empowering, and protecting staff; engaging in relevant processes; establishing networks; and leveraging their position in order to increase the success of the program implementation (Kuiper et al., 2012). Thus, environmental health leaders can create (or dismantle) avenues for successful implementation. Conversely, leadership barriers are crucial barriers that can make RU or innovation adoption a challenge for practitioners, even when the innovation would provide measurable benefits for practitioners, the organization, and the community being served. Positive and negative expectations about an innovation can be shaped by the communication, support, and relationships that exist between a practitioner and organizational leaders (Aarons et al., 2016). Leadership is critical when thinking about the facilitators and barriers to RU and innovation in the workplace. By providing change and task leadership, and most importantly, by demonstrating a commitment to innovation and RU, leaders set the conditions for change (Gifford et al., 2007).

Leadership Drivers are the second most important barrier to RU identified by EHOs in this study. For active implementation to occur, leaders must invite the use of effective

innovations and implementations so that the organizational norms align with the goals of driving innovation (Fixsen & Blase, 2020). The AIFs identify two leadership characteristics that effectively support innovation: Technical Leadership, which exemplifies good managers and leaders who understand practice problems and can be helpful in the process of problem solving, and Adaptive Leadership, which becomes active in the zone of complexity and uncertainty and is critical to system adaptation and innovation (Fixsen et al., 2009; Fixsen & Blase, 2020). These findings were echoed in a systematic review of the organizational and system level characteristics that influence implementation in allied health professional work environments where it was identified that active and intentional leadership support enable implementation and embed RU as an acceptable and expected practice behaviour (Slade et al., 2018). Applying interventions that normalize innovations and provide leadership support for the exploration and implementation of improvements, has great potential to influence RU. The barriers identified under Leadership Drivers require thoughtful consideration by organizations and teams to ensure supportive leadership driven cultures and norms that facilitate and encourage RU in practice.

3.5.1.4 Organization Drivers

Organization Drivers is the descriptor applied to the final principal component that was extrapolated in this study and it includes concepts related to: decision support data systems, facilitative administration, and systems intervention (Fixsen & Blase, 2020). Decision support data systems include access to information about program outputs, outcomes, and impacts, to ensure that services are delivered as intended and achieving the desired outcomes. These systems help practitioners and funders understand the success of programs and services in achieving their goals. Facilitative administration focuses on operational support that allows ease of implementation and sustainment of change including infrastructure, resourcing, and organizational policies that accommodate the proposed changes. Systems intervention relates to funding, resources, and other supports, such as adequate staffing, which incorporate sufficient time for implementation to occur. Organization Drivers are exemplified in six items in the

BARRIERS Scale that are linked to barriers related to resourcing, access to information about practice, and research that would support change analysis by EHO practitioners.

This component includes two of the top cited barriers to RU, in both 2012 and 2020, insufficient time to read research and insufficient time to implement new ideas, both are linked to resourcing issues. Survey items found in the Organization Drivers component also relate to the availability of relevant information about the innovation, which often comes at an organizational cost. Effective implementation and its sustainment are contingent on access to information about the innovation, assessing its impacts internally through a review of existing programs, and access to the tools and resources that facilitate the exploration of the research (Fixsen & Blase, 2020). Access to research evidence and the ability to evaluate programs services allow EHO practitioners to determine need and to select an appropriate innovation. Adequate time and resources to effectively explore innovations and measure program success is key to facilitating innovation in the EHO workplace.

Mitigating implementation barriers in this domain go beyond providing practitioners with the permission to take the time to review and implement research. Structures must be put in place, including adequate resources, to ensure that implementations can be completed successfully. A recent systematic review of published and gray literature found that organizational hurdles including a lack of resources, financial constraints, inadequate staffing, low organizational readiness for change, rigid hierarchies, and technological inadequacies, are organizational barriers influencing the uptake of innovation in healthcare (Parmar et al., 2022). Funding and resources for implementation, scaling, and sustainment are also common barriers to implementation in the health sector (Gupta et al., 2016). Organizations often do not have established conduits for obtaining information about programs and services for ongoing decision-making (Twose et al., 2008), meaning that ineffective programs and services continue, and the information needed to make change is not available to practitioners who are therefore unable to make the case for change, even when research conflicts with current practice.

Interventions that can influence the barriers found in Organization Drivers include the provision of adequate resources and the establishment of policies, and systems that facilitate RU and innovation implementation (Fixsen et al., 2009). This includes removing administrative barriers to RU and ensuring there is access to necessary resources to perform innovation work including time to review and implement research. Organization Drivers is the most important cluster of barriers to RU and includes the number two of the top three barriers to RU in the EHO context. Employers should make efforts to ensure that EHOs experience the type of organizational conditions that support RU and the application of evidence to practice.

The three Implementation Drivers: Competency Drivers, Organization Drivers, and Leadership Drivers, should occur in tandem to create a supportive environment for implementation (Fixsen & Blase, 2020); however, without a Useful Innovation, implementation strategies to improve outcomes would not be required. As science advances, so does the knowledge base and potential for ongoing improvements, including better outcomes to improve population health and better use of limited resources. With more complex problems facing public health, it is important to leverage the best information to inform practice, and thus, deliver the best outcomes.

3.5.1.5 EHO Active Implementation Frameworks and Goodness of Fit

The two structural equation models developed to test the results of the Original Model and the new 2012 EHO Model were analyzed for goodness of fit against the 2020 survey responses. The results showed that the 2012 EHO Model is a better statistical fit, with the 2020 data. This better fit allows us to infer that the new components identified in this study are both empirically and theoretically more useful for understanding the barriers to RU experienced by EHOs in Canada. However, the 2012 EHO Model is not a perfect fit, indicating a gap in the model. There are two potential reasons for the imperfect results: i) low survey participation rates in 2020, inferred to be caused by pandemic response demands (Sekercioglu et al., 2020), and ii) the items in the BARRIERS Scale may not reflect the full scope of issues now recognized to have an impact on implementation

outcomes as identified in the AIFs (Fixsen & Blase, 2020). As a result, the BARRIERS Scale may not reflect the full range of issues influencing RU in Canada.

To address the issue of low survey participation, one solution is to apply the BARRIERS Scale to future, larger studies with EHOs and applying CFA to determine goodness of fit against the 2012 EHO Model again. However, this is not recommended until an assessment is completed to determine if the true concern is the comprehensiveness of the BARRIERS Scale in relation to the current best evidence and the full range of factors known to impact evidence-informed practice in the EHO context. It is proposed that a more comprehensive tool that collects a broader swath of data might provide a more insights into the barriers to RU in EHOs, and thus providing a better model, and greater goodness of fit.

To address this gap, additional research is needed to understand how the other AIFs impact on RU in EHO practice including the (i) the processes involved in implementation, found in the frameworks describing Implementation Stages and Improvement Cycles, and (ii) the establishment of new structures that support innovation that are found in the frameworks that focus on the use of Implementation Teams and Systemic Change (Fixsen et al., 2009). It is anticipated that as implementation science advances, more variables of importance will be incorporated into our understanding of RU in practice and those variables incorporated into the tools used to understand and improve the rigorous adoption of useful innovations.

Despite this limitation, the application of the AIFs to the interpretation of the four identified components provides action-oriented guidance to EHOs and their employers to support the development of strategies that have the potential to be useful practice interventions. It is hoped that this new model, based on the 2012 EHO data and validated with 2020 EHO data, will provide more insight into how to apply these findings to EHO practice.

Overall, this study demonstrates four concrete areas that present opportunities for targeted intervention to improve RU by EHOs in Canada. This includes strategies applicable to the workplace and to the design and communication of research findings in

environmental public health. In particular, the recommendations to enhance Leadership and Organization Drivers, is useful to researchers and practitioners. These two drivers are reported by EHOs as having the greatest impact on RU and are the primary areas for employers of EHOs to consider when trying to increase RU and the adoption of innovations in the EHO practice context.

3.5.2 Strengths and Limitations

Dimensionality reduction is the methodology used to understand the relationship between observed variables through a process that allows the researcher to summarize those variables and maximize the information gleaned from the original and complete data set (Finch, 2013). PCA is one method to do this; it provides a simpler and more useful interpretation of all the data for application by knowledge users. By reducing the 29-item BARRIERS Scale into its four principal components, some information about the items studied in the original scale were lost. Principal components are not as directly readable and they do not report as much variance as the original data, resulting in a loss of specificity in the analysis. However, by focusing on the correlated features and reducing the data's dimensionality, new broader concepts that are more meaningful and easier to visualize and understand are presented to users of the data (Tabachnick & Fidell, 2019). This study's findings provide, a useful, conceptual model for understanding the broad dataset that can be used to target focused mitigation strategies and support the increased use of all the evidence available through this study.

A vital consideration of this study is the low response rate to the survey in 2020, when significantly fewer EHOs responded to the invitation to participate. It is presumed that many EHOs did not have time to participate due to Covid-19 and the time demands associated with responding to the pandemic. A lower 2020 response rate was anticipated, and the number of participants was, in fact, significantly reduced. Strategies, including reminder emails, were applied to promote a greater response. In the end, the response rate was sufficient to allow the planned analysis in this study. For the purposes of practice decision-making, this research met its goal of being practical and useful for guiding the

development of strategies to mitigate the barriers to RU experienced by EHOs in the practice.

Lastly, although the results of this study are useful, they do not provide a comprehensive picture of the barriers to RU experienced by EHOs in Canada. Due to the gaps related to systems and processes, identified by applying the AIFs to the interpretation of the data, it is clear that more research is needed to capture and understand these missing variables and their impacts.

3.6 Conclusion: Supporting Evidence-Informed Environmental Health Practice

The AIFs were used to make sense of the four components derived from the complex data obtained from the EHO responses to the items in the BARRIERS Scale. The grand means of the principal components demonstrate the particular importance of Leadership Drivers and Organization Drivers to RU and innovation adoption amongst EHOs in Canada. By applying this mid-range theory to this study, these action-oriented frameworks can provide useful direction to those who manage and lead EHO practitioners in the environmental public health context. The barriers identified through this study are known to place the implementation of research evidence at risk in organizations. This study also outlines useful steps that can be taken to improve RU based on what is known about the application of evidence to EHO practice and its associated BARRIERS. Although this novel research is informative, more research is needed to confirm the applicability of these factors for guiding the development of interventions to increase RU amongst EHOs in their unique practice environment. A deeper dive into the specific barriers to RU in the Canadian context, particularly in those areas not captured in the BARRIERS Scale, can further support practitioners in applying evidence to their public health work. A recommended area of future study is the application of the AIFs beyond these four new components, particularly with respect to systems and processes, which align with other frameworks to support the development of strategies in the domains of processes and systems that can be used to enhance RU in EHO practice.

3.7 References

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3.8 Appendices

3.8.1 Appendix H: Detailed Summary of the Relevant Studies Applying Factor Analysis to the Results of the BARRIERS Scale

Title	Authors	Country	Study Population	Exploratory Factor Analysis	Confirmatory Factor Analysis	Methods Used	Rationale	No. of factors	No. of items included	Cronbach's Alpha Subscales	Percent of variance
BARRIERS: The Barriers to Research Utilization Scale	Funk et al. 1991	United States	Nurses	X		Principal Component Analysis (PCA) with varimax rotation	Original Study	4-factor solution	28 items	0.65-0.80	43.4-44.9%
Testing the revised barriers to research utilization scale for use in the UK.	Marsh et al. 2001	Europe	Nurses	X	X	PCA with varimax rotation followed by confirmatory factor analysis	New context	4-factor solution	24-27	0.31-0.60	Not reported

Title	Authors	Country	Study Population	Exploratory Factor Analysis	Confirmatory Factor Analysis	Methods Used	Rationale	No. of factors	No. of items included	Cronbach's Alpha Subscales	Percent of variance
A cross-cultural investigation into the dimensional structure and stability of the Barriers to Research and Utilization Scale	Williams et al. 2015a	Oceania, Asia, and Europe	Occupational Therapists	X		PCA using varimax rotation and Procrustes transformation	New context and professional group	4-factor solution	19 items	0.91-0.99	44.03%
An investigation of counselor educators'	Patel et al. 2010	United States	Counselor Educators	X		Not reported	New context and profession	5-factor solution	26 items	0.61-0.80	40.93%

Title	Authors	Country	Study Population	Exploratory Factor Analysis	Confirmatory Factor Analysis	Methods Used	Rationale	No. of factors	No. of items included	Cronbach's Alpha Subscales	Percent of variance
attitudes towards evidence-based practices and perceived barriers to the incorporation of evidence-based practices in counselor education curricula (Dissertation)							al group of counselor educators				

Title	Authors	Country	Study Population	Exploratory Factor Analysis	Confirmatory Factor Analysis	Methods Used	Rationale	No. of factors	No. of items included	Cronbach's Alpha Subscales	Percent of variance
Barriers to nurses' use of research: an Australian hospital study	Retsas and Nolan 1999	Oceania	Nurses	X		PCA with varimax rotation	New context	3-factor solution	26 items	Not reported	38.90%
Barriers to using research evidence in nursing practice	Retsas 2000	Oceania	Nurses	X		PCA with varimax rotation	New context	4-factor solution	29 items	0.68-0.85	46.50%
Bridging the divide: a survey of nurses'	Hutchinson and Johnston 2004	Oceania	Nurses	X		PCA	New context	4 factor solution	27 items	0.54-0.74	39.20%

Title	Authors	Country	Study Population	Exploratory Factor Analysis	Confirmatory Factor Analysis	Methods Used	Rationale	No. of factors	No. of items included	Cronbach's Alpha Subscales	Percent of variance
opinions regarding barriers to, and facilitators of, research utilization in the practice setting											
Perspectives of breast care nurses on research dissemination and utilisation.	Kirshbaum et al. 2004	Europe	Nurses	X		Least squares extraction with varimax rotation	New context	3 factor solution	Not reported	Not reported	Not reported

Title	Authors	Country	Study Population	Exploratory Factor Analysis	Confirmatory Factor Analysis	Methods Used	Rationale	No. of factors	No. of items included	Cronbach's Alpha Subscales	Percent of variance
The BARRIERS scale: Does it 'fit' the current NHS research culture?	Closs and Bryar 2001	Europe	Nurses	X		PCA with varimax rotation	New context	4-factor solution	23 items	0.66-0.79	47.50%
The spectrum of barriers to and facilitators of research utilization in Iranian nursing	Mehrdad et al. 2008	Asia	Nurses	X		PCA	New context	4-factor solution	31 items	Not reported	46.50%

Title	Authors	Country	Study Population	Exploratory Factor Analysis	Confirmatory Factor Analysis	Methods Used	Rationale	No. of factors	No. of items included	Cronbach's Alpha Subscales	Percent of variance
Barriers to Research Utilization Scale: psychometric properties of the Turkish version	Bayik et al. 2010	Asia	Nurses		X	Goodness of Fit Test	New context and Turkish translation	4-factor solution	29 items	0.73-0.80	Not reported
Cultural adaptation and validation of an instrument on barriers for the use of	Ferreira et al. 2017	South America	Nurses		X	Goodness of Fit Test	New context and Portuguese translation	4-factor solution	28 items	0.77-0.82	Not reported

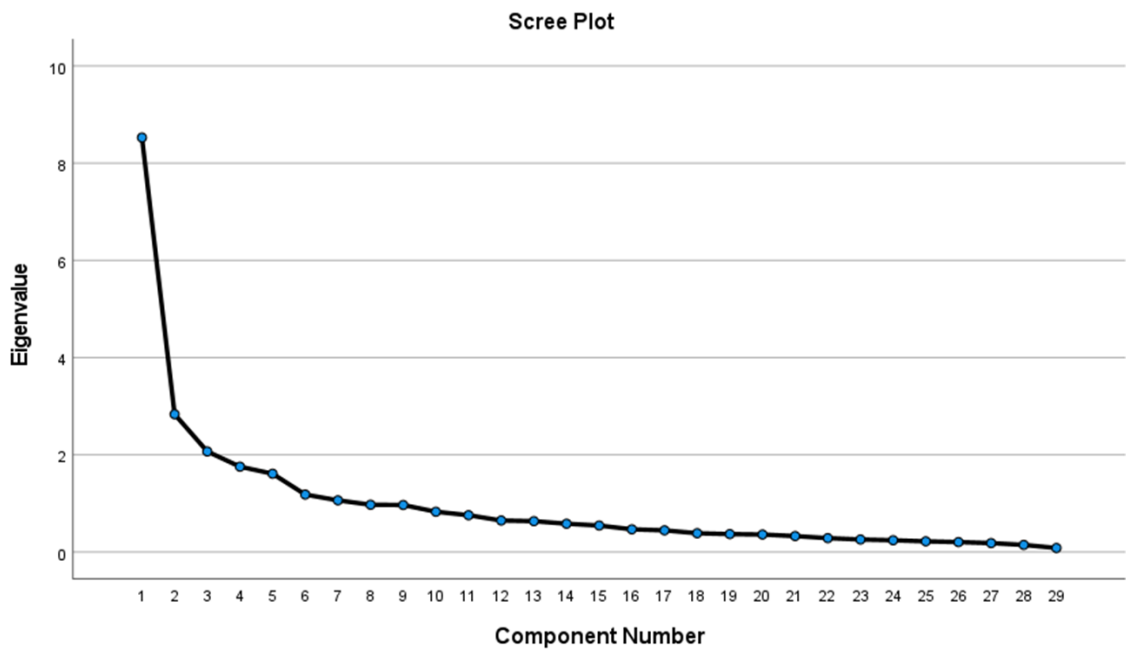
Title	Authors	Country	Study Population	Exploratory Factor Analysis	Confirmatory Factor Analysis	Methods Used	Rationale	No. of factors	No. of items included	Cronbach's Alpha Subscales	Percent of variance
research results											
Korean Translation of the Barriers to Research Utilization Scale: Psychometric Testing	Song et al. 2017	Asia	Nurses		X	Analysis of Moment Structure Program	New context and Korean translation	4-factor solution	25 items	0.79-0.87	62.90%
Using research for practice: a UK experience of the	Dunn et al. 1997	Europe	Nurses		X	Structural equation modeling	Factor model not appropriate	Not reported	Not reported	Not reported	Not reported

Title	Authors	Country	Study Population	Exploratory Factor Analysis	Confirmatory Factor Analysis	Methods Used	Rationale	No. of factors	No. of items included	Cronbach's Alpha Subscales	Percent of variance
of barriers to research utilization and administrative supports for research in hospitals (Dissertation)											

3.8.2 Appendix I: Total Variance 2012 Data Explained: Eigenvalues Associated with a 4-factor Solution (n=311)

Collection Period	Eigenvalue Component 1	% Variance Explained Component 1	Eigenvalue Component 2	% Variance Explained Component 2	Eigenvalue Component 3	% Variance Explained Component 3	Eigenvalue Component 4	% Variance Explained Component 4	Overall % Variance Explained	KMO Sampling Adequacy
2012	8.528	29.4	2.836	9.8	2.070	7.1	1.8	6.1	52.3	0.815

3.8.3 Appendix J: Scree Plot Representing the 2012 Eigenvalues (n=311)



3.8.4 Appendix K: 2012 Principal Component Analysis Four-Factor
Rotated Component Matrix (n=311)

Item No.	Item	Component 1	Component 2	Component 3	Component 4
1	Research reports/articles are not readily available.				0.489
2	Implications for practice are not made clear.				0.531
3	Statistical analyses are not understandable.	0.521			
4	The research is not relevant to the Environmental Health Officer's practice.				0.477
5	The Environmental Health Officer is unaware of the research.				0.684
6	The work environment is inadequate for implementation.			0.570	
7	The Environmental Health Officer does not have time to read research.				0.617
8	The research has not been replicated.		0.652		

Item No.	Item	Component 1	Component 2	Component 3	Component 4
9	The Environmental Health Officer feels the benefits of changing practice will be minimal.	0.647			
10	The Environmental Health Officer is uncertain whether to believe the results of the research.		0.457		
11	The research has methodological inadequacies.		0.754		
12	The relevant literature is not compiled in one place.		0.517		
13	The Environmental Health Officer does not feel she/he has enough authority to change environmental health practices, policies and/or procedures.			0.635	
14	The Environmental Health Officer feels results are not generalizable to his/her own setting.	0.525			
15	The Environmental Health Officer is isolated from	0.553			

