Microbial water quality communication: public and practitioner insights from British Columbia, Canada

G. Dunn, N. Henrich, B. Holmes, L. Harris and N. Prystajecky

ABSTRACT

This work examines the communication interactions of water suppliers and health authorities with the general public regarding microbial source water quality for recreational and drinking water. We compare current approaches to risk communication observable in British Columbia (BC), Canada, with best practices derived from the communications literature, finding significant gaps between theory and practice. By considering public views and government practices together, we identify key disconnects, leading to the conclusion that at present, neither the public's needs nor public health officials' goals are being met. We find: (1) there is a general lack of awareness and poor understanding by the public of microbial threats to water and the associated health implications; (2) the public often does not know where to find water quality information; (3) public information needs are not identified or met; (4) information sharing by authorities is predominantly one-way and reactive (crisis-oriented); and (5) the effectiveness of communications is not evaluated. There is a need for both improved public understanding of water quality-related risks, and new approaches to ensure information related to water quality reaches audiences. Overall, greater attention should be given to planning and goal setting related to microbial water risk communication.

Key words | British Columbia, communication, drinking water quality, microbial risk, public, recreational water quality

G. Dunn (corresponding author)
L. Harris
Program on Water Governance,
University of British Columbia,
439-2202 Main Mall,
Vancouver, BC,
V6T 1Z4 Canada
E-mail: *gemma.dunn@ubc.ca*

N. Henrich
Centre for Health Evaluation and Outcome Sciences,
588-1081 Burrard Street St. Paul's Hospital,
Vancouver, BC,
V6Z 1Y6, Canada

B. Holmes
School of Population and Public Health,
University of British Columbia,
2206 East Mall,
Vancouver, BC,
V6T 1Z3, Canada

L. Harris
Institute of Resources,
Environment and Sustainability,
University of British Columbia,
439-2202 Main Mall,
Vancouver, BC,
V6T 1Z4, Canada

N. Prystajecky
Department of Pathology and Laboratory Medicine,
University of British Columbia,
G227-2211 Wesbrook Mall Vancouver,
Vancouver, BC,
V6T 2B5, Canada

INTRODUCTION

Water is an important transmission route for human disease (Hrudey & Hrudey 2004). At least 28 bacterial, viral and protozoan pathogenic microorganisms are known to have caused waterborne outbreaks of disease via both recreational and drinking water exposures, and there are many more putative waterborne pathogens (WHO 2011). Although waterborne diseases are often perceived to be a developing world issue, microbial contamination events are prevalent throughout the world, affecting recreational and drinking water supplies in both developed and developing nations (Medema *et al.* 2003; Pond 2005; Nsiah-Kumi 2008; WHO 2011). Drinking water quality can be affected by poor source water quality (SWQ), inadequate treatment or treatment failure, inadequate monitoring, as well as poor responses to these issues. SWQ is also highly relevant given that surface waters such as lakes, reservoirs, rivers and beaches are often used for primary contact recreational activities such as swimming, scuba-diving, windsurfing and waterskiing. (Secondary contact activities refers to fishing and canoeing, etc. Other uses including hot tubs and swimming pools are beyond the scope of this study.) Even as some elements of microbial risk can be mitigated through source water protection, testing

doi: 10.2166/wh.2014.126

and treatment, SWQ remains a key component to a comprehensive understanding of overall microbial risk.

Water quality notifications for recreational and drinking water quality are important mechanisms for protecting public health, particularly to warn against exposures to contaminated water. For water crisis situations in particular, communication with the public is essential (Nsiah-Kumi 2008). Public perceptions of water quality have a direct influence on behaviors (Frewer 2004; Renn 2006; Pratap *et al.* 2011); however, communicating water quality is not straightforward; issues related to water quality communication include message fatigue, non-compliance and public misunderstanding or disbelief (BC Ombudsman 2008; Byleveld *et al.* 2008; Nsiah-Kumi 2008; Grover 2011). These issues may be due to variable communication strategies; limited education about water quality; lack of communications planning and the absence of evaluations of the effectiveness of communication strategies (see, for example, O'Connor 2002; BC Ombudsman 2008; Byleveld *et al.* 2008; Guidotti & Ragain 2008; Nsiah-Kumi 2008; Grover 2011; Pratap *et al.* 2011).

Little is documented regarding the intersect between public expectations of water quality communications and governmental communication practices. This study addresses this gap by exploring microbial water quality communications in British Columbia (BC), Canada. By considering both public views and governmental practices together, we identify key disconnects and suggest that at present, neither public health officials' nor the public's needs are being met. We discuss our findings in relation to risk communication literature and recommend improvements. The main recommendation is to undertake comprehensive communications planning to consider issues such as public perceptions of water quality threats; overall confidence in the supply; receptivity to microbial water quality communication and resource constraints for public health officials and water authorities. While we recognize the importance of chemical or other contamination risks, these considerations are beyond the scope of this study.

