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CITY OF WATERLOO COUNCIL AGENDA
COUNCIL CHAMBER OF THE MUNICIPAL BUILDING – 136 N. MONROE STREET
Thursday, September 1, 2022 – 7:00 p.m.
Participate Remotely Or In-Person
Updated 8/30/22 10 am

Join Zoom Meeting: https://us02web.zoom.us/j/85762315540?pwd=SGpycE9HZC9ZaVUrNXFrc1QvMkhzdz09
Meeting ID: 857 6231 5540 Passcode: 207446
Dial by phone: +1 312 626 6799 US (Chicago)

Pursuant to Section 19.84 Wisconsin Statutes, notice is hereby given to the public and news media, that a public meeting will be held to consider the following:

1) CALL TO ORDER, PLEDGE OF ALLEGIANCE AND ROLL CALL

2) MEETING MINUTES APPROVAL :Open and Closed August 18, 2022

3) CITIZEN INPUT / PUBLIC COMMENT

4) OLD BUSINESS

5) MEETING SUMMARIES (since last Council meeting)
   a) 08/22/2022 Fire/EMS Meeting
   b) 08/23/2022 Plan Commission
   c) 08/23/2022 Library Board
   d) 08/23/2022 Special Finance, Insurance & Personnel Meeting - Budget
   e) 08/25/2022 Special Finance, Insurance & Personnel Meeting - Budget
   f) 08/31/2022 Special Finance, Insurance & Personnel Meeting - Budget
   g) 08/04/2022 Public Safety & Health Committee
   h) 08/04/2022 Public Works & Property Committee

6) RECOMMENDATIONS OF BOARDS, COMMITTEES AND COMMISSIONS
   a) Public Safety & Health Committee
      i) Request to Hire Kevin Giroux Full Time to Fill Vacancy
      ii) Request to Replace Yield Signs on Pierce St at Adams St with Stop Signs
      iii) Promote Officer Warner to Sergeant to Fill Open Position
      iv) Lateral Entry into Waterloo PD – Compensation discussion [NOTE: Council may meet in closed session per Wis. Stat. 19.85 (1)(c) "considering employment, promotion, compensation or performance evaluation data of an public employee over which the governmental body has jurisdiction or exercise responsibility. Upon concluding a closed session, the Council will reconvene in open session.]

7) NEW BUSINESS
   a) Fluoridation of Waterloo's Water – Dr. Andrew Notham will be presenting about the necessity of Fluoride in our water.
   b) Appointing a new agent for Kwik Trip for Liquor License purposes –

8) FUTURE AGENDA ITEMS AND ANNOUNCEMENTS

9) ADJOURNMENT

Jeanne Ritter Clerk/Deputy Treasurer Posted & Emailed: 08/26/2022

PLEASE NOTE: It is possible that members of and possibly a quorum of members of other governmental bodies of the municipality may be in attendance at the above meeting(s) to gather information. No action will be taken by any governmental body other than that specifically noticed. Also, upon reasonable notice, efforts will be made to accommodate the needs of disabled individuals through appropriate aids and services. For additional information or to request such services please contact the clerk's office at the above location

CITY OF WATERLOO COMMON COUNCIL - MEETING MINUTES: August 18, 2022
[a digital recording of this meeting also serves as the official record]

1) CALL TO ORDER, PLEDGE OF ALLEGIANCE & ROLL CALL. Council President Thoma called the meeting to order at 7:00 p.m. Alderpersons present: Cummings, A. Kuhl, C. Kuhl, Griffin, Weihert and Petts. Alderpersons/Mayor attending remotely: Mayor Quimby. Absent:none. Others attending remotely or in-person: Police Chief Sorenson; Utility Supervisor Sorenson; Library Director Kelli Mountford; DPW Director Yerges; Clerk Jeanne Ritter, Ben Heideman and WLOO videographers. The pledge of allegiance was recited.

2) MEETING MINUTES APPROVAL: August 4, 2022 [Griffin/Cummings] VOICE VOTE: Motion Carried.

3) CITIZEN INPUT / PUBLIC COMMENT – none

4) OLD BUSINESS - none

5) MEETING SUMMARIES (since last Council meeting)
   a) 08/16/2022 Community development Authority
   b) 08/18/2022 Finance, Insurance & Personnel Committee

6) CONSENT AGENDA ITEMS
   a) July Reports of City Officials & Contract Service Providers Motion [Weihert/Griffin] VOICE VOTE Motion carried.
      i) Parks
      ii) Fire & Emergency Medical Services – no report
      iii) Building Inspections
      iv) Public Works
      v) Police
      vi) Library Board
      vii) Water & Light Utility Commission
      viii) Watertown Humane Society
      ix) Cable Television

7) RECOMMENDATIONS OF BOARDS, COMMITTEES AND COMMISSIONS
   a) Waterloo Utilities
      i) Industrial Sewer Agreements – Final [C.Kuhl/Cummings] VOICE VOTE: Motion carried.
   b) Finance, Insurance & Personnel
      i) July 2022 Financial Statements: General Disbursements $824,227.05; Payroll $82,316.02 & Clerk/Treasurer's Reports [see on municipal website] [C. Kuhl/Cummings] Roll Call: Ayes: Cummings, A. Kuhl, C. Kuhl, Griffin, Weihert and Petts. Noes: none Motion carried.
      ii) Resolution 2022-28 Establishing a 2023 municipal Vehicle Registration Fee Status Per adopted Ordinance #2019-08 [A. Kuhl/Cummings] Roll Call Ayes: Cummings, A. Kuhl, C. Kuhl, Weihert and Petts. Noes: Griffin. Motion Carried.
      iii) Lateral Entry into Waterloo PD – Compensation discussion [NOTE: Council may meet in closed session per Wis. Stat. 19.85 (1)(c) "considering employment, promotion, compensation or performance evaluation data of a public employee over which the governmental body has jurisdiction or exercise responsibility. Upon concluding a closed session, the Council will reconvene in open session.] Motion to convene in closed session [C. Kuhl/Petts] Motion to reconvene in open session [C. Kuhl/Cummings] Motion $5,000 Signing bonus with $2,500 on signing and remaining $2,500 at the successful completion of one year with the department. Unsuccessful completion of the year would result in repayment of all disbursed bonus money by signee. Additional allowance for vacation,carryover up to 12 years of employment, and pay would be allowed with 1 year of experience would be considered Officer 1 (13-24 months) pending agreement by the police union. [C. Kuhl/ Petts] ROLL CALL: AYES:Cummings, A. Kuhl, C. Kuhl, Griffin, Weihert, and Petts. NOES: none. Motion carried.

8) NEW BUSINESS
   a) Class A Beer, Liquor & Cider License Applications Along With a Cigarette License Application For The Period 8/10/2022 – 6/30/2023. Piggly Wiggly Store/Day's Family Foods INC. 810 N Monroe St. Waterloo Nathan Perry Agent. [Weihert/Griffin] VOICE VOTE: Motion carried.