Item No.	Item	Component 1	Component 2	Component 3	Component 4
	knowledgeable colleagues with whom to discuss the research.				
16	The Environmental Health Officer sees little benefit for self.	0.787			
17	Research reports/articles are not published fast enough.		0.664		
18	The Medical Officer of Health and senior managers within the organization will not cooperate with implementation.			0.885	
19	Administration will not allow implementation.			0.875	
20	The Environmental Health Officer does not see the value of research for practice.	0.724			
21	There is not a documented need to change practice.	0.442			
22	The conclusions drawn from the research are not justified.		0.648		
23	The literature reports conflicting results.		0.676		

Item No.	Item	Component 1	Component 2	Component 3	Component 4
24	Research in general is not reported clearly, in that it is not easy to read or understand.	0.445			
25	Other staff are not supportive of implementation in general.			0.721	
26	The Environmental Health Officer is unwilling to change/try new ideas.	0.487			
27	The amount of research information is overwhelming.	0.500			
28	The Environmental Health Officer does not feel capable of evaluating the quality of the research.	0.594			
29	There is insufficient time on the job to implement new ideas.				0.497

3.8.5 Appendix L: Component 1: Competency Drivers - Item Total Statistics

Item No.	Item	Cronbach's Alpha if Item Deleted
16	The Environmental Health Officer sees little benefit for self.	0.818
20	The Environmental Health Officer does not see the value of research for practice.	0.824
9	The Environmental Health Officer feels the benefits of changing practice will be minimal.	0.828
28	The Environmental Health Officer does not feel capable of evaluating the quality of the research.	0.831
15	The Environmental Health Officer is isolated from knowledgeable colleagues with whom to discuss the research.	0.829
14	The Environmental Health Officer feels results are not generalizable to his/her own setting.	0.830
3	Statistical analyses are not understandable.	0.836
27	The amount of research information is overwhelming.	0.834
26	The Environmental Health Officer is unwilling to change/try new ideas.	0.839

24	Research in general is not reported clearly, in that it is not easy to read or understand.	0.829
21	There is not a documented need to change practice.	0.833
Removing any of these items would reduce the reliability of Component 1 (0.844)		

3.8.6 Appendix M: Component 2: Usable Innovations - Item Total Statistics

Item No.	Item	Cronbach's Alpha if Item Deleted
11	The research has methodological inadequacies.	0.752
23	The literature reports conflicting results.	0.758
17	Research reports/articles are not published fast enough.	0.779
8	The research has not been replicated.	0.783
22	The conclusions drawn from the research are not justified.	0.771
12	The relevant literature is not compiled in one place.	0.801
10	The Environmental Health Officer is uncertain whether to believe the results of the research.	0.789
Removing any of these items would reduce the reliability of Component 2 (0.802)		

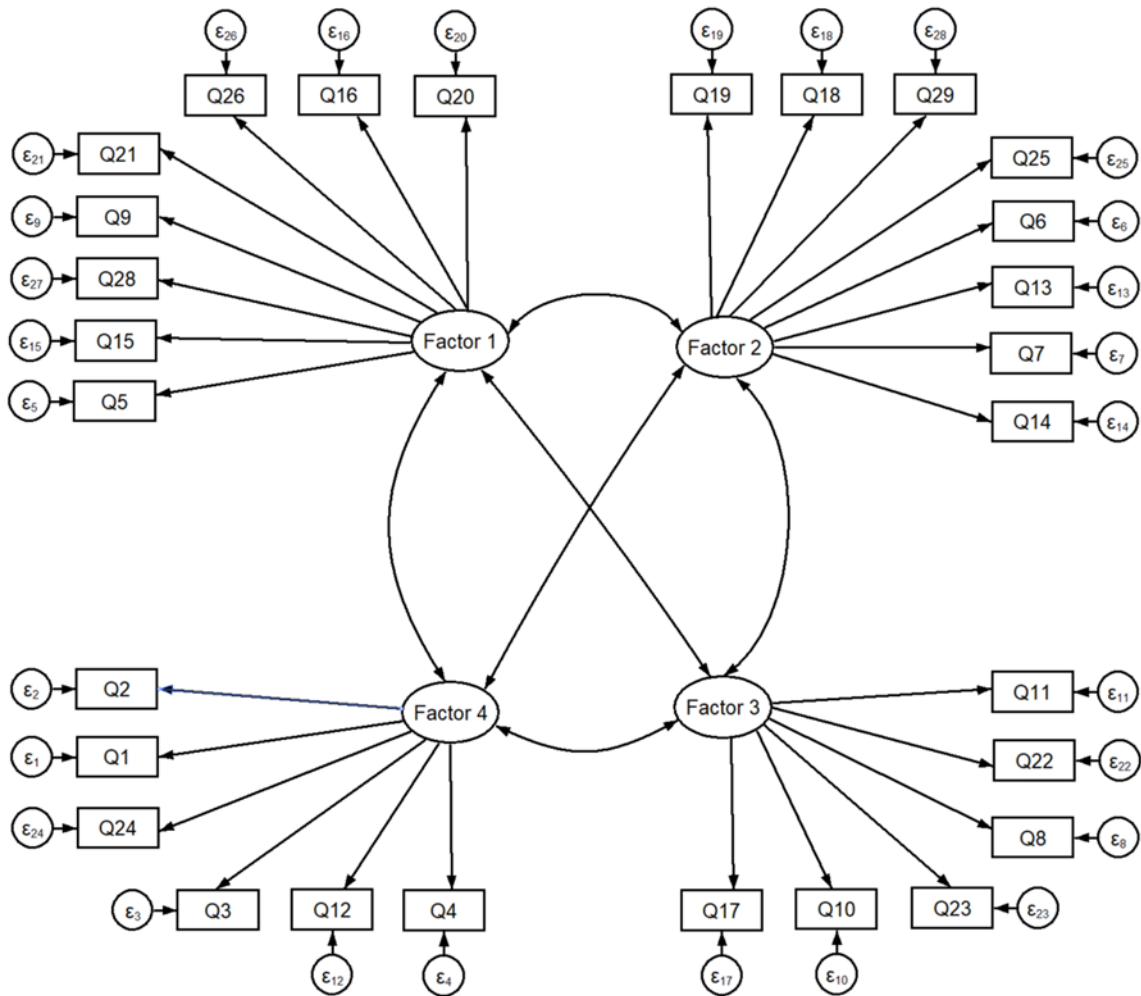
3.8.7 Appendix N: Component 3: Leadership Drivers - Item Total Statistics

Item No.	Item	Cronbach's Alpha if Item Deleted
18	The Medical Officer of Health and senior managers within the organization will not cooperate with implementation.	0.782
19	Administration will not allow implementation.	0.769
25	Other staff are not supportive of implementation in general.	0.833
13	The Environmental Health Officer does not feel she/he has enough authority to change environmental health practices, policies and/or procedures.	0.829
6	The work environment is inadequate for implementation.	0.837
Removing any of these items would reduce the reliability of Component 3 (0.844)		

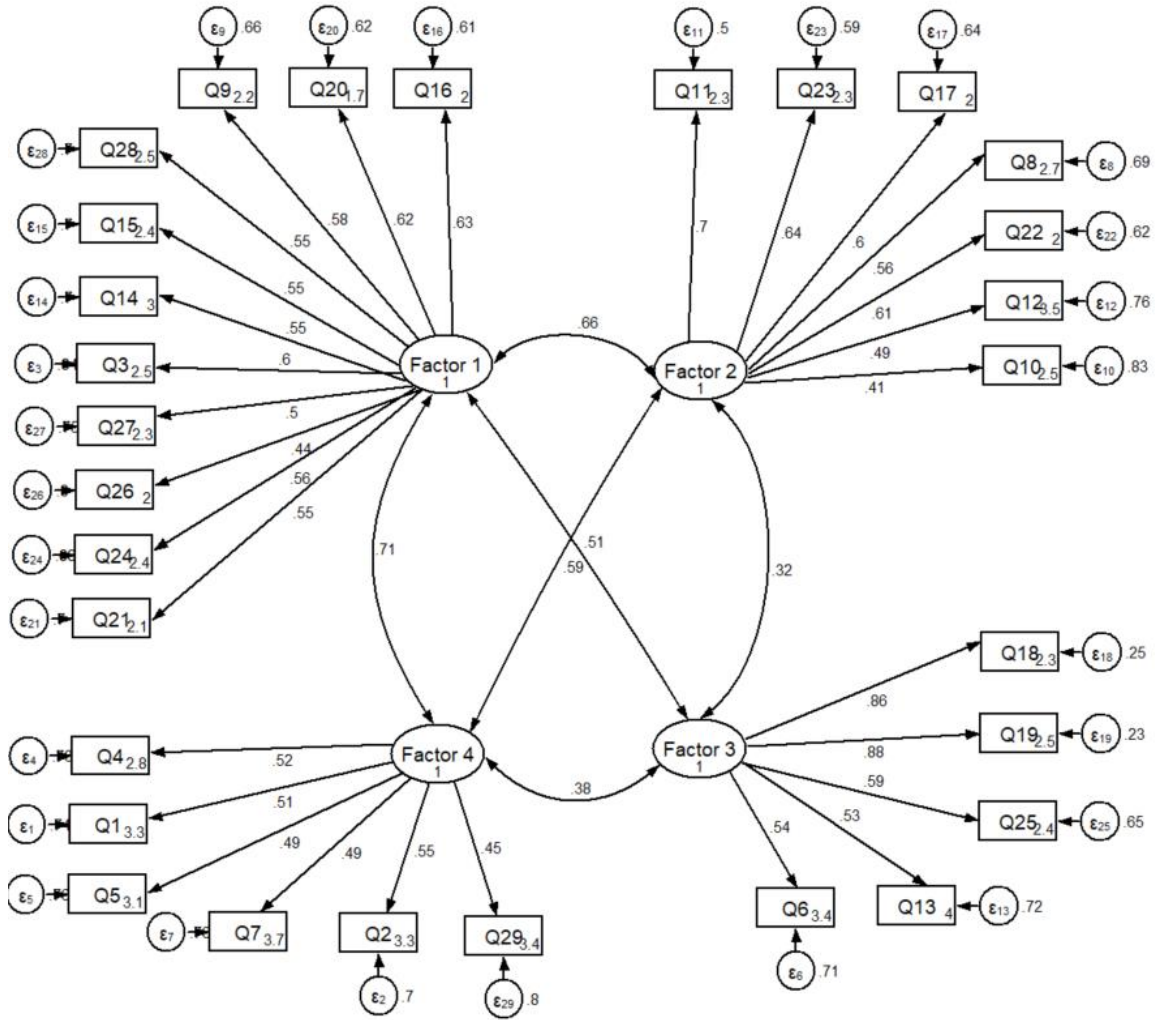
3.8.8 Appendix O: Component 4: Organization Drivers - Item Total Statistics

Item No.	Item	Cronbach's Alpha if Item Deleted
5	The Environmental Health Officer is unaware of the research.	0.663
7	The Environmental Health Officer does not have time to read research.	0.646
2	Implications for practice are not made clear.	0.653
29	There is insufficient time on the job to implement new ideas.	0.672
1	Research reports/articles are not readily available.	0.664
4	The research is not relevant to the Environmental Health Officer's practice.	0.652
<p>Removing any of these items would reduce the reliability of Component 4 (0.698) which would be below an acceptable level</p>		

3.8.9 Appendix P: Structural Equation Model of the Original Clinical Nurse Specific Responses to the BARRIERS Scale (28-items)



3.8.10 Appendix Q: Structural Equation Model of the EHO Specific Responses to the BARRIERS Scale (29-items)



Chapter 4

4 The Barriers to Research Utilization Experienced by Environmental Health Officers in Canada as Revealed through the Open-Ended Questions of the BARRIERS Scale³

4.1 Abstract

Purpose: To report the qualitative findings from the responses of Canadian Environmental Health Officers (EHOs) to three open-ended questions in the Barriers to Research Utilization (BARRIERS) Scale.

Method: The survey used in this cross-sectional study was disseminated online. EHOs in Canada were invited to respond to the questions in the BARRIERS Scale through an online survey that was distributed at two points in time, once in 2012 during a normal work year and again in 2020 during the COVID-19 pandemic. In total, 196 (63%) of the 311 survey participants responded to the three open-ended survey questions in 2012, and 63 (77%) of the 82 participants responded to the open-ended questions in 2020. A three-step process was used to analyze the data in this study. First, a thematic analysis of the EHO open-ended responses were completed to understand the perceived barriers and facilitators of Research Utilization (RU) in the EHO context. Next, deductive coding was used to categorize the open-ended responses to the Active Implementation Frameworks (AIFs); this served to align results with this broader evidence-based framework recognized within the field of implementation. Finally, NVivo 12 utilities were applied to the data (i.e., data frequency, matrix coding, and cross-tabulation) to answer the three

³ A version of this chapter has been drafted for publication as follows: Shawna Bourne, Anita Kothari, Jessica Polzer, and Nadine Wathen. (2022). The Barriers to Research Utilization Experienced by Environmental Health Officers in Canada as Revealed through the Open-ended Questions of the BARRIERS Scale. [Manuscript drafted for publication]. School of Health and Rehabilitation Sciences, Faculty of Health Sciences, Western University.

open-ended questions contained in the survey and identify differences between the 2012 and 2020 responses.

Findings: The top three themes arising from the data included: *Legislative Policy, Programs and Services, Political and structural barriers*, and *EHO practitioners in sufficient numbers to enable practice delivery while exploring the evidence*. In addition, the most frequently identified barriers aligned with the following AIFs: *Implementation Drivers Framework*, the *Systemic Change Framework*, and the *Usable Innovations Framework*.

Differences were noted between the open-ended responses in 2012 and 2020 which showed the relative importance of the theme: *The necessary tools and resources to support evidence-informed decision-making* in 2012 was disproportionately referenced as compared to 2020. Whereas in 2020, the following five themes were disproportionately referenced, and they include: (i) *Processes to engage the impacted community*; (ii) *Strong leaders to support change*; (iii) *Emerging evidence that is relevant and applicable*; (iv) *A culture that enables organizational innovation*; and (v) *Leadership support for evidence-informed practice*.

Conclusion: These findings demonstrate that EHOs experience a number of systemic barriers to RU that are not captured in the BARRIERS Scale including barriers related to legislation, politics, and broad policy approaches. These are in addition to the organizational and leadership barriers previously identified as important to barriers to RU in the literature. Targeted interventions in these areas have the potential to increase the use of evidence in environmental health practice in Canada. This study also demonstrates that during emergencies, EHOs seek easy access to emergent research and clear processes and pathways for evidence implementation, including processes for engaging with impacted communities, and leadership that understands and supports the implementation of emerging information into practice. This study adds to our current knowledge of the specific barriers to evidence-informed decision-making experienced by EHOs in their regular and emergency practice.

4.2 Introduction

Evidence-informed decision-making (EIDM) is well-recognized as an efficient and effective strategy for meeting population level needs with the goal of streamlining practice, eliminating waste, and improving outcomes in healthcare and public health (Brownson et al., 2009; Hardy et al., 2015; McKenzie et al., 2009; Patton, 1997). Despite the acknowledged importance of EIDM to achieving better outcomes in public health, there is also an equally long and well documented research history of the slow or limited uptake of evidence in public health practice (Haynes et al., 2011; Lapaige, 2009; McGinnis, 2001). These gaps exist across the continuum of public health, including in the field of environmental health, and they impact on the work of Environmental Health Officers (EHOs), also known as Public Health Inspectors, in Canada.

The role of the EHO is to address environmental health issues, such as access to safe air, water, and food, that are influenced by environments at population and community levels; many of the problems that arise at that level are complex and ill-defined (Howze et al., 2004; Kreuter et al., 2004). This includes problems like climate change, racial and ethnic health disparities within communities, issues of the built environments, communicable disease prevention and control, and outbreak response; each problem requiring effective risk communication to a diverse community in a manner that leads to behaviour change (Brownson et al., 2009; Koehler et al., 2018; Lobb & Colditz, 2013). Addressing these problems in environmental health practice is further complicated by a lack of practice-focused environmental health research (Chociolko et al., 2010). Research specific to the field of environmental health, has focused primarily on the “what”. Specifically, what the standards ought to be (e.g., setting criteria or indicating when an intervention ought to be applied), with little to no attention paid to the “how” of interventions and their effectiveness (Barratt et al., 2013; Dhesei & Stewart, 2015). Understanding how to deliver effective environmental health services with a focus on supporting evidence-informed delivery is important information for practitioners. This research will further the goal of determining how to support better population-based outcomes in public health in general, and environmental health specifically.

4.2.1 The Promise of Evidence Informed Environmental Health Practice

The promise of greater efficiency and effectiveness is an important consideration in the delivery of public health services in Canada and the Public Health Agency of Canada has made efforts to promote improved public health practices by understanding the evidence needs of EHOs. The National Collaborating Centre for Environmental Health has earmarked funding for these purposes in order to: support awareness and understanding of existing and emergent environmental threats; mitigate the associated risks; and optimize benefits for the population; and of most significance to EHO practice, prepare EHOs to address complex issues in practice and policymaking through access to evidence (Dubois & Lévesque, 2020). This federal focus on supporting EHOs in their practice is an important mandate and driver for continuous improvement in environmental health practice. As a result of this approach, the [National Collaborating Centre for Environmental Health has developed a wealth of useful and easily accessible practice resources](#) for EHOs. These practice resources provide an important tool for EHOs to access current and relevant information, and are increasing in numbers and relevance to EHO practice over time. What is not addressed by the provision of these new resources is the more difficult and less understood question: how these resources are being adopted, adapted, and applied in the various practice environments of EHOs. It is not clearly understood at this point in time, how well these tools fit the evidence needs of EHOs practicing in Canada and what specifically, and generally, gets in the way of EHOs accessing and applying relevant information in the EHO work settings and contexts. There is little evidence to guide strategic approaches for employers and governments to support evidence-informed decision-making by EHOs in their practice context. This study addresses the question: what are the evidence-informed opportunities that exist to reduce the barriers to research utilization (RU) experienced by EHOs?

4.2.2 Measuring the Barriers to Research Utilization

The BARRIERS Scale, developed in 1991, has been used in multiple studies to understand the types of barriers faced by health care practitioners (Funk et al., 1991). The

tool asks survey participants a series of closed- and open-ended questions to gather information about the barriers experienced in their professional work contexts. As a part of this study, the 29 closed-ended survey items were used to build knowledge about the barriers facing EHOs in Canada by collecting research data at two points in time. The survey was administered first in 2012, during a period of routine, or non-emergency practice, and again in 2020, at the beginning of the COVID-19 pandemic when public health human resources across Canada, including EHOs, were diverted to focus on implementing emergency measures to mitigate the population level impacts of COVID-19 (Haas et al., 2021; Kuhn et al., 2021; Sekercioglu et al., 2020). This approach was applied to learn how barriers experienced by EHOs would compare between emergency and non-emergency (normal) practice contexts. To achieve this research goal, both qualitative and quantitative methods were applied to the data collected through the BARRIERS Scale and to date the research has resulted in two important findings about the barriers to RU experienced by EHOs in Canada.

First, the closed-ended survey data was analyzed using descriptive statistics (see chapter two). The analysis demonstrated that EHOs reported the same three greatest barriers to RU in 2012 and in 2020, despite presumed differences in the priorities between non-pandemic (normal) and pandemic work priorities (Bourne, Kothari, Wathen, et al., 2022b). In the normal work year and during the COVID-19 pandemic, EHOs indicated that the greatest barriers to RU in practice were: (i) lack of authority to implement changes to practice, (ii) lack of time to review research, and (iii) lack of time to implement research findings. This revealed that in general, these three barriers to RU are embedded and persistent in the contexts in which EHO practice occurs in Canada.

Given the embeddedness of these barriers, the closed-ended survey data results were further analyzed to understand the dimensional structure of the findings and the interrelationships between the survey items and responses (see chapter three). The dimensional analysis was designed to: (i) provide a more holistic understanding of the barriers to RU in the Canadian context using the complete dataset to identify meaning and patterns in the data (Finch, 2013) and (ii) position these dimensional results within the theoretical underpinnings of the Active Implementation Frameworks (AIFs) (Fixsen

& Blase, 2020). The AIFs were used to locate the findings within the current body of knowledge. It also allowed the findings to be interpreted and analyzed using a broadly accepted means of understanding the process of knowledge translation through an inductive process. The results of the dimensional analysis were categorized and defined based on the clusters of barriers identified through the dimensional analysis. The study revealed that the four constructs identified aligned best with the following AIFs: Implementation Drivers and Usable Innovations (Bourne, Kothari, Wathen, et al., 2022a). By applying the AIFs, it was possible to identify the importance of these two organizational barriers to RU, and to also identify that only two of the six frameworks that make up the AIFs were represented in the model (Fixsen & Blase, 2020). This suggested that there were gaps in the findings arising from the use of the BARRIERS Scale (Bourne, Kothari, Wathen, et al., 2022a). These gaps revealed the need for this third study: to analyze participants' written responses to the open-ended questions included in the BARRIERS Scale and compare responses between the two data collection points, first in 2012 and then in 2020.