METHODS

This paper reports on research as part of a 4-year (2011–2015) research project on 'Applied Metagenomics of the Watershed Microbiome'. As part of this broader research project, in this paper we focus on microbial risk in source water, including implications for both drinking and recreational water. The risk communication research included interviews and focus groups with water suppliers, health authorities and the public in BC to gather qualitative data (in total, 87 participants).

Case study selection

The research was conducted in three communities in the province of British Columbia (Table 1), one from each of the three watershed sampling sites that are part of the broader research effort. Each watershed community receives its drinking water from a surface water municipal supply (private groundwater wells were beyond the scope of this study). Recreational water activities in these watershed communities occur in a variety of water types including lakes, rivers (estuaries) and marine. In general terms, Community One receives drinking water from a protected watershed and recreational water activities are conducted in both freshwater and marine environments (both unprotected). Community Two is similar to Community One (protected drinking water source) but recreational activities are conducted more commonly in marine environments and some beaches nearby have had historical water issues including beach closures, presumed to be microbial contamination from human or animal sources. Community Three is located in a watershed with intense agricultural land use, with freshwater (lakes and rivers) recreational water usage. Our goal is not to offer a comparative analysis across the case study sites, but rather to raise issues of relevance from agency and public perspectives as revealed through research across the different entities.

Table 1 | Watershed communities

Community	Source of treated drinking water	Type of recreational water	Source of impacts to recreational water quality
1	Protected surface water	Lakes and coastal	Urban
2	Protected surface water	Lakes and estuary	Urban
3	Unprotected surface water	Rivers and Lakes	Agriculture

Interviews and focus groups

Eight focus groups were conducted with the public ($n = 72$ individuals). This included two focus groups in each of the three watershed communities; and an additional two focus groups (not community-specific) with members of the public who were professionally associated with the water sector (for example working at a non-profit association related to water conservancy, or working on a research project related to water) or who self-identified as being knowledgeable about water issues.

Phone interviews were conducted with water utilities in each of the three communities ($n = 3$), representing the municipal water provider from each watershed. All water suppliers interviewed are medium (>10,000 individuals served) to large drinking water systems (>90,000) supplied by surface water. We interviewed those with expertise in water management and policy who were familiar with day-to-day microbial risk assessment, water quality management and communications (interviewees included directors, water process engineers and water utility managers).

Phone interviews were also conducted with representatives from each of BC's five regional health authorities, and included health authority representatives from each of three watershed communities. Representatives from all health authorities were interviewed to develop a broader understanding of water quality communication in BC, as the health authorities are an important source of water quality communication, particularly in the event of a crisis. Participants included managers or directors of environmental health, health protection, and drinking water programs, medical health officers, and a water specialist; those responsible for governing and communicating with the public about water issues ($n = 12$ individuals). In some interviews, multiple agency representatives participated.

Collection of data

Questions asked for water suppliers included how microbial risk is assessed and managed, identification of key stakeholders for communications, and how information is shared. For health authorities, we asked a series of semi-structured questions related to what types of water-related concerns and situations are communicated to the public, what information is communicated and how, and what challenges and opportunities exist with respect to public communication and effectiveness. Focus groups involving members of the public included questions about water quality concerns, information received related to microbial risk or water quality, and how people prefer to receive such information. While initially we sought to distinguish between source water for drinking versus recreational activities, ultimately it was difficult to keep these two purposes separate. For instance, respondents frequently moved back and forth between addressing recreational water concerns, drinking water issues, or SWQ concerns. While this makes the analysis complex at times, we believe this does not compromise the data since all participants were discussing water quality and associated communications in the broadest sense. As such, we engage these discussions to address water quality related communications for both drinking water and recreational water – although we also consider that any communications strategy of planning should likely seek to distinguish these in considering types of communications, or types of information, particularly when dealing with the public.

Interviews were audio-recorded, transcribed and coded (in 'QSR NVivo', a qualitative software analysis program and in Excel) using thematic codes (overarching issues) based on the questions and sub-theme codes (specific points that fit within an overarching theme) derived from the content of the discussions (Summerill *et al*. 2010; Taylor *et al*. 2013). Free and informed consent of the participants was obtained. The study protocol was approved by the University of British Columbia, Vancouver, Canada, Behavioral Research Ethics Board (H12-01626 & H11-00800).

RESULTS

Findings from the public focus groups are presented first, followed by findings from water supplier and health authority interviews.

Public perspectives

Overall, participants in all focus groups have few concerns about microbial water quality. Participants in the

community focus groups had little knowledge about microbial water quality; those in the two focus groups comprised of people whose work relates to the water sector were more knowledgeable. There were varied preferences for what information people would like to receive and how.

Public perceptions of water quality

In general, participants in all focus groups reported high confidence in the quality of their drinking water. People described their water as 'the best water in the world' and as having a good smell and taste. As one participant explained, 'I've never really thought about [contamination]. We have such good water in Canada that it's not really a concern.'