9) FUTURE AGENDA ITEMS AND ANNOUNCEMENTS –
   a) Proposal to do an assessment for TID #4 and discuss closure

10) ADJOURNMENT [C. Kuhl/Cummings] VOICE VOTE: Motion carried. 7:29 pm

Attest:
Jeanne Ritter Clerk/Deputy Treasurer

Jeanne Ritter

From: Jeni Quimby
Sent: Monday, August 29, 2022 1:29 PM
To: Jeanne Ritter
Subject: FW: Public Water Fluoridation in Waterloo

----- Forwarded Message -----
From: "info Waterloo Family Dental" <wfd@waterloofamilydental.com>
To:
Cc: "Andrew Nothem" <dr.andrew@waterloofamilydental.com>, "Emma Sowieja" <dr.emma@waterloofamilydental.com>, "Nicole Forster" <nicole@waterloofamilydental.com>
Sent: Fri, Aug 26, 2022 at 10:08 AM
Subject: Public Water Fluoridation in Waterloo

Greetings to you and your family,

I wanted to write an email to all of my patients in regards to the recent public water changes that have taken place in our town of Waterloo. I am not sure how many of you are aware of this, but the city council voted to stop the public water fluoridation that has been in place for dozens of years. Public water fluoridation has been one of the most successful public health initiatives in modern medicine. It is a safe and cost effective way of building strong teeth and preventing cavities for the entire family.

I am emailing you to ask for your help. I have discussed the situation with the city council several times and I have been told on multiple occasions that there has not been any public interest in changing the ruling. They noted to me that they have not had a single member from the community express concerns to them. They stated that if the community expresses concerns, they would be more open to re-discussing the issue. If this issue is something that is important to you, please take a few minutes and send an email to a council member regarding your concerns.

Tim Thomas (Council President, Alderperson Ward 3) - Alder3@waterloowi.us
Charles Kuhl (Alderperson-At-Large) - AlderAtLargeA@waterloowi.us
Ron Griffin (Alderperson-At-Large) - griffinrepair@gmail.com
Sara Cummings (Alderperson Ward 1) - Alder1@waterloowi.us
Austin Kuhl (Alderperson Ward 2) - Alder2@waterloowi.us
Jeanette Petts(Aldperson Wards 4/5)- Alder4-5@waterloowi.us

If you have any questions or would like to discuss this with me or Dr. Emma, please feel free to contact us. Thank you for your time.

-Dr. Andrew

-Dr. Emma

Andrew Nothem, DDS/Owner
Waterloo Family Dental
920-478-2850
dr.andrew@waterloofamilydental.com

Emma Sowieja, DDS
Waterloo Family Dental
920-478-2850
dr.emma@waterloofamilydental.com

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245 N Monroe St
Waterloo, WI 53594

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Fax 920-478-3768
www.waterloofamilydental.com

Jeanne Ritter

From: Jeni Quimby
Sent: Monday, August 29, 2022 1:45 PM
To: Jeanne Ritter
Subject: FW: Govt Report Reveals Fluoridation Futile & Wasteful - It's Harmful Too

Please include for Sept 1 meeting. Thanks,
Jeni

From: Nys Cof <nyscof4@aol.com>
Sent: Tuesday, May 3, 2022 6:53 AM
To: Jeni Quimby <mayor@waterloowi.us>; Rich Weihert <alderatlargeb@waterloowi.us>; City Hall <cityhall@waterloowi.us>; griffinrepair@gmail.com; jasonwtlw1@gmail.com; thomastr2000@yahoo.com; jeanette.petts@yahoo.com; h2olooalder@gmail.com; ericjrhynes@gmail.com
Cc: rspoehr@hngnews.com
Subject: Govt Report Reveals Fluoridation Futile & Wasteful - It's Harmful Too

NIDCR Report Reveals 22 Years of Effort, Money and Fluoridation Failed to Improve Oral Health

New York -- April 2022 -- Despite increases in public water fluoridation, dental visits, sealants, fluoride varnish applications, and significant financial, training, and program investments, oral health hasn't improved in 22 years in the US, according to a National Institute of Dental and Craniofacial Research (NIDCR) Oral Health in America Report (December 2021), reports the New York State Coalition Opposed to Fluoridation, Inc. (NYSCOF).

Unnecessary fluoride chemicals are added to about 70% US public drinking water supplies in a failed effort to reduce tooth decay in tap water drinkers. Fifty percent of US 6-8 year-olds have cavities, according to the CDC.

US Surgeon General Vivek H. Murthy: "Nine out of 10 adults 20 to 64 years of age have had dental caries, a figure that hasn't meaningfully changed during the past 20 years...dental care costs have increased by 30%," reported in *the New England Journal of Medicine*
Millions of Americans can't access dental care, while 70% of US children and adolescents are fluoride-overdosed, afflicted with fluorosis (white spotted, yellow or brown permanently stained teeth).

The Pew Charitable Trusts writes: "the nation has failed to reduce the prevalence of untreated tooth decay among certain populations...limited access to dental care is a persistent factor contributing to oral health inequities among racial and ethnic minorities, low-income individuals, older Americans, rural residents, and other marginalized groups." (February 9, 2022)

"America's shockingly poor dental system, poverty and poor diets are to blame," says attorney Paul Beeber, NYSCOF President. "Fluoridation can't fix that."

"It's obvious that American's need dental care; not fluoride in their drinking water or other band-aid fixes," says Beeber.

NIDCR reports little improvement since the 2000 US Surgeon General's Oral Health report revealed "a silent epidemic" and its now-failed Call to Action "to eliminate oral health disparities."

For example, the NIDCR reports:

- The military continues to face challenges in meeting recruitment goals and military readiness because of oral health-related issues.
- Untreated cavities among the poor remain twice that of non-poor. Disparities persist by race/ethnicity status.
- Primary tooth decay increased in boys aged 6-11 and didn't change in adolescents' and adults' permanent teeth.
- Untreated decay in permanent teeth shows no progress.
- In ages 2-11, decayed tooth surfaces increased with a greater impact on boys
- Four out of 5 Americans aged 6 years and older experience cavities, irrespective of poverty or race/ethnicity status.
- 40% of children have eroded teeth.

NIDCR cherrypicked Carstairs 2015 to claim "fluoridation achieved wide success in the mid-20th century for primary prevention of dental caries" but left out her fluoridation criticism in the same paper. She wrote: "some of the early fluoridation studies had methodological problems which may have exaggerated their benefits" and "there are still questions about how effective water fluoridation is at preventing dental decay and whether the possible risks are worth the benefits."

Dental Therapists could alleviate the dental access problem; but the politically powerful American Dental Association (ADA) lobbies against their legalization, according to the W K Kellogg Foundation and Wendell Potter

NIDCR admits vitamin D deficiency is a cavity risk. But the ADA turned this nutritional deficiency into a profitable fluoride drug treatment (*Nutrients* 2021). Forty-two percent of Americans are vitamin D deficient. None are fluoride-deficient. Fluoride, like all drugs, has side effects.

Politics, not science, supports fluoridation as evidenced by the ADA's lobbying the US National Toxicology Program to conclude fluoridation is not neurotoxic when the science says it is. Adverse health effects, outside of the oral cavity from ingested fluoride, are not within the purview of dentistry, according to the California Board of Dental Examiners. 4433/http://www.nofluoride.com/cal_dental_examiners.cfm

Few know that fluoridation chemicals aren't natural, but are lead- and arsenic-laced waste products of phosphate fertilizer manufacturing (hydrofluosilicic acid) which often requires adding an acid-neutralizing chemical to the water such as sodium hydroxide.

