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Exploring readiness for the adoption of new molecular water quality tests: Insights from interviews with policy makers, laboratory managers and watershed managers

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ABSTRACT

Adoption of molecular-based water quality tests has been limited despite their advantage over traditional culture-based tests. A better understanding of the factors affecting adoption of these tests is needed for effective implementation. The Consolidated Framework for Implementation Research (CFIR) was used to analyze interviews with policy makers, watershed managers and laboratory managers in British Columbia (BC), Canada about their perceptions of molecular water tests currently under development in order to assess readiness for adoption and identify factors that may impact implementation. Many of the CFIR constructs were addressed by study participants, thus confirming their validity in the water-testing context. Other constructs were not mentioned, which suggests that awareness about these constructs need to be increased to ensure that they are incorporated into implementation strategies. In general, there was much enthusiasm for the new tests, which were seen to provide valuable information that could enable improved management of watersheds and treatment of source water. However, prior to adopting the tests, stakeholders would require evidence supporting the tests' validity and reliability, would need to assess the complexity of introducing the tests into laboratories and water sampling processes, and would require support interpreting the test results. Even if all the aforementioned issues are satisfactorily addressed, the tests may not be adopted unless regulations and policies were changed to allow the use of these test results to inform decision making. The results support that implementation of new technologies, such as these water quality tests, need to address potential barriers that could hinder uptake despite the advantages of the new product.

1. Introduction

Water is essential for life yet is also a potential source of disease, with contaminated water an important transmission vehicle for enteric pathogens. As such, routine microbiological testing of water supplies has become a cornerstone of the multiple barrier approach for the provision of potable water.

New ways of testing for microbial contamination of water are rapidly being developed, but despite their advance over traditional tests, their uptake has been limited. Although frameworks to guide implementation exist, including the United States Environmental Protection Agency's Alternate Test Procedure Program, these are focused primarily on technical validation for traditional culture based methods (USEPA, 2010). There is little peer-reviewed literature related directly to the adoption of new molecular tests for water, beyond several publications that have reviewed the technical barriers to their use (Oliver et al., 2014; Aw and Rose, 2012; Noble and Weisberg, 2005) and implementation challenges (Oliver et al., 2014).

Despite a long history of work on the diffusion of innovations (Greenhalgh et al., 2004), there is still a strongly-held belief that new and improved products and ways of doing things — especially when based on well-documented and accepted evidence - will naturally be incorporated into practice and policy (Best and Holmes, 2010). Yet enabling the uptake of innovations such as new water quality testing requires opening "the black box of implementation" (Damschroder et al., 2009), recognizing that resistance to change is a human characteristic (Straus et al., 2009), and there is a need to systematically address core implementation components (Fixsen et al., 2009). In the case of uptake of new molecular tests for water quality, technical issues are only one of many considerations. Regulatory and other political, as well as institutional, professional and social/behavioral factors will also play a role in uptake. In this paper we explore these and other considerations, applying a framework for implementation readiness to results of stakeholder

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interviews conducted as part of a broader study on the identification and development of novel molecular-based water quality tests. Below we provide background on water quality testing and the broader study before describing our methodology and results and discussing their implications.

Currently and for the past century, culture of fecal indicator bacteria such as *Escherichia coli* (*E. coli*) and total coliforms are used to assess the microbial quality of water (Leclerc et al., 2001). While there are many advantages to the culture-based detection of fecal indicator bacteria (cost-effectiveness, relatively simple testing, standardization and wide acceptance), there are many limitations (Boubetra et al., 2011; Maheux et al., 2014). These limitations include the possibility of false-positive and false-negative results, slow turn-around-times, the requirement to conduct tests in specialized laboratories and poor correlation with some pathogens, such as adenovirus and *Cryptosporidium* (Griffin et al., 2001; Dunn et al., 2014).

Molecular methods such as the quantitative polymerase chain reaction (qPCR) have the possibility of revolutionizing water quality assessment. These culture-independent approaches have the advantage of rapid turn-around-times, are highly sensitive and specific, are flexible and adaptable, and are amenable to high-throughput testing through automation (Griffith et al., 2009; Aw and Rose, 2012; Dunn et al., 2014). Furthermore, some molecular tests can be used for microbial source tracking (MST), which can be used to identify the source of pollution (e.g., can discriminate between human and livestock contamination) (Scott et al., 2002). Building on the promise of these methods, a water metagenomics study is underway by scientists at the British Columbia (BC) Public Health Microbiology Reference Laboratory (PHMRL) to identify new indicators and develop novel molecular-based water microbial quality tests (see www.watersheddiscovery.ca for more details). As part of this work, the team sought to understand the stakeholder landscape as it pertains to the uptake of molecular methods for routine water quality monitoring. The goal of this paper is to identify possible barriers and facilitators to implementation of new water quality tests by applying a framework for implementation to the results from the stakeholder exploration.