4.2.3 EHO Responses to Open-Ended BARRIERS Scale Items

The goal of this study was to generate insights about barriers to, and facilitators of, RU that were not captured by the closed-ended, quantitative, survey items. Open-ended survey responses have been shown to corroborate or refute the related quantitative findings and provide new ideas for further study (Feng & Behar-Horenstein, 2019; Robins & Eisen, 2017). Furthermore, the systematic analysis of the open-ended responses of a survey can provide insights beyond the information that is generated by the closed-ended questions alone (Feng & Behar-Horenstein, 2019). In both 2012 and 2020, Canadian EHOs were provided with the opportunity to respond to three open-ended questions that are standard items in the BARRIERS Scale. These questions were: (i) which of the above items (all closed-ended items in the BARRIERS Scale) do you feel are the three greatest barriers to EHO use of research; (ii) are there other things you think are barriers to research utilization; and (iii) what are the things you think facilitate research utilization? (Funk et al., 1991). Responses to the first question provided an opportunity for the researcher to confirm alignment of the open-ended responses and the

findings of the closed-ended responses. Questions two and three provide an opportunity to explore barriers and facilitators that were not captured in the standardized scale, allowing for new hypotheses to form about the barriers experienced by EHOs.

The specific objectives of this study were to understand the other barriers to, and facilitators of, research utilization experienced by Canadian EHOs as identified through the analysis of the open-ended responses and to identify if there were differences between the open-ended responses received from EHOs in the normal period of work, 2012, and the emergency conditions of 2020.

4.3 Methodology

The BARRIERS Scale was originally developed with critical care nurses in mind. To reflect the Canadian public health context, the BARRIERS Scale was modified to mirror the work context of the Canadian EHO respondents participating in the study. This was achieved by reflecting the typical constructs found in their work environments (e.g., working in public health units as opposed to hospitals); these minor changes were pilot tested with a small group of EHOs in Ontario (Bourne, Kothari, Wathen, et al., 2022b). The Canadian Institute of Public Health Inspectors national listserv was used to recruit participants at the two points of data collection, in 2012 and 2020. Participants confirmed their consent to participate by choosing to complete the survey and by confirming that they met the inclusion criteria. Participants responded to three mandatory survey questions to confirm that they: (i) were an EHO; (ii) were certified as a public health inspector (also known as an EHO in Canada) with the CPHI(C) designation; and (3) had at least one year's experience of working within the Canadian context specifically. All other questions in the survey, including those related to demographic data and the open-ended questions, were optional and participants were able to respond or skip those questions. The open-ended data were collected anonymously and have been analyzed using NVivo 12. This study was reviewed and approved by the [Western University's Research Ethics Boards](#) (NMREB# 102798 and REB# 115466).

4.3.1 Participants

The BARRIERS Scale (Funk et al., 1991), disseminated as an online survey to EHOs across Canada, provided an opportunity for practitioners to respond to the 29 closed- and three open-ended questions of the survey to share their perspectives about the barriers to RU they experience in their practice. In total, 393 EHO participants responded to the survey at the two points of data collection. Overall, 196 (63%) of the 311 survey participants in 2012, and 63 (77%) of the 82 survey respondents in 2020, responded to the three open-ended questions. Although a significantly lower number of people participated in the survey during the COVID-19 pandemic in 2020, those who participated in the study were more likely to provide a response to the three open-ended questions. An analysis of their demographic characteristics (see Table 6) reflected the general changes noted in Canada between the two points of data collection, including an increase in women and Black, Indigenous, and people of colour in the workforce (Martel, 2019). There was also an increase in educational attainment between the two points of data collection, reflecting the current certification requirements of EHOs which calls for, at minimum, a bachelor's degree from an accredited program (Canadian Institute of Public Health Inspectors, 2022a).

Demographics	Attribute	2012 (n=311)	2020 (n=82)	N (n=393)
Gender	Male	95 (31%)	20 (24%)	115
	Female	99 (39%)	41 (50%)	140
	Other	3 (1%)	0 (0%)	3
Racial Identity	Indigenous	3 (1%)	1 (1%)	4
	Person of Colour	26 (8%)	9 (11%)	35
	White	156 (50%)	52 (63%)	208
	1-4	18 (<1%)	2 (2%)	20

Length of Service	5-9	45 (14%)	9 (11%)	44
	10-14	32 (10%)	18 (22%)	50
	15-19	26 (8%)	11 (13%)	37
	>20	75 (24%)	23 (28%)	98
Educational Attainment	Diploma	26 (8%)	3 (4%)	29
	Bachelor's Degree	130 (42%)	43 (52%)	173
	Graduate Degree	40 (13%)	16 (20%)	56

Table 6: Demographics of Participants Who Responded to the Open-Ended Questions in the Survey by Year of Data Collection.

Participants had the opportunity to provide open-ended responses within up to seven free-text fields in the online survey; each response was optional. Across both data collection points, there was a total of 259 unique responses to the open-ended questions, 196 in 2012 and 63 in 2020 (see Table 7). In general, there were three unique responses to the open-ended questions in 2012 for every unique response to the open-ended questions in 2020. Given the lower number of respondents in 2020 (one respondent for every five respondents in 2012), this suggests respondents were more motivated to respond to the open-ended questions in 2020 than they were in 2012.

The first open-ended question, addressing the three greatest barriers to RU from amongst the closed-ended survey items, generated 228 unique responses (171 in 2012 and 57 in 2020). The second question asked respondents to identify other barriers to RU beyond those identified in the closed-ended questions; there were 134 unique responses to this question, 99 in 2012 and 35 in 2020. The final question about facilitators of RU generated 187 unique responses, 136 in 2012 and 51 in 2020 (see Table 7).

Open-ended Question	2012 Unique Responses	2020 Unique Responses	Total Unique Responses
Q1: Considering all the Barriers identified in this survey, which...are the three greatest barriers to an Environmental Health Officer's use of research?	171 (75%)	57 (25%)	228
Q2: Are there other things you think are barriers to research utilization?	99 (74%)	35 (26%)	134
Q3: What are the things that you think facilitate research utilization?	136 (73%)	51 (27%)	187
Total Unique Responses	196 (76%)	63 (24%)	259

Table 7: Number of Unique Responses to Each Open-Ended Question by Year.

4.3.2 Research Approach

This study followed a three-step process of data analysis to understand and identify the additional barriers to, and facilitators of, RU experienced by Canadian EHOs not captured by the closed-ended questions. Results are presented in the following order: (i) thematic analysis of the open-ended responses to open-ended items two and three; (ii) categorization and validation of the themes from step one and the EHO responses to open-ended item one; and (iii) exploration of the analytical results from steps one and two using NVivo utilities to answer the three open-ended questions from the survey, discern unique characteristics of the open-ended survey data, and identify the differences between the open-ended responses received from EHOs in 2012 and 2020. Annotations and memos were used throughout the analysis to capture researcher reflections and

thoughts about the data and to provide a reminder of the observations and rationales for decisions made throughout the process of analysis.

The following provides an overview of the analytical approach applied to each step of the three steps of the analysis that was completed. In step one, a thematic analysis of the open-ended data was conducted using an iterative, inductive coding approach that explored the relationships within and across the responses to open-ended items two and three. The data was analyzed with the intention of developing informative and useful themes that would be helpful to practitioners or researchers to apply the learnings from the themes (Patton, 1997, 2002). The responses to open-ended item one were not included in the thematic analysis as the responses did not introduce new ideas but rather focused on the ranking the closed-ended items of the BARRIERS Scale. Next, the responses to open-ended item one and the themes generated from step one, were categorized using the AIFs (see Table 8 for a listing of the AIFs and their conceptual definitions). This deductive analysis used the results of the dimensional items from chapter three which assigned each closed-ended item in the BARRIERS Scale to an AIF category (Bourne, Kothari, Wathen, et al., 2022a). A summary of the 29-items in the BARRIERS Scale and their associated frameworks within the AIFs can be found in Appendix R. Finally, NVivo Utilities were used to answer the three open-ended questions to the research study questions to determine differences between the responses to the open-ended responses in 2012 and 2020. Item one: “What are the three greatest barriers to RU” was explored using the Word Count Utility to address concerns about variability in the data. Item two: “What are the most important barriers and facilitators RU cited by EHOs across Canada” was assessed using the Matrix Analysis Utility in NVivo. Finally, the research question: “What differences are there between the views expressed by the EHO respondents in 2012 (normal year), as compared to 2020 (pandemic emergency year)” was addressed using the Crosstab Utility.

AIFs Analytical Categories	Definition
Implementation Drivers Framework	Focuses on the conditions that support behaviour change and drive innovation and adoption. This theme is comprised of the following sub-drivers: Organization Drivers (organizational factors), Leadership Drivers (leadership factors), and Competency Drivers (competency factors).
Implementation Stages Framework	Focuses on the iterative steps required to achieve full implementation of an innovation.
Implementation Teams Framework	Centres the importance of practitioners who initiate and manage organizational and system change as a speciality. These specialists are necessary to deliver successful implementations.
Improvement Cycles Framework	Focuses on the continuous improvement cycles necessary for sustainment and the embeddedness of an innovation in an organization or system.
Systemic Change Framework	Considers the systemic and structural supports needed to facilitate the transition from the status quo or the new normal.
Usable Innovations Framework	Emphasizes the need to have well-defined, accessible, and practical evidence or innovations that are highly correlated to outcomes to support implementation.

Table 8: Active Implementation Frameworks and Conceptual Definitions

The inductive and deductive coding processes used and reported in this study were triangulated through comparison with other data available through previous studies and

the broader literature as well as through qualitative checks completed with the other authors who were engaged in this research study (Patton, 1999). The second author conducted a detailed review of the findings by reviewing the raw data, the memos, annotations, and analytical results to assess rigour and quality. A further high-level overview was performed by the third and fourth authors which included a review of the summary of the findings and further discussions to challenge the results and assumptions. These additional steps were taken to refine, improve, and increase the trustworthiness of the analytical findings.

4.3.3 Researcher Perspectives

The research team was composed of four researchers. The primary researcher is a Ph.D. candidate completing this research in fulfillment of the requirements of their doctoral degree. The primary researcher has expertise in evaluation, policy, and program delivery, and has five years' experience working as an EHO in Ontario. The remaining team members are accomplished and experienced qualitative and quantitative researchers. The secondary author is a scholar in knowledge translation and implementation science in public health and community settings, and the third author has expertise in critical qualitative research. The fourth author studies and practices critical knowledge mobilization in the areas of gender-based violence and health equity. These multiple perspectives ensured that the individual point of view of the primary researcher was not taken for granted as the only way of analyzing and understanding the data collected. These perspectives challenged and sharpened the findings presented in this report and across the entire research study.

The primary researcher's interest in this study stems from their own experience in the environmental health field, and personal experiences with barriers to RU that have affected their own practice as an EHO and in other public service roles. The primary researcher's goal is the development of evidence that is best suited to provide pragmatic and useful information to decision-makers. Most importantly, they are interested in developing a useful evidence set that has the potential to effect transformation in environmental health and support the modernization of environmental health practice in

Canada. The methods, analysis, and approach to communicating the results used in this study have been selected to achieve these goals.

4.4 Findings

The following lists the findings arising from each step of the analysis, as describe in the methods section of report.

4.4.1 Step One: Inductive Thematic Analysis

The first step of the analytic process focused on the thematic analysis of EHO responses to open-ended items two and three. These two questions asked EHOs about the other barriers to RU not captured in the BARRIERS Scale (open-ended survey item two) and the facilitators that they perceive to support RU (open-ended survey item three). EHO responses ranged from a single word, “Regulations”, to a paragraph describing in greater depth, the barriers or facilitators faced by EHOs in their work context. For example, an EHO provided this more detailed explanation of the barriers related to regulations:

The provincial level at the ministries have to take the research forward to the politicians to have the regulations amended to incorporate current research, i.e., it has been well known for over a decade that having mandatory food handler training will decrease non-compliance issues in the food service industry and will decrease the burden or likelihood of foodborne disease. However, the Ontario Food regulation has never been updated to reflect this fact. The regulation is outdated and has never been amended in my career.

The themes coalesced around 19 concepts focused on targeted and specific themes for decision-making. Three themes were most frequently occurring in the data and can be inferred to be perceived by EHOs as particularly important barriers to RU in Canada (see Table 9 for a summary of the top three themes, their definitions, relevant examples from the open-ended data, and their frequency of reference in the responses). The top three themes reflect the most frequently cited themes in the data.

Analytical Theme	Definition	Relevant EHO open-ended responses	No. of References
Legislative Policy, Programs, and services	Regulatory policy, programs, and services intended to deliver the safe and consistent application of public health interventions is often slow to change and reflect the best evidence, thus policies, programs, and services do not often reflect the current and emerging evidence about risk and prevention in environmental health.	<ul style="list-style-type: none"> • “New findings conflict with existing regulations which by law must be followed/enforced” • “Outdated legislation” • “The legislation is sometimes unclear or lacking in certain areas and this is where the science-based evidence is applied and referred to. Credible sources are imperative.” 	91
Political and structural barriers	Changing the status quo when there are competing interests or demands.	<ul style="list-style-type: none"> • “When external pressures (public perception, politics) are a higher priority or conflict with research” • “Political intervention (mayors, etc.)” 	82
Enough EHO practitioners to enable	Having a sufficient number of EHO practitioners for current workload	<ul style="list-style-type: none"> • “Increase in workload without adding staff” 	81

Analytical Theme	Definition	Relevant EHO open-ended responses	No. of References
practice delivery while exploring the evidence	requirements and to dedicate time to implementation efforts.	<ul style="list-style-type: none"> • “Staff are overworked and have no time” • “Reasonable staffing levels” 	

Table 9: Top Three Themes, Definitions, Relevant Examples, and Frequency of the Theme in the Data.

Overall, the thematic analysis resulted in the identification of 19 distinct themes. These analytical themes describe the range of barriers and facilitators identified in the participants’ responses with enough granularity to guide application to the work context (Patton, 1997). Themes identified include the need for: practitioner supports, sufficient EHO human resources, and regular reviews of practice and policy. Themes also related to the context of the workplace including the overall influence of politics and policy on RU. The most common themes arising in the data were embedded in the theme of **Legislative policy, programs and services** which was referenced 91 times and **Processes to engage the impacted community** was a distinct and granular concept found in the data, though it was referenced the least frequently by the EHO participants, a total of 15 times.

The themes identified were chosen to focus on a particular type of barrier impacting on RU as expressed by the EHOs who participate in the survey. For example, there are two themes related to leadership and management of the implementation of research into EHO practice: **Leadership support for evidence-informed practice** and **Project, change, and implementation management**. Leadership support for evidence-informed practice refers to the leadership that exists within the organizational structures. This type of leadership directs, protects, and creates pathways for implementation through positional power, whereas project or change management are provided by staff members at any level of the organization who are focused on delivering a project or implementing

a change. Although, these two concepts could be combined into a single theme, the theme overall would have had less usefulness from the perspective of a practitioner wishing to target an intervention in their workplace. A full listing of the themes, their conceptual definitions, and the number of times they are referenced in the data can be found in Appendix S.

4.4.2 Step Two: Deductive Categorization Using the Active Implementation Frameworks

The second step of the research approach involved categorizing the newly developed themes and all of the responses to open-ended item one from the BARRIERS Scale using the AIFs (see Table 8). The AIFs were used as an already recognized framework to validate the identified themes and responses in order to determine whether the responses to the open-ended questions introduced new information that fit into the system and process related gaps. These gaps were identified through the Dimensional Analysis completed as a part of this study in Chapter 3 (Bourne, Kothari, Wathen, et al., 2022a). This step in the process allowed for additional rigour and systematic analysis of the data by using a well-researched theory to help identify the frameworks within the AIFs not represented by the EHO responses. A further pragmatic benefit of this step was that it allowed for the research to be positioned into a larger body of work in implementation science (Fixsen & Blase, 2020), increasing the usefulness of findings for application in future research and to guide interventions in the workplace.

The definitions associated with the six AIFs (Fixsen et al., 2005) facilitated the matching of each theme with a relevant conceptual definition. For example, the theme **Enough EHO practitioners to enable practice delivery while exploring the evidence**, is comprised of matters that relate to work structure and operational planning including staffing levels, workload, and time to review and implement research findings. All of these factors align with the Organization Drivers Framework. The Organization Drivers Framework, a subset of the Implementation Drivers Framework, has the most references of all the frameworks in this study. This approach was applied to each of the themes developed through the analysis completed in step one of the study. As many as eight

themes and as few as two themes were categorized under each of the six AIFs along with the most important barriers to RU identified by EHOs using the findings of the dimensional analysis found in Appendix R, using this deductive process. As a result of this analysis, the top three AIFs with the greatest number of coded references were Implementation Drivers (793 references), Systemic Change (204 references), and Usable Innovations (170 references) which are captured in descending order in Table 10 with associated themes and number of references. The categorization process revealed the importance of Systemic Change, one of the AIFs not previously captured in the closed-ended questions of the BARRIERS Scale (see Appendix T: for a hierarchical diagram of the themes and their categorization within the AIFs).

AIFs Analytical Categories	Associated Themes	No. of References
Implementation Drivers Framework	<p>Competency Drivers</p> <ol style="list-style-type: none"> 1. Support practitioner capacity, autonomy, and confidence 2. Support practitioner access to knowledge networks <p>Leadership Drivers</p> <ol style="list-style-type: none"> 3. Strong, competent leaders to support change 4. Leadership support for evidence-informed practice <p>Organization Drivers</p> <ol style="list-style-type: none"> 5. A culture that enables organizational innovation 6. Adequate funding to deliver evidence-informed practice 	793

AIFs Analytical Categories	Associated Themes	No. of References
	<ol style="list-style-type: none"> 7. Enough EHO practitioners to enable practice delivery while exploring the evidence 8. The necessary tools and resources to support evidence-informed decision-making 	
Systemic Change Framework	<ol style="list-style-type: none"> 1. Legislative policy, programs, and services 2. Political and structural barriers 	204
Usable Innovations Framework	<ol style="list-style-type: none"> 1. Emerging evidence that is relevant and applicable 2. Evidence that meets expectations of quality 	170
Implementation Teams Framework	<ol style="list-style-type: none"> 1. Implementation expertise 2. Project, change, and implementation management 3. Clear pathways to successful implementation 	113
Improvement Cycles Framework	<ol style="list-style-type: none"> 1. Embed practice review and inform in day-to-day practice 2. Systematic evaluations of processes and outcomes 	74
Implementation Stages Framework	<ol style="list-style-type: none"> 1. Strategic management of long-term implementations 2. Processes to engage the impacted community 	48

Table 10: The Six AIFs in Descending Order of Relevance and Their Associated Themes and Number of References.

4.4.3 Step Three: Applying NVivo Utilities

Finally, NVivo utilities were used to explore patterns in the data. In particular, the utilities were applied to answer the two open-ended questions from the BARRIERS Scale: (i) Considering all of the Barriers identified in this survey, which of the above items do you feel are the three greatest barriers to an Environmental Health Officer's use of research; and (ii) "What are the other barriers and facilitators of research utilization" in response to open-ended items two and three. Lastly, the utilities were used to (iii) identify the differences between the views expressed by the EHO respondents in 2012, as compared to those expressed in 2020, during the COVID-19 pandemic.