People also expressed very little concern about potential threats or contaminants in source water, at least with respect to microbial contamination (some chemical contamination issues were identified). Fecal contamination was mentioned as a concern in all of the focus groups, although the source identified varied. The frequency with which fecal contamination was mentioned as a threat to source water may have been influenced by the participants being aware of the research project with which the focus groups were associated and the discussion at the start of each session about developing new water quality tests to identify fecal contamination in source water. Community Three, which is heavily impacted by agricultural activity, was the only focus group where participants mentioned run-off of manure as a threat to SWQ. In the other groups, participants did not identify agricultural activity but did identify wildlife (in particular geese), dogs, and sewage as fecal sources that could threaten SWQ. Other water concerns noted by focus group participants included over-consumption of water (mentioned by at least one person in each of the communities) as well as air pollution (e.g. from car exhaust, burning coal, mercury, mentioned in three of the groups as having effects for water quality).

Although fecal contamination was noted in several instances, our findings suggest a general lack of awareness of the associated potential threats to human health across all focus groups, including the two non-geographic based groups, where concerns related more to over-consumption and pollution. Participants noted the possibility of getting an upset stomach from microbial contaminants but thought the consequences were likely not serious. Some suggested benefits of fecal inputs due to a sense that it is unhealthy to live in an 'overly hygienic environment'. The lack of concern for some is likely due to a sense that at least for drinking water, treatment is believed to eliminate potential risk. However, we saw a similar lack of concern related to recreational uses. Some drew on personal experience and said they have gone swimming at beaches that were closed because of fecal contamination and they did not get sick. For instance:

> '*I've swum in [water X] every single year, and I love swimming in [water X]. And, you know, it's not like you don't pay attention when they say the fecal count is high or whatever. But you only live once. You can shower afterwards*.'

In Communities One and Two, people distinguished between feces from wildlife, which they considered to be 'natural' and thus less dangerous, and human feces, which was of greater concern.

> '*And then the other issue is the natural things. I think goose poo is meant to be in water, and I think the dead leaves that are composting are meant to be in the water, and that's probably one of the reasons it's good for me in moderation*.'

Some participants were aware that some diseases are spread through feces, with several suggesting that exposure to feces could make you very sick. The more common sentiment among participants, however, was that exposure would likely not be life threatening. Again, whether this is based on a sense of 'naturalness' or that protection such as monitoring and treatment are in place we are not certain – but it is clear that a general lack of public concern related to microbial risk is in evidence.

In sum, although all focus groups demonstrated that people are aware of some microbial pathways that could compromise water quality – including agricultural activity in Community Three – there is little current concern with respect to implications for drinking water or recreation.

Public information needs

Participants were asked how and if they accessed information about potential contamination in source water. They noted that in the event of contamination of recreational water, there is often a sign posted at the site. Participants in all three communities mentioned that water quality information is made available in the local newspapers when there are potential problems in the drinking water, such as high *Escherichia coli* (*E. coli*) counts.

Only a few participants were aware that information on water quality is available on municipal government (drinking water and recreational water) and water supplier (drinking water) websites. Participants indicated they rarely access this information, if at all. Despite the availability of water quality information sources, in Communities One and Two, participants felt that there is not currently enough information provided when contamination events occur and they would like to have an improved alert system to notify the public.

Focus group participants were divided on how much and what type of information they would like regarding water quality. Here it is possible to distinguish between drinking water contamination events and ongoing information on SWQ (which could impinge on water for multiple uses, including the use of untreated water for recreational activities and possibly the quality of treated drinking water). For the majority who do want information, their highest priority is to understand the risks associated with both recreational and drinking water. Participants in all focus groups expressed strongly that they would like the information to be communicated in a way that makes the implications clear. For example, participants suggested an easily understandable scale that lets the public know the level of risk they face if exposed to the water, information on the precautions that need to be taken, and implications of the risk. As one participant noted:

> *'I guess, just kind of agreeing [with others in the group] …, for me, for my own personal water use, I'd just like to see some kind of scale, you know. Is it a good water-use day or a bad water-use day.'*

With respect to how people would like to receive information, there was considerable variability. In Communities One and Two, there was a strong preference to convey SWQ information on the Weather Channel/Network, similar to the way that air quality and the UV indices are shown. Many participants across all groups favored accessing information from a reliable website. Others preferred to receive information from the media, as long as media use information sources that the public perceives as credible (e.g. scientists or others seen to be unbiased and knowledgeable).

Similar to the sense that they are unlikely to want regular information on microbial concerns for SWQ, participants also did not suggest a preference for talking directly with health or water experts (i.e. no respondents mentioned that they would like in-person or two-way communication among their preferred ways of getting information). A selection of participants felt that water quality information does not need to be shared with the public unless there is a problem. It was clear that these people agreed with one participant's sentiment that *'no news is good news'*. Here is it imaginable that message fatigue and similar problems would surface if there were regular communications absent a crisis or cause for concern.

