jcda.ca
ESSENTIAL DENTAL KNOWLEDGE

Fluoridation Exposure Status Based on Location of Data Collection in the Canadian Health Measures Survey: Is it Valid?

Lindsay McLaren, *PhD*

Cite this as: *J Can Dent Assoc* **2016;82:g17**

Abstract

Background: Statistics Canada's population health surveys may be an important source of up-to-date evidence on fluoridation and population oral health. The objective of this study was to examine the validity of a geographic measure of fluoridation from a national survey (based on site of data collection), by comparing it with estimates of fluoride level from urine samples.

Methods: The data source is the environmental urine subsample (*n*=2563) from Cycle 2 (2009-2011) of the Canadian Health Measures Survey. Mean comparison and multivariable linear regression were used to examine whether urinary fluoride levels differed between respondents classified as "fluoridated" versus "non-fluoridated" based on data collection site.

Results: Respondents who attended data collection sites classified as fluoridated had significantly higher mean urinary fluoride levels than those who attended sites classified as non-fluoridated. This effect was robust to adjustment for covariates and was somewhat stronger among an "exposed" subpopulation (defined based on tap water consumption and residential history) compared with a non-exposed subpopulation. No apparent added value was associated with using a more precise geographic indicator based on home postal code.

Conclusions: Fluoridation status based on data collection site seems crude, but is actually reasonably accurate compared with fluoride level in urine, in the context of a large national Canadian survey of urban and rural residents. Although findings are of limited use for individual-level risk assessment, they may be of interest to dental public health researchers and to those engaged in public health surveillance, because they inform efficient and readily available options for monitoring fluoridation status in populations.

Since its initiation in 1945, community water fluoridation has been credited with contributing to significant improvements in population oral health, although the quality of many studies is modest.[1] Increasingly, the impact of fluoridation is difficult to assess because of the changing epidemiology of oral disease and the increasing availability of other sources of fluoride, such as toothpaste.[2,3]

It is important that evidence of the effect of fluoridation on population oral health be kept current, and population health surveys can be an important source of such information. An example is Statistics Canada's Canadian Health

Measures Survey (CHMS), which in 2007–2009 (Cycle 1) collected clinical oral health data from a population-based national sample.[4]

In 2012, we published a study[5] on fluoridation and oral health using data from that survey and observed a significant association between fluoridation exposure and lower decayed, extracted/missing (due to caries) or filled teeth, either deciduous or permanent (deft/DMFT), adjusting for behavioural and sociodemographic variables. We also observed that the effect of fluoridation was strongest among income and education groups with the poorest oral health.

In that study, our measure of fluoridation exposure was crude: "yes" or "no" based on location of data collection (survey respondents attended one of 15 data collection sites). Classification was based on information from various Internet sources about the current and historical fluoridation status of the location. Although crude, this was the only option available for that survey at the time, and it had some face validity: the main effects of fluoridation were stronger among those who reported usually drinking tap water and having lived in their current home for at least 2 years, which would be expected if we were capturing true fluoridation exposure status to at least some extent.[5] (Note: Although 2 years is limited, it was chosen to represent a balance between identifying those who had some history in their current location and retaining as much data as possible; a longer period would result in a smaller sample size and, thus, reduced statistical power.)

Cycle 2 of the CHMS (2009–2011) provides an opportunity to examine the validity of the exposure variable used in our 2012 paper. Specifically, Cycle 2 includes estimates of fluoride presence in urine samples for a random subsample of respondents, aged 3–79 years. Although fluoride in urine is from all sources, not only tap water,[6] the sensitivity of urinary fluoride to variations in community water fluoridation under stable conditions (at least 1 year) has been demonstrated. [7]

The objective of this study was to examine the validity of the geographic measure of fluoridation in the CHMS (based on data collection site), by examining its association with fluoride estimates from urine samples. A secondary objective was to use home postal codes to identify respondents' community of residence and to assess whether fluoridation status assigned based on that more precise geographic location is more closely associated with urinary fluoride estimates than fluoridation status based on CHMS data collection site.

Findings will inform options for monitoring fluoridation status in populations, which is of relevance to dental public health researchers, as well as options for policy and practice for those involved in public health surveillance.