Beeber says, "Artificial fluoridation is outdated, ineffective, politically motivated, harmful and must cease across the US"

Hundreds of studies support 74 human studies which show fluoride damages babies' developing brains. Prominent scientists urge you protect babies' brains from fluoride

Many fluoridation reviews consistently found fluoridation studies faulty. For example:

The US National Institutes of Health (2001)

The UK York Review of Fluoride (2003)

Chairman of the US National Research Council's Report on Fluoride (2006)

UK Cochrane Research Group (2015)

Journal of Clinical and Experimental Dentistry (2016)

Journal of Risk Assessment (2016).

END

Contact: Paul Beeber, JD nyscof@aol.com http://fluoridealert.org

SOURCE:
New York State Coalition Opposed to Fluoridation, Inc. (NYSCOF)
PO Box 263
Old Bethpage, NY 11804
NYSCOF on Facebook
NYSCOF on Twitter
Previous News Releases

Meyer *et al. BMC Oral Health* (2018) 18:215
https://doi.org/10.1186/s12903-018-0684-2

BMC Oral Health

RESEARCH ARTICLE Open Access

Consequences of community water fluoridation cessation for Medicaid-eligible children and adolescents in Juneau, Alaska

Jennifer Meyer[1], Vasileios Margaritis[2*] and Aaron Mendelsohn[2]

Abstract

Background: The general aim of this research was to determine whether cessation of community water fluoridation (CWF) increased oral health disparities, as measured by dental caries procedures and restoration costs for children and adolescents.

Methods: The analysis was based on all Medicaid dental claims records of 0- to 18-year-old patients residing in zip code 99801 (Juneau, Alaska) during an optimal CWF year (2003, $n = 853$) compared to all claims for the same age group from 2012 ($n = 1052$), five years after cessation of CWF. A bivariate analysis (Mann-Whitney U test) of the mean number of caries procedures performed per client was conducted in the study groups under both independent CWF conditions. Furthermore, logistic regression was performed using the dependent variables of caries procedures and the cost of caries-related procedures, with adjustments for CWF group, gender, and race.

Results: The statistically significant results included a higher mean number of caries-related procedures among 0- to 18-year-old and < 7-year-old patients in the suboptimal CWF group (2.35 vs. 2.02, $p < 0.001$; 2.68 vs. 2.01, $p = 0.004$, respectively). The mean caries-related treatment costs per patient were also significantly higher for all age groups, ranging from a 28 to 111% increase among the suboptimal CWF cohorts after adjusting for inflation. The binary logistic regression analysis results indicated a protective effect of optimal CWF for the 0- to 18-year-old and < 7-year-old age groups (OR = 0.748, 95% CI [0.62, 0.90], $p = 0.002$; OR = 0.699, 95% CI [0.52, 0.95], $p = 0.02$, respectively). Additionally, the age group that underwent the most dental caries procedures and incurred the highest caries treatment costs on average were those born after CWF cessation.

Conclusions: These results expand our understanding of caries epidemiology under CWF cessation conditions and reaffirm that optimal CWF exposure prevents dental decay. These findings can offer fiscal estimates of the cost burden associated with CWF cessation policies and help decision-makers advance oral health, prevent dental caries, and promote equity in oral health outcomes.

Keywords: Dental caries, Water fluoridation, Alaska

Introduction

While the oral health of most Americans has improved over the last century, it remains a significant unmet health care need for children and structurally marginalized groups [1, 2]. Dental caries continues to be the most common chronic childhood disease, and dental pain is the second most common cause of school absences [1, 3, 4]. Importantly, the burden of negative oral health outcomes is disproportionately borne by vulnerable groups, including those least able to advocate for themselves, such as children, members of non-majority ethnic groups and low-income families [5–7].

From the 1930s through the early part of the twenty-first century, the research community has dedicated time and resources toward producing and reviewing comparison studies of fluoridated versus non-fluoridated communities [8]. Investigating potential associations among optimal community water fluoridation

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(CWF) and reductions in both pediatric dental caries and adult tooth loss are also important for improving economic, racial, and ethnic disparities in oral health [9–15]. Over the decades, researchers have established a large body of empirical work supporting both the efficacy and safety standards of CWF systems, which are often summarized in major meta reviews [2, 7, 16–19]. In addition to caries prevention, studies have demonstrated the treatment cost savings secondary to CWF. For example, estimates specify that for every $1 spent on oral health preventative measures, such as CFW, taxpayers can save $50 in annual treatment costs for each low-income citizen who relies on state and federal subsidies for dental care [3, 16, 20–24].

The U.S. Centers for Disease Control, along with several independent commissions, conclude that CWF is both a safe and cost-effective method for decreasing dental disease and caries among populations, regardless of age or income [3, 11, 18, 19, 21, 25]. Two large meta-reviews with different inclusion parameters noted that much of the evidence regarding CWF is based on mid- to late-twentieth century studies and cautioned about the applicability of the findings to modern conditions with widely available fluoridated toothpaste and advanced dental technologies [18, 19]. In 2010, the U.S. Department of Health and Human Services convened an interagency panel to review all the available evidence regarding CWF and its potential positive and negative health effects [7]. The panel determined that even after the introduction and widespread availability of fluoridated toothpaste, U.S. populations still benefited from CWF as a result of reductions in tooth decay up to 25% [7, 14, 21]. This panel also found that the only negative health effect associated with optimal CWF, even at higher than recommended levels (2–4 ppm), was severe dental fluorosis [7]. Therefore, considering the concerns regarding dental fluorosis, particularly for children whose teeth are still developing, the U.S. Public Health Service issued a new recommendation that community water programs fluoridate the water supply at 0.7 mg/L versus the previous range of 0.7–1.2 mg/L given the multiple sources of fluoride in the modern context and to balance decay prevention benefits while reducing the risk of dental fluorosis [2, 7]. Recent trends toward CWF discontinuation in public water systems represent an opportunity to evaluate caries epidemiology and caries treatment cost variations under suboptimal CWF conditions [26]. Given the relatively new phenomenon of policy change inspired by CWF cessation advocacy groups, the impact on population health after removing exposure to optimal fluoride levels in public water systems remains understudied [27–29].

The epidemiological impact of CWF discontinuation has been analyzed in only a small number of studies, and the results have been mixed [25–30]. Additionally, whether specific age groups or income levels are more or less at risk for caries development following CWF cessation has not yet been established [25–30]. The first known meta-analysis of CWF cessation reviewed 13 multidisciplinary databases, and the authors noted only 15 research instances in which CWF cessation was the studied intervention [26]. These publications occurred over several decades, from 1956 to 2003, and represented thirteen different countries [26]. Variations among these published works include methodological factors, such as utilization of a comparison group for whom CWF was not ceased, application of a concurrent cross-sectional versus time series approach, and differences in the type of metric utilized – typically full dental records, claims records or open-mouth screening exams (i.e., DMFT scores), and contextual factors, such as the time interval post-cessation, healthcare delivery systems, local socio-economic conditions and consideration of other sources of fluoride in the community (the introduction of fluoride rinse programs, supplements, or available fluoride salts) [26]. This research intends to contribute to the growing CWF cessation evidence base by assessing and quantifying oral health changes secondary to CWF discontinuation among Medicaid-eligible children and adolescents in Juneau, Alaska, using documentation of caries-related procedures from Medicaid dental claims records six years post-CWF cessation.