4.4.3.1 Open-Ended Item One: The Greatest Barriers to Research Utilization from the BARRIERS Scale

Word Frequency was used to identify the number of references cited across the participant responses to open-ended question one. This utility was used to identify words of significance or importance that were used with greater frequency by the survey respondents (Feng & Behar-Horenstein, 2019). Word frequency analysis was applied to the responses in question one with the following conditions: words must be at least 4 letters in length and be an exact match. The results of this analysis were used to identify a response to question one, "Considering all of the Barriers identified in this survey, which of the above items do you feel are the three greatest barriers to an Environmental Health Officer's use of research". Word frequency was chosen to analyze this question to address the variation with which the question was answered by respondents. Some EHOs responded by quoting verbatim the items they perceived to be the most important barrier from the 29-items in the BARRIERS Scale. For example, one EHO quoted Item 7: "The Environmental Health Officer does not have **time** to read research" whereas another EHO responded, "Insufficient **time** to implement new ideas" which clearly aligns with Item 29 in the BARRIERS Scale that reads "There is insufficient time on the job to implement

new ideas”, yet another stated, “Not enough **time**” and another simply stated “**time**”. Overall, there are 142 references to the term “**time**” in the responses to question one (see Table 11 the top ten most frequent words cited in question one).

Word	Length	Count	Weighted Percentage (%)
1. health	6	203	5.4
2. research	8	196	5.2
3. environmental	13	161	4.3
4. officer	7	147	3.9
5. time	4	142	3.8
6. change	6	96	2.6
7. implementation	14	80	2.1
8. enough	6	55	1.5
9. feel	4	54	1.4
10. authority	9	51	1.4
Total	7.7 (average)	1185	31.6

Table 11: The Top Ten Most Frequently Cited Words by EHOs in Question One.

The top four most frequently cited words: health, research, environmental, and officer are words used consistently within the items of the BARRIERS Scale to frame the key concepts under study including: “Research” use and “Environmental Health Officer”. These four words were used in almost every question, which would weight the prevalence of those words, without providing real insight to the top barriers perceived by EHOs from the items in the BARRIERS Scale. In consideration of these facts, the

remaining six most frequent words: “time” (x=142), “change” (x=96), “implementation” (x=80), “enough” (x=55), “feel” (x=54), and “authority” (x=51) were the key words to consider for this analysis. Combinations of these key words align with the following top items found in the BARRIERS Scale (see Appendix A for a full list of the items in the BARRIERS Scale) with the frequency of direct quotation in the EHO responses in descending order:

- (1) Item 13: “The Environmental Health Officer does not **feel** she/he has **enough authority** to **change** environmental health practices, policies and/or procedures” (x=43);
- (2) Item 29: “There is insufficient **time** on the job to **implement** new ideas” (x=39);
- (3) Item 7: “The Environmental Health Officer does not have **time** to read research” (x=36);
- (4) Item 18: “The Medical Officer of Health and senior managers within the organization will not cooperate with **implementation**” (x=31); and
- (5) Item 19: “Administration will not allow **implementation**” (x=25).

A review of key words from the remaining 29 items in the scale confirm that the above five items best represent the greatest barriers identified by EHOs in this study. By employing the Word Frequency utility in the analysis of open-ended item one, it is possible to infer the top concerns of EHOs with respect to the items in the BARRIERS Scale. This analysis places time, change, implementation, enough, feel, and authority as key words within the top 10 barriers to RU identified by EHOs in question one of the open-ended questions.

4.4.3.2 Open-Ended Items Two and Three: The Other Barriers to and Facilitators of Research Utilization

The Matrix Query in NVivo was used to perform a matrix analysis of the themes arising from the EHO open-ended responses to items two and three. The matrix query is a utility

that allows data to be explored for potential differences across and within different coding categories in NVivo (Feng & Behar-Horenstein, 2019). This was used in this study to identify the intersection of the themes and AIFs, with the responses to open-ended items two and three of the BARRIERS Scale. The resulting matrix table compares the prescribed data. For example, the frequency of responses matched to themes in open-ended item two, would result in a summary chart of the number of references related to the themes and AIFs that arose from the other barriers to RU identified by EHOs only in item two. Similarly, a matrix query was run to match the themes and AIFs associated only with open-ended item three that dealt with the facilitators to RU identified by the EHO respondents. The analysis revealed the frequency of the other barriers and their frequency of reference by EHOs in the study (see Appendix U: Matrix Analysis of Other BARRIERS to RU by Themes and Categories) and the number and frequency of references made to the facilitators of RU (see Appendix V: Matrix Analysis of the Facilitators to RU by Themes and Categories) identified by participating EHOs. This intersection revealed the greatest barriers and greatest facilitators to RU according to the associated themes.

The matrix analysis identified the following top three themes as barriers not addressed in the BARRIERS Scale (see Table 12): (i) **Legislative policy, programs, and services** (60 references); (ii) **Political and structural barriers** (47 references), and (iii) **Enough EHO practitioners to enable practice delivery while exploring the evidence** (38 references). These results demonstrate the importance of system level and organizational level barriers to RU perceived by EHOs in Canada.

Themes	Relevant EHO open-ended responses	Total References
Legislative Policy, Programs, and services	<ul style="list-style-type: none"> “New findings conflict with existing regulations which by law must be followed/enforced” 	60

Themes	Relevant EHO open-ended responses	Total References
	<ul style="list-style-type: none"> • “Regulation/policy does not reflect current research” 	
Political and structural barriers	<ul style="list-style-type: none"> • “Political intervention (mayors, etc.)” • “PHI/EHOs primarily work in isolation, i.e., most interactions are with clients (operators/public). Discussions with peers are limited to coffee breaks, conferences, social events” 	47
Enough EHO practitioners to enable practice delivery while exploring the evidence	<ul style="list-style-type: none"> • “Adequate staffing to be able to conduct research and complete required workload.” • “Emphasis on meeting required # of inspections” 	38

Table 12: Top Three Other Barriers to RU Identified by EHOs.

The top three themes identified by EHOs as facilitators to RU were also captured through a matrix analysis (see Table 13). Like the top three barriers, the top three facilitators identified by EHOs are predominantly broader issues that are organizational and structural in nature, and outside of the span of control of individual EHOs. These facilitators include: (i) **Emerging evidence that is relevant and applicable** (51 references), (ii) **A culture that enables organizational innovation** (47 references), and (iii) **Enough EHO practitioners to enable practice delivery while exploring the evidence** (43 references).

Themes	Relevant EHO open-ended responses	Total References
Evidence that is relevant and applicable	<ul style="list-style-type: none"> • “Ensuring that research is conducted to address defined topics” • “Direct applicability to EHO portfolios” 	51
A culture that enables organizational innovation	<ul style="list-style-type: none"> • “A supportive organization that values research” • “Support from your organization” 	47
Enough EHO practitioners to enable practice delivery while exploring the evidence	<ul style="list-style-type: none"> • “EHO's having the time to review and discuss research” • “This requires adequate staffing (which is often an issue)” 	43

Table 13: Top Three Facilitators to RU Identified by EHOs.

4.4.3.3 Research Question: Differences in the Barriers to and Facilitators of Research Utilization in 2012 versus 2020

The NVivo Crosstab Query was used to understand how EHO perceptions of the barriers to RU compared at the two points of data collection: in 2012 during normal conditions as compared to perceptions in 2020, during the COVID-19 pandemic. The crosstab utility allows a researcher to compare an attribute, such as the year of data collection and the data (Feng & Behar-Horenstein, 2019). For the purposes of this study, the themes and AIFs resulting from the analysis of the EHO responses in 2012 (n=311, 79%) were compared with the findings from the EHO responses in 2020 (n=82, 21%). There are two approaches to understanding the differences between the qualitative findings at the two points of data collection which is achieved by analyzing: (i) the total number of cases that map to a theme or an AIF at the two points in time of interest in this study, which

answers the question how many EHOs talked about a particular theme in a given year, and (ii) the number of coding references coded to cases in 2012 and 2020, which answers the question how often did EHOs mention a particular theme in a given year. The crosstab analysis was used to identify large disproportionalities (greater than 10% difference) between the average and the referenced results.

In analyzing the cases coded at each node by year, there was one theme that met the criteria for having a disproportionate number of EHOs citing it as a barrier or facilitator of RU in 2012: (i) **The necessary tools and resources to support evidence-informed decision-making** (85.7% of respondents) had a larger than expected share of the results at that time. However, in 2020, there were six themes that met the criteria for demonstrating disproportionality: (i) **Strong leaders to support change** (50% of respondents); (ii) **Processes to engage the impacted community** (50% of respondents); (iii) **Project, change, and implementation management** (40% of respondents); (iv) **A culture that enables organizational innovation** (38.5% of respondents); (v) **Clear pathways to successful implementation** (37.0% of respondents); and (vi) **Emerging evidence that is relevant and applicable** (36.1% of respondents). These results showed that of the according to the number of respondents, a disproportionately higher number of EHOs discussed the concepts related to these specific themes in 2020, than in 2012. For a full list of the results of the crosstab by year and related case counts, see Appendix W.

The second Crosstab analysis examined the coding references by year to determine the number of unique cases that code at each of the themes in each year. Through this analysis it was discovered that one theme fit the criteria in 2012 with an unexpectedly high proportion of the coding references: (i) **The necessary tools and resources to support evidence-informed decision-making** (86.4% of coding references). In 2020, there are five themes that meet the same requirements which were used to demonstrate disproportionality: (i) **Processes to engage the impacted community** (53.3% of coding references); (ii) **Strong leaders to support change** (52.6% of coding references); (iii) **Emerging evidence that is relevant and applicable** (39.0% of coding references); (iv) **A culture that enables organizational innovation** (38.8% of coding references); and (v) **Project, change, and implementation management** (38.8% of coding references). The

summary of the crosstab analysis of the coding references to theme by year is available in Appendix X.

When considered together, these results show that there is one theme in 2012 that is both talked about by a disproportionately large number of EHOs and is disproportionately referenced: (i) **The necessary tools and resources to support evidence-informed decision-making**. In 2020, there are five themes that overlap in the same manner showing a strongly disproportionate number of EHOs discussing those themes and having those themes mentioned by more EHOs. Those themes are (i) **Processes to engage the impacted community**; (ii) **Strong leaders to support change**; (iii) **Emerging evidence that is relevant and applicable**; (iv) **A culture that enables organizational innovation**; and (v) **Project, change, and implementation management**. These six themes show important differences between the EHO responses in 2012 and 2020.

4.5 Discussion

The purpose of this study was to determine the barriers to RU experienced by EHOs in their everyday practice and how those barriers change in emergencies. The EHO responses to the open-ended questions in the BARRIERS Scale were analyzed to ascertain how participants described the factors they perceived as impeding or facilitating RU in their practice. Thematic analysis and further categorization were completed using the AIFs to position the views of the EHO participants within the broader context of the field of implementation science and validate the findings. The open-ended questions of the BARRIERS Scale, analyzed using qualitative methods, were: (i) which of the closed-ended items in the BARRIERS Scale do you feel are the three greatest barriers to EHO use of research; (ii) are there other things you think are barriers to research utilization; and (iii) what are the things you think facilitate research utilization? These three questions provided the opportunity to further approaches to improving RU amongst EHOs that are not captured through the analysis of the closed-ended survey items of the BARRIERS Scale. The final question answered is: how do those other barriers to, and

facilitators of, RU in EHO practice change during emergency conditions, such as the COVID-19 pandemic?

4.5.1 Other Barriers and Facilitators Identified in the Open-Ended Questions

4.5.1.1 Which of the Closed-Ended Items in the BARRIERS Scale Do You Feel are the Three Greatest Barriers to EHO Use of Research?

EHOs identified the following top three barriers to RU associated with the items with the BARRIERS Scale through the open-ended questions:

- i. Item 13 “The Environmental Health Officer does not **feel** she/he has **enough authority** to **change** environmental health practices, policies and/or procedures” (x=43);
- ii. Item 29 “There is insufficient **time** on the job to **implement** new ideas” (x=39);
and
- iii. Item 7 “The Environmental Health Officer does not have **time** to read research” (x=36).

This analysis demonstrates that there is an alignment in perspectives between the individuals who responded to the open-ended and the closed-ended questions in this survey. Previously, the quantitative analysis of the closed-ended questions in the BARRIERS Scale found the three top barriers to RU identified by EHOs in Canada in both 2012 and 2020 to be: (i) a lack of authority to implement changes in practice, (ii) a lack of time to review research, and (iii) a lack of time to implement research findings (Bourne, Kothari, Wathen, et al., 2022b). This also aligns with systematic reviews of the BARRIERS Scale that found that time and authority were within the top five barriers to evidence-informed practice in studies conducted in healthcare (Carlson & Plonczynski,

2008; Kajermo et al., 2010; Prosser et al., 2003) and aligns with recent findings that time is a constraint to knowledge translation in EHO practice in Canada (Tang et al., 2015).

4.5.1.2 Are There Other Things You Think are Barriers to Research Utilization?

In terms of other barriers not included in the scale, the following three themes were most commonly referenced by respondents: (i) **Legislative policy, programs, and services**, (ii) **Political and structural barriers**; and (iii) **The right number of EHOs to enable practice delivery and explore the evidence**. These barriers are of particular interest as they reflect broad systemic and organizational issues outside of the span of control of practicing EHOs. For example, under the first theme, re-envisioning legislative policy, programs, and services, EHOs raise concerns about the application of “outdated legislation” and the fact that they are “...often confined by the regulation and act” as a significant barrier to RU. EHOs raise concerns that the way that legislative policy is structured around environmental health issues in Canada leads to slow and laborious updates to regulations. Having legislation that reflects the latest and best evidence requires updates to statutes that must be championed by bureaucrats and politicians in order for new research evidence to be adopted; work to effect change in this complex sphere requires both theoretical and practical expertise (Armstrong et al., 2006). This leads to the second most important barrier to research utilization: the political and structural barriers that hinder the adoption of innovation in practice.

EHOs identify “external pressures” as an important barrier that often “conflicts” with the implementation of current research into practice. In fact, EHOs identify that “some changes based on research are politically unpopular” indicating that at times, they perceive a lack of will from politicians and bureaucrats to make the necessary policy changes needed to reflect the latest evidence. Research suggests that practical tools can be leveraged to assist in restructuring evidence-informed environmental health decision-making, including broadly based health impact assessments, engaging with the communities, and employing health surveillance strategies, and conducting more complex cumulative risk assessments (Koehler et al., 2018; Lobb & Colditz, 2013).

Finally, EHOs identify that although the complexity of environmental health challenges faced by modern society continue to introduce novel issues and solutions (e.g., climate change, social determinants of health, built environments, etc.), resourcing in the field has not kept pace. Staffing levels do not reflect the current work demands, time, or attention required for the adoption of new approaches to complex issues (Bourne, Kothari, Wathen, et al., 2022b; Haas et al., 2021; Sekercioglu et al., 2020; Tang et al., 2015). EHOs identified workload as a significant barrier to identifying and responding to emerging issues and related research. Respondents indicate that staffing levels are unreasonable, they are “overworked”, and have “no-time”. The nature of the work is also addressed in the responses. A focus on “inspection numbers” and “reactive” response to community-based emergencies leave little dedicated time for RU, proactive planning, or to deliver the related necessary implementation efforts (Sly, 2014).

Although the importance of a theme is not solely related to the frequency of its reference by respondents, frequency does demonstrate that a particular theme is seen by a large number of the survey participants across Canada as being particularly important and warranting consideration by those with power and influence over the design and development of the structures and systems within which EHOs practice.

4.5.1.3 What Are the Things You Think Facilitate Research Utilization?

In terms of facilitators that improve research utilization, EHOs indicated the following priorities (i) access to **Emerging evidence that is relevant and applicable**, (ii) **A culture that enables organizational innovation**, and (iii) **Enough EHO practitioners to enable practice delivery while exploring the evidence**. The concept of emerging, relevant, and applicable evidence shows up frequently in the EHO responses when questioned about the facilitators of RU. From the EHO perspective, “good quality peer reviewed research that is relevant to setting” is necessary to apply evidence (Tang et al., 2015). EHOs also need access to innovations that are clearly explained and in plain language. For application to practice, EHOs must understand the innovation, its benefits, its impacts, and of equal importance, how the implementation will fit within their existing

policies and practices. Furthermore, to apply research, EHOs need evidence with “direct applicability to EHO portfolios” (Twose et al., 2008). They also need to understand the community factors that will be impacted upon by the implementation, thus having well organized pilots in various settings to understand the factors influencing uptake in communities is important. EHOs are seeking “information on other health units that have implemented new ideas/research” and evidence on how to apply that information locally. In the most basic sense, EHOs need to be aware of the evidence to apply it at all; simply having, “easy access for EHOs to get the research” is a driver of RU in practice that still needs to be implemented.

The second most frequently occurring theme relates to the work environment or context, as an enabler of RU. In this theme, the right culture to enable organizational innovation is mentioned frequently. EHOs speak of the importance of creating a work culture that supports innovation and change and the need for a work environment where, “the incorporation of research into daily inspections is both supported by management and peers and even expected”. Another notion shared by multiple EHOs is that dedicated time, “designated for reviewing, assessing, and evaluating ongoing research and development” is necessary for RU to be a part of practice and that the actual structure of the workday and the expectations of leadership about innovation and RU is a key cultural facilitator of RU (Fixsen & Blase, 2020). To truly facilitate RU in practice, evidence use must be built into the very fabric of practice. Knowing that EIDM is expected acts as a facilitator and when it is not expected and supported, it is a barrier.

Finally, EHOs indicate that there are additional important cultural influences within the work environment that influence RU. EHOs cite the presence of a “management versus staff environment”. They articulate clearly in their responses that there is a perception that “management (is) not receptive to the opinions of public health inspectors”. Creating a culture of learning that supports continuous improvement and professional development, requires respect for the input and insights of EHOs and their practice contributions, especially during emergencies (Hemsley-Brown, 2004). The role of leaders in fostering a culture that facilitates EIDM is of utmost importance to supporting RU in EHO practice in Canada, if that is truly the end goal in public health.

The third most frequently cited facilitator of RU in EHO practice focuses on having the right number of EHOs to enable practice delivery and exploration of the evidence at the same time. This concept also showed up as a top barrier to research utilization and as such, shows its overall importance to evidence informed practice. From the perspective of facilitating RU, EHO responses focused on strategies to manage time within the organization, in particular incorporating time into their daily work schedule for reviewing the evidence, including “having the time to review and discuss research” which is only possible to achieve with sufficient staffing to permit time in the workday for thinking and reading. In addition, EHOs see the value of “having dedicated staff who can properly evaluate research and conduct literature reviews on issues”. By adding resources to create “adequate staffing levels” there is the potential for “devoted time” to “review and filter information and then summarize and present to staff”. Additional time and focused efforts would allow EHOs, who spend much of their day “in the field” to network and collaborate within and across work environments, on emerging evidence and to find opportunities to apply those learnings in their work context. Finally, the notion of expectations of quality and excellence arises as an important facilitator to RU within this theme. EHOs speak about creating a culture where EHOs have “Time to research without compromising inspection time” and sufficient leeway “to review literature and identify ways to improve quality of service”.

4.5.2 Validating the Findings: Active Implementation Frameworks

Finally, to knit all of this knowledge together within the context of the best current evidence supporting the adoption of innovations within the field of implementation science, the AIFs provide a theoretical framework that is useful for guiding the implementation and adaptation of evidence in context, addressing questions about the “what”, the “how”, and the “where” to implement (Fixsen et al., 2005). AIFs are thus used to position RU in EHO practice environments in Canada amongst the broader literature in the domain of implementation science.

The top three AIFs referenced across all of the data analyzed in this study are as follows: Implementation Drivers, Systemic Change, and Usable Innovations. Previous research

findings of EHOs using the BARRIERS Scale suggested that there were other unknown barriers with an important impact on evidence use influencing EHO practice (Bourne, Kothari, Wathen, et al., 2022a). The Systemic Change Framework, as identified through the open-ended questions in this current study, is a potential key factor heavily influencing the use of evidence in the practice of EHOs in Canada, although further research is needed to confirm this fact. However, the findings in this study provide some new and useful information to guide future research. It is also important to note that all the data were successfully categorized and aligned with at least one of the AIFs. This indicates that the open-ended responses covered a broad spectrum of barriers experienced by EHOs in their work, and the AIFs show promise as a useful tool for guiding future studies related to evidence-informed decision-making by EHOs in the environmental health context in Canada.