Methods

Data Source

The data source is Cycle 2 (2009–2011) of Statistics Canada's CHMS.[8] Cycle 2 was a cross-sectional, nationally representative survey that included a clinical examination administered in a mobile clinic, as well as a household interview. The target population was people aged 3–79 years, living in all provinces and territories; sample exclusions (Aboriginal settlements in the provinces, full-time Canadian Forces members, the institutionalized population and people in certain remote regions) represented less than 4% of the target population.[8] This study focuses on the environmental urine subsample (*n*=2563).

Multistage sampling was used, in the following manner.[8] The sampling frame from the Labour Force Survey was used to create 257 geographic areas, each containing at least 10 000 people. These sites were stratified into 5 regions (British Columbia [including Whitehorse], Prairies [including Yellowknife], Ontario, Quebec and Atlantic provinces). Within each region, sites were sorted by census metropolitan area status and population size, and 18 sites were systematically selected (Note: these are different sites than those used in CHMS Cycle 1). This process ensured inclusion of both census metropolitan areas and non-census metropolitan areas, and both larger and smaller populations. Within each site, stratified sampling by age group was performed, using the 2006 census as a sampling frame. The mobile clinic (where data collection took place) was set up at a designated location within each of the 18 sites. Maximum travel distance from a site was set at 50 km for urban areas and 100 km for rural areas.[8]

The household response rate was 75.9%; of those participants, 90.5% provided questionnaire data, and, of those, 81.7% reported to the mobile clinic. Of the mobile clinic sample (*n*=6393), 2623 people were randomly selected for the environmental urine subsample; of these, 2563 (97.7%) provided a valid spot urine sample.[8]

Urine was collected using a 120-mL specimen container with an aliquot volume of 1.0-mL (3–5 year olds) or 1.8-mL (6–79 year olds). Analysis was carried out at the Centre de toxicology du Québec of l'Institut national de santé publique du Québec (accredited under ISO 17025) using standardized operating procedures.[9] Fluoride was analyzed using an Orion pH meter with fluoride ion selective electrode (Orion Research Inc.).[10] The limit of detection, 20 µg/L, was estimated based on the United States Environmental Protection Agency protocol (EPA 40 CFR 136).[9]

Analysis

First, the fluoridation status of each data collection site was assigned based on publicly available information from such sources as municipal websites, water quality reports, media items and websites of anti-fluoridation groups. Corroboration across multiple sources was sought. Although it was more difficult to find information for some sites than for others, it was possible to discern fluoridation status with reasonable certainty for all sites. The assessment based on publicly available sources was confirmed through correspondence with the Office of the Chief Dental Officer, Public Health Agency of Canada, and there were no instances of contradictory information. Individual survey respondents were classified as fluoridated or non-fluoridated based on this site-level information. Fluoridated was defined according to current national guidelines,[7] which, in practice, correspond to a range of 0.5–0.8 mg/L. Non-fluoridated means no fluoride is added to the water supply, and natural fluoride levels are below 0.5 mg/L.

Second, mean urinary fluoride concentration for fluoridated and non-fluoridated groups was compared, both as crude weight per volume of urine (µg fluoride/L urine) and adjusted for urinary creatinine (e.g., µg fluoride/g creatinine). Urinary creatinine is commonly used for adjustment of spot urine samples because its 24-h production and excretion rates are relatively constant,[9] and can thus help adjust for the effects of urinary dilution, some differences in renal function, and lean body mass.[9]

Third, ordinary least squares (OLS) regression was used to measure the relation between urinary fluoride level (µmol/L and µg fluoride/g creatinine) and fluoridation status (yes/no) based on data collection site and the covariates age, sex, highest level of household education, home ownership, language spoken at home, presence of a chronic health condition and water consumption. (Note: water consumption is based on respondents' reports of the number of times per day they drink water. Based on that information we created three approximately equal sized groups [tertiles] to roughly represent higher, medium, and lower water consumption). It is especially important to take age into account, because the ratio of intake to excretion of fluoride varies with age.[7]

If an association between fluoridation status and fluoride estimates from urine is detected, it is important to consider whether the association reflects fluoridated drinking water versus something else that is systematically influencing urinary fluoride estimates in regions classified as fluoridated. To do that, an exposure variable was created using household interview data to identify those who reported that they usually drink tap water (versus bottled or other water); do not do anything to treat their drinking water; and have lived in their current home for at least 2 years. (Note: 2 years is a limited and somewhat arbitrary cutoff point, selected to achieve a balance between some residential exposure and retaining an adequate sample size. Ideally one would use lifetime exposure, if available). If there truly is an association between fluoridation status and fluoride estimates from urine, that association should be stronger among the subset of people identified by this new variable. Urinary fluoride was regressed on fluoridation status based on data collection site (yes/no), new exposure variable (yes/no) and the interaction of these 2 variables, unadjusted and adjusted for covariates.