According to the previous Surgeon General of the United States, as a nation, approximately 75% of the population has access to optimally fluoridated water [31]. The Healthy People 2020 [32] objective on CWF aims to increase that percentage to 79.6% of the population receiving the optimum level of CWF associated with caries prevention (0.7 mg/L or 0.7 ppm) in community water sources. However, the percentage of Alaska's population served by CWF was 65% in 2007 and fell to 49.3% in 2014 as a result of local city officials changing the public water fluoridation policies [33]. City assemblies in both Juneau (2007) and Fairbanks (2011) reversed CWF policies citing a 'lack of evidence' regarding the oral health benefits and risks of CWF [34]. Currently, the oral health impacts of these local water policy decisions on population oral health in Alaska remain unknown.

This research aimed to assess the impacts of these decisions using the following three research objectives. The first objective was to determine the extent to which CWF cessation impacts the frequency of dental caries-related procedures among Medicaid-eligible children and adolescents. The second objective was to determine the extent to which CWF cessation impacts caries severity as measured by caries-related treatment costs among Medicaid-eligible children and adolescents. The third objective was to determine the extent to which

CWF cessation impacts caries development rates for specific age cohorts among Medicaid-eligible children and adolescents. Recent trends toward CWF discontinuation from public water systems represent an opportunity to evaluate caries epidemiology and caries treatment cost variations under suboptimal CWF conditions [26].

Methods

Juneau served as an ideal study population, with 96% of the residents in zip code 99801 serviced by city water [35, 36]. The rugged terrain of Southeast Alaska makes Juneau one of only two U.S. state capitals accessible only by plane or sea. While Juneau lacks connections to major road systems, thus mitigating the risk of confounding from optimal CWF exposure due to in-and-out migration or travel from neighboring counties (also known as the 'halo' effect), it maintains all the modern conveniences that one would expect in the third largest Alaskan city – including schools, public transportation, a hospital, multiple clinics and a variety of dental professional offices, as well as the Southeast Alaska Tribal Health Consortium (SEARHC) headquarters. We also note the widespread availability of fluoridated toothpaste before, during, and after the study at retail outlets, as well as the distribution of such toothpaste to patients at dental clinics. The annual residential population characteristics are similar to those that we may observe on an island or in a closed population. For example, the Juneau census reported a population of 31,283 in 2003 and 32,832 in 2012, reflecting a total increase of 1549 over the nine-year period. In other words, a small population increase of 0.006%, or 172 persons, per year occurred during the study period [37, 38].

The target population of this study included children and adolescents between the ages of 0–18 years living in families whose incomes met Medicaid requirements. The eligibility requirements for Alaskans seeking Medicaid includes children up to 18 years old if the family income does not exceed 150–200% of the Federal Poverty Level [39]. Medicaid income limits vary depending on family size. The rationale for this focus was to assess two groups living in the same zip code with similar ages and economic experiences at two points in time, thus mitigating the influence of confounding factors known to influence oral health status, such as parent educational attainment and wide variations in income [40]. Families living in poverty also represent a vulnerable group likely to be affected by CWF cessation policy decisions and the group that is least able to participate in health policy decision-making processes [4, 24, 41]. As the entire study population was sourced from a homogeneous economic group at two different time points, we were able to observe the influences of the independent variable (CWF) on the dependent variables (dental caries procedures and treatment costs) both before and after CWF cessation.

The retrospective comparative research design provided a method for investigating the main effect of CWF removal from community water systems on pediatric and adolescent oral health using Medicaid dental claims billing records. Data from Medicaid dental claims have been utilized in previous research, and the form is standardized by the American Dental Association to specify demographic indicators, exact procedure codes, reimbursement rates and provider service charges [16, 22, 23, 42]. Data were secured from all Medicaid dental claims records submitted during 2003, three years prior to cessation, and 2012, six years post-cessation, for all Medicaid-eligible children aged 0 to 18 years residing in the 99801 zip code who were examined by a dentist. The State of Alaska Chief Dental Officer confirmed that Juneau had been optimally fluoridated since the early 1980s, noting a 'fluoride stoppage' during the last half of 2003 to study pipe corrosion, although documentation of the actual study was not available (Dr. Whistler, personal communication, February 2, 2016). Therefore, the year 2003 was selected to obtain a clean representation of optimal (0.7 mg/L-1.2 mg/L) CWF exposure. Medicaid claims records were not available from the central Medicaid processing center for the period after 2012 for Alaska; therefore, as CWF cessation occurred in January of 2007, 2012 was selected as the comparison year to maximize the number of children in the sample with only suboptimal (< 0.065 mg/L) CWF exposure as measured annually from 2007 through 2012 [35].

Walden University's Institutional Review Board approved the study (Walden IRB #10–31–16-0075333). Then, the dental claims database was released after approval by the Centers for Medicare and Medicaid Research Unit [43, 44]. Due to high database costs ($10,500 USD) and study time constraints, only two years of claims were purchased.

The entire study population, including both 2003 and 2012, yielded 1905 patients, exceeding required sample size estimates. All dental claims records for every individual meeting the zip code and age criteria during the study years were reviewed and coded according to study parameters (i.e., Levels 1–4). In 2003, under optimal CWF conditions, the sample size for the 0- to 18-year age group was 853, and in 2012, under suboptimal CWF conditions, the sample included all claims for 1052 patients. Nationally standardized dental code reference material, specifically, Current Dental Terminology (CDT) codes used for procedure and service claim reimbursement, were publicly available for referencing procedure types and costs for both study years. Overall, CDT claims reimbursement rates do not change year to year like Current Procedural Terminology (CPT) codes typically used in medicine.

According to the retired State Dental Chief Dr. Whistler (personal communication August 1, 2018), Medicaid made adjustments in the form of increases for dental claims CDT codes in 2009 and 2010, which may have resulted in Medicaid reimbursement increases even without provision of more services. From 2003 to 2008, the Medicaid dental reimbursement rate would largely have been the same (i.e., remained unchanged). Therefore, since this study spanned 2003 and 2012, provider service fees were the more consistent metric and could also be adjusted for inflation, thus allowing comparisons.

Further variables were developed to accurately address the research objectives. In addition to sorting data into age group cohorts, a variable reflecting the number of caries-related procedures and total costs for caries-related procedures was used. More specifically, all dental procedure codes were organized into four levels. Level 1 represented the type of oral exam (e.g., partial or comprehensive), Level 2 represented preventative care (e.g., x-rays, sealants or fluoride varnish), Level 3 represented caries-related services (e.g., restoration by amalgam, resin, crown, filling under sedation or endodontic/root canal treatments), and Level 4 represented all other services, such as extractions and surgeries. While some Level 4 procedures were likely caries-related, such as extractions, we were not able to confirm this assumption by CDT codes alone as they lack diagnostic details. Therefore, to maximize precision regarding decay without a full medical record, the claims for extractions and outpatient surgeries were not included in the analysis.