Water suppliers and health authorities

Water suppliers and health authority representatives identified two regulatory drivers that influence how they communicate water quality information with the public. First, in compliance with 'BC Drinking Water Regulation 2003' [BC Reg. 200/2003 Drinking Water Protection Regulation Section 10 and 13 (1–5)] the BC water suppliers and health authorities interviewed have developed crisis communication strategies, namely Emergency Response Procedures (ERPs). These procedures are typically activated once an actual or perceived microbial contamination event occurs (e.g. *E. coli* present in treated water or an elevated total coliform count or turbidity measurement in source waters). Although the regulation identifies water suppliers as having responsibility to communicate water quality concerns with the public, in our interviews all five of the BC regional health authorities identified that they too play a significant role in communicating water quality information to the public – both directly and indirectly. Examples of water-related

emergencies or high-risk situations that require their direct communication with the public include BWAs and beach closures, as well as high water levels, flooding, and landslides that may impact water quality. An indirect approach is when health authorities provide content and messaging to the water suppliers, who in turn relay to this information onto the public (particularly with respect to BWAs). Apart from ERPs, water suppliers are also required to report annually the results of source and treated drinking water quality to the public (BC Reg. 200/2003 Drinking Water Protection Regulation Section 11). These reports are generally posted on the suppliers' websites. However, as already indicated, very few representatives of the public seemed to be aware that this information exists.

Our interviews confirmed that communication with the public is largely limited to these legislated requirements. Key themes that emerged from the interviews are as follows.

Communications are primarily crisis-oriented and one-way

Communication with the public is limited to crisis events or fulfilling legislated reporting requirements. One health authority representative described his role as being in the '*bad news management game*'. The primary mode of communication is through websites, especially for annual reporting as well as drinking water and recreational test results and BWAs. For water suppliers, apart from interactions that might occur in times of crisis, direct public engagement is limited to information requests made by the public or the occasional public meeting. Four of the five regional health authorities described two-way communication as an important element of effective communication in general – but their current approaches to communicate microbial water quality information are primarily one-way. They also said they sometimes distribute information door-to-door, and occasionally communicate through the media in emergency situations or when information needs to be communicated across a region.

Building trust with the public was a key theme highlighted by one public health representative who spoke extensively about the importance of outreach and engagement to build relationships with the public over time. However, the other four health authorities never mentioned issues of trust and did not report engaging in any activities to develop trusting relationships related to water communications.

None of the water suppliers or health authorities use social networking to communicate about water. Two health authorities have considered using social media for water communication: one said they are unclear on what is required and unsure about its effectiveness; another said they may use social media in the future for situations that require rapid and widespread dissemination of messages. A third health authority uses social networking for other programs but not for water-related communications.

Information sharing

Health authorities and water suppliers reported different approaches to sharing information with the public, focusing on drinking and recreation water quality communication rather than *risk* communication more generally. Water suppliers tend to translate raw data for example, converting water quality tests into graphs and posting these on websites and in annual reports. As one representative highlighted:

> *'All the data is posted on the website and in reports; we are an open book. The data presented are primarily presented as graphs, the information includes current year to date in relation to a 5-year average. In some cases minimum and maximum values detected. Since data used is graphical, so it's not raw data … this information [the graphs] is more meaningful than raw data, particularly from a communications perspective.'*

Health authorities, by contrast, tend to post only raw test values for drinking water quality on their websites. For recreational water, there are several coding schema and other efforts to help interpret scores, in the ways that members of the public had suggested would be useful. One health authority interviewee explained that interpretation of *E. coli* levels is not provided with the sharing of results, although the public is able to call and ask for more information if they have questions about the meaning or implication of the results. Another health authority has a beach webpage with water quality information, which incorporates a color-based scale to interpret results (green = good, yellow = moderate, red = swimming not

recommended). Descriptors for test results have also been included on their website to explain how the results relate to public health. When water quality test results are shared, another health authority said that their practice is to provide information on the type of testing, what they believe to be the cause of the problem, the solution (if known), and what they do not know.

Although health authority representatives gave some examples of context provided (e.g. fact sheets to help interpret results, a focus on health impact, level of risk, what people can do to protect themselves), there seems to be an ongoing challenge related to how to effectively communicate complex results, particularly in ways that might be more meaningful for the public. Consider the following quotes by two different health authority representatives:

> *'… we need to be careful before information goes out to the public for several reasons. You don't want to create a situation that may get out of hand for no reason, [a] very minor reason.'*

> *'One of the big challenges in communicating is communicating complex messages. People just want to know, is it safe or not? And the answer is, it depends! Part of the challenge is communicating nuance; nothing is safe, 100% safe. What does it mean to be safe? What constitutes an acceptable level of risk – safeness from our point of view or their point of view?'*

Evaluating the effectiveness of communication strategies

Health authority representatives described several goals of effective communication in general, including: public confidence in how the situation is being handled, understanding of the risk, compliance with recommended actions, and increased knowledge about an issue. However, in practice, water suppliers and health authorities interviewed in BC do not currently evaluate the extent to which their water communications achieve these goals.