1.1. Consolidated Framework for Implementation Research (CFIR)

To better understand the barriers and facilitators to the implementation of new water quality tests, the results of the stakeholder interviews conducted for the above study were contextualized within an implementation framework (Damschroder et al., 2009). The Consolidated Framework for Implementation Research (CFIR) was chosen given its practical intent to help identify potential influences on implementation, its transferability across contexts (e.g., “patient needs” could in the case of water tests be “laboratory managers' needs”) and its comprehensive foundation of existing published models, theories, and frameworks related to dissemination, innovation, organizational change, implementation, knowledge translation, and research uptake. The CFIR has five domains: intervention characteristics, outer setting (economic, political, and social context), inner setting (structural, political, and cultural contexts), characteristics of the individuals involved, and the process of implementation. Each domain has associated constructs that users can select according to their particular needs.

One of the benefits of using findings from broad interviews about stakeholders' perceptions of new molecular tests — as opposed to conducting separate interviews focused on specific barriers and facilitators to adoption — is the ability to map participants' general comments onto validated implementation constructs from the literature. Analysis of points of agreement (i.e. where stakeholders touch on constructs) should confirm some of the critical factors for uptake. However, analysis of gaps (i.e. constructs not mentioned by stakeholders) could also be important, potentially shedding light on aspects of uptake that are not seen as issues by stakeholders, but that in fact are significant factors in adoption.

2. Methods

2.1. Stakeholder interviews

Policy makers (PM) ($n = 12$), laboratory managers (LM) ($n = 11$) and watershed managers (WM) ($n = 6$) from primarily British Columbia, Canada were interviewed using a semi-structured approach to explore the benefits and challenges associated with uptake of two molecular water quality tests. Interviewees were senior-level individuals identified from a comprehensive stakeholder database created by the project. The database included people who use water quality tests or their results from public sector organizations, as well as some individuals from key NGOs and private sector companies. The policy makers interviewed included stakeholders from the BC Health Authorities (e.g., chief medical health officers, drinking water leaders/managers), the BC Ministry of the Environment, other individuals in the provincial government responsible for policies and decision making related to water issues (e.g., water policy analysts and advisors), and several key Federal government stakeholders (e.g., leaders in the microbiological assessment division of Health Canada). The laboratory managers interviewed were managers from provincial and private laboratories in BC that conduct water quality testing. The watershed managers were from township and district governments with responsibility for water quality and water services. Stakeholders selected to be interviewed were contacted by email, which provided background information about the study and a request for their participation in a phone interview; if interested in participating, stakeholders replied by email to schedule their interview.

Two types of molecular tests were explored in the interviews; one test that would assess the microbial water quality (primarily for source water) and the second that would identify the species of animal from which the microbial contaminants originated (microbial source tracking [MST]). Participants were introduced to the characteristics of the molecular tests under development and were informed of several reasons the new tests would be superior to water quality tests that are currently used. They were then led through a series of semi-structured questions (see sample interview guide in Supplemental On-line Materials). Interviews were conducted by telephone, were led by an experienced qualitative researcher, lasted approximately 60 min, and were audio-recorded. Interviews were transcribed and imported into *NVivo 9* (software for qualitative analyses; QSR) for thematic coding and analysis. Ethics approval for the study was received from the University of British Columbia's Behavioural Research Ethics Board.

2.2. Integration of results into the consolidated Framework for Implementation Research (CFIR)

A key feature of the CFIR is that it is a flexible framework and the constructs that are most relevant to the implementation context can be used, while constructs that do not apply in a given context can be omitted. To apply CFIR to the implementation of molecular water testing, we focused on the constructs outlined in Table 1.

Other constructs from CFIR were excluded from Table 1 because there was no significant mention of them by the study participants. These constructs are:

- Intervention characteristics: intervention source
- Outer setting: cosmopolitanism
- Inner setting: structural characteristics, networks and communications, culture
- Characteristics of individuals: self-efficacy, individual stage of change, individual identification with organization, other personal attributes
- Implementation process: planning, engaging, executing, reflecting and evaluating.