Public Written Comments

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From:	Karen Spencer
To:	FN-OSTP-PCAST
Cc:	[redacted]
Subject:	Comment: Study on Drinking Water Safety
Date:	Thursday, October 13, 2016 10:59:31 AM
Attachments:	IBD_Follin-Arbelet-2016.pdf ATT00001.htm Communicating risk for issues that involve 'uncertainty bias'.pdf .pdf ATT00002.htm

PCAST -

I did not receive any confirmation that my June 21st comment to you was received. I trust it was. I would like to additionally bring your attention to last week's letter to the AWWA and governor of Georgia from Civil Rights leader, Andrew Young: http://nebula.wsimg.com/f6f4c9baaaaa931ce4ad02257a449f96?AccessKeyId=A4D71DDB38C1C74A9260&disposition=0&alloworigin=1

- What is needed from you is one line in your report stating that given the evidence of fluoridation chemicals corrosive impact on plumbing, its sinister biochemistry when associated with metals which is intensified in the presence of disinfectants, and documentation of adverse health impact in brains, bodies and bones, we advise that artificial fluoridation of water supplies end immediately.

A few lead resources: http://momsagainstfluoridation.org/sites/default/files/pdf-documents/FluorideChloramineLead_2_2.pdf

I am also attaching two 2016 items that should be of interest. One documents a sharp increase in Crohn's disease subsequent to fluoridation in US, Canadian, Australian and Welch communities. The other documents the misrepresentation of scientific and historical facts by fluoridation advocates:

1. Benoit Follin-Arbelet and Bjørn Moum. Scand J Gastroenterology. Fluoride: a risk factor for inflammatory bowel disease? Scandinavian Journal of Gastroenterology . Volume 51, 2016 - Issue 9
2. Anat Gesser-Edelsburg and Yaffa Shir-Raz. Communicating risk for issues that involve 'uncertainty bias': what can the Israeli case of water fluoridation teach us? Journal of Risk Research · August 2016. DOI: 10.1080/13669877.2016.1215343.

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Communicating risk for issues that involve 'uncertainty bias': what can the Israeli case of water fluoridation teach us?

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Water fluoridation is a controversial issue in public health. Despite the uncertainty regarding its efficacy and safety, health officials continue to communicate it as 'unequivocally' safe and effective. Our focus is on how health officials and policy-makers in Israel frame the issue of water fluoridation in terms of certainty while promoting a mandatory fluoridation policy. According to van Asselt and Vos, the uncertainty paradox describes situations in which uncertainty is acknowledged, but the role of science is framed as providing certainty. Our study is an analysis of documents and media articles emphasizing the paradoxical language used by official representatives on the controversial topic of fluoridation. A central contribution of this study is that we coin the term 'uncertainty bias,' in which policy-makers do exactly what they accuse laypeople of doing, framing uncertainty in biased terms. We found that in order to establish mandatory regulation, health ministry officials expressed information in an unbalanced format, promoting the topic of fluoridation by framing it in exclusively positive terms. This study does not focus on the practice of water fluoridation per se, and is not intended to decide for or against it, but rather, to explore how the debate regarding it is communicated. Understanding this particular case can shed light on how other controversial topics are transformed into health policy that is characterized in equivocal terms.

Keywords: water fluoridation; risk communication; uncertainty bias; framing by policy-makers

1. Introduction

1.1. Water fluoridation

Water fluoridation to prevent dental caries is a controversial issue in public health (Cheng, Chalmers, and Sheldon 2007; SCHER 2011). Many studies have been conducted in this field, including epidemiological and clinical studies, trying to reach conclusions regarding the safety and efficacy of fluoridation of drinking water. Some of those studies have concluded that water fluoridation is an effective measure to reduce dental caries, and found no evidence for health hazards. Examples from recent years include Armfield (2010), Mullen et al. (2012), Cho et al. (2014), Broadbent et al. (2014) and Levy et al. (2014). However, some studies, including recent ones, have found no difference in the level of dental caries between children who drink fluoridated water, compared to those who drink non-fluoridated water, and some have found evidence for various adverse impacts on health. Examples include

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Warren et al. (2009), Choi et al. (2012), Grandjean and Landrigan (2014) and Peckham, Lowery, and Spencer (2015).

In an effort to reach science-based recommendations, three major expert committees have systematically reviewed the evidence on the safety and efficacy of water fluoridation over the past 15 years – The York Committee (McDonagh et al. 2000); NRC (Committee on Fluoride in Drinking Water 2006); and Scientific Committee on Health and Environmental Risks (SCHER) (2011). Yet, all three expert committees have found that much of the evidence produced by studies – both for and against fluoridation – is of poor quality, and the bottom line emerging from all three is that there is uncertainty surrounding both the safety and the efficacy of fluoridation.

A similar conclusion also emerged from the most recent review in this field – Cochrane's systematic review of water fluoridation (July 2015). The authors of this review concluded that there is very little updated and high-quality evidence indicating that fluoridation reduces dental caries, while there is significant association between fluoride levels and dental fluorosis (Iheozor-Ejiofor et al. 2015).

Despite this uncertainty, dental health policy-makers and health officials continue to communicate it as a safe and effective intervention, and actively promote policies to implement it (Cheng, Chalmers, and Sheldon 2007; Wilson and Sheldon 2006).

The Israeli case is a particularly interesting example in this context. On 16 March 2016, the Knesset's (the Israeli parliament) Interior and Environment Committee voted to reinstate mandatory fluoridation of drinking water. Israeli Health Minister Yaakov Litzman, who in recent months has moved to restore mandatory fluoridation, initiated the Knesset vote. His predecessor Yael German had stopped this policy on August 2014 (The Times of Israel 2015). Litzman's measure and the Knesset's decision have transformed Israel once again into one of the only two countries in the world, along with Ireland, in which water fluoridation is mandatory, as had been the case until 2014 (State of Israel Ministry of Health 2014). Moreover, despite the uncertainty associated with this decision and in spite of the opposition of various experts, health policy-makers and health officials in Israel opposed German's decision to end mandatory fluoridation and worked relentlessly to prevent it (The Times of Israel 2015; Lis and Rinat 2016).

This throws into relief the questions arising regarding policy-making for public health measures that involve uncertainty, especially when it comes to policies intended to mandate such measures. The current study presents the Israeli case and examines how Israeli health policy-makers and officials promoted and communicated mandatory fluoridation. Understanding this particular case can shed light on how other controversial topics are transformed into health policies that are characterized in equivocal terms.

1.2. Water fluoridation – a case of scientific uncertainty

Over the past three decades, levels of caries have fallen significantly worldwide, regardless of the concentration of fluoride in water or the use of fluoridated salt (Cheng, Chalmers, and Sheldon 2007).

In Israel, studies have been inconclusive regarding the possible benefits of fluoridation for dental health. For instance, a survey conducted by the Department of Community Dentistry indicated that cities with fluoridated water have lower levels of dental caries compared with non-fluoridated cities (State of Israel Ministry of Health 2012). Yet, a survey recently commissioned by the Health Ministry

(Shir-Raz 2015b) found that 62.6% of Israeli 6-year-olds suffer from caries. This rate is similar to that found in a previous survey (59%), conducted in 1989–1990, before the mandatory fluoridation policy was implemented. Therefore, as Sheldon concludes (Shir-Raz 2015a), this finding implies that the mandatory fluoridation policy has not had notable effects. To date, no studies have examined the effects of fluoridation on the overall health of the Israeli population.

The ongoing controversy over the benefits and risks has led to a policy of discontinuing water fluoridation in many locations throughout the world (Cheng, Chalmers, and Sheldon 2007; Scientific Committee on Health and Environmental Risks (SCHER) 2011). Currently, only about 5% of the world's population – 350 million people – consumes artificially fluoridated water. In several countries, only a small portion of the population consumes fluoridated water, and in some of them, it is naturally occurring fluoride, and not an artificial additive. For example, in England and in Wales, about 9–10% of water supplies contain 0.5–1 mg/l fluoride, either naturally or as an additive (Cheng, Chalmers, and Sheldon 2007).

1.3. A brief history of water fluoridation policy in Israel

German's 2014 decision reversed more than 12 years of mandating fluoridation in Israel. The first water fluoridation plant in the country opened in Jerusalem in 1981. The Ministry of Health stated that each local authority could decide independently whether to fluoridate its water. Yet, in 1998, after years of 'voluntary' fluoridation, the regulations were amended and mandatory fluoridation was introduced in Israel (Zusman 2012). The implementation of these regulations commenced in 2002.