Implementation Drivers, which focus on the resources and capacity of organizations to deliver evidence-informed policy (Fixsen & Blase, 2020), are well represented in the BARRIERS Scale and in the present findings. The EHO responses signal the importance of the Implementation Drivers Framework to the uptake of research in their practice. Implementation Drivers relate to the organizational conditions that enable EHOs to implement research in their practice. EHOs often have little flexibility to carve out their own time due to the organizational priorities often focusing on “inspection numbers” and less so on impact or outcome. For practitioners to respond effectively to changing community needs and risk, there must be sufficient time and other resources as it is critical to create space for the behaviours that lead to evidence-informed practice including networking amongst communities of practice and information sharing (Lave & Wenger, 1991; McDonald & Viehbeck, 2007; Wenger et al., 2002). All of this requires management support and strong leadership is recognized in implementation science as having a significant impact on creating a culture of work that supports evidence adoption (Lunden et al., 2019; Peirson et al., 2012; R. Williams et al., 2011).

The Systemic Change Framework is the second most frequently referenced of the AIFs in this study, introducing new insights about the barriers to, and facilitators of, RU as there were no closed-ended questions in the survey that addressed EHO barriers in this domain.

The concepts in this framework extend beyond the organizational context, and consider the structures, roles, and functions that operate across multiple organizations. In effect, the Systemic Change Framework looks at the structural and system level barriers and facilitators in which EHOs, their organizations, and the evidence itself are situated (Fixsen et al., 2017), these include the federal, provincial, and regional legislative and political structures of practice. In this study, EHOs clearly articulate the need to restructure the policies and programs that influence the delivery of environmental health services across Canada, including the need to modernize the design of legal policy that is “less prescriptive”. EHOs share notions of the barriers to and facilitators of RU that include “funding to support a broadened focus on emerging and chronic issues in EHO practice” and provide “better structures to implement protocols and oversight” at a provincial and federal level. These changes require “political”, “administrative”, and bureaucratic support at the highest of levels. EHOs provide a clear picture of the systemic barriers they find most challenging including the conflict between novel and emerging research, and its misalignment with existing prescriptive legislation. The structures and systems that exist are also of concern when dealing with complex and newly emerging issues where new information is constantly changing while legislation is fixed, and public opinion is varied (Howze et al., 2004; Kreuter et al., 2004). It is therefore critically important for environmental health “Policy makers (to use) ...research to drive changes in legislation”. Regulation, bureaucracy, and politics have been identified in the literature as being important barriers to public health innovation in previous studies (Burriss et al., 2016; Lister et al., 2017; Torvinen & Jansson, 2022). The open-ended responses in this study provide clarity around the specific systemic barriers found in the EHO context.

Lastly, the third most frequently referenced insights shared by EHOs are notions that fit within the Usable Innovations Framework which focuses on the influence of clear, adaptable, understandable, and actionable innovations to practice that facilitate the adoption of research evidence (Fixsen & Blase, 2020). The usefulness and user-friendliness of an innovation will have a clear impact on how likely it is to be adopted into practice, regardless of how beneficial it may appear to be for achieving desired outcomes (Rogers, 2003). EHOs articulate the importance of “relevance” and “good quality research that is easily applied” to their work setting as a key determinant of

evidence adoption; however, the practice and evidence needs of EHOs are varied due to the nature of their work. EHOs are responsible for delivering diverse programs, and to be successful in providing these services, they must be systems thinkers who can identify and solve complex problems to resolve health risks (Brooks et al., 2019). The ability to engage with the evidence through useful summaries, ascertain its trustworthiness, context clarity, and easy access has potential to increase evidence uptake into EHO practice in public health (Armstrong et al., 2013). The translation of evidence into practice is only possible when evidence is of sufficient quality and relevance to EHOs and their practice contexts. Research must address real gaps in environmental health knowledge to be deemed a usable innovation.

4.5.3 Comparing Barriers and Facilitators to Research Utilization in Normal and Emergency Periods

Finally, this analysis considered how the open-ended responses provided by EHOs might have changed between the years 2012 and 2020 in the hopes of understanding how the EHO perceptions of barriers to RU may have differed at the two time points. This supports the overall research goal to develop an understanding of those factors that influence RU amongst Environmental Health Officers (EHOs) working at the frontlines of public health in Canada in normal periods of work as compared to an emergency, in this case during the COVID-19 pandemic.

In 2012, more EHOs talked about and mentioned the importance having the right tools and resources to make the right decisions. This theme is categorized under the Implementation Drivers Framework and focuses on access to research evidence and systems that support practitioners in making short and long-term decisions related to their practice. It is a logical extension that during periods of normal activity EHO practitioners would want access to publications that can inform practice as well as systems and tools to make improvements to day-to-day practice and improve outcomes based on ongoing monitoring of activities.

In 2020, five themes were discussed by more individual EHOs and had more references across the data than was observed in 2012. These themes included: (i) Processes to engage the impacted community; (ii) Strong leaders to support change; (iii) Emerging evidence that is relevant and applicable; (iv) A culture that enables organizational innovation; and (v) Project, change, and implementation management. Having access to relevant and emergent evidence and having the right culture to support the implementation of those emerging practice innovations are important concerns in periods of emergency where rapid decision-making is necessary. In addition, when responding to emergencies, EHOs require strong leaders who can be relied upon to remove the barriers they are facing to applying the best evidence to allow them to perform their response efforts efficiently and effectively. EHOs need leaders who have the knowledge necessary to support implementation, either by facilitating the work or leading the incorporation of relevant evidence into environmental health practice.

Lastly, EHOs response to issues in the community and their work is greatly facilitated if the regulated or general community is on board with the proposed changes; having the means to incorporate stakeholder input into practice makes it easier for EHOs to achieve the desired outcomes associated with the implementation efforts. Major outbreaks are recognized as a particularly challenging time for staffing and workload in public health in general (Basrur et al., 2004; Wu et al., 2020), and within the field of environmental health specifically (Haas et al., 2021; Sekercioglu et al., 2020, 2021). Furthermore, Black and Indigenous communities experienced significantly worse outcomes during the initial waves of the COVID-19 pandemic, laying bare the need for increased community engagement and better public health services and supports (Huysen et al., 2022; Kemei et al., 2023). Engagement is recognized as a means to increase trust in communities experiencing greater systemic and institutional racism in the delivery of health sector programs and services (Dong et al., 2022); engagement can also lead to improved contextualization and adaptation of health sector offerings to meet community needs (Fixsen & Blase, 2020).

These five themes demonstrate the inherent barriers EHOs face in navigating the practice barriers they experience when rapid EIDM is needed to support the successful

implementation of interventions in the community setting during an emergency. These themes also reflect the ever-changing nature of the evidence during the pandemic emergency response, and the challenges experienced by EHOs in having enough time to process the changes and apply evidence in their environmental health practice (Sekercioglu et al., 2020).

4.5.4 Strengths and Limitations

Open-ended textual data in a survey does not often provide the breadth and depth of perspective gained through other methods of qualitative inquiry, such as in interviews or focus groups, where probes and follow-up questions can be asked to further define and clarify participant responses. In this research project, the open-ended data fields contained as little as one word in some cases, while in others, responses contained detailed paragraphs thoughtfully describing the barriers and facilitators to RU experienced by EHOs. Despite this limitation, this study has reported novel findings that provide a deeper understanding of the EIDM practices in the study population.

Using both inductive (thematic analysis) and deductive (categorization using the AIFs) coding in this study and using a number of analytic tools in NVivo allowed the data to be explored in new and thoughtful ways. The software was used to conduct an analysis that aligned with the survey structure through a combination of traditional and non-traditional methods. As a result, the researchers were able to highlight patterns in the data not typically used in qualitative research such as percent coverage of coding by year (Feng & Behar-Horenstein, 2019). This blend of research approaches led to new insights, including the disproportionalities in the perceptions of EHOs about the barrier to RU experienced in a normal year as compared to during the COVID-19 pandemic.

In addition, the data and its analysis were impacted by the characteristics of the participants who were willing to share their views in the survey. Contributing to open-ended questions requires more time and effort than responding to the closed-ended questions in a survey. In this particular research study, it is unclear to what degree survey respondents reflected the opinions of the people who did not respond to the survey at all, nor can we confirm differences between those who participated in the survey but

specifically did not respond to the open-ended questions. Although fewer EHOs responded to the open-ended questions in the survey in 2020, fundamentally, there was agreement across the open-ended and closed-ended EHO survey responses at both points of data collection regarding the most important barriers to RU experienced by EHOs, as participants identified the same top three barriers to RU. There was also a smaller number of respondents to the survey in 2020; however, a greater proportion of those 2020 respondents answered the open-ended questions than those who responded in 2012. This could indicate that respondents in 2020 had a higher level of interest in the subject matter or were more highly motivated to respond based on their COVID-19 work experiences, including a generally increased social awareness and sensitivity to issues of systemic and institutional racism in healthcare that were exposed during the pandemic (Dong et al., 2022; Huyser et al., 2022; Kemei et al., 2023). Conversely, there may be other unknown differences in the overall mix and characteristics of the participants in 2020 as opposed to the participants in 2012 that influenced their decision to respond to the open-ended questions and the types of responses they provided (Holland & Christian, 2009).

Finally, the data that were analyzed represent a snapshot in time amongst the individuals who responded. Some of the data being analyzed was more than five years old at the point when analysis for this study began. The snapshots taken in this study are useful as they allow us to understand, to some degree, how changing times and pressures may have influenced the barriers to RU experienced by EHOs in their practice in normal and emergency times by analyzing the data collected in two very different work contexts and points in time. It is important to note, however, that the insights gained may not represent all of the participant experiences nor all of the potential barriers to RU that EHOs face in either normal or emergency practice.

4.6 Conclusion: The Other Barriers to Research Utilization

This study of the EHO responses to the open-ended items in the BARRIERS Scale offers researchers, practitioners, and employers, two contextually diverse opportunities to understand the barriers to, and facilitators of, RU in normal and emergency practice. This analysis provides new knowledge that surpasses what was revealed through the statistical

analysis of the closed-ended survey items on their own. In fact, this study expands our understanding of the barriers to RU experienced by EHOs by incorporating ideas from EHOs themselves into the barriers to RU in EHO practice. Some of these additional learnings include the importance of systemic and structural barriers to EIDM in EHO practice, for example legislation and politics, which are used to set the framework within which EHOs perform their environmental health practice across Canada. Legislation has been identified by the EHO respondents as having a significant impact on the adoption of evidence in both normal and emergency situations. It is imperative that these types of barriers be further examined to find appropriate ways to improve the design and development of legalisation, and other systemic and structural barriers that impede the implementation of evidence into practice by EHOs. Environmental health practitioners operate in an environment of rapidly changing evidence that ought to inform best practices and the legislation that practice relies upon.

This study also reinforces and confirms that time and authority are important barriers to RU for EHOs. It reveals that typical organizational needs such as leadership, funding, and access to tools and resources that support EIDM are more important issues during normal conditions. In emergencies, access to emergent evidence, clear processes, and strong leadership, help practitioners to navigate stressful work situations and have a positive influence on the communities that EHOs and their employers seek to support and protect. This new information is important and helps in the design and development of evidence informed strategies and interventions that may improve evidence uptake in environmental health teams in both normal and emergency periods.

Finally, categorizing the data from the open-ended responses using the AIFs provides key insights into leveraging the implementation science literature to situate these findings and apply a wider body of knowledge to design and develop the innovations that fit the context of EHOs. The alignment with the themes identified in this research is an indicator, that the AIFs provide a useful theoretical approach for understanding and supporting the EIDM needs of EHOs. The long-term goal is the development of evidence informed methods to optimize and improve environmental health practice and its outcomes. The use of an evidence-informed approach to improve practice should guide

how public health makes decisions about evidence-informed practice in environmental health; there is a great deal of new information to apply in new studies within the field of implementation science. To gain further insights, more research is needed to test and gain a deeper understanding of the systemic and organizational barriers influencing EHO practice and to identify successful, evidence informed strategies to mitigate those barriers in the Canadian context and scale improvements that increase RU in the environments where EHOs practice.

4.7 References

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4.8 Appendices

4.8.1 Appendix R: 29-Items in the BARRIERS Scale and Associated AIFs

29-Items in the Barriers Scale	Associated AIFs Category
Q1 Research reports/articles are not readily available.	Organization Drivers
Q2 Implications for practice are not made clear.	Organization Drivers
Q3 Statistical analyses are not understandable.	Competency Drivers
Q4 The research is not relevant to the Environmental Health Officer's practice.	Organization Drivers
Q5 The Environmental Health Officer is unaware of the research.	Organization Drivers
Q6 The work environment is inadequate for implementation.	Leadership Drivers
Q7 The Environmental Health Officer does not have time to read research.	Organization Drivers
Q8 The research has not been replicated.	Usable Innovations
Q9 The Environmental Health Officer feels the benefits of changing practice will be minimal.	Competency Drivers
Q10 The Environmental Health Officer is uncertain whether to believe the results of the research.	Usable Innovations
Q11 The research has methodological inadequacies.	Usable Innovations

Q12 The relevant literature is not compiled in one place.	Usable Innovations
Q13 The Environmental Health Officer does not feel she/he has enough authority to change environmental health practices, policies and/or procedures.	Leadership Drivers
Q14 The Environmental Health Officer feels results are not generalizable to his/her own setting.	Competency Drivers
Q15 The Environmental Health Officer is isolated from knowledgeable colleagues with whom to discuss the research.	Competency Drivers
Q16 The Environmental Health Officer sees little benefit for self.	Competency Drivers
Q17 Research reports/articles are not published fast enough.	Usable Innovations
Q18 The Medical Officer of Health and senior managers within the organization will not cooperate with implementation.	Leadership Drivers
Q19 Administration will not allow implementation.	Leadership Drivers
Q20 The Environmental Health Officer does not see the value of research for practice.	Competency Drivers
Q21 There is not a documented need to change practice.	Competency Drivers
Q22 The conclusions drawn from the research are not justified.	Usable Innovations

Q23 The literature reports conflicting results.	Usable Innovations
Q24 Research in general is not reported clearly, in that it is not easy to read or understand.	Competency Drivers
Q25 Other staff are not supportive of implementation in general.	Leadership Drivers
Q26 The Environmental Health Officer is unwilling to change/try new ideas.	Competency Drivers
Q27 The amount of research information is overwhelming.	Competency Drivers
Q28 The Environmental Health Officer does not feel capable of evaluating the quality of the research.	Competency Drivers
Q29 There is insufficient time on the job to implement new ideas.	Organization Drivers

4.8.2 Appendix S: Analytical Themes and Conceptual Definitions and Frequency in the Data

Analytical Theme	Definition	Relevant EHO open-ended responses	No. of References
A culture that enables organizational innovation	New ways of working are prone to problems as systems, people, and processes change. These changes require an enabling culture that supports innovation	<ul style="list-style-type: none"> • “An atmosphere in which the incorporation of research into daily inspections is both supported by management and peers and even expected.” • “Never encouraged to utilize research” • “Bottom line is actual formal institutional structures is what drives utilization. Since there is no structure there will never be meaningful and timely uptake.” 	80
Adequate funding to deliver	Funding allocations adequate to maintain	<ul style="list-style-type: none"> • “Providing access to research 	19

Analytical Theme	Definition	Relevant EHO open-ended responses	No. of References
evidence-informed practice	and increase services based on current needs and support implementation efforts	<p>databases to all EHO's. Currently I have no access to reputable research databases or journals”</p> <ul style="list-style-type: none"> • “Lack of funding to implement changes based on research findings” • “Employer based professional development” 	
Clear pathways to successful implementation	Having an implementation plan and an organization structured to carry it out with steps that EHO practitioners can follow. Knowing how to apply evidence or a practice innovation through a process that is recognized across the organization to create rigour and a	<ul style="list-style-type: none"> • “A health unit program as we have at Peel Public Health in Ontario where we are focused on EIDM will definitely facilitate research.” • “Designated research office within health unit function to 	24

Analytical Theme	Definition	Relevant EHO open-ended responses	No. of References
	clear approvals pathway	<p>facilitate research and pilot results”</p> <ul style="list-style-type: none"> • “Ability to make decisions/provide input in the way things are done” 	
Strong leaders to support change	Environmental health leadership that is identified and nurtured to support continuous improvement and sustain good outcomes in simple, complicated, complex, and chaotic leadership contexts. Professional respect from leaders regarding EHO practice, environmental health issues, and their importance at the population level.	<ul style="list-style-type: none"> • “Interest and knowledge of EH work by employer and MOHs” • “Lack of formal leadership training.” • “Openness by senior management to adjust approaches to work based on evidence.” 	19
EHO practitioners in sufficient numbers to enable	Sufficient number of EHO practitioners for current workload	<ul style="list-style-type: none"> • “A large portion of the work of EHOs is reactive 	81

Analytical Theme	Definition	Relevant EHO open-ended responses	No. of References
practice delivery while exploring the evidence	requirements and to dedicate time to implementation efforts	<p>(compared to work of other public health professions e.g., nurses), thus EHOs have little time to contribute to the research”</p> <ul style="list-style-type: none"> • “Staff are overworked and have no time” • “Reasonable staffing levels” 	
Embed practice review and information sharing in day-to-day practice	Structured processes for implementation, identifying opportunities for innovation, rationalizing change acceptance based on the evidence, and providing resources to support implementation is critical to implementation success. Structured	<ul style="list-style-type: none"> • “policies/practices in place that encourage EHOs to bring forward research findings that they have read about” • “Organizational requirement to conduct situational assessments for specific programs that requires review of evidence-based 	30

Analytical Theme	Definition	Relevant EHO open-ended responses	No. of References
	<p>processes are transparent and provide a pathway to implementation.</p>	<p>research to support changes to the way programs are implemented.”</p> <ul style="list-style-type: none"> • “Need organizational round tables for evolution of ideas that is owned by all participating.” 	
<p>Emerging evidence that is relevant and applicable</p>	<p>New evidence and relevant practice innovations deviate from normal practice. Practitioners need to understand the evidence’s relevance to practice, implementability, risks associated with implementation, and expected outcomes for incorporation into service delivery. EHOs must understand how novel approaches differ from</p>	<ul style="list-style-type: none"> • “Research often does not apply to the variables found in the real world” • “Public health research has focused primarily on health outcomes (infectious diseases and chronic diseases) rather than knowledge and behaviour change e.g., safe food handling practices, 	<p>77</p>

Analytical Theme	Definition	Relevant EHO open-ended responses	No. of References
	the standard to support adoption. Most importantly they must be aware of the evidence.	<p>environmental exposures”</p> <ul style="list-style-type: none"> • “Good solid research that is easily applied to your work environment.” 	
Evidence that meets expectations of quality	Decision-making about adopting new evidence or practice changes requires clear information to allow a practitioner to decide whether the evidence can be relied upon in the context and with the population or practice where it will be applied.	<ul style="list-style-type: none"> • “Reports that have no direction” • “Research does not extend to actions/solutions for issues. (EHO's are action oriented.)” • “Simplify information, include recommendations on how to implement changes” 	46

Analytical Theme	Definition	Relevant EHO open-ended responses	No. of References
Implementation expertise	Implementation expertise requires knowledge of how to identify, synthesize, incorporate, and embed organizational, process, people, and system changes efficiently and effectively. Expertise includes knowing how to make change "stick".	<ul style="list-style-type: none"> • “Specialized positions or staff or organizations that look for research and disseminate the information and applications to practice” • “EHO Program Coordinators” • “Having someone at the health unit (especially the smaller health units) that can help to facilitate the process and aid the PHI” 	19
Leadership support for evidence-informed practice	Transformative decision-makers who show leadership by directing, protecting, and providing clear processes or paths for innovation. Creating a culture of innovation	<ul style="list-style-type: none"> • “Environmental Health is not a priority at my agency” • “Support from employers: we need to make using 	64

Analytical Theme	Definition	Relevant EHO open-ended responses	No. of References
	<p>throughout the organization. Engaged leadership with technical environmental health knowledge that can support evidence application in complex situations where there may be uncertainty and varied opinions</p>	<p>evidence the baseline expectation, not the ‘bonus’”</p> <ul style="list-style-type: none"> • “Having management support to identify and address gaps in current practice with evidence-based best practices” 	
<p>Legislative Policy, Programs, and services</p>	<p>Regulatory policy, programs, and services intended to deliver the safe and consistent application of public health interventions is often slow to change and reflect the best evidence, thus policies, program, and services do not often reflect the current and emerging evidence about risk and</p>	<ul style="list-style-type: none"> • “New findings conflict with existing regulations which by law must be followed/enforced” • “We are often confined by the regulation and act. There isn't a lot of space to implement new evidence in our decision making” 	<p>91</p>