The study objectives required analysis of the Level 3 category of procedure claims. We manually counted the number of caries-related claims (Level 3 claims) and the total dollar amount charged by the service provider for these restorative treatments. For example, if a patient had a one-surface primary amalgam restoration and a three-surface anterior resin restoration during the study year, then this patient's experience would be summed as two caries-related procedures, along with the total caries-related costs for these specific procedures.

Descriptive statistics were calculated in SPSS for the independent variable of CWF and the dependent variables of dental caries procedures and dental caries-related costs, followed by adjustments for gender and race. Adjustments for income and parental educational attainment were not applied since the entire sample included only low-income participants whose family incomes met the criteria for Medicaid eligibility. Parent education was not a variable in the database, but it is assumed to be similar between the two study years since the child or adolescent was receiving Medicaid benefits. Qualification for Medicaid was and remains based on income level and varies by family size, disability status, and other metrics. For example, in 2003, the poverty level for a family of three in Alaska was defined as an annual income of $15,140, and in 2012, the income level was $23, 870 [45, 46]. Medicaid expansion in Alaska did not occur until 2015 under the Affordable Care Act. Proximity to a dental provider in the small community of Juneau, which utilizes public transit and has approximately 40 miles of paved, two-lane highway, remained unchanged during the study period.

Results

Univariate analysis of the data indicated that half of the participants were male (51.2%). Slightly more than one-half (53.9%) of the participants self-identified as American Indian or Alaska Native (AI/AN), and 30.9% self-identified as white/Caucasian. While the AI/AN community accounts for only 13.4% of Alaska's total population, they are over-represented in the Medicaid group due to historical oppression resulting in poverty. Table 1 summarizes the full descriptive statistics of the complete study population for the 0- to 18-year-old age groups.

We conducted a bivariate analysis of the mean number of caries procedures for the study groups under both conditions to address the first research objective assessing the extent to which CWF cessation impacts the frequency of dental caries procedures. According to the results of a Shapiro-Wilk test ($p < 0.0001$), the data were not normally distributed. Therefore, a Mann-Whitney U test was used to evaluate the difference in the mean number of dental caries-related procedures per child between the two independent CWF groups of different sizes. The results in Table 2 demonstrate that the mean number of caries-related procedures for the 0- to 18-year-old age groups was significantly higher in the suboptimal CWF group than that in the optimal CWF group (2.35 vs. 2.02, $p < 0.001$). The binary logistic regression results indicated that the odds ratio for patients aged 0 to 18 years living under optimal CWF conditions to receive a dental caries procedure was 0.748, indicating a protective effect (OR = 0.748, 95% CI [0.62, 0.90], $p < 0.0001$). In other words, the odds of a child or adolescent undergoing a dental caries procedure in 2003 was 25.2% less than that of a child or adolescent in the suboptimal CWF group.

Our analysis for the second research objective yielded similar results (Table 3). The mean caries-related treatment cost for the 0- to 18-year-old age cohort was significantly higher in the suboptimal CWF group than that in the optimal CWF group ($593.70 vs. $344.34, $p < 0.0001$) without adjusting for inflation. According to the U.S. Department of Labor Consumer Price Index [47], the inflation rate increased an estimated 24.75% between 2003 and 2012. Therefore, the increase in inflation-adjusted provider service charges in caries treatment costs

Table 1 Descriptive Statistics of the Juneau Study Sample by CWF Status ($n = 1905$)

Descriptor	Optimal CWF Year 2003 (0.7–1.2 mg/L)		Suboptimal CWF Year 2012 (< 0.1 mg/L)	
	Frequency	Percent	Frequency	Percent
N	853	44.8	1052	55.2
Gender				
Female	402	47.2	528	50.1
Male	451	52.8	524	49.9
Race/Ethnicity				
White/Non-Hispanic	319	37.5	269	25.6
Black/African American	19	0.02	19	0.02
American Indian or Alaskan Native	423	49.6	604	57.4
Asian or Pacific Islander	23	2.7	37	3.5
Hispanic or Latino	18	2.1	52	4.9
Native Hawaiian or Other Pacific	18	2.1	55	5.2
Unknown	33	3.9	16	1.5

associated with CWF cessation for the 0- to 18-year-old age group was + 47%, or $161.84. According to logistic regression analysis, the odds that a patient aged 0 to 18 years under optimally fluoridated conditions would be billed for dental caries treatment was 0.749, which was 25.1% less than that for a patient of the same age in the suboptimal CWF conditions group (OR = 0.749, 95% CI [0.623, 0.90], $p < 0.002$).

Lastly, our analysis for the third research objective considered which age group suffered the largest caries procedure burden under both CWF conditions. Bivariate analysis revealed that the mean number of caries-related procedures per patient for children under 7 years old was significantly higher in the suboptimal CWF group than that in the optimal CWF group (2.68 vs. 2.01, $p < 0.004$). The results from binary logistic regression were also significant (OR = 0.699, 95% CI [0.52, 0.95], $p < 0.02$) and similar to previous results, indicating a protective effect for optimal CWF exposure. Caries treatment costs were also higher in the under 7-year-old suboptimal CWF group than those in the optimal CWF group ($692.87 vs. $350.13, $p < 0.0001$). After adjusting for inflation, we observed a caries treatment cost increase of 73% attributable to CWF cessation and estimated at approximately $255.60.

The results for the group of individuals born after CWF cessation and aged < 6 years were of particular interest to the research team. These results are also included in Tables 2 and 3 and Fig. 1, which summarize the differences in the mean number of caries procedures and treatment cost results and illustrates consistent epidemiologic trends. The children without exposure to optimal CWF suffered a higher percent increase in caries procedures along with higher restoration costs, thus signifying greater tooth surface loss to decay secondary to weaker enamel (2.52 vs. 1.55, $p < 0.0001$) ($644.72 vs. $272.73, $p < 0.0001$) (Fig. 1). According to binary regression analysis for the under six-years-old age group, the odds of undergoing dental caries procedures under optimal CWF conditions was 51% less than that for a child of the same age in 2012 under suboptimal conditions (OR = 0.488, 95% CI [0.33, 0.73], $p < 0.0001$).

Discussion

The results of this study confirm the benefits of optimal CWF supported by previous research and can contribute

Table 2 The Mean (SD) Number of Caries Procedures per Child in 2003 and 2012, and a Summary of the Bivariate and Binary Regression Analyses

Age Group (years)	*Mean (SD) 2003 Optimal CWF*	*Mean (SD) 2012 Suboptimal CWF*	*Mann-Whitney U p*	*Logistic Regression[a] Optimal CWF OR, [95% CI]*
0 to < 6	1.55 (3.89) $n = 194$	2.52 (4.35) $n = 301$	0.0001	0.488, [0.33, 0.73]
0 to < 7	2.01 (4.22) $n = 303$	2.68 (4.57) $n = 461$	0.004	0.699, [0.52, 0.95]
7 to < 13	1.61 (3.38) $n = 352$	1.64 (2.60) $n = 400$	NS	NS
13 to 18	2.75 (4.73) $n = 198$	3.04 (4.66) $n = 191$	NS	NS
0 to 18	2.02 (4.05) $n = 853$	2.35 (3.99) $n = 1052$	0.001	0.748, [0.62, 0.90]