In May 2003, the Ministry of Health appointed an expert committee (the Adin Committee), to update standards for potable water (Knesset Research and Information Center 2010, 2007). In view of the public debate in Israel and worldwide regarding the health and environmental effects of fluoridation, the issue was included in the committee's deliberations. It was discussed by the chemistry subcommittee (Zusman 2012), which was comprised of chemistry, toxicology, and water experts (Knesset Research and Information Center 2010, 2007). In 2006, the sub-committee issued interim recommendations, then released for public review. The committee recommended that mandatory fluoridation would remain unchanged, but would be conditional upon a long-term study on the health effects of fluoridation and a discussion of these findings within 10 years. Yet, after criticism from the public, at the end of 2006, the committee further deliberated, and following a heated debate among the committee members, they voted – in a majority of 6 to 4 – to halt mandatory fluoridation and leave the decision to each local authority. According to Prof. Avner Adin, the committee chair and world-renowned water expert, the decision was based on two central considerations. First, the paucity and inconclusiveness characterizing all studies on the health effects of fluoridation; and second, the reports indicating that over the years, cases of caries decreased at a similar rate both in fluoridating and in non-fluoridating countries (Knesset Research and Information Center 2007). Nevertheless, the Ministry of Health did not adopt the recommendation, arguing that the Ministry's Managing Director 'consulted public health and dentistry experts, who expressed a position according to which the needs of the public require fluoridation throughout the whole country,' and therefore 'decided not to change the situation' (Knesset Research and Information Center 2010).

In April 2013, shortly after Yael German became health minister, she approved new regulations, formulated in accordance with the recommendations of the Adin Committee, ending mandatory fluoridation in Israel. On 26 August 2014, the regulations were to come into effect (State of Israel Ministry of Health 2014). Shortly thereafter, several dental health policy-makers and mayors submitted a petition to the Supreme Court (DoctorsOnly Desk 2014), demanding that German's decision be canceled (in a petition submitted to the Supreme Court in October 2014). The petition was to be discussed in court in June 2015, but in the interim, German was replaced by Health Minister Yaakov Litzman, who revoked her decision (The Times of Israel 2015). This time, instead of commissioning an expert committee or reconvening the Adin Committee, the Ministry of Health chose to move the issue into the political arena. In accordance with Litzman's decision, the Ministry prepared an amendment to the drinking water regulations, and submitted it to the Knesset's Interior and Environment Committee (Efrati and Rinat 2015). The Water Authority, a governmental entity, strongly opposed this move. It argued that not only does it mandate coercion of individual citizens, while the health benefits of fluoridation still up in the air, but as Hannah Frenkel, the legal advisor to the Water Authority put it, it is 'inconsistent with the rules of proper administration' (Water Authority 2015, 1). In a letter to the legal advisor of the Interior and Environment Committee, Frenkel stressed that the amendment contradicts the Adin committee's recommendations, and oversteps the authority of the Ministry of Health. 'It seems indisputable that adding fluoride is not required and is not relevant with regard to sanitary quality of water, but rather, is an advisable supplement,' she wrote. 'Hence, in our opinion, the Public Health Act does not have the power to enact regulations according to which fluoride is added to the water, and in order to make this change, we must correct the ordinance itself.' Frenkel added that 'Reviewing the explanations of the application of mandatory fluoridation indicates that only arguments related to dental health were considered, whereas relevant considerations, like the risks entailed by consuming fluoride, were not considered.' She also reminded the Health Ministry that, 'globally, there are significant controversies about whether drinking water should be flouridated, and many consequences not fully addressed from health and environmental perspectives' (Water Authority 2015, 2).

The Israel Water Association expressed objections along a similar vein in a letter addressed to Litzman and to energy and water minister, Yuval Steiniz (Israel Water Association 2015).

During a pre-vote discussion in the Knesset on 16 March 2016, arguments were presented by supporters of the policy and by opponents. One such opponent was Gideon Oron, a water-engineering expert from Ben Gurion University, who argued that fluorosilicic acid is in fact a waste product that should be buried in toxic waste sites – not added to drinking water. Another opponent, Dr. Daniel Mishori from the School of Environment at Tel Aviv University, said he was shocked that the Ministry of Health and experts who supported fluoridation denied the very existence of a scientific controversy surrounding the topic. Yet, the Ministry of Health officials who attended the discussion argued in response that among professionals there is no controversy on this issue. Following this heated discussion, some of the committee members expressed their reluctance to vote on a health issue that they felt needed to be decided by professionals in the field. Some explicitly asked why such a health issue is discussed in the Interior and Environment Committee, rather than by health experts. Nevertheless, the committee did vote 11 vs. 3, to approve the restoration of

mandatory fluoridation (The Knesset Internal Affairs and Environment Committee 2016). Yael German, who attended the discussion, filed a revision, demanding a repeated vote, yet on 21 March 2016, the decision was upheld, entailing a reinstatement of water fluoridation with no further voting. Again, some of the committee members expressed their reluctance to vote on the issue, and some, including the committee's chair, stressed that the decision should have been made by professionals in the field, but since they had to vote, they adopted the Health Ministry's view (The Knesset Internal Affairs and Environment Committee 2016).

1.4. Regulation in situations of uncertain risks

Scholars have acknowledged that uncertainty is a salient feature of societal debates on new technologies, an inevitable byproduct or 'side-effect' of innovation (Fox 2009; Nowotny, Scott, and Gibbons 2001). Uncertainty refers to any situation where the consequences are unknown – whether due to inadequate data (Einhorn and Hogarth 1985), or because of incomplete scientific understanding or an indeterminate chain of causality (Wynne 1992). This, in turn, leads to vagueness from the decision makers' point of view (Wallsten 1990).

Risk scholars have stressed that dealing with uncertain risks is an important challenge in risk management and assessment (Fox 2009; Lofstedt 2005; Nowotny, Scott, and Gibbons 2001; Ravetz 2001; Renn 2006; Wynne 1982, 1995). According to van Asselt and Vos (2008, 281) 'Uncertain risks need to be sharply distinguished from traditional, simple risks which can be calculated by means of statistics.'

According to Frewer et al. (2003), there is a widespread belief among experts that the public is unable to conceptualize uncertainties associated with risk management processes, and that providing it with information about uncertainty might cause panic and confusion and increase distrust in science and scientific institutions. Yet this belief has proved to be wrong. In general, studies have indicated that in situations of risk, especially risks that involve uncertainty, the public wants full transparency of information, and that providing it does not raise negative reactions among the public in terms of behavior, but rather, helps reduce negative feelings, and increases the public's respect for the risk-assessing agency (De Vocht et al. 2014; Lofstedt 2006; Palenchar and Heath 2002; Slovic 1991, 1995). Nevertheless, the scientific literature indicates that many times, in situations of uncertainty, policymakers do not provide full information, and instead, use science to frame the uncertainty as absolute certainty. van Asselt and Vos (2008, 281) refer to such situations as the 'uncertainty paradox' – situations in which uncertainty is acknowledged, but the role of science is framed as providing certainty. Analysis of actual cases of EU risk regulation conducted by van Asselt and Vos (2005, 2006) and Fox (2009) demonstrates that the uncertainty paradox leads to unintelligible policy-making processes. Moreover, they argue that sometimes, the uncertainty is not even acknowledged (Fox 2009). They use the term 'uncertainty intolerance,' borrowed from psychology, to describe such situations. In psychology, the term 'uncertainty intolerance' is used to refer to people who cannot accept that something negative might happen, regardless of the chances (Vleayen 2008). A similar term used in risk perception literature is 'risk aversive' (Slovic 1995). Yet, van Asselt and Vos (2008, 281) explain that unlike 'risk aversive,' uncertainty intolerance in the context of policy-making refers to situations in which institutions and organizations do not acknowledge the uncertainty and are *unwilling* to demand and produce information

on uncertainty. Instead of systematically investigating the uncertainty, they choose to regard it as irrelevant, or simply ignore it. In their analysis, Fox (2009) found that in some cases, even when some stakeholders do acknowledge the uncertainty and provide uncertainty information, when a dominant or influential stakeholder that is intolerant of uncertainty enters the scene, they can impose uncertainty intolerance. The authors argue that this may result in unintelligible risk regulation.

2. Methods

2.1. The research design

In order to examine how the issue of water fluoridation was communicated by health policy-makers and officials in Israel who promote mandatory fluoridation policy, the method of thematic analysis was employed. Thematic analysis is a qualitative analytic method for 'identifying, analyzing and reporting patterns (themes) within data' (Braun and Clarke 2006; 79). This method goes beyond simply counting phrases or words in a text and moves on to identifying implicit and explicit ideas within the data (Guest, MacQueen, and Namey 2012).

We explored articles in online newspapers that treated the issue of fluoridation, and focused on interviews with health policy-makers and officials, and on articles they wrote. In addition, we analyzed documents on fluoridation such as internal correspondence between health policy-makers and officials, and protocols of Knesset deliberations on this issue.