Analytical Theme	Definition	Relevant EHO open-ended responses	No. of References
	prevention in environmental health	<ul style="list-style-type: none"> • “The dramatic difference/gap between what is reported from research and what we know today prevents implementation of the research where there is no bridge shown to exist between the old knowledge and the new knowledge.” 	
Political and structural barriers	Changing the status quo when there are competing interests or demands	<ul style="list-style-type: none"> • “When external pressures (public perception, politics) are a higher priority or conflict with research” • “Some changes based on research are politically unpopular” • “Political interference” 	82

Analytical Theme	Definition	Relevant EHO open-ended responses	No. of References
<p>Processes to engage the impacted community</p>	<p>Including stakeholders who are delivering the change and who are impacted by the implementation increases the likelihood of success as defined by the project.</p>	<ul style="list-style-type: none"> • “Industry forcing the regulatory community to recognize and assess new research.” • “Partnerships with industry creating centres of excellence with health authorities and schools of environmental health” • “Consultation between researchers and EHOs at the point where research questions are being formulated and research methods developed” 	<p>15</p>

Analytical Theme	Definition	Relevant EHO open-ended responses	No. of References
Project, change, and implementation management leads	Implementation leads act to review research, engage stakeholders, incorporate feedback, identify supports, project, and change management, team development, and facilitate adoption.	<ul style="list-style-type: none"> • “Having dedicated staff who can properly evaluate research and conduct literature reviews on issues.” • “Need a way to flag pertinent research studies that have been published or underway” • “Application of specific disciplines such as evaluation specialists and project managers.” 	21
Strategic management of long-term implementations	Implementation processes occur over time; the more complex a solution (e.g., politically, contextually, socially, etc.), the longer an implementation may take. A strategy provides a plan of	<ul style="list-style-type: none"> • “The process to review and change the regulations that we work under is too political and therefore things never change” • “Research must be peer reviewed, 	16

Analytical Theme	Definition	Relevant EHO open-ended responses	No. of References
	<p>action to achieve goals, in this case the use of evidence to inform practice. Implementation requires a commitment and strategy that that must be sustained over time and extend beyond leadership cycles.</p>	<p>repeatable and then the provincial government must use this to modify and update regulations and acts to reflect the evidence”</p> <ul style="list-style-type: none"> • “Extensive time is required to compile the research and develop the changes into local policy/guidelines” 	
<p>Support practitioner access to knowledge networks</p>	<p>EHO practitioners seek input and collaboration on complex environmental health issues within their social networks. Communities of practice form both organically and in structured ways and require organizational support.</p>	<ul style="list-style-type: none"> • “There is not enough information sharing scenarios (conferences, workshops, videoconferences) that present new and innovative research. There is a tremendous amount of incredibly valuable research out there that the 	<p>32</p>

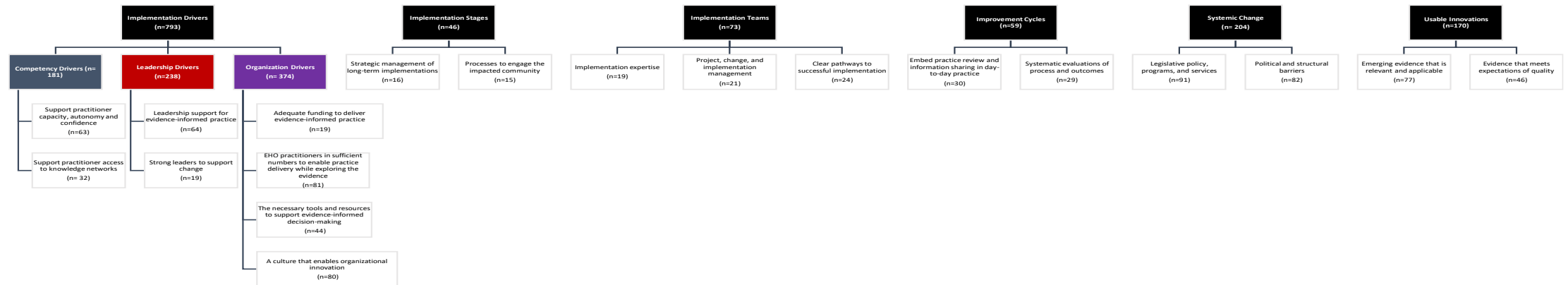
Analytical Theme	Definition	Relevant EHO open-ended responses	No. of References
		<p>EHO has never even heard of”</p> <ul style="list-style-type: none"> • “Collaboration and discussion with others in similar professional capacities” • “The establishments of groups like the NCCEH (National Collaborating Centre for Environmental Health) and journal clubs/meetings to discuss papers/topics” 	
<p>Support practitioner capacity, autonomy, and confidence</p>	<p>EHO use of evidence in practice is influenced by the level of knowledge and direct experience with knowledge translation and critical thinking on the job.</p>	<ul style="list-style-type: none"> • “Not sure where to look” • “Having the expertise to interpret the research and the knowledge and expertise to 	<p>63</p>

Analytical Theme	Definition	Relevant EHO open-ended responses	No. of References
	<p>Practitioners require self-confidence and a sense of support from their managers and peers. These factors influence the perceived safety of applying evidence in every-day and emergency situations (e.g., comfort making judgement calls based on criteria)</p>	<p>translate the findings to practice”</p> <ul style="list-style-type: none"> • “I also observe a lack of a desire to learn from many inspectors after many years of service to the public. Some inspectors are happy-enough to keep plugging along as they have for the last 15 - 20 - 25 years with no desire to learn something new or do anything different. This can be frustrating for trying to implement change and to ensure some level of consistency between inspectors and between regions.” 	

Analytical Theme	Definition	Relevant EHO open-ended responses	No. of References
Systematic evaluations of processes and outcomes	Evaluations, or check points for determining success, ensures that implementations are suitable, adapted, adjusted, or tailored based on current and ever-changing data and contexts.	<ul style="list-style-type: none"> • “A good understanding of the current situation and whether changes are required/desirable based on quality research findings.” • “Program planning including constant evaluation” • “Evaluative tools and process of evaluating the relevancy or outcome of current practice” 	29
The necessary tools and resources to support evidence-informed decision-making	Access to data and systems to support practitioner for immediate, short, or long-term decision making that is evidence based	<ul style="list-style-type: none"> • “Access - Great Extent” • “Many health units focus on medical and nursing publications vs. environmental 	44

Analytical Theme	Definition	Relevant EHO open-ended responses	No. of References
		<p>health journals, so full articles maybe unavailable or personally expensive to attain”</p> <ul style="list-style-type: none"> • “Money to change a program including educational materials.” 	

4.8.3 Appendix T: Hierarchical Diagram of the Alignment of AIFs



4.8.4 Appendix U: Matrix Analysis of Other BARRIERS to RU by Themes and Categories

Active Implementation Frameworks and Associated Themes	Other Barriers to Research Utilization Reference #1	Other Barriers to Research Utilization Reference #2	Other Barriers to Research Utilization Reference #3	Total Number of References
1: Implementation Drivers	65	49	27	141
A: Competency Drivers	14	13	6	33
Support practitioner access to knowledge networks	5	3	1	9
Support practitioner capacity, autonomy, and confidence	9	10	5	24
B: Leadership Drivers	13	13	10	36
Leadership support for evidence-informed practice	12	13	10	35
Strong leaders to support change	1	1	2	4

Active Implementation Frameworks and Associated Themes	Other Barriers to Research Utilization Reference #1	Other Barriers to Research Utilization Reference #2	Other Barriers to Research Utilization Reference #3	Total Number of References
C: Organization Drivers	42	33	20	95
A culture that enables organizational innovation	8	17	8	33
Adequate funding to deliver evidence-informed practice	4	3	5	12
Enough EHO practitioners to enable practice delivery while exploring the evidence	22	10	6	38
The necessary tools and resources to support evidence-informed decision-making	13	5	1	19
2: Implementation Stages	5	6	2	13
Processes to engage the impacted community	0	2	1	3

Active Implementation Frameworks and Associated Themes	Other Barriers to Research Utilization Reference #1	Other Barriers to Research Utilization Reference #2	Other Barriers to Research Utilization Reference #3	Total Number of References
Strategic management of long-term implementations	5	4	1	10
3: Implementation Teams	0	4	2	6
Clear pathways to successful implementation	0	0	2	2
Implementation expertise	0	4	0	4
Project, change, and implementation management	0	1	0	1
4: Improvement Cycles	5	2	3	10
Systematic evaluations of processes and outcomes	2	2	1	5
Embed practice review and information sharing in day-to-day practice	3	1	2	6
5: Systemic Change	52	24	16	92

Active Implementation Frameworks and Associated Themes	Other Barriers to Research Utilization Reference #1	Other Barriers to Research Utilization Reference #2	Other Barriers to Research Utilization Reference #3	Total Number of References
Political and structural barriers	22	9	16	47
Legislative Policy, Programs, and services	37	19	4	60
6: Usable Innovations	23	13	7	43
Emerging evidence that is relevant and applicable	14	9	3	26
Evidence that meets expectations of quality	9	4	5	18

4.8.5 Appendix V: Matrix Analysis of Facilitators of RU by Themes and Categories

Active Implementation Frameworks and Associated Themes	Total Number of References
1: Implementation Drivers	175
A: Competency Drivers	61
Support practitioner access to knowledge networks	23
Support practitioner capacity, autonomy, and confidence	39
B: Leadership Drivers	43
Leadership support for evidence-informed practice	29
Strong leaders to support change	15
C: Organization Drivers	101
A culture that enables organizational innovation	47
Adequate funding to deliver evidence-informed practice	7
EHO practitioners in sufficient numbers to enable practice delivery while exploring the evidence	43
The necessary tools and resources to support evidence-informed decision-making	25
2: Implementation Stages	17

Processes to engage the impacted community	12
Strategic management of long-term implementations	6
3: Implementation Teams	44
Clear pathways to successful implementation	22
Implementation expertise	15
Project, change, and implementation management	20
4: Improvement Cycles	42
Embed practice review and information sharing in day-to-day practice	24
Systematic evaluations of processes and outcomes	24
5: Systemic Change	58
Political and structural barriers	35
Legislative policy, programs, and services	31
6: Usable Innovations	70
Emerging evidence that is relevant and applicable	51
Evidence that meets expectations of quality	28

4.8.6 Appendix W: Crosstab Analysis of NVivo Coding of Cases by Year

NVivo Nodes	Cases Coded at Node			Percent of References at Node (cases coded/all cases by node)		
	2012 (311)	2020 (82)	Total (393)	2012 (311)	2020 (82)	Total (393)
Implementation Drivers	179	56	235	76.2%	23.8%	100%
Competency Drivers	93	32	125	74.4%	25.6%	100%
Support practitioner access to knowledge networks	19	9	28	67.9%	32.1%	100%
Support practitioner capacity, autonomy, and confidence	34	16	50	68.0%	32.0%	100%
Leadership Drivers	120	28	148	81.1%	18.9%	100%
Leadership support for evidence-informed practice	37	15	52	71.2%	28.9%	100%
Strong leaders to support change	8	8	16	50.0%	50.0%	100%
Organization Drivers	133	44	177	75.1%	24.9%	100%

NVivo Nodes	Cases Coded at Node			Percent of References at Node (cases coded/all cases by node)		
	2012 (311)	2020 (82)	Total (393)	2012 (311)	2020 (82)	Total (393)
A culture that enables organizational innovation	40	25	65	61.5%	38.5%	100%
Adequate funding to deliver evidence-informed practice	14	3	17	82.4%	17.7%	100%
EHO practitioners in sufficient numbers to enable practice delivery while exploring the evidence	43	22	65	66.2%	33.9%	100%
The necessary tools and resources to support evidence-informed decision-making	30	5	35	85.7%	14.3%	100%
Implementation Stages	26	14	40	65.0%	35.0%	100%
Processes to engage the impacted community	7	7	14	50.0%	50.0%	100%
Strategic management of long-term implementations	9	5	14	64.3%	35.7%	100%

NVivo Nodes	Cases Coded at Node			Percent of References at Node (cases coded/all cases by node)		
	2012 (311)	2020 (82)	Total (393)	2012 (311)	2020 (82)	Total (393)
Implementation Teams	36	16	52	69.2%	30.8%	100%
Clear pathways to successful implementation	16	8	24	66.7%	33.3%	100%
Implementation expertise	14	5	19	73.7%	26.3%	100%
Project, change, and implementation management	12	8	20	60.0%	40.0%	100%
Improvement Cycles	28	13	41	68.3%	31.7%	100%
Embed practice review and information sharing in day-to-day practice	17	8	25	68.0%	32.0%	100%
Systematic evaluations of process and outcomes	17	10	27	63.0%	37.0%	100%
Systemic Change	73	29	102	71.6%	28.4%	100%
Political and structural barriers	45	20	65	69.2%	30.8%	100%

NVivo Nodes	Cases Coded at Node			Percent of References at Node (cases coded/all cases by node)		
	2012 (311)	2020 (82)	Total (393)	2012 (311)	2020 (82)	Total (393)
Legislative policy, programs, and services	49	17	66	74.2%	25.8%	100%
Usable Innovations	73	31	104	70.2%	29.8%	100%
Emerging evidence that is relevant and applicable	39	22	61	63.9%	36.1%	100%
Evidence that meets expectations of quality	27	9	36	75.0%	25.0%	100%
Total (unique)	194	62	256	75.8%	24.2%	100%

4.8.7 Appendix X: Crosstab Analysis of Coding References at Node by Year

NVivo Node	Coding References at Node			Coding References by all References at the Node		
	2012 (311)	2020 (82)	Total (393)	2012 (311)	2020 (82)	Total (393)
Implementation Drivers	552	150	702	78.6 %	21.4 %	100%
Competency Drivers	138	42	180	76.7 %	23.3 %	100%
Support practitioner access to knowledge networks	23	9	32	71.9 %	28.1 %	100%
Support practitioner capacity, autonomy, and confidence	40	23	63	63.5 %	36.5 %	100%
Leadership Drivers	182	52	234	77.8 %	22.2 %	100%
Leadership support for evidence-informed practice	44	20	64	68.8 %	31.3 %	100%
Strong leaders to support change	9	10	19	47.4 %	52.6 %	100%
Organization Drivers	263	82	345	76.2 %	23.8 %	100%

NVivo Node	Coding References at Node			Coding References by all References at the Node		
	2012 (311)	2020 (82)	Total (393)	2012 (311)	2020 (82)	Total (393)
A culture that enables organizational innovation	49	31	80	61.3%	38.8%	100%
Adequate funding to deliver evidence-informed practice	15	4	19	79.0%	21.1%	100%
EHO practitioners in sufficient numbers to enable practice delivery while exploring the evidence	55	26	81	67.9%	32.1%	100%
The necessary tools and resources to support evidence-informed decision-making	38	6	44	86.4%	13.6%	100%
Implementation Stages	30	15	45	66.7%	33.3%	100%
Processes to engage the impacted community	7	8	15	46.7%	53.3%	100%
Strategic management of long-term implementations	11	5	16	68.8%	31.3%	100%
Implementation Teams	40	18	58	68.8%	31.0%	100%

NVivo Node	Coding References at Node			Coding References by all References at the Node		
	2012 (311)	2020 (82)	Total (393)	2012 (311)	2020 (82)	Total (393)
Clear pathways to successful implementation	16	8	24	66.7 %	33.3 %	100%
Implementation expertise	14	5	19	73.7 %	26.3 %	100%
Project, change, and implementation management	13	8	21	61.9 %	38.1 %	100%
Improvement Cycles	36	16	52	69.2 %	30.8 %	100%
Embed practice review and information sharing in day-to-day practice	19	10	29	65.5 %	34.5 %	100%
Systematic evaluations of process and outcomes	20	10	30	66.7 %	33.3 %	100%
Systemic Change	134	47	181	74.0 %	26.0 %	100%
Political and structural barriers	55	27	82	67.07 %	32.9 %	100%
Legislative policy, programs, and services	69	22	91	75.8 %	24.2 %	100%

NVivo Node	Coding References at Node			Coding References by all References at the Node		
	2012 (311)	2020 (82)	Total (393)	2012 (311)	2020 (82)	Total (393)
Usable Innovations	114	43	157	72.6 %	27.49 %	100%
Emerging evidence that is relevant and applicable	47	30	77	61.0 %	39.0 %	100%
Evidence that meets expectations of quality	36	10	46	78.3 %	21.7 %	100%
Total	2069	737	2806	73.7 %	26.2 %	100%

Chapter 5

5 Understanding the Barriers to and Facilitators of Research Utilization in the Practice of Environmental Health Officers in Canada: Integrated Study Findings

5.1 Introduction

In this thesis, a mixed methods approach was used to understand, the barriers and facilitators to research utilization (RU) identified by Canadian Environmental Health Officers (EHOs) followed by a triangulation of findings across the studies (Creswell & Plano Clark, 2011). The data were collected at two points in time to understand the differences between EHO perceptions of the barriers to RU changed in normal as compared to emergency work conditions. The study was designed to answer the following three questions:

- i. How do EHO practitioner perceptions of the barriers to RU change during an emergency?
- ii. What factors influence evidence use during an emergency?
- iii. What can be done to ensure access to evidence and support effective and appropriate practice decision-making?

These questions were answered by inviting EHOs across Canada to participate in an online survey using the Barriers to Research Utilization Scale (BARRIERS Scale) (Funk et al., 1991). The BARRIERS Scale, previously tested in multiple studies in nursing and allied health care fields (Athanasakis, 2013; Carlson & Plonczynski, 2008; Kajermo et al., 2010), was disseminated to EHOs across Canada, once in 2012 during a normal work year and again in 2020 during the COVID-19 pandemic (Bourne, Kothari, Wathen, et al., 2022b). In response, there were 311 survey participants in 2012, of whom 196 (63%) respondents answered the three open-ended survey items (Bourne, Kothari, Wathen, et

al., 2022a). In 2020, there were a total of 82 respondents, of whom 63 (77%) responded to the open-ended items (Bourne, Kothari, Polzer, et al., 2022). In this final thesis chapter, the outcomes and significance of the three individual studies in this body of work are overviewed and the quantitative and qualitative findings integrated to present overall findings and contributions of this body of work to the fields of environmental health, knowledge translation research, and implementation science; opportunities for future research and the implications of the study for the scientific community (Lewis et al., 2021). The findings were analyzed using the Active Implementation Frameworks (AIFs), which were developed to expand knowledge about the factors influencing the application of research evidence in practice and methods to effectively support the adoption of evidence (Fixsen & Blase, 2020). The AIFs take a comprehensive look at the factors influencing RU, including factors related to the evidence, processes, organization, leadership, and the systems and structures within which the barriers exist.

5.2 Study Findings and Significance

A recent study showed that almost 90% of EHO respondents reported that they use evidence, in that they reviewed literature, and accessed resources from trusted sources like governmental organizations, colleagues, and other professional associations, to support decision-making in their daily practice (Tang et al., 2015). This research demonstrates the level of reliance on evidence across the profession and its importance to EHO practice. This thesis builds on this knowledge by uncovering the barriers that affect EHO use of evidence and how those barriers compare when considering two important work conditions: decision-making in typical day-to-day practice and during a large-scale emergency.

The objectives and key findings of each of the three studies that comprise this thesis are summarized and discussed below:

5.2.1 Study One: Canadian Environmental Health Officer Perceptions of Barriers to Research Utilization in Everyday and Emergency Practice

Objectives: To report the quantitative findings from the analysis of the EHO responses to the 29 closed-ended questions in the BARRIERS Scale to (i) understand the barriers to research utilization experienced by Canadian EHOs in their everyday work and (ii.) determine how these barriers change in the context of emergency practice.

Method: Responses were analyzed using measures of central tendency. Data collection occurred during a normal period of work in 2012 (311 respondents) and during the COVID-19 pandemic in 2020 (82 respondents). The Mann–Whitney U-test was used to determine if there was a statistically significant difference between the responses to the BARRIERS Scale in 2012 and 2020.

Key Findings: Mean ratings were not statistically different in 2012 and 2020, indicating that in the normal work year and during the COVID-19 Pandemic, EHOs indicated that the greatest barriers to RU in practice were:

- i. lack of authority to implement changes to practice,
- ii. lack of time to review research, and
- iii. lack of time to implement research findings.

Conclusion: In general, lack of authority, lack of time to review research, and lack of time to implement findings, are embedded barriers for EHOs regardless of whether their practice is occurring in typical work conditions or a large-scale emergency.