NS Not Significant
[a]Adjusted for gender and race

Table 3 Mean Caries-related Treatment Costs by Age in 2003 and 2012 and Adjusted for Inflation

Age Group (years)	*Mean ($) 2003 Optimal CWF*	*Mean ($) 2012 Suboptimal CWF*	*Mann-Whitney U p*	*Total Cost Inc/ % Inc*	*Adjusted[a] –25% Inflation*	*Increase ($) Attributed to Suboptimal CWF*
0 to < 6	272.72	644.72	0.0001	372.00/136%	111%	302.71
0 to < 7	350.13	692.87	0.0001	342.74/98%	73%	255.60
7 to < 13	241.52	382.44	0.001	140.92/58%	33%	79.70
13 to 18	519.07	795.68	0.035	276.61/53%	28%	145.34
0 to 18	344.34	593.70	0.0001	249.36/72%	47%	161.84

[a]Service provider charges were used rather than Medicaid reimbursement amounts for comparisons by accurately adjusting for inflation

additional research-based evidence regarding the oral health consequences and costs that can arise when CWF is discontinued. The most common modality of study among previous CWF cessation research was a concurrent cross-sectional analysis using DMFT screening in a community that had ceased CWF at some point in the past compared to a community that continued optimal CWF [26]. Therefore, this research offers an alternative modality for studying the effects of CWF using Medicaid claims data from the same community before and after CWF cessation.

The results demonstrate a statistically significant increase in the number of dental caries procedures and associated treatment costs for the general cohort under suboptimal CWF conditions in 2012 among patients aged 0 to 18 years (2.35 vs. 2.02, $p < 0.001$). This increase was more pronounced among younger age groups under suboptimal CWF conditions, specifically the < 7-year-old age group (2.68 vs. 2.01, $p = 0.004$) and the < 6-year-old age group who were born after CWF was ceased (2.52 vs. 1.55, $p < 0.0001$).

The naturally occurring fluoride level in Juneau's water since CWF was ceased in January 2007 has remained between 0.05–0.065 mg/L per annual reporting, which is more than ten-times less than the optimal CWF level needed for caries prevention [35]. Previous research indicates that without the presence of optimal levels of fluoride in drinking water, and thus in the mouth and saliva, teeth may form with weaker enamel and lack the ability to remineralize early signs of decay [9, 25, 31, 48]. Therefore, we expected to observe a general increase in dental caries-related procedures and treatment costs across age groups because fluoride acts primarily topically [9, 48]. Additionally, we expected to observe more significant impacts among patients with the lowest exposure to optimal CWF.

In this study, a major advantage of acquiring both pre- and post-fluoride cessation data in this natural setting was the potential to assess the net differences in the intervention condition (suboptimal CWF) and in the control condition (optimal CWF) [49]. The results indicate a clear caries epidemiologic shift toward a caries increase among patients without the protective benefit of optimal CWF. As no significant difference in the mean number of caries procedures was observed between the 7- to 12- and 13- to 18-year-old age groups, we suggest that these individuals may have a residual protective effect from optimal CWF exposure during childhood and

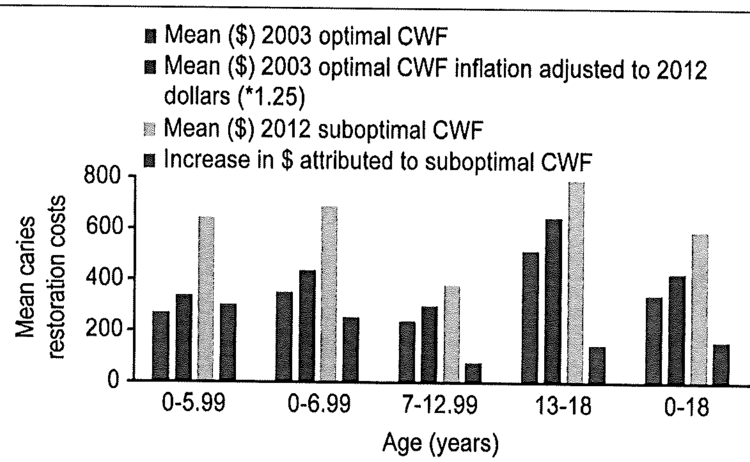

Fig. 1 Mean caries restoration costs according to age for children with optimal or suboptimal community water fluoridation (CWF). First, the mean cost in 2003 for children with optimal CWF was calculated; the mean cost in 2003 was then adjusted for inflation (*1.25) according to the 2012 dollar value; and lastly the increase cost attributed to suboptimal CWF was calculated

early adolescence. Additionally, between 2003 and 2012, we observed a sevenfold overall increase in the placement of sealants. Optimal CWF exposure during childhood, plus the increased use of dental sealants during school-aged years, may explain the results among the older cohorts; however, this topic requires further investigation [27–29].

Overall, we were able to measure the influence of the independent variable, CWF, on the dependent variables, dental caries procedures and treatment costs, both before and after cessation by utilizing a study population comprising participants living at or near poverty conditions. The similarity of the target groups' income criteria for Medicaid eligibility adds strength to the internal validity of the study; therefore, the results and causal implications are more valid than if the results had been derived from the general population [22, 49]. Second, the external validity of the results was also increased by working with only Medicaid claims data, which limited the influence of higher-income groups [22, 50]. Families with high incomes may have easier access to dental care and may more routinely visit a dentist or refill supplemental fluoride tablets, which could potentially dilute small changes in caries rates under fluoridation and non-fluoridation conditions [22, 24, 27, 50]. Therefore, the results are likely generalizable to other Medicaid groups in communities considering CWF cessation.

Regarding reliability, variations in providers' therapeutic approaches and billing practices may have had some influence, but we anticipate that these variations were similar in both study years. The data were managed and recoded by only two individuals, and errors were estimated to be minimal. In summary, the internal and external qualities of this study support generalizability to other 0- to 18-year-old Medicaid populations in Alaska who have already ceased CWF or are considering CWF cessation. The methodology and analysis processes are certainly transferrable to other regions and offer an innovative metric option for future oral health research and statewide public health surveillance programs.

The results presented in Table 3 indicate a progressively higher caries risk and cost burden for the younger age groups in the suboptimal CWF cohort. Please recall that older patients in this study were exposed to several years of optimal CWF as young children born prior to cessation in 2007. For example, patients in the 7- to 13-year-old age group were born between 2000 and 2005 and thus benefited from early-life/childhood optimal CWF exposure. Overall, the costs of caries treatment services increased for each age group cohort, even after adjusting for inflation, and were markedly higher under suboptimal CWF conditions. These results support current evidence that even in modern conditions with widely available fluoride toothpaste, rinses, and professionally applied prophylaxis, CWF is associated with population benefits, including cost effectiveness and caries prevention [6, 7, 22, 24, 31, 50, 51].

Limitations

The study has a number of limitations. First, due to funding limits, only two years of data were purchased for comparison rather than five to ten years of data, which would have enabled a more sophisticated trend analysis. Second, dental claims for extractions or full-mouth reconstruction were removed from the primary data analysis because we could not confirm that these procedures were caries-related without the clients' full medical records. Therefore, caries procedures and costs may be underrepresented in the results. Third, the coding scheme also assumes that within 1 year, the dental professional treated all points of decay for each individual patient and did not over- or undertreat. Lastly, if an eligible child did not visit the dentist that year, then no claims forms were generated, and they were not included in the study.