First, we examined newspaper articles on fluoridation. To this end, we considered three online newspapers: ynet (http://www.ynet.co.il), *Haaretz* Online (http://www.haaretz.co.il/) and DoctorsOnly (http://doctorsonly.co.il/). Ynet and *Haaretz* are the online affiliates of two of the three main daily newspapers in Israel, while the target audience of DoctorsOnly is physicians and health professionals. Ynet was chosen because it is Israel's most popular internet news portal, according to a TIM poll (Avraham 2013). *Haaretz* Online is the online version of *Haaretz*, a top-notch newspaper in Israel (Caspi and Limor 1999), and DoctorsOnly is the leading internet website for doctors and health professionals.

Since we aimed to examine how policy-makers and health professionals framed the issue of fluoridation over the years in which this issue was discussed, we considered all articles on fluoridation published on these 3 websites. We found and analyzed 46 articles published between 6 June 2002 and 1 June 2015. After carefully reading all articles, we identified 40 articles in which health policy-makers and officials were interviewed, or articles authored by them. We considered health officials and policy-makers who favor and promote mandatory fluoridation, including government policy-makers, such as health ministry officials, as well as heads of medical and dentistry associations and heads of academic departments in these fields. The articles also provided information on key official documents on fluoridation, such as petitions and internal correspondence. Some of the articles even provided links to documents. We managed to obtain other documents, including Knesset protocols, located through Google search. We obtained and analyzed 14 documents.

2.2. Data extraction and analysis

All 40 articles and 14 documents were read multiple times by both authors. This process of 'repeated reading' (Braun and Clarke 2006) results in data immersion and

generates the researcher's proximity to the data. Following from this initial stage and building on the notes and ideas generated through data immersion was the coding phase. The codes identified features of the data that the researchers considered relevant to the question under study. Moreover, as is intrinsic to the method, the whole data-set was given equal attention, so that full consideration could be given to repeated patterns within the data. The third stage involved pinpointing themes. All initial codes relevant to the study question were consolidated into a theme. At this point, themes that did not have enough data to support them or were too diverse were discarded. The fifth stage involved defining and characterizing the themes. We considered not only the story told within individual themes but also how these related to the overall story that emerged from the data. The final stage involved choosing examples to illustrate the themes. These excerpts clearly exemplified issues within the theme.

3. Results

The thematic analysis process that was applied to the documents and newspaper articles elicited eight central themes: (1) The science is unequivocal; (2) All experts agree; (3) The whole civilized world does this; (4) Enjoying fluoridation; (5) 'Science' and 'evidence-based' versus 'values' and 'dubious evidence'; (6) We are the (sole) experts; (7) Don't let them frighten you; (8) Public health is at stake if the correct policy is not carried out (See Table 1 for selected quotations).

3.1. The science is unequivocal

As the following examples indicate, a central theme that emerges is the argument of conclusiveness and definitiveness. Despite the uncertainty surrounding the questions of safety and efficiency, health policy-makers and health officials not only characterize the science regarding fluoridation as providing 'certainty,' but use decisive and definitive terms, such as 'unequivocal' and 'undisputed,' to stress that 'certainty':

> It was determined *unequivocally and in disputably* by the medical and academic establishment in the world and in Israel, that there is a significant benefit for dental health and preventing dental caries disease by adding fluoride to water … It was determined *unequivocally and indisputably* by the medical and academic establishment in the world and in Israel, that adding fluoride in the accepted dose … does not cause any damage or any increase in morbidity. (petition submitted to the Supreme Court 2014)

In addition, a prominent tactic used to create a sense of certainty despite conditions of uncertainty, is withholding information and studies that are inconsistent with the promotion of fluoridation. Although in almost all of the documents and newspapers analyzed in this study, policy-makers and health professionals recruit science and 'scientific evidence,' few actually mention scientific sources. Thus, instead of explaining that some of the studies support the efficacy and safety of fluoridation while others do not, and presenting this information so that the public can consider it, what is presented is a consolidated and simplified version of this information – a 'ready-made meal' cooked by these policy-makers and health professionals.

Perhaps the most interesting example of a study that was ignored is the survey commissioned by the Ministry of Health itself. Although Health Ministry officials were aware of the findings, they chose to ignore it in their arguments, and did not

Table 1. Central themes – selected quotations.

Theme	Quotations
1. The science is unequivocal	'Decades of research in Israel and world-wide believe *unequivocally* that at present there is no better health, economic and social substitute to the inclusion of fluoride in tap water in Israel …' (Open letter to German, TheMEDICAL 2014) 'Litzman: My decision relies on the *unequivocal recommendation* of most leading professionals, in Israel and worldwide … This is the most efficient and safe way to prevent tooth decay' (Efrati and Rinat 2015)
2. All experts agree	'*All the committees have confirmed* the benefits of water fluoridation and ruled out evidence any health problems'. (A petition submitted to the Supreme Court in October 2014)
3. The entire civilized world does this	'It is estimated that *about 400 million people from 30 countries* consume fluoridated water' (Grosman and Somech 2013) 'Worldwide *300 million people drink fluoridated water*, and 2.5 million in Israel drink fluoridated water' (Moalem 2002) Today there are *400 million people worldwide* who receive fluoridated water in all these places (The Knesset Labor Welfare and Health Committee 2014) The Pediatricians Association... emphasize that *over 400 million people in more than 60 countries*, are taking advantage of the water with optimal fluoride concentration (Gal 2013)
4. Enjoying fluoridation	'Today …, more than 170 million people in 39 countries *enjoy it* [fluoridation]' (Goldman 2013) 'As for the claim that fluoride is not approved as a drug by the FDA, says Zusman that fluoride preparations are registered as a drug, but the fluoride itself cannot be registered, 'because *it's like registering oxygen'* (Moalem 2002) *'I have never heard* of global research authority who claimed that water fluoridation is dangerous' (Somech 2015) '…there is *no proven danger*' (Moalem 2002) 'Common assumptions about water fluoridation: *True or False?*' (Grosman and Somech 2013)
5. 'Science' and 'evidence based' versus 'values' and 'dubious evidence'	'We've seen that your decisions are taken based on *scientific facts,* drawing on *negligible studies*, as a substitute decisions making based on *scientific comprehensive and high-quality facts*' (Open letter to German, TheMEDICAL 2014)
6. We are the (sole) experts	'It is pity is that the discussion is not first conducted in the presence of academics and the Health Ministry professionals, before bringing *'experts'* from overseas to discuss the issue. Such step could be a precedent for bringing other

(*Continued*)

Table 1. (*Continued*).

Theme	Quotations
	preachers to stop the chlorination, end the use of vaccines or stop the use of 'Ritalin" (Shafir 2009) 'The minister is *imbued with a delusional crusade* against fluoridation' (e-med 2014) 'All opponents cite the same studies which are distributed by international movement opposing fluoridation *from political, emotional and social motives*' (Open letter to German, TheMEDICAL 2014) 'Different groups are *making political capital* of the opposition to fluoridation and are *happy to bash the government* whenever possible' (Goldman 2013)
7. Don't let them frighten you	'*Intimidating the public* against this required substance is like inciting the public against the use of chlorine in swimming pools. Chlorine and fluorine are required for keeping the water clean and healthy' (Open letter to German, TheMEDICAL 2014)
8. Public health is at stake if the correct policy is not carried out	Cessation of mandatory water fluoridation – *a mistake that will cost in health* (Goldman 2013) Discontinuing water fluoridation for the first time in forty years, while creating baseless delegitimization *will cause generations of suffering* (Open letter to German, TheMEDICAL 2014)

mention it at all in the documents and newspapers articles. Instead, they cite previous studies conducted in Israel.

Moreover, on several occasions, policy-makers and health professionals explicitly deny that such studies exist. For example:

> Dr. Shlomo Sussman, director of Dental Health Division in the Ministry of Health … said: '*There are no studies* that indicate damage to health. The only fact is that fluoride increases resistance to tooth decay.' (The Knesset Labor Welfare and Health Committee 2011)

Even in the rare instances in which scientific sources such as the YORK and the NRC reports are mentioned, the reports are cited selectively, eliminating the uncertainty they expressed:

> UK has set up an external governmental committee, through the University of York … I tell you: *it was found that drinking water fluoridation is effective in reducing the incidence of dental caries.* (Gruto, Knesset Labor Welfare and Health Committee 2011)

3.2. All experts agree

Another prominent theme we found is 'All experts agree.' According to this theme, there is a consensus among experts regarding the safety and efficiency of fluoridation, as well as its importance:

> The importance of fluoridation to prevent dental caries disease has been recognized *by the whole medical and academic establishment, both in Israel and worldwide.* (Petition submitted to the Supreme Court 2014)

This argument serves an important role – it enables policy-makers and health officials to ignore the debate on questions of safety and efficacy regarding mandating fluoridation. The heated debate in the Adin Committee in Israel is an example of such a debate that was not mentioned (Knesset Research and Information Center 2007). It seems that the debate is simply ignored and instead of presenting the range of opinions, a dubious 'consensus' is presented.