Finally, home postal codes and Statistics Canada's Postal Code Conversion File (corresponding to 2011 census geography) were used to identify the communities of residence represented in the survey. For each province included in the CHMS, the list of communities was sent to that province's representative on the Federal/Provincial/Territorial Dental Working Group, with a request for information on fluoridation status in 2009–2011. Information received was used to reclassify (if necessary) each respondent as fluoridated or non-fluoridated, and the implications of reclassification based on this more precise geography were explored.

All analyses incorporated the sampling weight provided for the environmental urine subsample, which accounts for the complex sampling procedure. The variance estimates were computed using the conservative bootstrapping procedure. Stata software (StataCorp, College Station, Texas) was used.

Results

Analyses are based on 2393 participants for whom complete data on study varibles was available (93% of the full environmental urine subsample). Of the 18 data collection sites, 9 were determined to have fluoridated water and 9 did not (**Table 1**). **Table 2** shows descriptive statistics for the study sample.

Simple mean comparison of urinary fluoride levels revealed a statistically significant difference between respondents classified as fluoridated (mean = 40.8 µmol/L, standard error [SE] 2.46 µmol/L, 95% confidence interval [CI] 35.5–46.1 µmol/L) versus non-fluoridated (mean = 24.7 µmol/L, SE 1.20 µmol/L, 95% CI 22.1–27.3 µmol/L) based on data collection site ($p < 0.05$).

Table 3 shows the association between urinary fluoride level (µmol/L) and fluoridation status based on data collection site (yes/no) from regression analyses, unadjusted (middle column) and fully adjusted (right hand column). A positive effect of fluoridation remains statistically significant in the adjusted model.

For both mean comparisons, and the regression analyses, the effects described above were robust for creatinine-adjusted fluoride and log-transformed values of crude and creatinine-adjusted fluoride levels.

The OLS regression that incorporated the exposure variable

ISSN: 1488-2159

Table 1 Fluoridation status of selected data collection sites (n = 18) used in the Canadian Health Measures Survey, Cycle 2 (2009-2011).