While the use of reimbursement claims records as the primary metric for longitudinal evaluation in a pre- and post-CWF-exposed population was innovative, a precedent had been set by concurrent comparison population analyses completed in Louisiana [16] and New York [22] and by the Texas Department of Public Health [23]. Additional methodological factors include identification of strategies to control for confounders and the issue of measuring short-term versus long-term changes. Rugg-Gunn and Do [40] remark that among studies published in the last twenty-five years exploring CWF using a cross-sectional comparison methodology, the use of multivariate statistical analyses with adjustments for confounders has yielded minimal change in the net effect of CWF on caries reduction. Typical covariates for dental caries and dozens of other negative health outcomes include diet, parental education and parental income [40]. As with most negative health outcomes, these covariates can play roles in determining an individual's oral health, often influencing diet options, social norms toward seeking preventative dental care, prioritization of home oral care practices and stress levels [24, 28]. We acknowledge baseline and comparison data regarding parental education among low income families, home oral hygiene practices, and dietary habits to be unknown considerations. However, proxy measures may offer some estimates of influence. For example, the Alaska Youth Risk Behavioral Survey (YRBS) tracks sugar-sweetened beverage (SSB) consumption among teens, which appears to be declining, mirroring national trends. According to the YRBS for Alaska in 2007, 21.8% of youths drank one SSB one or more times per day during the past 7 days, while in 2013, the rate was 15.8% [52, 53]. While the trend of reduced SSB and thus added sugar consumption may be declining nationally and statewide, the reduction is highly unlikely to be sufficient to result in a reduction in caries (< 10% of total daily calories) [54, 55].

Based on available population estimates, we note only small changes between the 2003 and 2012 Juneau Borough censuses and minimal changes to Medicaid eligibility requirements. Therefore, common sense would support that the parental education level among Medicaid-eligible families was also comparable between the two groups. While the similarities in population size and socioeconomic conditions may strengthen the validity of the study conclusions, they can also be viewed as a limitation for the generalizability of the study's results to other populations that experience more in-and-out migration or wider variations in income.

Other covariates that may have influenced the results include prescriptive fluoride supplementation, school fluoride rinse programs, and dental sealants. No school-based oral health or school rinse programs existed in Juneau before, during or after the study period, and prescriptive supplementation has always remained very limited (personal communications with Dr. Whistler and Dr. Hort, January 2016). Notably, among studies exploring other probable confounders, such as widely available fluoride toothpaste, moderate access to school-based fluoride varnish programs and in-office fluoride applications, researchers have reported that optimal CWF still improves oral health among children through caries prevention, enamel remineralization and cost savings [22, 28, 31, 50, 51, 56, 57]. Lastly, another potential limitation of this study is that we do not have information regarding fluoride toothpaste use in this low-socioeconomic status population, and fluoride toothpaste use may be much lower than that expected in other populations. Such information could strengthen the conclusion regarding the benefit of CWF in this population compared to other populations that regularly use fluoride toothpaste.

Conclusion

This study analyzed oral health changes secondary to CWF discontinuation among Medicaid-eligible children and adolescents in a community in which the local government ceased fluoridation of the public water system. We examined the relationship between dental caries-related procedures and costs under optimal and suboptimal CWF conditions through rigorous statistical analysis of Medicaid dental claims records and formed the following conclusions. According to the aforementioned results, CWF cessation promoted a marked increase in the number of caries-related procedures and treatment costs for Medicaid-eligible children and adolescents aged 0–18 years. Additionally, the results indicated that children in the younger age group cohorts underwent more dental caries procedures than the older age group cohorts, who had benefited from early childhood exposure to optimal CWF. These results add to the growing body of information available regarding CWF cessation epidemiology by both confirming the dental caries prevention benefit of CWF and expanding the evidence base regarding the oral health impacts of CWF cessation under contemporary conditions.

The analysis also can offer fiscal estimates that can be used by community leaders and decision-makers who are considering CWF cessation and may need to plan for the increased revenue required to address the treatment costs among clients relying on state and federal government subsidies. With this study, dental and public health professionals also have access to more evidence to accurately inform officials establishing future community water fluoridation policies and to illustrate how CWF cessation can affect individuals, especially children, in economically vulnerable or low-income circumstances [22, 24, 28, 50].

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Availability of data and materials
Data supporting this study can be released by the Centers for Medicare and Medicaid Services (CMS) Research Data Assistance Center (ResDAC) after an application process. The claims database used in this study are not publicly available because they contain beneficiary-protected health information and thus require a Data Use Agreement. This agreement is awarded after an application/approval process conducted by the Centers for Medicare and Medicaid Research Data and Assistance Center (ResDAC), and only then can data be purchased https://www.resdac.org/. This application also requires IRB approval from your institution prior to submission.

Authors' contributions
JM and VM conducted the data management and analysis. JM and VM contributed to the design of the study. JM, VM and AM contributed to the data interpretation and preparation of the manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate
Walden's Institutional Review Board also approved the study (Walden IRB #10–31–16-0075333).

Consent for publication
Not Applicable.

Competing interests
The authors declare that they have no competing interests.