Representatives from two health authorities expressed frustration in not knowing whether their communications are effective in terms of message content, delivery and associated changes in behavior. They suggested lack of formal evaluation is due to insufficient resources and challenges in determining attribution (i.e. to what extent are actions taken by the public or an increase in understanding the result of health authority communications?). A limited understanding of public information needs contributes to evaluation challenges. As noted by one health authority representative:

> *'I think probably the biggest challenge is finding out what people want to know …. we'll tell you whatever you want to know, but we don't always know what people want to know … in fact, for all of our programs, [having a process to find out what people want] is a gap.'*

DISCUSSION

Public interest in microbial water quality is warranted in Canada. A 2008 study in Canadian Medical Association Journal documented 1,766 boil water advisories (BWAs) (as an indicator of a community's water quality) across Canada in small towns, cities and townships (Eggerston 2008). This same report identifies British Columbia as having the highest number of BWAs per capita in the country (530) (Eggerston 2008). A more recent tally of publicly posted BWAs in BC, conducted in November 2013, found a nearly identical number of BWA – 533 BWAs currently in effect. Many of these BWAs have been in effect for over a year, and in extreme cases, some last decades (BC Ombudsman 2008; Grover 2011). The highest profile microbial water contamination event in Canada occurred in May 2000 in Walkerton (Ontario), where contaminated drinking water supplies resulted in 2,300 illnesses (almost half the town's population at that time), 65 hospitalizations, 27 people suffering hemolytic uremic syndrome (acute kidney failure) and seven deaths (Hrudey & Hrudey 2004; Hamilton *et al.* 2006; Dupont & Jahan 2012). In this tragedy poor communication was identified as a contributing factor (Jalba *et al.* 2010). Conservative estimates suggest that the economic impacts of the outbreak were more than CAD$64.5 million (Livernois 2002). Across the country, bottled water consumption and the use of household filtration devices has increased, in part, due to public perceptions of poor tap water quality (Doria *et al.* 2009; Statistics Canada

2009; Dupont & Jahan 2012). Impacts to human health from microbially-contaminated recreational waters in Canada are harder to ascertain. However, researchers in the USA estimated that the health burden of swimming-related gastrointestinal illnesses at two popular California beaches cost over US$1.3 million per year (Pond 2005).

Public perception and communication challenges are evidenced in recent examples of high profile Boil Water Advisory events in BC including Metro Vancouver in 2006 and White Rock in 2010. The recent BWA in Chilliwack in February 2013 (the result of a single positive *E. coli* test result), exposes two key communication challenges: (1) public misperceptions of the threats and (2) misinformation being conveyed to the public during the BWA. In British Columbia, groundwater under the direct influence of surface water (GWUDI) or groundwater at risk of pathogens (GARP) requires disinfection; non-GWUDI/GARP groundwater may be exempt from treatment. The groundwater supply for the municipality had been determined to be non-GWUDI and therefore exempt from disinfection. Even prior to the recent BWA, other *E. coli* positive test results resulted in Fraser Health Authority (2013) advising the City of Chilliwack to start adding chlorine to its drinking water. The Mayor and hundreds of Chilliwack residents opposed chlorination of their drinking water supply because of (1) beliefs that the levels of *E. coli* were miniscule, (2) fears of chlorination being linked with cancer, and (3) taste concerns (CBC News 2013, February 12, 27 and 28). The public health authority made attempts to allay these concerns through information on their website. The risk of illness from microbial disease is far higher than potential health related illness from DBPs (associated with chlorine) (Hrudey & Hrudey 2004). Indeed, in a later piece Hrudey (2009) argues that there has 'been a number of cases where negative attitudes to chlorination (including taste) or the fear of health effects from chlorination DBPs has played a role in contributing to allowing a waterborne disease outbreak to occur (e.g. Creston/Erickson, B.C.; Walkerton, Ontario; Bramham, England; Asikkala, Finland; Transtrand, Sweden)' (Hrudey 2009). In addition to these misperceptions of the threats, during the event there were several clear instances of miscommunication, including whether or not *E. coli* was actually present in the water, what a positive *E. coli* test result actually means, and whether the strain was actually deadly (CBC News 2013, February 12).

The results of our research suggest several opportunities for improving microbial water quality communications, particularly to more effectively meet the needs of the public, as well as the requirements of the water suppliers and health authorities (both to ensure public health and to fulfill their mandates in terms of reporting requirements). As well, some of our findings also suggest the need to look beyond the stated needs of the public and the regulated requirements of the authorities in order to build effective communications about water quality more generally. This discussion is informed by best practices from the communications literature, as detailed below. As we work through these recommendations, we remain cognizant of the complexities and nuance of some of these issues as clearly conveyed by our interviewees – whether lack of resources, or lack of interest for communication by members of the public. Nonetheless, we learn from the communication literature, in conversation with our interviewees, and detail several opportunities for more effective communication in the section that follows.

Communications planning and evaluation

Our research supports Morgan's (2002) assertion that risk communication is often 'earnest but also surprisingly ad hoc'. Whilst communicators we spoke to in BC understand the need for effective communication, time and resources (both financial and staff) constrain their ability to plan and evaluate their communications, a challenge also identified in work by Pratap *et al.* (2011).