Site	Fluoridation	Rationale
Centre-East Ottawa, Ont. (University of Ottawa, Lees Campus)	Yes	Ottawa began fluoridating drinking water in 1965. According to the City of Ottawa's Water and Environment department, "The City of Ottawa adds fluoride to the drinking water.... The target level of 0.70 mg/L is within the 0.50–0.80 mg/L concentration range for fluoride suggested by the Ontario Ministry of the Environment, where fluoridation of drinking water is practiced" (http://ottawa.ca/en/residents/water-and-environment/drinking-water-and-wells/fluoride)
Oakville, Ont.	Yes	Oakville is situated within the region of Halton, Ont. According to the Halton region website, "the Region adds fluoride to the water supplies in Burlington, Halton Hills, Oakville, and the new developments in Milton to bring it up to the recommended levels," i.e., 0.5–0.8 parts per million (http://www.halton.ca/cms/one.aspx?pageId=15215).
South of Brantford, Ont. (Simcoe)	Yes	The 2010 water quality report for Simcoe includes hydrofluorosilicic acid in the list of "all water treatment chemicals used over this reporting period" (http://www.norfolkcounty.ca/download/living/environmental/2010/simcoe_dws_2010_annual_reportnew_version.pdf)
Laval, Que.	No	Laval began fluoridating drinking water in 1958. According to various online documents (e.g., news stories, anti-fluoridation websites), fluoridation was stopped in 2000 or 2003. This is consistent with a 2013 scientific publication[13] which classified Laval as a municipality that did not have fluoridation between 2002 and 2010, which partly includes the time frame of the CHMS Cycle 2.
South Montérégie, Que. (St-Jean-sur-Richelieu)	No	There is no mention of fluoridation on the city's website (www.ville.saint-jean-sur-richelieu.qc.ca). Media items corroborate the non-fluoridated status of this site (e.g., radio-canada.ca article titled Buvez-vous de l'eau fluorée (http://blogues.radio-canada.ca/rive-sud/2013/07/03/buvez-vous-de-leau-fluoree/) provides a map indicating the communities that have fluoridated water. St-Jean-sur-Richelieu is not one of them.
St. John's, NL	No	According to St. John's Water Services website, "Fluoride is not added to City of St. John's dri nking water" (http://www.stjohns.ca/living-st-johns/city-services/water-services).
Winnipeg, Man.	Yes	According to Winnipeg's Water and Waste Department, "We add fluoride according to the Provincial Fluoridation Program guidelines to reach an optimal concentration of 0.7 parts per million. Fluoride protects tooth enamel against the acids that cause tooth decay. We have added fluoride to our water since 1956" (http://www.winnipeg.ca/waterandwaste/water/qualityFAQ.stm).
Richmond, BC	No	Richmond is served by the Metro Vancouver watersheds (http://richmond.ca/__shared/assets/2015_Water_Quality_Report44511.pdf), and those are not fluoridated (e.g., see www.metrovancouver.org, search for "physical & chemical analysis summaries")
Edmonton, Alta.	Yes	Edmonton has fluoridated its water since 1967.[14] Drinking water treatment for Edmonton is contracted out to Epcor, and Epcor's website states, "In Edmonton, where EPCOR operates 2 water treatment plants, fluoride is added to the treated water to increase the concentration to the optimal and approved Health Canada guideline level of 0.7 ppm." (http://corp.epcor.com/News/2013/Pages/nov-21-fluoride.aspx)
Centre-East Kootenay BC (Cranbrook)	Yes	According to the City of Cranbrook website, "The decision to add fluoride to Cranbrook's water system was by referendum in 1966 and has been a bylaw since then." Fluoride is added to the water system at "a concentration of 0.8 mg/L (or ppm)" (http://cranbrook.ca/our-city/city-departments/corporate-services/elections/fluoride/water-fluoridation-in-cranbrook/). A referendum to continue fluoridation was held in conjunction with the city's November 2014 municipal election, and residents voted to continue the practice.
Calgary, Alta.	Yes	Based on a 1989 plebiscite, Calgary began fluoridating its drinking water in 1991, but stopped in May 2011 based on a city council vote. Therefore, Calgary had fluoridation in place during most of the time frame of CHMS Cycle 2.
Southwest Toronto, Ont. (Exhibition Place, Toronto)	Yes	The drinking water of Metropolitan Toronto, which includes this data collection site, has been fluoridated since 1963.[15] A 2010 fact sheet confirms that fluoride was still added to the water at that time, at a target level of 0.6 ppm (http://www1.toronto.ca/city_of_toronto/toronto_public_health/dental_and_oral_health/files/pdf/fluoride.pdf).
Kingston, Ont.	No	The municipality of Kingston does not add fluoride to drinking water, though naturally occurring fluoride is present at approximately 0.2 mg/L (https://www.utilitieskingston.com/pdf_downloads/KingSt-WTP_Annual_Report_2010.pdf).
Colchester-Pictou, NS (Truro)	No	The 2016 water quality report for Truro indicates very low (< 0.12 mg/L) fluoride levels in drinking water (http://www.truro.ca/water-treatment-plant.html), and we found no indication that fluoridation was practiced in Truro during the study period.
East Toronto, Ont. (Scarborough)	Yes	Scarborough drinking water is supplied by Toronto Water, which is fluoridated (see Southwest Toronto above).
Gaspésie, Que. (Sainte-Anne-des-Monts)	No	Various online documents suggest that Sainte-Anne-des-Monts does not add fluoride to its drinking water (e.g., radio-canada.ca article titled Buvez-vous de l'eau fluorée (http://blogues.radio-canada.ca/rive-sud/2013/07/03/buvez-vous-de-leau-fluoree/) provides a map indicating the communities that have fluoridated water. Sainte-Anne-des-Monts is not one of them.
North Shore Montréal, Que. (Blainville)	No	Drinking water for Blainville is provided by La station de purification de la Ville de Sainte-Thérèse (http://blainville.ca/citoyens/reglements-et-permis/eau/#eauPotable). There is no mention of fluoridation on the website for la Ville de Sainte-Thérèse (http://www.sainte-therese.ca/services-aux-citoyens/eau-potable/) including the document that describes the water treatment process (http://www.sainte-therese.ca/fichiersUsagers/Parcours-eau-magazine-citoyen-automne-2010.pdf).
Coquitlam, BC (Burnaby)	No	Coquitlam's drinking water is provided by Metro Vancouver watersheds, and those are not fluoridated (e.g., see 2012 chemical and physical analysis summaries (http://www.metrovancouver.org/services/water/WaterPublications/2012Chemical-PhysicalAnalysisSummaries.pdf).