5.2.2 Study Two: The Dimensional Structure of the BARRIERS Influencing EHO Evidence Informed Practice Decisions in Canada

Objective: To investigate the dimensional structure of the responses of EHOs to the BARRIERS Scale to (i) find relationships between variables in the data; (ii) simplify the data in its entirety for further analysis; and (iii) provide new ways to interpret and visualize the data to the gain additional knowledge about the factors influencing research utilization by EHOs in Canada.

Method: Principal Component Analysis (PCA) was used to analyze the dimensional structure of the EHO responses and develop a structural equation model (SEM) of the EHO responses to the BARRIERS Scale collected in 2012 (n=311), meaning that the variables were reduced into related clusters of information known as components, or more commonly as factors. The resultant factors were categorized deductively using the AIFs to describe the relationships between the items contained in each factor. Confirmatory Factor Analysis was then used to determine goodness of fit of the SEM that had been developed when assessed against the data collected in 2020 (n=82).

Findings: A four factor solution was identified, and the resultant SEM aligned with the following AIFs: Competency Drivers, Useful Innovations, Leadership Drivers, and Organization Drivers. The SEM was found to explain 52% of the loading variation, meaning that the four factors capture a satisfactory amount of the information from the original 29 variables in the new SEM. This SEM created from the EHO responses in this study, and a second based on the original factors identified when the BARRIERS Scale was developed, were both analyzed for Goodness of Fit with the data collected from EHOs in 2022. The Goodness of Fit test results showed that both models provide a statistically sound but imperfect fit with the 2020 data; however, the model based on the 2012 data provided a significantly better fit and hence is a better model for understanding the EHO barriers to RU.

Conclusion: The four factors provide a useful way of thinking about and approaching the development of interventions that can be applied to improve the uptake of research evidence and thereby innovations in EHO practice. Three of the factors aligned with the sub-drivers that make up the Implementation Drivers Framework (Competency Drivers, Leadership Drivers, and Organization Drivers) and the fourth factor was associated with the Useful Innovations Framework. This indicates that the BARRIERS Scale does not address four of the frameworks that make up the AIFs which can be used to explain the imperfect fit observed by testing Goodness of Fit with the 2020 data. These theoretical gaps identified in the model indicate that more research is needed to understand the research to practice gaps and what information is missing from our understanding about the barriers to RU experienced by EHOs.

5.2.3 Study Three: Barriers to Research Utilization Experienced by Environmental Health Officers in Canada as Revealed Through the Open-Ended Questions of the BARRIERS Scale

Objective: To report the qualitative findings from the analysis of the EHO responses to the three open-ended questions in the BARRIERS Scale. The purpose of this study is to (i) understand the other barriers to RU experienced by Canadian EHOs in their everyday work not captured in the BARRIERS Scale and (ii.) determine how these other barriers to RU change in the context of emergency practice.

Method: Responses were analyzed using qualitative methods. In 2012, 196 (63%) of survey participants answered at least one of the three open-ended questions and in 2020, during the COVID-19 Pandemic, 63 (77%) of survey respondents answered the open-ended questions. Open-ended questions two and three were thematically analyzed and 19 utilization focus themes for supporting evidence-informed practice were identified. All open-ended responses to item one and the themes were categorized using the AIFs. Word frequency, matrix coding, and cross-tabulation were used to answer the research questions and analyze differences in the EHO responses in 2012 as compared to 2020.

Findings: The top three themes arising from the data were: (i) Legislative policy, programs, and services; (ii) Political and structural barriers, and (iii) EHO practitioners in sufficient numbers to enable practice delivery while exploring the evidence. In addition, the most frequently identified barriers aligned with the following AIFs: (i) Implementation Drivers Framework, the (ii) Systemic Change Framework, and the (iii) Usable Innovations Framework.

Differences were noted between the open-ended responses in 2012 and 2020 which showed the relative importance of the theme: (i) The necessary tools and resources to support evidence-informed decision-making (EIDM) in 2012. Whereas in 2020, the following five themes were more frequently referenced: (i) Processes to engage the impacted community; (ii) Strong leaders to support change; (iii) Emerging evidence that is relevant and applicable; (iv) A culture that enables organizational innovation; and (v) Project, change, and implementation management.

Conclusion: EHOs experience several systemic barriers to RU including barriers related to legislation, politics, and broad policy approaches. These are in addition to the organizational barriers (e.g., sufficient human resource, time, tools, and funding); leadership barriers (e.g., management and executive support), and the innovation barriers (e.g., relevance and clarity) previously identified in the research. During emergencies, EHOs need easy access to emergent evidence and pathways to facilitate the implementation of those emergent findings into practice including engagement with impacted communities. Whereas, in non-emergency periods of practice, the need for tools and resources to support EIDM by EHOs are referenced more frequently by EHOs.

5.3 Integrated Findings

Each of the three studies that comprise this thesis have inherent strengths on their own and were employed to contribute to the goal of answering the research questions and producing relevant and useful information. Descriptive statistical analysis was conducted using the closed-ended survey questions in study one. Through this analysis the top three barriers to RU were identified; these findings were found to be statistically significant

and have sufficient statistical power to support the findings. Through PCA, a large volume of data with multiple variables, in this case the 29-variables in the BARRIERS Scale, was reduced into smaller factors that reduced redundancy in the data and made the data more understandable and useful to practitioners interested in applying a comprehensive plan to improve the uptake of evidence by EHOs. Lastly, the use of qualitative thematic analysis to analyze the open-ended item responses in this study resulted in new utilization focused themes from the EHO responses to identify other barriers and facilitators to RU. These responses were leveraged to build on the insights gained from the closed-ended questions, and these answers identified many more opportunities for supporting EIDM in environmental health. This was further enhanced by categorizing the responses and the themes within the AIFs. This deductive process allowed the themes to be aligned with a recognized theoretical framework in the field of implementation science, resulting in the novel findings about the importance of systemic barriers to evidence use experienced by EHOs. Overlaying the deductive and inductive approaches, provided strong insights into the barriers and facilitators of RU, while allowing the research to be more easily replicated by other researchers and evaluated across multiple fields, jurisdictions, and across time (See Figure 1 for a summary of the integration of methodology and methods used in this study). It also allowed the findings to be assessed theoretically against the frameworks included in the AIFs.

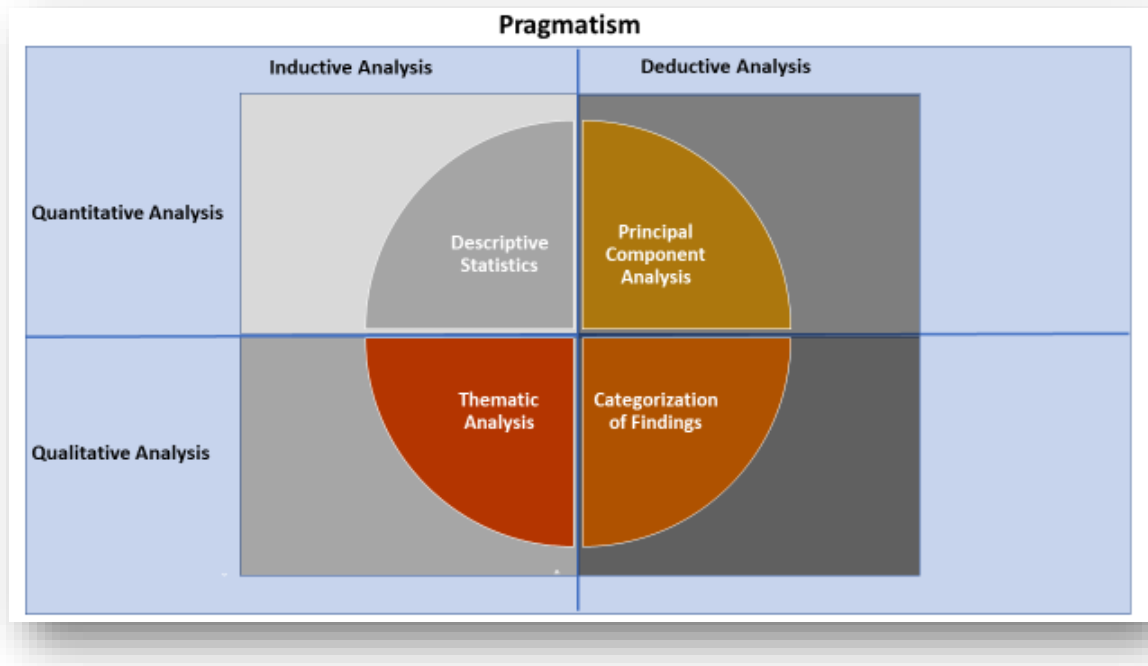


Figure 1: Summary of the Integration of Methodology and Methods Used across the Studies.

Separately, the three studies answer specific questions about the perceived barriers to RU experienced by EHOs in a pandemic and in normal years of working and provide insights into how to best support the use of evidence in EHO practice. These insights are generalized below as four novel contributions to understanding the barriers to and facilitators of RU in Canada, including:

- i. The three greatest barriers to RU in Canadian EHO practice are a lack of authority to implement changes to practice, lack of time to review research, and lack of time to implement research findings (Bourne, Kothari, Wathen, et al., 2022b). These barriers are embedded in the contexts of EHO practice and there is no statistically significant difference between these key barriers in normal conditions as compared to during the emergency conditions of the COVID-19 pandemic. These findings provide three focused targets for interventions for researchers and practitioners who seek to improve the uptake of evidence by EHOs in Canada.

- ii. That in general, the Implementation Drivers Framework, including Organizational Drivers (e.g., allocation of staff time, adequate staffing, access to information), and Leadership Drivers (e.g., support for evidence-informed practice, championship of change, granting authority for decision-making at the appropriate level), contains the most crucial factors influencing the adoption of research evidence in EHO practice according to the AIFs (Fixsen & Blase, 2020). This research finding provides necessary evidence to support the design and development of interventions that target the organization and have the potential to increase and sustain evidence-informed practice by EHOs in Canada both in normal and emergency conditions. These findings, arise from dimensional analysis and are supported by the thematic analysis and were guided by a theory-driven analysis.
- iii. Systemic barriers are the second most important type of barrier to EHO evidence-informed practice across Canada. Systemic barriers were not captured in the closed-ended items of the BARRIERS Scale but were identified through thematic analysis of the open-ended responses. Although not quantified, the consistency with which these barriers were cited in the open-ended questions, revealed the scope and permeation of this barrier as important to EHOs in Canada. Systemic barriers that influence the uptake of evidence in the practice of EHOs include legislation, policy, and the slow government structures and processes that resist change (e.g., the legislative policy process). In addition, through their open-ended responses, EHOs bring light to the impact of political influence in the implementation process. Politicians and impacted members of the public may have opinions and mandates that do not align with the best available research evidence. These barriers can affect the ability of EHOs to implement the best available evidence, regardless of its strength of findings, quality, or relevance.
- iv. The fact that although the top three barriers to RU are consistent in emergency and non-emergency conditions, there are insights gleaned from thematic analysis that can be used to inform strategic interventions designed to improve information uptake in emergencies. These insights reveal that a lack of: access to emergent and relevant evidence, change supportive culture and leadership, project and change professionals

to manage change implementation efforts, and means to engage with impacted partners, all have negative impacts on evidence-informed practice by EHOs in emergencies in Canada. In non-emergency situations, lack of access to tools and information, are more frequently cited barriers to RU.

5.3.1 Integrated Strengths

This study sought to answer a specific set of research questions about a unique population of public health professionals in Canada. To achieve this goal, it was necessary to find a respected tool to collect data that would meet the philosophical aims of the researcher to generate research findings that are useful to EHO practitioners, bureaucrats, policy makers, leaders in public health, and the research community. The overarching intent is to drive continuous improvement in the field. The BARRIERS Scale, initially identified as appropriate for this study in 2010, is the data collection tool that is the basis of the three studies that make-up this thesis, and each study extends the knowledge base about the EIDM practices of EHOs.

There are strengths across the body of work including the fact that approaches used in this study are philosophically pragmatic (Patton, 1997). This research has a utilisation focus which includes using the best methods to answer the core research questions in the most informative, reliable, and trustworthy manner. This study provides a descriptive and evocative source of information that builds on each study to support decision-making about the best ways to achieve EIDM in EHO practice. The use of deductive categorization of data across the quantitative and qualitative data, with aid of a sound theoretical framework in the AIFS, allows for the findings to be triangulated, improving the overall trustworthiness of the results (Creswell & Plano Clark, 2011; Fixsen & Blase, 2020). Most importantly, by utilizing both quantitative and qualitative methods across the studies in this thesis, the integrated conclusions of the overall thesis are better positioned to inform practice, policy, and decision-making through multi-level, multi-pronged insights that are likely to succeed in driving the desired improvements to practice.

5.3.2 Integrated Limitations

Although, this study robustly answers the three research questions, findings must be considered in light of study limitations inherent in any mixed-methods body of work. This is true both within the individual studies and across them as a set.

First, data were collected using an online survey at two points in time. While the cross-sectional snapshots provide useful information about these two periods; they do not cover how those views may have changed over time as would be the case had data been collected using a longitudinal approach. The number of respondents during the COVID-19 pandemic was significantly lower than when data were collected originally, which is assumed to be due to increased strain and pressure of having to respond to the pandemic; however, the quantitative findings met statistical thresholds and the qualitative findings were meaningful and resulted in added information for decision-making. Furthermore, because the data were only collected using a survey tool, the research does not benefit from the types of knowledge that can be generated using different methods and methodologies of data collection (Creswell & Plano Clark, 2011). For example, interviews or an observational study might have provided more insights not only into the barriers to and facilitators of RU, but also other opportunities to improve outcomes.

5.4 Implications for Future Research

By combining quantitative and qualitative methods, a deeper understanding is gained of the barriers to RU experienced by EHOs in Canada and these learning can be used to guide future research efforts related to EIDM in Canada.

5.4.1 Understanding EHO Barriers to Research Utilization

Although this novel research is informative, more research is needed to confirm the applicability of these factors for guiding the development of interventions to support RU amongst EHOs in their unique practice environment. A deeper dive into the specific barriers to RU in the Canadian context, particularly in those areas not captured in the

BARRIERS Scale, can further support practitioners in applying evidence to their public health work. This involves:

- (i) Research further probing the systemic barriers to RU, for example, the prescriptive legislation that enhances the specific factors that inhibit evidence use is critically important to make visible, followed by the identification of measures that can be used to successfully address those barriers. This finding is particularly useful as **the goal of this research study is to develop an understanding of those factors that influence RU amongst EHOs working at the frontlines of public health in Canada.** The policy development processes that occur at the federal, provincial, and regional levels of the system that create the structure or frameworks that guide EHO practice in Canada are key to mitigating the barriers to RU experienced by EHOs.
- (ii) Political and structural barriers are also important barriers to EIDM experienced by EHOs because the best available evidence may not always align with popular or political opinion, creating a significant barrier to implementation at the population level. This is not a new phenomenon to public health as there is a long history of conflict between best evidence and popular perspective, including in the adoption of seatbelt safety and tobacco control legislation in Canada (Gielen & Green, 2015). Learnings from these two examples can be leveraged to address the political and structural barriers identified by EHOs as significant barriers in this study.
- (iii) Although the same barriers to RU persist during emergencies as compared to normal work conditions, it was found that access to emergent evidence, clear processes, community engagement, and strong leadership, are more important barriers during emergencies. Further research into differences between large-scale emergencies (e.g., the COVID-19 pandemic) and small-scale emergencies (e.g., an outbreak in a single facility) will further inform strategies to increase RU in environmental health. In either type of emergency, decisions are required quickly

and understanding how to support EHOs in these specific high-risk situations should improve evidence uptake and outcomes in emergencies.

- (iv) Finally, understanding whether EHOs globally experience similar issues in their practice is another interesting point to consider. Research focused on how embedded these barriers are globally may help to identify means to effectively address some of the “wicked issues” that cross jurisdictions and add to the complexity of addressing inter-jurisdictional environmental health issues like climate change (Kreuter et al., 2004).

5.4.2 The Barriers to Research Utilization Scale

The EHO responses to the BARRIERS Scale were the basis for understanding the experience of EHOs in Canada; however, through this study, it was determined that this survey tool is not the best fit for future studies of the barriers to RU experienced by EHOs (Bourne, Kothari, Wathen, et al., 2022a). Through PCA, it was identified that the EHO responses in this study only aligned with two of the six frameworks found within the AIFs and confirmatory factor analysis demonstrated that the model developed of the barriers to RU experienced by EHOs was not a perfect fit. Thematic analysis further demonstrated that the Systemic Change Framework, not addressed in the BARRIERS Scale, is an especially important barrier to RU experienced by EHOs. This new information advises researchers and practitioners that the BARRIERS Scale, though a useful tool for data collection, is an inadequate tool for future research into the barriers to RU experienced by EHOs. A new tool that addresses systemic barriers and broadens the question set to include other areas of the AIFs is likely to enhance research into the EIDM practice of EHOs (Alavi et al., 2020b). Identifying another tool or developing an EHO specific tool to identify and target barriers to RU, including the systemic and process related issues identified in this study, can help to further understanding of these unique issues. The results of the thematic analysis could be used to develop a more comprehensive list of items within a new scale and to inform intervention planning.

5.4.3 Opportunities in Implementation Science

Increasing the amount of practice-based research focused on the process of doing and embedding research in environmental health practice in Canada is recommended as a result of the findings in this study. EHOs have indicated that the lack of relevant research that they have access to for the purpose of guiding practice, is a significant barrier to RU. Interventions to address the conditions of implementation such as the lack of time and authority experienced by EHOs and increasing the general understanding of how to effectively address issues with high environmental health risk and consequence will support better implementation of environmental health strategies in a manner that supports objectives and outcomes.

The AIFs also demonstrated a high alignment with the barriers to, and facilitators of, RU experienced by EHOs. Employing the AIFs consistently when considering interventions related to organizational, systemic, or innovation (evidence) related barriers to implementation will help researchers and practitioners to understand the factors influencing outcomes and make studies more relevant to in vivo application. The AIFs can be used to support knowledge translation and implementation science efforts to enhance RU in EHO practice.

5.4.4 Implications for the EHO Scientific Community

This research brings to light the fact that in general, EHOs face noteworthy and pervasive barriers to RU in their practice in both emergency and everyday work conditions; however, there are barriers that deserve more scrutiny and support during emergencies based on these findings. Furthermore, this information shows that organizational and systemic barriers are the most influential barriers to EIDM experienced by EHOs. To maximize the impact and influence of future studies, it is important for the research community to understand and capture the specifics of the contexts within which the studies take place, including information about the specific practices being studied, organizational characteristics, as well as the systems level parameters that are important

for understanding EIDM. Most importantly, these studies should take place in different contexts and settings to understand and enhance the external validity of the results.

5.5 Conclusion

There have been ongoing calls for additional support to increase RU in public health practice through a better understanding of the practice needs of EHOs in Canada and beyond (Barratt et al., 2013; Dhesi & Stewart, 2015; Forsting, 2004; Rodrigues et al., 2021). Investments are required to comprehend and meet the needs of environmental health practitioners, as research has lagged when compared to the progress observed in other areas of healthcare, in particular in clinical nursing. Findings such as those of this study, may help to address those gaps. This work sheds light on the pervasive nature of the barriers to RU, and the persistence of those barriers in both everyday practice and in emergencies. Despite the similarities in barriers cited in these two work conditions, there are specific barriers and facilitators that warrant further study to understand how they may influence RU particularly in an emergency. These include: EHO access to emergent evidence and implementation pathways, opportunities to engage with the communities impacted by change in an emergency, strong leadership support, and the need for tools and resources to support EIDM. This thesis also sheds light on the importance of organizational and systemic barriers to RU in environmental health, as well as the need for more relevant information. This research will provide useful information to applied researchers in environmental health, implementation science, and policy and practicing professionals.