A first step towards building a more comprehensive communication framework is goal setting. Bier (2001) emphasizes the importance of this step, since risk communication can have purposes as varied as raising awareness of a hazard; educating people; motivating people to take action; or reaching agreement on a controversial issue and whether it is related to drinking water versus recreational activities – each of which requires different strategies. We argue that without a communications planning and evaluation frameworks for water quality, risk communication best practices by themselves may be ineffective. For example, there is little use in developing two-way communications strategies (a

best practice suggested by Covello (2003), Sandman (2006) and Seeger (2006)) if the public, as our research indicates, has little desire to engage. Holmes *et al.* (2009) argues that goal setting is rarely foregrounded in risk communication, and its absence has clear ramifications. For example, a goal to empower people to make a decision of their own is very different from a goal of moving them to compliance or to certain actions, again, each entailing different strategies.

Planning should involve public health officials who have an important perspective in determining what the public may need to know. However, it must be kept in mind that risk assessments of public health officials, although grounded in expertise, are not value-free (Holmes 2008), and their ideas about what the public 'should' know must be carefully examined.

Besides goal setting, key planning steps include determining target audiences and characteristics, and the gaps between the desired knowledge level and actual knowledge level (Bier 2001; Seeger 2006; Nsiah-Kumi 2008). For example, our results suggest there is a lack of familiarity and concern with the possible threats posed by fecal contamination in water, particularly from viral, bacterial and protozoan pathogens that are well known to have adverse (even fatal) health effects, regardless of whether the origin is 'wild' sources (wildlife), agricultural, or sewage or other anthropogenic sources.

Our interviews with health authorities revealed an understanding of the importance of evaluating communications strategies, but few examples of evaluation. Creating mechanisms and allocating resources to evaluate the outcomes of the communications plan is key. Evaluation should be built into the communications plan from the beginning (cf. Fischhoff 2009).

Implementing communications: other lessons from best practices

As part of communications planning, it is possible to assess the potential effectiveness of best practices such as those outlined below, which relate to the results of our research.

Proactive communications

Experts argue that effective communication must be proactive and regular in order to build trust and create confidence in risk management processes (Renn 2006; Seeger 2006). However, done poorly, regular or unnecessary communication can result in message fatigue, public disengagement and non-compliance with recommendations. The risk communication literature generally suggests that proactive communication, undertaken both in times of crisis and non-crisis times, is important (Covello 2003; Seeger 2006). Such communication creates an environment of familiarity and trust, introduces key players, and establishes credibility (Covello 2003; Frewer 2004; Leiss 2004; Seeger 2006; Doria 2010).

With the situation of microbial water risk, we might infer that proactive and regular communication is necessary so that in the event of a contamination event, there is enhanced awareness, understanding of the issues, and improved compliance. Yet given the lack of public interest in receiving more information, and the possibility of message fatigue and other concerns (such as reducing confidence in tap water, driving people to bottled water (see Means *et al.* 2002; Jones *et al.* 2007; Doria *et al.* 2009; Dupont *et al.* 2010; Dupont & Jahan 2012), how exactly should these proactive, regular communications be implemented?

Our findings clearly suggest that trust is important, with focus group participants indicating a preference for communications from scientists or other 'impartial' communicators. It may be that trusted individuals are the key to providing more proactive communications that the public will attend to. Similarly, our findings suggest a preference by the public for information to be communicated in a way that makes implications clear. Communicating proactively through a lens of 'what this means to me and what I can do about it' could also make communications palatable to the public.

Two-way communication

As noted above, two-way communication is often emphasized as a best practice, particularly to ensure public understanding of an issue (even if they choose not to follow recommended actions). From the public perspective, two-way communication is important so that people may feel that those in authority are providing them the information and explanations they need to understand and

respond to an issue, and that their opinions or concerns are being heard and taken seriously.

Communicators can reach the public in myriad ways, enabling them to understand public needs and perspectives and, importantly, to accommodate changing public needs (Pratap *et al.* 2011). In many respects, this is becoming easier via smart phone applications (i.e. apps), social networking, interactive web forums, etc. Key elements of two-way communication are respect, honesty, transparency, and acknowledgement of the limitations of the information and what is not known. Benefits of two-way communication include working with the public as partners, which leads to an enriched understanding and appreciation of public concerns (Covello 2003; Frewer 2004; Leiss 2004; Seeger 2006).

Our findings reveal limited evidence of two-way interactions with the public occurring by water suppliers or health authorities in BC, but as was the case with regular and proactive communications, there is limited desire on the public's part for two-way communication. As such, there is considerable room for improvement to realize the benefits of two-way communication. Dialogue with the public – even through mechanisms such as the focus groups we conducted – can surface valuable information for communications planning, including goal setting and strategies. By focusing more on information sharing interfaces between government agencies and the public, we might also more adequately address the following issues.