(usually drink tap water, do not treat their water, have lived in their current home for 2 or more years) showed a statistically significant interaction between exposure and fluoridation status: coefficient from fully adjusted model = 13.1, SE (bootstrapped) 2.9, 95% CI 6.7–19.4 ($p < 0.01$). Stratifying by exposure, the association between fluoridation status and urinary fluoride was statistically significant in both exposed (fully adjusted model coefficient = 24.0, SE 4.1, 95% CI 15.3–32.8, $p < 0.01$) and non-exposed groups (fully adjusted model coefficient = 11.1, SE 3.1, 95% CI 4.3–17.8, $p < 0.05$). The magnitude of the effect is larger in the exposed group, although the 95% CIs overlap.

Based on home postal code, survey respondents represented 216 communities. Information about fluoridation status was obtained for 62 (29%) of these. Of these, only 5 communities (all rural) would be classified differently based on the more precise geographic information. Because of the very small number of communities for which reclassification would make any difference, the initial intention to re-run urinary fluoride comparisons based on reclassifications was deemed unecessary.

Table 2 Descriptive statistics (weighted) for those included in the study sample (*n*=2393)

Variable	Mean (SD) or %
Fluoride in urine sample, μmol/L	33.6 (25.3)
Fluoridation status based on data collection site (% fluoridated)	55.4%
Age, years	38.4 (20.0)
Sex, % female	50.1%
Household education	
High school graduation*	21.7%
College or vocational certificate or diploma†	37.2%
University bachelor's degree‡	29.4%
University degree beyond bachelor's degree§	11.7%
Home ownership (% participants living in a home that is owned v. rented)	22.5%
Language spoken at home	
English	66.1%
French	20.5%
Other	13.4%
1 or more chronic conditions (% yes)	58.1%
Times per day drink water (tertile)¥	32.2%

*Graduated from high school (secondary school); may have had some post-secondary education but no completed credentials.

†Trade certificate or diploma from a vocational school or apprenticeship training; non-university. certificate or diploma from a community college, CEGEP, school of nursing, etc.

‡Bachelor's degree from a university or a completed university certificate below bachelor's level.

§University degree or certificate above bachelor's degree (e.g., master's degree, PhD, professional degree above a bachelor's degree).

¥ Respondents reported the number of times per day that they drink water. We divided this variable into three approximately equal sized groups (tertiles).

Discussion

Findings suggest that fluoridation status based on data collection site, which seems quite crude, is reasonably accurate when compared with fluoride from urine, in the context of a large national Canadian population-based survey of both urban and rural residents. This statement is based on the statistically significant differences in mean urinary fluoride level between survey respondents classified as fluoridated versus non-fluoridated based on data collection site, which was robust to adjustment for covariates and was somewhat stronger among exposed (based on tap water consumption and residential history) versus non-exposed subpopulations.

In addition to supporting the findings of our earlier paper,[5] where we used a site-based measure of exposure, these results are important in terms of options for monitoring fluoridation status at the population level. Specifically, population-based research on fluoridation exposure can be undertaken even in the absence of biomarker data, which is expensive and logistically complex to collect, as long as one has a general idea of each individual's area of residence.