3.3. The whole civilized world does this

'The entire civilized world fluoridates' is the third theme we found. One of the prominent arguments made by health officials and policy-makers in almost every document, article or newspaper interview is that 300–400 million people in the world in about 30 countries drink fluoridated water. For example: 'Fluoridation is practiced in about thirty countries around the world … According to various estimates about 400 million people consume fluoridated water' (Grotto 2015).

However, these 300–400 million people from 25–30 countries actually constitute only 5% of the world population (Cheng, Chalmers, and Sheldon 2007). Thus, by choosing to stress the number of people who consume fluoridated water, they 'eliminate' the fact that vast majority of the world's population does not drink artificially fluoridated water. Furthermore, in listing the 25–30 countries that fluoridate drinking water, they include countries such as England and Spain, in which only a small (sometimes even tiny) percentage of water supplies is artificially fluoridated, and countries in which the fluoride occurs naturally. They also ignore the many instances in which fluoridation was discontinued (Cheng, Chalmers, and Sheldon 2007; Scientific Committee on Health and Environmental Risks (SCHER) 2011).

3.4. Enjoying fluoridation

The fourth theme we pinpointed is 'enjoying fluoridation.' According to this theme, fluoridation is framed as a practice that is purely beneficial, while no risks are involved. One way to achieve this framing is by using the verb 'Enjoy' in relation to fluoridated water, instead of using verbs such as 'drink' or 'receive.' For instance:

> Zusman: The only means that reduces health disparities is fluoridation of drinking water … There is no need for awareness and no need for special action in order to benefit from its positive effects. *Everyone enjoys it*. (The Knesset Labor Welfare and Health Committee 2011)

While verbs such as 'drink' or 'receive' are neutral, the verb 'enjoy' implies that there is no question the practice is efficient and safe – one can only benefit from it. Moreover, on one occasion, water fluoridation is compared to the need for oxygen (Moalem 2002).

Another tactic used to achieve the frame of 'benefits only' is by presenting only advantages, not mentioning potential adverse effects. In some cases, this is expressed explicitly: 'It was determined… that *there is no danger or side effects* …'. (Petition submitted to the Supreme Court 2014)

Even in the rare cases when such potential side effects or disadvantages are mentioned, they are framed as 'myths' which need to be refuted. For example, an article written by two health officials entitled 'Common assumptions about water fluoridation: True or False?' (Grosman and Somech 2013). Each of the 10 assumptions presented in the article is refuted, as the answer given is 'False!' In order to stress the fact that the assumption is in fact a myth, the answer is reinforced with an exclamation point.

3.5. 'Science' and 'evidence-based' versus 'values' and 'dubious evidence'

This theme redirects the controversy to issues other than science and evidence, focusing instead on irrelevant issues, such as values or politics, or even 'dubious evidence,' meaningless studies, 'populist,' 'political demagoguery,' or 'nonsense'.

For example, the position of the professional staff at the Ministry of Health, which was in favor of fluoridation, and even today is in favor of fluoridation, *is based on dozens of studies in Israel and worldwide*, conducted over time, that meet accepted scientific standards. (A petition submitted to the Supreme Court in October 2014).

In contrast: 'We strongly protest the populist use of *meaningless studies*, raising claims regarding the possibility that fluoride causes cancer and other formidable health risks. This is unequivocally untrue and the use of this unfounded claim constitutes *incitement of the public against science*, and political *demagoguery.*' (TheMEDICAL desk 2014).

Unlike 'science' and 'evidence-based' studies, presenting 'meaningless studies' endangers the public's health, and therefore must be 'treated' with the utmost severity, as the following quote indicates: 'Prof. Itamar Grotto and I will fight with all our might to prevent this nonsense' (Gamzu 2011).

In this last example, 'nonsense' describes the conclusions of the Adin Committee, a committee comprised of leading experts on chemistry, toxicology, and water, and adopted by members of a parliamentary committee (The Knesset Labor Welfare and Health Committee 2011). This leads to the next theme, according to which – only dentists, physicians, or epidemiologists can be characterized as experts.

3.6. We are the (sole) experts

Although chemistry, toxicology, and water engineering are disciplines that are as relevant to the issue of fluoridation as medicine and dentistry (in fact, this complicated issue should be deliberated by an interdisciplinary teams of experts), their expertise was dismissed as irrelevant. By overlooking the Adin Committee's debate, as well as the fact that Prof. Adin himself explained that the committee's conclusion was based on the uncertainty surrounding the safety and efficacy of fluoridation, and by referring to the committee's conclusion as 'nonsense,' the health professionals and policy-makers actually present themselves as the sole experts in this field. Thus, the controversy is characterized not as a controversy between disciplines, but between 'experts' and 'non-experts.'

Moreover, those who oppose water fluoridation are framed as motivated by personal or political interests or even 'preachers' or 'delusional.' For example, 'The minister is imbued with a delusional crusade against fluoridation.' (e-Med desk 2014)

3.7. Don't let them frighten you

The seventh theme refers to the information and studies published in the media that indicate the uncertainty regarding the efficacy of fluoridation and describe potential risks in terms of intimidation, 'scare-tactics' and rumor-mongering. For example:

> It is important to avoid rumors and scare tactics and to adhere to scientific facts: additional fluoride concentrations recommended do not have adverse effects on bones, they do not cause cases of cancer or nerve damage. (Somech 2015)

3.8. Public health is at stake if the correct policy is not carried out

While opponents are accused of using intimidation tactics, this theme indicates that in their desire to promote a mandatory fluoridation policy, health policy-makers themselves use these tactics. For example: 'Discontinuing water fluoridation for the first time in forty years, creates baseless delegitimization of fluoridation and will cause generations of suffering' (TheMEDICAL desk 2014).

On one occasion, they even went as far as to accuse German of removing the 'dental and societal Iron Dome' that shielded the Israeli public – because she ended the fluoridation policy. The Iron Dome is an air defense system used by Israel to protect civilian areas from rockets (TheMEDICAL desk 2014).

4. Discussion

4.1. Uncertainty as main theme

The decision to overturn the decision and to turn Israel into one of only two countries in the world that mandates fluoridation has global implications, raises a range of compelling questions and issues. This study focuses on one such issue, namely how uncertainty was communicated to the public. Our decision to approach the issue in terms of certainty and uncertainty stems from how the supporters of mandatory fluoridation framed their promotional strategies. The Israeli health officials chose to frame this issue as a 'certainty.' Our study indicates that this was the overarching theme, and as such, the other themes that we pinpointed and discussed above, are sub-themes that support this overall framing. Out of various frames they could have chosen to promote mandatory fluoridation, they chose to frame this controversial issue in terms of 'certainty,' just as one would frame the recommendation to eat fruits and vegetables – as though it were unanimously recommended and grounded in solid research.

Our findings revealed how policy-makers and health professionals in the media and in documents convey inconclusive scientific information on safety and efficacy of fluoridation in terms that are nevertheless conclusive and unequivocal. This is what van Asselt and Vos (2008, 281) refer to as the 'uncertainty paradox.' This refers to situations in which uncertainty is acknowledged, but the role of science is framed as one of providing certainty, despite uncertainty precluding both conclusiveness and definitiveness. Moreover, Fox argues that sometimes, the uncertainty is not even acknowledged (Fox 2009).

4.2. Why are policy-makers who support fluoridation so passionate about mandating this measure that they would renounce the uncertainties?

Two possible explanations can be found in the arguments made by the officials supporting mandatory fluoridation. The first is a fear of mass panic or 'hysteria,'

generated by the opponent's conspiracy theories. As Prof. Shlomo Zusman, the Director of Dental Health at the Israeli Ministry of Health (Zusman 2012, 5–6) contends: 'It was considered preferable to refuse to comment on a newspaper article on the grounds that public interest recedes quickly if there is no response. Likewise, participation in television talk shows was resisted, however tempting it sounded. The anti-fluoridation lobby was treated politely as being well meaning but sadly misinformed as *aggressiveness and verbal violence often gives rise to hysteria rather than intelligent discussion.*' Similarly, Prof. Herold Segen-Cohen and Dr. Yuval Vered, two dentistry officials who supported fluoridation wrote: 'One way to counteract against the rising tide of opposition to water fluoridation is to avoid response and confrontations 'until the storm passes.' This type of restraint and lack of response is often mentioned in the scientific literature in the US, which discusses ways of responding when facing opposition propaganda. The logic behind this approach stems from the fear that even raising the subject might arouse suspicion and doubt about its safety, efficacy and necessity, and will provide the opponents a convenient platform for action' (Vered and Sgan-Cohen 2002). Indeed, as several scholars have pointed out, organizations and governments often refrain from communicating risks for fear of arousing negative feelings among the public and causing negative reactions the public's behavior (De Vocht et al. 2014; Maxim, Mansier, and Grabar 2012; Sandman 2006; Sjöberg 1998). However, studies have indicated that while concerns can be a normal and even a useful 'adjustment reaction' when facing crisis situations, panic and hysteria are comparatively rare (Lanard and Sandman 2014; Sandman 2014; Sandman and Lanard 2011).