5.6 References

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6 Appendices

6.1 Appendix Y: Ethics Approval



Research Ethics

Use of Human Participants - Ethics Approval Notice

Principal Investigator: Dr. Anita Kothari
 File Number: 102795
 Review Level: Delegated
 Approved Local Adult Participants: 39
 Approved Local Minor Participants: 0
 Protocol Title: Understanding the KT Practices of Environmental Health Officers in Canada: A Mixed Methods Study
 Department & Institution: Health Sciences/School of Health Studies, Western University
 Sponsor:
 Ethics Approval Date: September 25, 2012 Expiry Date: June 30, 2014

Documents Reviewed & Approved & Documents Received for Information:

Document Name	Comments	Version Date
Other	Summary of Changes to National Survey EHO KT Study Sept 23 2012	
Other	Survey to Identify Phase II EHO KT Interview Participants	
Other	Revised EHO KT National Survey	

This is to notify you that The University of Western Ontario Research Ethics Board for Non-Medical Research Involving Human Subjects (NMREB) which is organized and operates according to the Tri-Council Policy Statement: Ethical Conduct of Research Involving Humans and the applicable laws and regulations of Ontario has granted approval to the above referenced revision(s) or amendment(s) on the approval date noted above.

This approval shall remain valid until the expiry date noted above assuming timely and acceptable responses to the NMREB's periodic requests for surveillance and monitoring information.

Members of the NMREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussions related to, nor vote on, such studies when they are presented to the NMREB.

The Chair of the NMREB is Dr. Riley Hinson. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 0000941.

6.2 Appendix Z: Revised Ethics Approval



Date: 6 July 2020

To: Dr. Anita Kothari

Project ID: 115466

Study Title: Understanding the Knowledge Translation Practices of Environmental Health Officers in Canada: A Mixed Methods Study

Short Title: Understanding the KT Practices of Environmental Health Officers in Canada: A Mixed Methods Study

Application Type: NMREB Initial Application

Review Type: Delegated

Full Board Reporting Date: 07/Aug/2020

Date Approval Issued: 06/Jul/2020 13:39

REB Approval Expiry Date: 06/Jul/2021

Dear Dr. Anita Kothari

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the WREM application form for the above mentioned study, as of the date noted above. NMREB approval for this study remains valid until the expiry date noted above, conditional to timely submission and acceptance of NMREB Continuing Ethics Review.

This research study is to be conducted by the investigator noted above. All other required institutional approvals must also be obtained prior to the conduct of the study.

Documents Approved:

Document Name	Document Type	Document Date	Document Version
Probes for Member Checks Feb 2020	Interview Guide	09/Feb/2020	1
Research Ethics Member Check Documentation February 2020	Interview Guide	09/Feb/2020	1
Survey CIPHI Invitation to Participate in the Survey via Listserve Final Revised 2020v2Clean	Recruitment Materials	30/Apr/2020	2
Interview Invitation CIPHI National Executive Board Members April 30 2020v2	Recruitment Materials	30/Apr/2020	2
Letter of Information and Consent Interview June 20 2020 v4	Written Consent/Assent	20/Jun/2020	4
Letter of Information and Consent Survey June 20 2020 v4	Implied Consent/Assent	20/Jun/2020	4
Updated Survey Monkey File as of June 20 2020v2	Online Survey	20/Jun/2020	2

Documents Acknowledged:

Document Name	Document Type	Document Date	Document Version
Ethics Amendments February 9 2020	Other	09/Feb/2020	1
EIHO KT Condensed proposal for thesis committee April 25 2012 Final	Other	09/Feb/2020	1

No deviations from, or changes to the protocol should be initiated without prior written approval from the NMREB, except when necessary to eliminate immediate hazard(s) to study participants or when the change(s) involves only administrative or logistical aspects of the trial.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Katelyn Harris, Research Ethics Officer on behalf of Dr. Randal Graham, NMREB Chair

Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).

6.3 Appendix AA: Letter of Information and Consent

Letter of Information and Consent - Survey

Thank you for your interest. This page provides important information about the study.

Invitation to Participate

You are invited to participate in this survey to collect information on the types of evidence EHOs use in their everyday and emergency practice and how that information is used for their decision-making.

Inclusion Criteria

You are eligible to participate in this survey if you meet the following eligibility criteria: you have Canadian CPHI credentials and at least one's years' experience working in Canada as an Environmental Health Officer or Public Health Inspector.

Voluntary Participation

Participation in this study is voluntary. Once you have completed the first three questions to confirm you meet the inclusion criteria, you may refuse to participate or answer any further questions. You may also withdraw from the study at any time with no effect on your professional standing.

Study Procedures

If you consent to participate in this study, you will be asked to complete an online survey by July 31, 2020. It is anticipated that the survey will take approximately 15 minutes to complete. You will receive two reminders to encourage you to complete the survey before it closes.

Confidentiality

Your survey responses will be collected through an online survey platform called Survey Monkey that uses encryption technology and restricts access to authorized account holders (the investigators of this study). The data will be retained in SurveyMonkey until the study is complete to allow for ongoing data collection, if required. The data will be exported and saved to the Western secure network for 7 years once the study ends. All survey data (electronic and paper) will be destroyed after 7 years. By participating in this research, you agree that the anonymous results of the survey may be used for scientific purposes, including sharing the [BARRIERS Scale](#) data (no demographic information will be shared) with the creators of the Scale. Aggregate data may be published in a manuscript or in resource materials useful for environmental health practitioners once the study is complete. You do not waive any legal rights by consenting to this study. Representatives of The University of Western Ontario Non-Medical Research Ethics Board may contact you or require access to your study-related records to monitor the conduct of this research.

Possible Benefits

You may not directly benefit from participating in this survey, but your input may provide benefits to society. The information gathered may contribute to ongoing conversations about the way that public health is structured and provide new insights into how EHOs make decisions and the enablers and barriers associated with efforts to seek, use and exchange knowledge.

Possible Risks

There are possible risks associated with participating in this study including a very low risk of re-identification. Indirectly identifying information (e.g., gender, year of birth, work status, etc.) is collected as a part of this survey. However, this data will only be reported at an aggregate level and the risk of re-identification has been determined to be very low. No directly identifying information is collected. Also, this online survey is hosted by "Survey Monkey" which is a web-based platform that stores and accesses

survey data using servers in the USA. If you choose to participate in this survey, your responses to the questions will be stored and accessed in the USA; however, no personal information is collected as a part of this survey (i.e., no personally identifying information is being collected). The security and privacy policy for Survey Monkey can be viewed at <http://www.surveymonkey.com>.

6.4 Appendix BB: Barriers to Research Utilization Scale: Survey Items 2012 and 2020

Invitation to Participate

You are invited to participate in this survey to collect information on the types of evidence EHOs use in their everyday and emergency practice and how that information is used for their decision-making.

Inclusion Criteria

You are eligible to participate in this survey if you meet the following eligibility criteria: you have Canadian CPHI credentials and at least one's years' experience working in Canada as an Environmental Health Officer or Public Health Inspector.

Please review the [Letter of Information and Consent](#) for this study which provides important information.

1. Do you consent to participate in this survey? *

By selecting **Yes**, you consent that you have reviewed the Letter of Information and Consent and have decided to voluntarily participate in this survey.

By selecting **No**, you indicate that you do not consent to participate in the survey and have chosen to exit the survey.

Yes

No

2. Are you a certified Environmental Health Officer with the CPHI(C) * designation?

Yes

No

3. How long have you held the CPHI(C) credential? *

< 1 year

1 to 4 years

5 to 9 years

10 to 14 years

15 to 19 years

> 20 years

4. Have you worked as an Environmental Health Officer in Canada for a period of at least 12 months at any point in your career? *

Yes

No

Articles in health professional journals indicate that in practice, health professionals do not use the results of research to help guide practice. There are a number of reasons why this might be.

I would like to know the extent to which you think each of the following situations is a barrier to an Environmental Health Officer's use of research to alter and/or enhance his or her practice. Please base your responses on your experiences working as an Environmental Health Officer in the Canadian context.

For each item, select the response that best represents your view.

- To no extent
- To a little extent
- To a moderate extent

- To a great extent, or
- No opinion.

You are free to skip a question or questions within the survey. Thank you in advance for sharing your views.

THIS IS A BARRIER (scalar questions)

5. Research reports/articles are not readily available.
6. Implications for practice are not made clear.
7. Statistical analyses are not understandable.
8. The research is not relevant to the Environmental Health Officer's practice.
9. The Environmental Health Officer is unaware of the research.
10. The work environment is inadequate for implementation.
11. The Environmental Health Officer does not have time to read research.
12. The research has not been replicated.
13. The Environmental Health Officer feels the benefits of changing practice will be minimal.
14. The Environmental Health Officer is uncertain whether to believe the results of the research.
15. The research has methodological inadequacies.
16. The relevant literature is not compiled in one place.
17. The Environmental Health Officer does not feel she/he has enough authority to change environmental health practices, policies and/or procedures.

18. The Environmental Health Officer feels results are not generalizable to his/her own setting.
19. The Environmental Health Officer is isolated from knowledgeable colleagues with whom to discuss the research.
20. The Environmental Health Officer sees little benefit for self.
21. Research reports/articles are not published fast enough.
22. The Medical Officer of Health and senior managers within the organization will not cooperate with implementation.
23. Administration will not allow implementation.
24. The Environmental Health Officer does not see the value of research for practice.
25. There is not a documented need to change practice.
26. The conclusions drawn from the research are not justified.
27. The literature reports conflicting results.
28. Research in general is not reported clearly, in that it is not easy to read or understand.
29. Other staff are not supportive of implementation in general.
30. The Environmental Health Officer is unwilling to change/try new ideas.
31. The amount of research information is overwhelming.
32. The Environmental Health Officer does not feel capable of evaluating the quality of the research.
33. There is insufficient time on the job to implement new ideas.

Text based questions

34. Are there other things you think are barriers to research utilization? Please identify these barriers in the text box below. Then rate them in the same text box by using one of the numbers attached to the descriptors in the following numeric scale:

1 - To no extent, 2 - To a little extent, 3 - To a moderate extent, 4 - To a great extent, 5 - No opinion

Greatest Barrier & Item #:

Second Greatest Barrier & Item #:

Third Greatest Barrier & Item #:

35. Considering all of the Barriers identified in this survey, which of the above items do you feel are the three greatest barriers to an Environmental Health Officer's use of research? Please rank them in descending order.

36. What are the things that you think facilitate research utilization?

This portion of the questionnaire was adapted from:

Crane, J., Pelz, D., and Horsley, J.A. CURN Project Research Utilization Questionnaire. Ann Arbor, Michigan: Conduct and Utilization of Research in Nursing Project, School of Nursing. The University of Michigan, 1977.

1987, Funk, Champagne, Tornquist & Wiese.

About Your Thoughts on Research and Evidence

You will now be asked some questions to help identify variations between groups and subgroups. As with the previous section of the survey, you are free to skip a question or questions. Your continued input is greatly appreciated.

37. Please select the sources of "research" that came to mind when you responded to the previous section of questions in the BARRIERS Scale. (Please select all that apply)

Newspaper and magazine articles

General search returns (i.e., reviewing data returned from search engines such as Google or Yahoo)

Search returns from health care databases (i.e., reviewing data returned from databases such as PubMed, The Cochrane

Collaboration, etc.)

Single research studies (i.e., an article in a journal)

Summaries of research studies (i.e., pamphlets directed to the general public that include recommended actions)

Systematic reviews

Synopses of reviews (i.e., descriptions of selected individual studies or systematic reviews in a journal or white paper)

Summaries of research for practice purposes (i.e., Best Practice Guidelines, Standard Operating Procedures, etc.)

Systems for practice decision-making (i.e., automated decision-making tools that recommend a decision based on inputs, such as the Ontario Small Drinking Water System Assessment Tool)

Discussions with colleagues and peers

Discussions with subject matter experts (i.e., toxicologists, industrial hygienists, etc.)

Attending workshops or conferences

Other (please specify)

38. Please select the sources of "evidence" that you believe are important for your practice decisions from the list below, whether or not you considered them in your responses to the BARRIERS Scale. (Please select all that apply)

Newspaper and magazine articles

General search returns (i.e., reviewing data returned from search engines such as Google or Yahoo)

Search returns from health care databases (i.e., reviewing data returned from databases such as PubMed, The Cochrane Collaboration, etc.)

Single research studies (i.e., an article in a journal)

Summaries of research studies (i.e., pamphlets directed to the general public that include recommended actions)

Systematic reviews

Synopses of reviews (i.e., descriptions of selected individual studies or systematic reviews in a journal or white paper)

Summaries of research for practice purposes (i.e., Best Practice Guidelines, Standard Operating Procedures, etc.)

Systems for practice decision-making (i.e., automated decision-making tools that recommend a decision based on inputs, such as the Ontario Small Drinking Water System Assessment Tool)

Discussions with colleagues and peers

Discussions with subject matter experts (i.e., toxicologists, industrial hygienists, etc.)

Attending workshops or conferences

Other (please specify)

About Demographics

39. What is your gender?

Male

Female

Non-binary

Other (please specify)

40. In what year were you born? Please indicate the year only.

41. Which of the following best describes your employment status?

Working full time paid employment (35 or more hours per week)

Working part time paid employment (less than 35 hours per week)

Casual employment

Not currently in paid employment

Other (please specify)

42. What is the highest degree or level of school you have completed?

If you are currently enrolled in a degree program, mark the previous grade or highest degree received.

High school graduate - high school diploma or the equivalent (for example: G.E.D.)

Bachelor's degree (for example: B.A., B.A.Sc.)

Master's degree (for example: M.P.A., M.H.S., M.Eng., M.Ed., M.B.A.)

Doctoral degree (for example: Ph.D., Ed.D.)

Other specialised licence or certification (please specify)

43. Did you receive your CPHI(C) credentials as a Canadian Forces member?

Yes

No

44. Are you currently enrolled in a degree program?

Yes, studying full time in a degree granting program

Yes, studying part time in a degree granting program

No, I am not currently undertaking formal study

Other (please specify)

45. Please self-identify as one of the following classifications under the federal Employment Equity Act:

Aboriginal

Visible minority

Caucasian or white

46. Do you self-identify as having a disability?

Yes

No

47. Are you a current member of the Canadian Institute of Public Health Inspectors (CIPHI) (Do you hold a 2020 membership)?

Yes

No

48. What type of membership do you currently hold?

Student

Regular

Retired

Life

Corporate

Affiliate

Fraternal

International

Honorary

49. Did you hold membership in 2019?

Yes

No

50. Did you participate in the CIPHI Continuing Professional Competencies (CPC) Program in 2019?

Yes

No

I am not aware of the CPC Program

51. Did you complete the 80 professional development hours (PDHs) that are part of the CIPHI Continuing Professional Competencies Program in 2019?

Yes

No

Don't Recall

About Your Position

52. Which of the following best describes your current position?

Environmental Health Officer (Front-line prevention and promotion)

Environmental Epidemiologist

Consultant

Policy and Program Analysis or Support

Environmental Health Educator

Management (Supervisor or Manager)

Senior Management (Director or CAO)

Other (please specify)

53. What is your personal annual income?

Less than \$10,000

\$10,000 to \$19,999

\$20,000 to \$29,999

\$30,000 to \$39,999

\$40,000 to \$49,999

\$50,000 to \$59,999

\$60,000 to \$69,999

\$70,000 to \$79,999

\$80,000 to \$89,999

\$90,000 to \$99,999

\$100,000 to \$149,999

\$150,000 or more

About your Work Environment

54. In which environmental health sector do you primarily work?

Public Sector –Local Government (including local health units and regional health authorities)

Public Sector – Provincial Government

Public Sector – Federal Government

Public Sector – Health Care Setting

Private Sector - Non-Governmental Organization

Private Sector - Private Consulting

Private Sector – Health Care Setting

Academic Institution

Currently Unemployed

Currently Retired

Other (please specify)

55. In which province or territory do you currently work?

Alberta

British Columbia

Manitoba

New Brunswick

Newfoundland and Labrador

Nova Scotia

Ontario

Prince Edward Island

Quebec

Saskatchewan

Northwest Territories

Nunavut

Yukon

Outside of Canada

Currently Unemployed

Currently Retired

56. Please select all of the locations that you have worked in as an Environmental Health Officer? (Please select all that apply)

Alberta

British

Columbia

Manitoba

New Brunswick

Newfoundland and Labrador

Nova Scotia

Ontario

Prince Edward Island

Quebec

Saskatchewan

Northwest Territories

Nunavut

Yukon

Outside of Canada

57. Do you work in a health unit that you would define as serving a population that is primarily:

Mostly Urban

Urban/Rural Mix (approximately 50:50 split)

Mostly Rural

Mostly Remote

Other (please specify)

58. Approximately how many Environmental Health Officers work in your workplace?

<10

10 to 19

20 to 49

50 to 74

75 to 99

100 to 149

150 to 199

200 to 499

>499

59. Do you spend a significant portion of your workday working with other health professionals such as Doctors, Nurses, Epidemiologists, Health Promoters, etc.?

I never work with other health professionals besides other EHOs

I rarely work with other health professionals besides other EHOs

I occasionally work with other health professionals in addition to other EHOs

I frequently work with other health professionals in addition to other EHOs

I always work with other health professionals in addition to other EHOs

60. How important is team work to your employer?

Extremely important

Very important

Moderately important

Slightly important

Not at all important

61. How large is your immediate team?

62. Is your direct supervisor an Environmental Health Officer?

Yes

No

6.5 Appendix CC: Curriculum Vitae

Name	Shawna Bourne-Shields
Post-secondary Education and Degrees	<p>Master of Health Studies</p> <ul style="list-style-type: none"> • Athabasca University • 1 University Dr., Athabasca, AB T9S 3A3 <p>Bachelor of Applied Sciences</p> <ul style="list-style-type: none"> • Toronto Metropolitan University • 350 Victoria St., Toronto, ON M5B 2K3
Related Work Experience	<p>Teaching Assistant, University of Western Ontario (2008, 2010, 2011):</p> <ul style="list-style-type: none"> • HS3200: Health Promotion • HS3092: A Brief History of Drug Use in Western Cultures • HS3071: Health Promotion and Disease Prevention <p>Research Assistant, University of Western Ontario (2008, 2009, 2012):</p> <ul style="list-style-type: none"> • The Lab for Knowledge Translation in Health
Peer Reviewed Publications	<p>Bourne, S. Kothari, A., Wathen, N. Polzer, J. (2022) Canadian environmental health officer perceptions of barriers to research utilization in everyday and emergency practice. <i>Environmental Health Review</i>. 65(2): 45-55. https://doi.org/10.5864/d2022-009</p>

Bourne S, Rihal T. (2018). Big data analytics: How it can be used to reduce costs and improve environmental public health outcomes in Canada. *UWOMJ*. 87(2):24-6.

<https://ojs.lib.uwo.ca/index.php/uwomj/article/view/1149>

Fruciano, D. Bourne, S. (2007). Phage as an antimicrobial agent: d'Herelle's heretical theories and their role in the decline of phage prophylaxis in the West. *Canadian Journal of Infectious Diseases and Medical Microbiology*. TO: Pulsus Group Inc. 1: 19-26

Dublanchet, A. Bourne, S. (2007). The epic of phage therapy. *Canadian Journal of Infectious Diseases and Medical Microbiology*. TO: Pulsus Group Inc. 1: 15-18

Arthur, R. Bourne, S. (2005). Global health security and the role of the WHO. *Environmental Health Review*. Vancouver: D2C3 Enterprises.

Bourne, S. (2005). Part II: A professional learning guide for the continuing education of environmental and public health professionals. *Environmental Health Review*. Vancouver: D2C3 Enterprises

Bourne, S. (2005). Part I: A literature review of continuous education and core competencies in environmental health. *Environmental Health Review*. Vancouver: D2C3 Enterprises

	<p>Berridge, V. Bourne, S. (2005). Illicit drugs, infectious disease and public health: An historical perspective. <i>Canadian Journal of Infectious Diseases and Medical Microbiology</i>. TO: Pulsus Group Inc. 16:3, 193-196.</p> <p>Bourne, S. (2003). An opinion paper: Strengthening the weakest link in food safety. <i>Canadian Journal of Infectious Diseases and Medical Microbiology</i>. TO: Pulsus Group Inc.</p>
<p>Invited Article Non-Peer Reviewed Publications</p>	<p>Bourne, S. (2007). Translating the PHI experience into other professional careers. <i>Ontario Branch News</i>. Cambridge: Canadian Institute of Public Health Inspectors—Ontario Branch Inc.</p>
<p>Invited Book Review</p>	<p>Bourne, S. (2005). Book Review: The environmental science of drinking water by Patrick J. Sullivan, Franklin J. Agardy, and James. J.J. Clark. <i>Environmental Health Perspectives</i>. Washington, D.C.: CDC 113(12): a858</p>