A secondary objective of this study was to assess the added value of using more precise geographic information (home postal code) to classify fluoridation status. A noteworthy finding (although somewhat unexpected) was that it was not at all easy to obtain information on fluoridation status for communities in Canada. Of the 7 provinces represented in the survey, only 4 were able to provide some information, either specific information about the communities or a link to a resource (e.g., http://gis4.natr.gov.ns.ca/website/nsgroundwater/viewer.htm). Conversations with provincial representatives revealed that, in some cases, this reflects limitations on data-sharing across ministries or agencies, such that databases that could link public water systems to postal codes may be incomplete, inaccessible or simply not exist.

Based on the subset of communities for which fluoridation status was available, it appears to make little difference whether data collection site (crude) or geographic community of residence (more precise) is used to assign fluoridation status: only 5 communities (of 62), all rural, would

Table 3 Results of ordinary least squares regression (*n*=2393), with urinary fluoride (µmol/L) regressed on fluoridation status (based on data collection site) and covariables, unadjusted effects and effects from fully adjusted model.

Predictor variable	Coefficient (bootstrap standard error), 95% confidence interval	
	Unadjusted effect	Adjusted effect
Constant		28.0
Fluoridation (yes v. no)*	16.1 (2.8), 10.0 to 22.2†	13.8 (3.3), 6.7 to 20.8†
Age (continuous)	0.04 (0.03), −0.02 to 0.10	0.13 (0.04), 0.04 to 0.22†
Sex (female v. male)	−4.3 (1.9), −8.4 to −0.15‡	−3.1 (2.1), −7.6 to 1.4
Household education (ref.: High school graduation§)		
College or vocational certificate or diploma¶	0.63 (2.9), −5.7 to 7.0	−1.5 (2.7), −7.3 to 4.3
University bachelor's degree**	−1.5 (2.9), −7.8 to 4.7	−2.6 (2.6), −8.1 to 3.0
University degree beyond bachelor's††	11.0 (6.3), −2.7 to 24.7	6.7 (5.9), −6.2 to 19.6
Home ownership (live in a home that is owned v. rented)	−3.8 (1.6), −7.2 to −0.38‡	−6.0 (1.7), −9.8 to -2.2†
Language spoken at home (ref.: English)		
French	−13.9 (2.2), −18.6 to −9.2†	-5.7 (2.5), −11.2 to −0.25‡
Other	0.66 (5.2), −10.6 to 11.9	0.15 (3.9), −8.2 to 8.5
Chronic condition (yes v. no)	−1.6 (2.8), −7.7 to 4.5	−2.7 (2.8), −8.8 to 3.3
Top tertile of times/day drink water v. bottom 2 tertiles¥	−0.92 (3.1), −7.7 to 5.9	−2.2 (2.8), −8.2 to 3.9

*A statistically significant effect of fluoridation (based on site of data collection) is also observed with creatinine-adjusted level of fluoride in urine, and log-transformed values of crude fluoride level and creatinine-adjusted fluoride level, used as outcome variables.

†$p < 0.01$.

‡$p < 0.05$.

§Graduated from high school (secondary school); may have had some post-secondary education but no completed credentials.

¶Trade certificate or diploma from a vocational school or apprenticeship training; non-university. certificate or diploma from a community college, CEGEP, school of nursing, etc.

**Bachelor's degree from a university or a completed university certificate below bachelor's level.

††University degree or certificate above bachelor's degree (e.g., master's degree, PhD, professional degree above a bachelor's degree).

¥ Respondents reported the number of times per day that they drink water. We divided this variable into three approximately equal sized groups (tertiles).

have been classified differently. Based on the difficulty of securing fluoridation information at the community level, this is good news. However, because of these difficulties, information was only obtained for fewer than a third of communities (62 of 216), and the discrepancy may have been larger if it were based on all communities.

Even if more precise geographic information has little added value for population-based fluoridation research, there may still be a reason to work toward a system where fluoridation information is readily available at a small area level in Canada. Such a resource would allow dental professionals to know and inform patients about local fluoride levels and to assist with treatment planning. Furthermore, it could permit members of the public to easily find reliable information about the fluoride content of their tap water, including how it fits into Health Canada safety guidelines.[7] There are excellent existing systems from which we could learn, such as the Water Fluoridation Reporting System in the United States[11] and the database of fluoridated local council areas in New South Wales, Australia.[12]

An important study limitation is the use of spot urine samples, which are vulnerable to fluctuations.[6] The creatinine-adjusted estimates help offset this limitation to some extent. Another limitation is the absence of information on the use of supplemental fluoride or fluoride toothpaste and, thus, the role of these important potential confounders is unknown. Finally, findings are of limited utility for individual-level risk-factor analysis, such as fluoride intake and fluorosis risk. Strengths of the study include the use of a large, nationally representative sample, high-quality data and rigorous analysis.