Regarding the issue of panic, the sociologist Lee Clarke has explained:

> Disasters, like other social situations, have rules, and people generally follow them. They are not special rules, even though disasters are special situations. The rules are the same ones at work when the theater is not on fire. Human nature is People die the same way they live, with friends, loved ones and colleagues – in communities. When danger arises, the rule – as in normal situations – is for people to help those next to them before they help themselves. (Clarke 2002, 24)

Another explanation found in the arguments made by the fluoridation supporters is that there is no real controversy about the issue of fluoridation. These supporters believe that the opposition to fluoridation is marginal, voiced mainly by extremists who are not experts, and therefore, create a scientific distortion. 'Some contend that there is debate or disagreement. If I would have expressed one opinion and Prof. Yhonatan Man, who is a professor of public dentistry, had expressed a different opinion, you could say there is a debate among experts. If Prof. Eli Somech (head of the Israeli Pediatric Association) expresses one opinion and Prof. Nadav Davidovich (head of the Association of Public Health Physicians in Israel) expresses another opinion, you could say that there is a debate among the professionals. But I heard and you heard that there is no dispute among the professionals' (The Knesset Internal Affairs and Environment Committee 2016).

Even if we overlook the question of what constitutes an 'expert,' and why the professionals on the Adin committee and in the Water Authority and the Israel Water Association were not viewed as experts, the two above-mentioned explanations are not supported by the scientific literature. As described above, water fluoridation is a controversial issue in public health, and the debate over its health benefits and risks between the various experts and researchers who studied this issue cannot be denied.

This debate has been the focus of three international committees, and was the reason for commissioning them. It also instigated the Cochrane's systematic review (Iheozor-Ejiofor et al. 2015). Perhaps the major difference between the Israeli experts who oppose fluoridation, such as the Adin Committee experts or the Water Authority experts and their counterparts abroad is the unwillingness of the Israeli experts to voice their reservations in the media. 'I had assumed because of everything I'd heard that water fluoridation reduces cavities, but I was completely amazed by the lack of evidence,' said Prof. Trevor Sheldon, the dean of the Hull York Medical School in the United Kingdom who headed the York committee, in a *Newsweek* interview, following the publication of the Cochrane's systematic review (Main 2015). 'My prior view was completely reversed … There's really hardly any evidence the practice works, and if anything there may be some evidence the other way.' 'Frankly, this is pretty shocking,' said Thomas Zoeller, a scientist at UMass-Amherst, in the same *Newsweek* article. 'This study does not support the use of fluoride in drinking water.' In another interview on the Israeli media, Sheldon stated: '*It is disappointing to see yet again ministry of health and government officials use our research to support views which are not supported by the research*. Whilst it is likely that water fluoridation will have a small positive effect the research was too poorly conducted and reported to estimate reliably the size of this effect and whether this effect exists in populations where there is good uptake of tooth brushing. *There is also uncertainty about the possible adverse effects* of fluoridation on health. Only large well designed studies are likely to be able cast light on potential hazards …' (Shir-Raz 2015a).

Not only do these experts voice their reservations and unambiguously declare that there indeed is a controversy among experts, they also publicly point to the conflict of interests involved in mandating fluoridation. '… *the Department of Health's objectivity is questionable – it funded the British Fluoridation Society* and, along with many other supporters of fluoridation, it used the York Review's findings selectively to give an overoptimistic assessment of the evidence in favour of fluoridation,' Sheldon stated in an article published in BMJ. 'In response to MRC recommendations, the department commissioned research on the bioavailability of fluoride … The study had only 20 participants and was too small to give reliable results. Despite this and the caveats in the report's conclusion, this report formed the basis of a series of claims by government for the safety of fluoridation. *Against this backdrop of one-sided handling of the evidence*, the public distrust in the information it receives is understandable (Cheng, Chalmers, and Sheldon 2007).

In contrast, Israeli experts who oppose mandatory fluoridation voice their views only in internal documents and in meeting rooms. They refrain from speaking out publicly, and it seems that since the decision to restore mandatory fluoridation, they are even more reluctant to do so. In addition, the mainstream media in Israel rarely publishes any investigative articles on this issue, which might have exposed the controversy between the experts, or the reasons behind the supporters' passion regarding this particular issue. This silence gives the officials who support and promote mandatory fluoridation free rein. The only players who remained on the stage to clearly voice their opposition were opponents on the Internet and social media. Indeed, these players consistently pointed out various conflicts of interest – for example, the connections between government officials and the industry that sells the fluorosilicic acid to the Ministry of Health (Another Truth Project Manager 2009; Hildsheim 2016) – which might be a third possible explanation for the

passion of supporters of mandatory fluoridation. Yet, their views are framed as extremist or even delusional (Lavi 2009; Rom 2009).

In order to hone our understanding of the passion characterizing health officials' views on this issue, it would be interesting to examine whether there are other potentially mandatory health-related policies that do not evoke a similar passion on the part of health officials and practitioners. A striking example is the case of adding iodine to table salt. Iodine deficiency disorders, which can start before birth and jeopardize children's mental health and often their very survival, are a major nutrition and public health problem worldwide (Gebretsadikan and Troen 2016; WHO 2016). Studies indicate that iodine deficiency affects about 30% of the world's population, and is the leading cause of preventable mental retardation (UNICEF 2015). A simple solution recommend by WHO, the ICCIDD Global Network (the International Council for the Control of Iodine Deficiency Disorders Global Network) and UNICEF, is to add iodine to table salt. In addition, in 2005, the World Health Assembly (WHA) adopted a resolution that urged member states to regularly monitor the iodine situation in their country (Zimmermann and Andersson 2012). Nevertheless, in Israel, not only is there no policy of adding iodine to table salt, but there are no national data on iodine intake (Ovadia et al. 2014). Israel is listed among 43 countries in which no UIC data (measurement of urinary iodine concentrations) are available (Zimmermann and Andersson 2012). Data from Israeli National Health Interview Surveys by Israel Center for Disease Control show that in 2003–2010, the self-reported use of thyroid disease medication among Israeli adults increased from 2.9 to 4.7% – a finding that may indicate a problem regarding the iodine levels among the Israeli population (Ovadia et al. 2014).

4.3. 'Uncertainty bias': from doubt to consensus

The contribution of this study is an analysis of the paradoxical language used by official representatives. As far as we know, our analysis is the first of its kind on the topic of fluoridation. Our findings show that health professionals and health ministry representatives, including the health minister, do not regard the uncertainty reflected in scientific studies with the seriousness it deserves. They go so far as to dub studies that raise questions as to the efficacy of fluoridation – nonsense. In so doing, they do not take into account that much of the public is interested in knowing about uncertainty, and does not always want unequivocal information. Studies have indicated that in situations of risk, especially risks that involve uncertainty, the public wants full transparency of information (De Vocht et al. 2014; Lofstedt 2006; Palenchar and Heath 2002; Slovic 1991). If people feel they do not have sufficient information regarding the risk, this tends to increase the sense of uncertainty and negative feelings (Gesser-Edelsburg, Shir-Raz, and Green 2014; Griffin, Dunwoody, and Neuwirth 1999; Huurne and Gutteling 2008; Kahlor 2010).

Van Asselt and Vos use the term 'uncertainty intolerance,' borrowed from psychology, to describe situations in which institutions and organizations do not acknowledge the uncertainty and are *unwilling* to demand and produce uncertainty information. Instead of genuinely and systematically investigating the uncertainty, they choose to discount it as irrelevant, or simply evade or ignore it (Fox 2009).

This study found that policy-makers from the health ministry rejected the opinions of experts from the Adin committee who opposed fluoridation, including chemistry experts, toxicologists, environmental and water engineers. The traditional

media focuses on the opinions of the policy-makers and health policy-makers and does not voice those of experts from other fields. These policy-makers also ignore the findings of international committees and leading experts who concluded that much of the evidence regarding fluoridation is of poor quality, and points to the uncertainty regarding both safety and efficacy of this practice.

This phenomenon was characterized by Fox (2009) in her analysis, which found that in some cases, even when some policy-makers or other stakeholders do acknowledge uncertainty and provide some uncertainty information, policy-makers who are intolerant of dissenting opinions, such as those within risk regulation, ignore them and manage to impose uncertainty intolerance.