Access to information: A subset of the public would like information about water quality and do not know where/how to get it. Whilst health authorities and water utilities generally provide water quality information on their website, it is clear from our research that members of the public do not know that this information exists. As Guidotti & Ragain (2008) highlight, websites require 'active access' and motivation to seek out the information.

Utility of communications: As we have suggested, whilst water suppliers and health authorities post water quality test results on their websites (for both source and drinking water), it was clear that this information would be more useful to the public if it is converted to a scale (or through some other interpretive lens) that reflects quality and/or risk to human health from different kinds of exposure to or uses of the water, and what the information means in terms of people's water use needs and practices. As such, there is a clear finding from our research that the public would like results to be presented in a way that more adequately emphasizes context and interpretation.

Emergent technologies and new opportunities: Thinking broadly about citizen engagement, there are many opportunities as mentioned to use new technologies for communication, including social networking. These practices would enable a reach to larger, or perhaps younger, audiences. For example, messages can be sent out via Twitter or the water utility (or health authority) can create a smart phone application (e.g. 'app' for iPhone or android) to communicate water quality scales for local beaches, drinking water quality alerts, or other information. A key advantage of these mediums is that people opt in to receive information ensuring that people who are interested can get information when they want it. These modes of communication are also often very time sensitive, and are increasingly the ways that people access news and information. Although the use of such technology is limited in the water sector they are being used in a range of other public outreach efforts, from tornado warnings to snow emergency situations.

CONCLUSION

In the context of British Columbia, Canada, our research shows that at present, there are clear and important disconnects between water quality related communication practices of government agencies and the needs and expectations of the public. There is a need for both improved public understanding of water quality-related risks, and new approaches to ensure information related to water quality reaches audiences. Our evaluation of communication practices strongly suggests that communication strategy is currently not central to microbial water risk communication. There is a clear need for stronger planning and evaluation to develop a comprehensive framework for risk communication; a more detailed and nuanced analysis of specific user needs would be a worthwhile part of any communication planning and goal setting exercise. While this may require commitment of resources, social media and other opportunities also exist that may be low cost

opportunities for improving assessment of public knowledge and needs, or frontiers for information dissemination and implementation. Another general conclusion is that water managers and communicators might benefit from greater attention to the risk communication field. We have highlighted some starting points for such an enriched engagement.

ACKNOWLEDGEMENTS

Research for this article was conducted as part of a 4-year (2011–2015) research project 'Applied Metagenomics of the Watershed Microbiome'. The authors would like to thank Genome British Columbia and Genome Canada for financially supporting this research. For more information about this project, please visit our website www.watersheddiscovery.ca. The authors would particularly like to acknowledge the contributions from research team members.

REFERENCES

BC Ombudsman 2008 Fit to drink: Challenges in providing safe drinking water in British Columbia. Special Report No. 32 June 2008 to the Legislative Assembly of British Columbia.

BC Reg. 200/2003 Drinking Water Protection Regulation.

Bier, V. M. 2001 On the state of the art: risk communication to the public. *Reliab. Eng. Syst. Safety* **71**, 139–150.

Byleveld, P. M., Deere, D. & Davison, A. 2008 Water safety plans: planning for adverse events and communicating with others. *J. Water Health* **6** (1), 1–9.

CBC News 2013 *E. coli Bacteria Sparks Chilliwack Water Chlorination Fight*. Available from: www.cbc.ca/news/canada/british-columbia/e-coli-bacteria-sparks-chilliwack-water-chlorination-fight-1.1374513 (accessed 27 November 2013).

Covello, V. T. 2003 Best practices in public health risk and crisis communication. *J. Health Commun. Int. Perspect.* **8** (3), 5–8.

Doria, M. F. 2010 Factors influencing public perception of drinking water quality. *Water Pol.* **12** (1), 1–19.

Doria, M. F., Pidgeon, N. & Hunter, P. 2009 Perceptions of drinking water quality and risk and its effect on behaviour: a cross-national study. *Sci. Total Environ.* **407**, 5455–5464.

Dupont, D. & Jahan, N. 2012 Defensive spending on tap water substitutes: the value of reducing perceived health risks. *J. Water Health* **10** (1), 56–68.

Dupont, D., Adamowicz, W. L. & Krupnik, A. 2010 Differences in water consumption choices in Canada: the role of socio-demographics, experiences, and perceptions of health risks. *J. Water Health* **8** (4), 671–686.

Eggerston, L. 2008 Investigative Report: 1766 boil-water advisories now in place across Canada. *Can. Med. Assoc. J.* **178** (10), 1261–1263.

Fischhoff, B. 2009 Risk perception and communication. In: *Oxford Textbook of Public Health* (R. Detels, R. Beaglehole, M. A. Lansing & M. Gulliford, eds). 5th edn. Oxford University Press, Oxford, pp. 940–952. Reprinted in N. K. Chater (ed.), *Judgement and Decision Making*. Sage, London.

Fraser Health 2013 The truth about Chilliwack water chlorination. Available from: www.fraserhealth.ca/your_environment/drinking_water/the-truth-about-water-chlorination (accessed 27 November 2013).