In conclusion, these findings may be useful to dental public health researchers and those engaged in public health surveillance, because they inform efficient and reasonably accurate options for monitoring fluoridation status in populations.

THE AUTHOR

Dr. McLaren *is associate professor, Department of Community Health Sciences, University of Calgary, Calgary, Alberta.*

Corresondence to: *Dr. Lindsay McLaren, Department of Community Health Sciences, University of Calgary, TRW3, 3280 Hospital Dr. NW, Calgary AB T2N 4Z6. Email: lmclaren@ucalgary.ca*

Acknowledgements

I thank Dr. Peter Cooney, former chief dental officer, Public Health Agency of Canada, and Dr. Carlos Quiñonez, associate professor, University of Toronto faculty of dentistry, for insightful comments and feedback on the study. I also thank Ms. Karen Lyon and Dr. Martin Chartier of the Office of the Chief Dental Officer, Public Health Agency of Canada, for their input and assistance with verifying fluoridation status information from across Canada.

This research was supported by an operating grant (#GIR 127083) from the Canadian Institutes of Health Research (CIHR) and an applied public health chair award (to LM) funded by CIHR (Institute of Population and Public Health and Institute of Musculoskeletal Health and Arthritis), the Public Health Agency of Canada and Alberta Innovates – Health Solutions.

The author has no declared financial interests.

This article has been peer reviewed.

References

1. McDonagh M, Whiting P, Bradley M, Cooper J, Sutton A, Chestnutt I, et al. A systematic review of public water fluoridation. York, UK: NHS Centre for Reviews and Dissemination, University of York; 2000. (Report 18).
2. Burt BA. Prevention policies in the light of the changed distribution of dental caries. *Acta Odontol Scand.* 1998;56(3):179-86.
3. Burt BA. Concepts of risk in dental public health. *Community Dent Oral Epidemiol.* 2005;33(4):240-7.
4. Health Canada. Report on the findings of the oral health component of the Canadian Health Measures Survey, 2007–2009. Ottawa: Health Canada; 2010.
5. McLaren L, Emery JC. Drinking water fluoridation and oral health inequities in Canadian children. *Can J Public Health* 2012;103(7 Suppl 1):eS49-56.
6. Guidelines for Canadian drinking water quality: guideline technical document — fluoride. Ottawa: Health Canada; 2010.
7. Marthaler TM, Schulte AG. Monitoring salt fluoridation programs through urinary excretion studies. *Schweiz Monatsschr Zahnmed* 2005;115(8):679-84.
8. Canadian Health Measures Survey (CHMS) data user guide: cycle 2. Ottawa: Statistics Canada; April 2013.
9. Second report on human biomonitoring of environmental chemicals in Canada: results of the Canadian Health Measures Survey Cycle 2 (2009–2011). Ottawa: Health Canada; April 2013.
10. INSPQ (Institut national de santé publique du Québec). (2009). *Analytical method for the determination of fluoride in urine (M-186) condensed version for CHMS*. Laboratoire de toxicologie, Québec, QC.
11. Malvitz DM, Barker LK, Phipps KR. Development and status of the National Oral Health Surveillance System. *Prev Chron Dis.* 2009;6(2):A66.
12. Skinner J. Use of GIS to allocate water fluoridation status in the NSW Teen Dental Survey 2010. *Aust NZ J Public Health* 2012;36(4):393.
13. Tchouaket E, Brousselle A, Fansi A, Dionne PA, Bertrand E, Fortin C. The economic value of Quebec's water fluoridation program. *J Public Health.* 2013;21(6):523-33.
14. Rabb-Waytowich D. Water fluoridation in Canada: past and present. *J Can Dent Assoc* 2009;75(6):451-54.
15. Lee AJ, Goettler F. The case for fluoridation: a comparison between Toronto and Montreal. *J Can Dent Assoc.* 1988;54(10):731-4.

ISSN: 1488-2159