The findings of this study point to the ways in which different experts – like those in the Adin Committee – communicate risk. It shows that communication stems not only from the language inherent to each discipline, but also from differing risk perceptions. It is problematic to communicate the risk of an interdisciplinary topic like fluoridation that involves professionals from different fields. The question is how professionals from across different fields can agree about the degree of severity of a complex and interdisciplinary topic. Moreover, in discussions among professionals from various fields, is there a transformation that must occur to communicate risk in a way that promotes dialog and is not monolithic? In such a professional committee, should hierarchic considerations be overlooked? Our findings show that in Israel the dissenting opinions were disregarded by a single influential and decisive voice that was the regulatory factor. The question that arises from this study is broader and considers the role of regulation in policies that are multidisciplinary like fluoridation.

In this study, we found that in order to establish mandatory regulation, health ministry officials did not use the language of risk communication. They did not express the information in a balanced and unbiased format, emphasizing multiple, and even contradictory points of view in order to address the concerns of different subpopulations. Rather, they chose to promote the topic of fluoridation by framing it in exclusively positive and popular (unscientific) terms, comparing it to the human need for oxygen and the Israeli use of the Iron Dome for necessary protection from missile attack.

As we explained, authorities tend to overlook or to deny situations that involve uncertainty. The opposite situation can also occur – wherein there is scientific certainty, but industry representatives create a situation of doubt in order to prevent regulation, as has been shown in examples such as the tobacco industry and climate change (Oreskes and Conway 2011). The case under discussion introduces an additional element. In the present case, despite the situation of uncertainty, public health professionals not only chose to 'ignore' documentation they found inconvenient, and to ignore other professionals, but – importantly, they framed their view of the situation in terms of consensus. This situation not only generates vagueness but also creates bias. This bias is created using two tactics: (1) By creating a situation of seeming consensus, and (2) To present the opponents as unprofessional or marginal. The consequences of this bias is that policy-makers vote on the issue believing that there is a consensus, and that it makes the public believe that there is no controversy and that fluoridated water is completely safe and necessary.

In light of this, we suggest that in such a case, the term 'uncertainty intolerance' is an understatement, because the fluoridation campaign that was carried out disregarded any studies that did not support the official representative's agenda, or rejected such evidence off the cuff, claiming that they did not uphold professional standards.

We suggest coining the term 'uncertainty bias.' Policy-makers often criticize citizens such as bloggers on the social networks who are not professionals for sharing only partial information with the public on topics that concern public health, accusing them of spreading misleading information and misconceptions. In the case of fluoridation, the American Dental Association dubbed questions regarding the safety and efficiency of fluoridation as 'myths' and misconceptions, while referring to their arguments in favor of fluoridation as 'facts': 'Fluoridation Facts contain answers to frequently asked questions regarding community water fluoridation. A number of these questions are based on myths and misconceptions advanced by a small faction opposed to water fluoridation' (American Dental Association 2005). Similarly, we found in our study that Israeli health officials and policy-makers accuse those opposing their policies of spreading misinformation and 'myths' (Grosman and Somech 2013).

In this study, we argue that the policy-makers themselves do exactly this, carrying out what they accuse others of doing. They share only partial, biased information in order to support their case, and convey information in terms that misrepresent the actual situation. We propose calling such a phenomenon 'uncertainty bias,' in which the policy-makers do exactly what they accuse laypeople of doing, framing uncertainty in biased terms. An example of such a manipulation is specifying the number of people who drink fluoridated water, neglecting to mention that these numbers comprise only 5% of the world population.

The limitations of this study are that we examined the communication from officials to the public, and not the public's reactions to this. We recommend examining the public's reactions in further studies. Regarding our examination of the media, this study focused on documents and interviews in newspapers, and not on television or radio. We recommend that further studies expand the communication aspect by examining other forms of media.

5. Conclusions and recommendations

In policy-making on public health issues, it is essential to change how communication is carried out, especially on issues characterized by uncertainty. Health officials should acknowledge the uncertainty and share the available information with full transparency. They should also adhere to scientific information to justify arguments regarding policy-making, and avoid disparaging comments that resort to unscientific arguments in order to undermine opposing opinions. Last is the question of whether in issues of uncertainty it is appropriate to determine broad-based policies intended to mandate public health measures – or how such decisions should be made, particularly in health issues under scientific debate.

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No potential conflict of interest was reported by the authors.

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REVIEW ARTICLE

Fluoride: a risk factor for inflammatory bowel disease?

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ABSTRACT

Although the association between inflammatory bowel disease (IBD) and oral hygiene has been noticed before, there has been little research on prolonged fluoride exposure as a possible risk factor. In the presented cases, exposure to fluoride seems indirectly associated with higher incidence of IBD. Fluoride toxicology and epidemiology documents frequent unspecific chronic gastrointestinal symptoms and intestinal inflammation. Efflux genes that confer resistance to environmental fluoride may select for IBD associated gut microbiota and therefore be involved in the pathogenesis. Together these multidisciplinary results argue for further investigation on the hypothesis of fluoride as a risk factor for IBD.

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Introduction

Crohn's disease (CD) and ulcerative colitis (UC) are chronic inflammatory diseases of the gastrointestinal tract with possibly multifactorial etiology. Known risks factors account only for a part of the observed variability.[1] It has been found that drinking water parameters [2,3] are correlated with the incidence of inflammatory bowel disease (IBD) and ambient air pollution with hospitalizations.[4] There are probably additional unknown environmental risk factors.[1]

The hypothesis that toothpaste is a risk factor for IBD was formulated first in 1950,[5] before fluoridated toothpaste or dental care products became widely available. Subsequent investigators focused on toothpaste microparticles and linked known IBD risk factors with oral hygiene.[6] Precisely, it was observed that oral hygiene is one possible unifying explanation for the increased risk due to an urban, modern, and western lifestyle. More recently, teeth brushing and mouth rinsing frequency have been demonstrated to be significantly higher for IBD patients at disease onset.[7]

Smoking is a confirmed risk factor for CD as well and could contribute to fluoride (F^-) intake since tobacco contains fluoride.[8] Fluoride has been used increasingly from the second half of the twentieth century for the prevention of cavities. It has broad biochemical properties and is therefore used in blood samples to inhibit glycolysis,[9] in protein chemistry buffers to inhibit phosphatases,[10] and aluminum fluoride is used to study the structure of nucleotide binding sites.[11]

The main sources of fluoride intake are drinking water, food, and dental hygiene products.[12] Intake from heavily polluted atmosphere can represent a significant portion too. Amounts vary widely in between individuals, for example in one Canadian study the average daily intake was 0.6 mg in communities with water under 0.2 ppm and 2.8 mg in communities with water fluoridated to 1 ppm.[13] Individuals could take as high as 6.7 mg daily.

In the acid gastric environment, a significant part of fluoride is absorbed as hydrofluoric acid (HF) through the stomach wall.[12] Fluoride transport through the intestinal epithelium takes place as well, though its mechanism has yet to be identified.[14] Generally, 10–20% of the fluoride is not absorbed.[12] Absorption will vary according to plasma concentration and to the diet, especially along cation content as it can form poorly soluble ionic complexes in the intestine.[12,15] More known individual and environmental factors can influence fluoride metabolism too, for example age, kidney function, bone status, and diet.

Findings arguing for exposure to fluoride as a risk factor for IBD are reviewed here. Furthermore, it is speculated about the relation between recently discovered fluoride transport genes and IBD associated microorganisms.

Epidemiological studies suggest an association between fluoride exposure and IBD

No studies have directly investigated or linked fluoride exposure and IBD. Being traceable for defined large bodies of population, artificial fluoridation of drinking water networks indirectly gives the possibility to compare IBD epidemiologic data with exposure to fluoride.

Canada has pioneered water fluoridation together with the USA [16] and suffers from very high prevalence of CD and UC.[17–19] In the province of Québec, less than 15% of the population had fluoridated water in 1995–2000.[20] Quebec geographical variation of CD incidence has been mapped, taking into account known genetic, demographic, and

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environmental risk factors.[21] When reinterpreting this study, health areas with the highest residual CD incidence seem to have more frequently fluoridated water [20,22,23] (Table 1).

Anecdotally, it has been noticed a particularly high incidence of CD in Casteltermini, Sicily, which *NOD2* genetics cannot explain.[24] This coincides with the highest naturally occurring concentration of fluoride in the drinking water of Sicily at 3.2 ppm [25] and indeed a high prevalence of gastrointestinal diseases has been attributed to fluoride in the neighboring village.[26]

Time series recording IBD incidence are informative as well, combining uninterrupted diagnostic with traceable water fluoridation start. In a recent systematic review of IBD epidemiology,[27] we could identify five time series when water fluoridated was started in at least the main population center of the catchment area.