Frewer, L. 2004 The public and effective risk communication. *Toxicol. Lett.* **149**, 391–397.

Grover, R. 2011 Boil, boil, toil and trouble: the trouble with boil water advisories in British Columbia. MSc Thesis, University of British Columbia: Vancouver, BC. Available from: https://circle.ubc.ca/handle/2429/33790 (accessed 19 July 2013).

Guidotti, T. L. & Ragain, L. 2008 Communicating with healthcare providers. *J. Water Health* **6** (1), 53–61.

Hamilton, P. D., Gale, P. & Pollard, S. J. T. 2006 A commentary on recent water safety initiatives in the context of water utility risk management. *Environ. Int.* **32**, 958–966.

Holmes, B. 2008 Communicating about emerging infectious disease: the importance of research. *Health Risk Soc.* **10** (4), 349–360.

Holmes, B., Henrich, N., Hancock, S. & Lestour, V. 2009 Communicating with the public during health crises: experts' experiences and opinions. *J. Risk Res.* **12** (6), 793–807.

Hrudey, S. E. 2009 Chlorination disinfection by-products, public health risk tradeoffs and me. *Water Res.* **43**, 2057–2092.

Hrudey, S. E. & Hrudey, E. J. 2004 *Safe Drinking Water: Lessons from Recent Outbreaks in Affluent Nations*. IWA Publishing, London, 514 pp.

Jalba, D. I., Cromar, N. J., Pollard, S. J. T., Charrois, J. W., Bradshaw, R. & Hrudey, S. E. 2010 Safe drinking water: critical components of effective inter-agency relationships. *Environ. Int.* **36**, 51–59.

Jones, A. Q., Dewey, C. E., Dore, K., Majowicz, S. E., McEwen, S. A., Waltner-Toews, D., Henson, S. J. & Mathews, E. 2007 A qualitative exploration of the public perception of municipal drinking water. *Water Pol.* **9** (4), 425–438.

Leiss, W. 2004 Effective risk communication practice. *Toxicol. Lett.* **149**, 399–404.

Livernois, J. 2002 The economic costs of the Walkerton Water Crisis. The Walkteron Inquiry: Commissioned Paper 14. Ontario Ministry of the Attorney General.

Means, E. G., Brueck, T., Dixon, L., Manning, A., Miles, J. & Patrick, R. 2002 Drinking water quality in the new millennium: the risk of underestimating public perception. *J. Am. Water Works Assoc.* **94** (8), 28–33.

Medema, G. J., Payment, P., Dufour, A., Robertson, W., Waite, M., Hunter, P., Kirby, R. & Andersson, Y. 2003 Chapter 1 – safe drinking water: an ongoing challenge. In: *Assessing Microbial Safety of Drinking Water: Improving Approaches and Methods*. IWA Publishing, London, pp. 11–45. Available from: http://www.who.int/water_sanitation_health/dwq/9241546301full.pdf.

Morgan, M. 2002 *Risk Communication: A Mental Models Approach*. Cambridge University Press, Cambridge, UK.

Nsiah-Kumi, P. A. 2008 Communicating effectively with vulnerable populations during water contamination events. *J. Water Health* **6** (1), 63–75.

O'Connor, J. D. 2002 Government Oversight of the Delivery of Drinking Water: Introduction. Part 2, Chapter 2. Report of the Walkteron Inquiry. Ontario Ministry Attorney General, Ottawa.

Pond, K. 2005 Water recreation and disease. Plausibility of associated infections: acute effects, squelea and mortality. *World Health Organization, Emerging issues in water and infectious diseases series*. IWA Publishing, London.

Pratap, P. L., Desai, P. & Dorevitch, S. 2011 Beach communication: a need for evaluation of current approaches. *J. Water Health* **9** (3), 556–568.

Renn, O. 2006 Risk communication – consumers between information and irritation. *J. Risk Res.* **9** (8), 883–849.

Sandman, P. M. 2006 Crisis communication best practices: some quibbles and additions. *J. Appl. Commun. Res.* **34** (3), 257–262.

Seeger, M. W. 2006 Best practices in crisis communication: an expert panel process. *J. Appl. Commun. Res.* **34** (3), 232–244.

Statistics Canada 2009 2007 Households and the Environment Survey (HES) 11-526-X. February 2009.

Summerill, C., Pollard, S. J. T. & Smith, J. A. 2010 The role of organizational culture and leadership in water safety plan implementation for improved risk management. *Sci. Total Environ.* **408**, 4319–4327.

Taylor, C. M., Pollard, S. J. T., Angus, A. J. & Rocks, S. A. 2013 Better by design: rethinking interventions for better environmental regulation. *Sci. Total Environ.* **447**, 488–499.

World Health Organization (WHO) 2011 *Guidelines for Drinking Water Quality*. 4th edn. World Health Organization, France.

First received 19 July 2013; accepted in revised form 22 January 2014. Available online 17 February 2014