Table 1. Number of Quebec health areas according to CD residual incidence and corresponding fluoride sources.

Residual incidence	No fluoride sources	Fluoride in drinking water	Atmospheric industrial release	Combined fluoride sources	Total
Very high	6	3[a]	1	4	10
High	36	10	4	14	50
Average	47	8	1	9	56
Low	34	3	3	5[b]	39
Very low	10	1	0	1	11
Total	133	25	9	33[b]	166

[a]Naturally occurring in Maria, Gaspésie.[23]
[b]Both industrial emissions and fluoridated water in Bécancour.

In the Rochester metropolitan area (New York), drinking water fluoridation was initiated from 1949 and completed in 1964 in the whole study area.[28] IBD incidence has been recorded since 1925,[29] and the remarkable time series has also been interpreted in the context of other putative risk factors [30] (Figure 1(a)).

In Rochester (Olmsted county, Minnesota), IBD epidemiological data have been recorded since 1940 [31] (Figure c1(b),(c)). Fluoridation started in 1960.[28]

In Edmonton, Alberta, Canada, water was fluoridated from 1967.[16] In Australia, water fluoridation programs were initiated later: 1971 for Newcastle, New South Wales,[32] and 1977 for Melbourne, Victoria. In all of these datasets, water fluoridation precedes a strong increase of incidence.[29,31,33–35]

The incidence of UC is significantly increased with the intake of drinking water contaminated with perfluorooctanoic acid.[36] The corresponding exposure to fluoride has not been modeled. There may be a positive correlation since fluoride environmental releases from the same facility were simultaneously high.[37]

Among other occupations, working in the glass, ceramic, and tiles industry and metal foundry industry has been associated with hospitalization for CD and UC, respectively.[38] These industries are the largest anthropogenic emitters of fluoride [39] and metal industry employees have probably been more exposed to it in their work environment.[40]

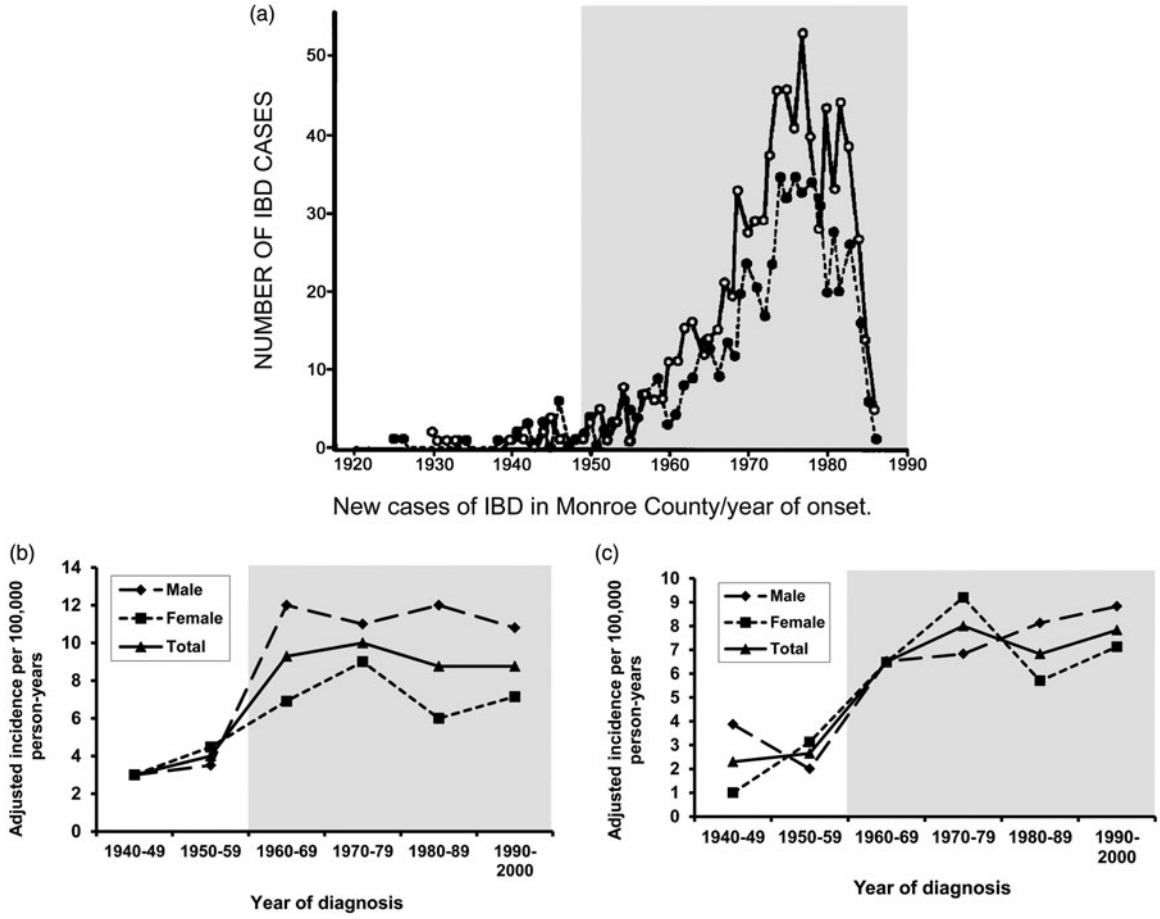

Figure 1. (a) Records of IBD cases in Monroe County, NY, adapted from Stowe et al. [29]. Records of UC (b) and CD (c) incidence, age-adjusted, by gender, in Olmsted County, MN, adapted from Loftus et al. [31]. The shaded area indicates the period with fluoridated water.

High fluoride exposure is associated with gastrointestinal symptoms and findings

Animal experiments show dose-dependent damages of the gastrointestinal tract [41–44] at doses of fluoride, which are high compared to usual human doses. When given 1 mg fluoride twice a week for 3 weeks, rats showed signs of inflammation of the small intestine.[42] The cellularity of Peyer's patches and mesenteric lymph nodes was increased and there were elevated amounts of $CD4^+$ T cells and immunoglobulin secreting cells. Rats being fed 25 mg/kg/day sodium fluoride for 90 days have lymphocyte infiltration, swelling and delamination of the ileal villi, probably from induced oxidative stress.[43] Extremely high doses increase apoptosis in avian cecal lymphoid tissue.[44]

Starting with the first chronic fluoride intoxication studies on cryolite industry workers,[45] unspecific gastrointestinal symptoms were observed within a few weeks after exposure start, even more frequently than occupational asthma. Most common were lack of appetite, nausea, diarrhea, or constipation. Fecal blood, rheumatic pain, and lumbar sclerosis and skin rashes were occasionally seen. In one of two autopsies reports on a worker that died of postoperative causes, the case has findings that CD sometimes shares: 'about 1/2m from the ileocaecal junction a limited area of the ileum has a thick coating of fibrin and is blue in colour, there are traces of strictures'.[45]

In northern India, UC is almost as frequent as in Europe and North America.[46] In parallel, fluoride in ground water is a serious public health issue and every report of gastrointestinal symptoms caused by chronic fluoride intake originates from this region.[47–54] Chronic abdominal pain, nausea, bloating, vomiting, diarrhea, or constipation are significantly more frequent in areas with endemic fluorosis, even for patients without signs of skeletal fluorosis. In some instances, these symptoms have been described as irritable bowel syndrome.[47] At a lower frequency, they are found in areas with reasonably low fluoride in water (1–1.5 ppm).[48] Upper gastroduodenal endoscopy on skeletal fluorosis patients reveals diffuse erythema, petechiae and features of inflammation.[49,50] On duodenal biopsies, the epithelium shows scanty microvilli and cell junctions are widened.[50]

On a small-scale study, serum fluoride concentrations were measured for patients with post-surgery short bowel syndrome in need of home parenteral nutrition, an unspecified number of them due to IBD.[55] Out of 31 patients, 28 had serum concentrations over the controls reference range. For 15 of them, the elevated values could be attributed to the high consumption of mineral water and tea to compensate for fluid losses and to fluoride supplements for osteoporosis. Two patients with villous atrophy or pseudoobstruction were even diagnosed with skeletal fluorosis. It is unknown if fluorosis preceded the intestinal pathology. It is not known either if intestinal failure changes the absorption of fluoride.

Fluoride may modify intestinal microbiota

Fluoride resistance mechanisms were recently discovered in a wide range of microorganisms. A riboswitch that many prokaryotes possess up-regulates genes in the presence of fluoride. The most frequent genes are Na^+/H^+ antiporters, enolase, and transporters *crcB* and *clcF*.[56] CrcB is a selective channel for fluoride and transports fluoride out of the cell according to the membrane potential.[57] ClcF is a member of CLC chloride transporters that exchanges one F^- for one proton.[58] When experimentally tested, clcF antiporters show variable efficiency in between species.[56,58,59] Genetically modified microorganisms without efflux genes are much more sensitive to fluoride and have reduced growth from 100 μM (1.9 ppm).[56–60]

Metagenomic studies give the opportunity to measure the frequency of fluoride efflux genes for IBD patients. Publicly available Roche 454 (Roche Diagnostics, Basel, Switzerland) data from the Human Microbiome Project SRP002423, comprising 42 datasets from 14 patients,[61] was searched using SRAblast for 264 non-identical Refseq bacterial *crcB* sequences. A number of hits have been normalized to *crcB* sequence length and to the size of metagenomic data. *CrcB* is more abundant in CD patients compared to controls (median 21.9 for controls; 49.6 for CD patients, $p = 0.16$). This may indicate a selection for fluoride resistance genes in CD patients (Figure 2) though larger datasets are needed. Conversely, this may be a casual association due to higher frequency of *crcB* in CD associated bacteria.

Indeed in a genome-wide comparative study, *crcB* was found in 4 of 13 adherent invasive *Escherichia coli* (AIEC) strains isolated from IBD patients and none of the six commensal strains.[62] There exist too plasmids that contain *crcB* and may confer resistance. For example, AIEC strains isolated from CD patients have plasmids bearing *crcB* among other virulence factors.[63,64]

Specific strains of *Streptococcus mutans*, an oral pathogen, may aggravate dextran sodium sulfate induced colitis.[65] Acquired chromosomal mutations that up-regulate *clcF* expression result in a better resistance to fluoride for *S. mutans*.[66]

Lactobacillus reuteri is a typical probiotic bacteria. When transposon-induced mutation takes place in the promoter of

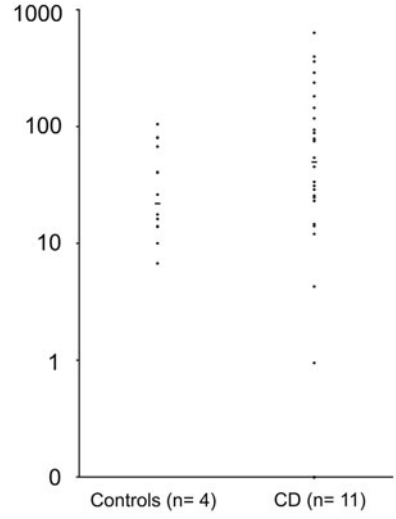

Figure 2. Indexed number of *crcB* blastn hits in metagenomic data of the Human Microbiome Project for patients or controls (logarithmic scale).

clcF, the culture supernatant loses the ability to reduce TNF production in a cellular assay screening.[67]

Several CLC chloride transporter genes are expressed in the human intestinal epithelium; however, it is uncertain if they transport fluoride or can be inhibited by it like their prokaryotes orthologs.[59] In transgenic mouse models, *Clcn2*, *Clcn3*, and *Clcn5* knock-out animals develop more severe dextran sodium sulfate induced colitis [68–71] than wild-types.

Discussion

The accumulated multidisciplinary findings suggest that chronic fluoride intake could be associated with IBD. The present hypothesis does not exclude the microparticle hypothesis either: calcium phosphate microparticles that are taken up in M-cells and antigen presenting cells of the Peyer's patches [72] could carry along fluoride [73] and increase its intracellular concentrations.

The presented similarities in epidemiological patterns call for rigorous epidemiological studies that verify if fluoride exposure or intake explains a part of the residual variability. Several countries including the USA and Canada have recently lowered the recommended fluoridation levels. Combined with IBD registries, this represents an opportunity to study an eventual relationship. Since fluoride intake is likely associated with oral hygiene and generally urban, western lifestyle, the main challenge of such epidemiological studies is to control for confounding.

Another issue is that the multiple sources of fluoride render difficult the accurate measure of intake. There is a similar challenge for aluminum, where measuring intestinal tissue concentration has been suggested as an alternative.[74] It should then be studied how the damaged intestinal epithelium absorbs fluoride and aluminum.

Considering that aluminum is mentioned as a risk factor too,[74] it is worth noticing the interactions with fluoride: aluminum increases fluoride intestinal concentration by reducing absorption [75] and they synergistically inhibit bacterial growth in the absence of deferoxamine.[76]

Frequent diffuse gastrointestinal symptoms have been repeatedly reported in endemic fluorosis areas. Inflammation, damaged epithelium, and abdominal pain are recurrent findings and symptoms shared with IBD although unspecific. These cases were not diagnosed as IBD, as this diagnosis is relatively uncommon and would normally require more invasive examinations than the simple imaging that some of these patients have undertaken.

It is surprising that these gastrointestinal symptoms have been found when the concentration of fluoride in drinking water is considered safe. This raises the question if this observation can be reproduced in countries where comparable anthropogenic exposure to fluoride and mild dental fluorosis have become common.[77]

In addition to variability of the dose, individuals absorb and respond differently to fluoride.[78] Genetics of fluoride metabolism may play a role, for example polymorphisms of glutathione-*S*-transferase *GSTP1* and myeloperoxidase give higher risk for skeletal fluorosis.[79,80] However, little is known about fluoride-related human genetics.

Transport mechanisms of fluoride determine resistance for microorganisms that possess them. We hypothesize that intestinal fluoride, even from the low fecal concentrations that are likely to occur, could contribute to give a competitive advantage for resistant microorganisms, which are frequently found among IBD patients. Metagenomic studies can use the insight to accurately study fluoride effects on the intestinal microbiota and verify if it results in a dysbiosis comparable to IBD. In this aim, undergoing large-scale studies that record fluoride intake, like the American Gut project, can give precious information.

Fluoride as a risk factor for IBD has explanatory potential for the presented results; but ultimately the absence of direct studies is limiting support and excludes any early conclusion. Considering the need for more studies on the effects of moderate doses of fluoride on the gastrointestinal system in general [81] and considering the implications for IBD epidemiology, the hypothesis deserves further investigation, ideally in conjunction with other potential risk factors.

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From: [redacted]
To: FN-OSTP-PCAST
Cc: [redacted]
Subject: PCAST Reference Listing for Forensic Document Examination
Date: Friday, October 14, 2016 12:06:51 PM

Per the suggestion by Diana Pankevich, please accept the below additional references for any future assessment of the discipline of Forensic Document Examination.
Regards,

Carl R. McClary

Carl R. McClary
Forensic Questioned Document Examiner
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Forensic Document Examination

Mitchell, L., Merlino, M., A Blind Study on the Reliability of Hand Printing Identification by Forensic Document Examiners, Journal of the American Society of Questioned Document Examiners, June 2016, Vol 19, No. 1, p. 25-31.

The study provided evidence that the qualified FDE can very reliably identify block letter hand printing (ALL CAP) and can do so using the same methods and protocols as in the identification of cursive handwriting. 53 qualified FDE participants were provided 25 questioned writings in case packets along with sample writings of three potential suspects. Participants used the nine point published opinion scale. It was concluded that qualified FDE's reliably rate with only 2.28% of calls inaccurate, when identifying (or excluding) a writer of block hand printing. 91.98% were made correctly and 5.6% of the calls were inconclusive.

Thomas Vastrick - Frequency Occurrence Study. To be published in the Journal of Forensic Sciences January 2017.
Johnson, Mark E. Ph.D., Vastrick, Thomas W., Boulanger, Michele Ph.D., Schuetzner, Ellen M., Measuring the Frequency Occurrence of Handwriting and Hand-Printing Characteristics

The following study, funded by a grant from the National Institute of Justice, is a

statistically validated frequency occurrence proportions for selected characteristics providing for a baseline figure of distinctiveness for Roman characters and numbers used in hand printing/handwriting. This study is a template to population sampling in the forensic document examination profession, providing scientifically objective data that provides an appreciation of the statistical heterogeneity in any given handwritten entry that may be a central issue in either civil or criminal litigation.
The project produced an initial set of over 2500 precise handwriting and hand printing features that were subsequently reduced to 903 features which passed an attribute agreement analysis and to 786 that were utilized in this project. These attribute features (presence/absence) can be unambiguously identified by forensic document examiners. Handwriting samples from over 1500 writers were collected representing a broad spectrum of contributors intended to be representative of the US adult population. Meeting the pre-specified population representation led to the selection of a subset of 880 cursive specimens and 839 hand printed specimens that closely approximated the demographic proportions represented in the US. The analysis of these specimens yielded numerous specific frequency occurrence proportions. Additional analyses have shown quantitatively the extent to which demographic features such as age, gender, ethnicity, education, location of second/third grade training and handedness impact the presence/absence of features. An immediate benefit of the databases analysis has been a detailed assessment of the scope of the appropriateness of the product rule.

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