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References

1. Jackson SL, Vann WF, Kotch JB, Pahel BT, Lee JY. Impact of poor oral health on children's school attendance and performance. Am J Public Health. 2011;101:1900–6. https://doi.org/10.2105/AJPH.2010.200915.
2. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention. Statement on the evidence supporting the safety and effectiveness of community water fluoridation. (2017). https://www.cdc.gov/fluoridation/pdf/cdc-statement.pdf. Accessed 1 Nov 2018.
3. Centers for Disease Control and Prevention. Community water fluoridation. (2015). https://www.cdc.gov/fluoridation/index.html. Accessed 1 Nov 2018.
4. Newacheck PW, Hughes DC, Hung YY, Wong S, Stoddard JJ. The unmet health needs of America's children. Pediatrics. 2000;105:989–97.
5. Abanto J, Carvalho TS, Mendes FM, Wanderley MT, Bönecker M, Raggio DP. Impact of oral diseases and disorders on oral health-related quality of life of preschool children. Commun Dent Oral Epidemiol. 2011;39:105–14. https://doi.org/10.1111/j.1600-0528.2010.00580.x.
6. U.S. Department of Health and Human Services, National Institutes of Health, National Institute of Dental and Craniofacial Research. Oral health in America: A report of the surgeon general. (2000). http://www.nidcr.nih.gov/DataStatistics/SurgeonGeneral/Documents/hck1ocv.@www.surgeon.fullrpt.pdf. Accessed 1 Nov 2018.
7. U.S. Department of Health and Human Services Federal Panel on Community Water Fluoridation. U.S. Public Health Service recommendation for fluoride concentration in drinking water for the prevention of dental caries. Public Health Rep. 2015;130:318–31. https://doi.org/10.1177/003335491513000408.
8. Freeze RA, Lehr JH. The fluoride wars: how a modest public health measure became America's longest running political melodrama. Hoboken: John Wiley & Sons; 2009.
9. American Dental Association. Fluoridation FAQs. (2016). http://www.ada.org/en/public-programs/advocating-for-the-public/fluoride-and-fluoridation/fluoridation-faq. Accessed 1 Nov 2018.
10. Centers for Disease Control and Prevention. Untreated dental caries (cavities) in children ages 2-19, United States. (2018). https://www.ncbi.nlm.nih.gov/pubmed/25932891. Accessed 1 Nov 2018.
11. Centers for Disease Control and Prevention. State Strategies - Preventing tooth decay. (2015). http://www.cdc.gov/policy/hst/statestrategies/oralhealth/. Accessed 1 Nov 2018.
12. Dye BA, Arevalo O, Vargas CM. Trends in paediatric dental caries by poverty status in the United States, 1988-1994 and 1999-2004. Int J Paediatr Dent. 2010;20:132–43. https://doi.org/10.1111/j.1365-263X.2009.01029.x.
13. Dye BA, Thornton-Evans G, Li X, Iafolla TJ. Dental caries and sealant prevalence in children and adolescents in the United States, 2011-2012. NCHS Data Brief. Hyattsville: National Center for Health Statistics; 2015. https://www.cdc.gov/nchs/data/databriefs/db191.htm. Accessed 1 Nov 2018
14. Griffin SO, Regnier E, Griffin PM, Huntley V. Effectiveness of fluoride in preventing caries in adults. J Dent Res. 2007;86:410–5. https://doi.org/10.1177/154405910708600504.
15. Neidell M, Herzog K, Glied S. The association between community water fluoridation and adult tooth loss. Am J Public Health. 2010;100:1980–5. https://doi.org/10.2105/AJPH.2009.189555.
16. Centers for Disease Control and Prevention. Water fluoridation and costs of Medicaid treatment for dental decay – Louisiana. (1999). https://www.cdc.gov/mmwr/preview/mmwrhtml/mm4834a2.htm. Accessed 1 Nov 2018.
17. Gillcrist JA, Brumley DE, Blackford JU. Community fluoridation status and caries experience in children. J Public Health Dent. 2001;61:168–71. https://doi.org/10.1111/j.1752-7325.2001.tb03385.x.
18. Iheozor-Ejiofor Z, Worthington HV, Walsh T, O'Malley L, Clarkson JE, Macey R, et al. Water fluoridation for the prevention of dental caries. Cochrane Database Syst Rev. 2015:CD010856. https://www.cochrane.org/CD010856/ORAL_water-fluoridation-prevent-tooth-decay
19. McDonagh M, Whiting P, Bradley M, Cooper J, Sutton A, Chestnutt I, et al. A systematic review of public water fluoridation. New York: National Health Service Centre for Reviews and Dissemination; 2000.
20. Centers for Disease Control and Prevention. Recommendations for using fluoride to prevent and control dental caries in the United States. Morb Mortal Wkly Rep. 2001;50(RR14):1–42 https://www.cdc.gov/mmwr/preview/mmwrhtml/rr5014a1.htm. Accessed 1 Nov 2018.
21. Griffin SO, Jones K, Tomar SL. An economic evaluation of community water fluoridation. J Public Health Dent. 2001;61:78–86. https://doi.org/10.1111/j.1752-7325.2001.tb03370.x.
22. Kumar JV, Adekugbe O, Melnik TA. Geographic variation in Medicaid claims for dental procedures in New York state: role of fluoridation under contemporary conditions. Public Health Rep. 2010;125:647–54. https://doi.org/10.1177/003335491012500506.
23. Texas Department of State Health Services. Water fluoridation costs in Texas: Texas health steps [EPSDT-MEDICAID]. Austin: Texas Department of State Health Services; 2000. http://www.dshs.texas.gov/dental/Fluoride-Cost.shtm?terms=Water%20fluoridation%20costs%20in%20Texas. Accessed 1 Nov 2018
24. Wong E. The real cost of removing water fluoridation: a health equity impact assessment-report. Wellesley Institute: Portland; 2013.
25. Armfield JM. Community effectiveness of public water fluoridation in reducing children's dental disease. Public Health Rep. 2010;125:655–64. https://doi.org/10.1177/003335491012500507.
26. McLaren L, Singhal S. Does cessation of community water fluoridation lead to an increase in tooth decay? A systematic review of published studies. J Epidemiol Commun Health. 2016;70:934–40. https://doi.org/10.1136/jech-2015-206502.
27. Maupomé G, Clark DC, Levy SM, Berkowitz J. Patterns of dental caries following the cessation of water fluoridation. Commun Dent Oral Epidemiol. 2001;29:37–47. https://doi.org/10.1034/j.1600-0528.2001.00007.x.
28. McLaren L, McNeil DA, Potestio M, Patterson S, Thawer S, Faris P, et al. Equity in children's dental caries before and after cessation of community water fluoridation: differential impact by dental insurance status and geographic material deprivation. Int J Equity Health. 2016;15:24. https://doi.org/10.1186/s12939-016-0312-1.
29. McLaren L, Patterson S, Thawer S, Faris P, McNeil D, Potestio M, et al. Measuring the short-term impact of fluoridation cessation on dental caries in grade 2 children using tooth surface indices. Commun Dent Oral Epidemiol. 2016;44:274–82. https://doi.org/10.1111/cdoe.12215.
30. Attwood D, Blinkhorn AS. Dental health in schoolchildren 5 years after water fluoridation ceased in south-West Scotland. Int Dent J. 1991;41:43–8.
31. Murthy VH. Surgeon general's perspectives. Public Health Rep. 2015;130:296–8. https://doi.org/10.1177/003335491513000402.
32. Healthy People 2020. Oral health. Washington, DC: U.S. Department of Health and Human Services, Office of Disease Prevention and Health Promotion. Published 2014. (2018). https://www.healthypeople.gov/2020/topics-objectives/topic/oral-health. Accessed 1 Nov 2018.
33. Centers for Disease Control and Prevention. State reported water fluoridation data and statistics 2000-2014. (2016). https://www.cdc.gov/fluoridation/statistics/2014stats.htm. Accessed 1 Nov 2018.
34. Chomitz D. Fairbanks city council halts additional fluoride in city water. The Fairbanks Daily News-Miner. (2011). http://www.newsminer.com/fairbanks-city-council-halts-additional-fluoride-in-city-water/article_3b1cde97-dcef-5b4b-be69-9c2fc34531e4.html. Accessed 1 Nov 2018.
35. City Borough of Juneau (CBJ) Water Utility. Water utility system information. Annual water quality reports for 2004-2016; (1993-2003 available by request). https://beta.juneau.org/engineering-public-works/utilities-division/water-utility. Accessed 1 Nov, 2018.
36. U.S. Environmental Protection Agency, Consumer Confidence Reports (CCR). Annual drinking water reports for Alaska, Juneau, 99801. https://ofmpub.epa.gov/apex/safewater/f?p=136:103:::NO:::. Accessed 1 Nov 2018.
37. Alaska Department of Labor and Workforce Development. Labor department estimates Alaska's 2003 population. Report prepared by the research and analysis section. (2004). http://labor.alaska.gov/news/2004/news04-33.pdf. Accessed 1 Nov 2018.
38. Alaska Department of Labor and Workforce Development. Alaska population overview 2012 estimates. Report prepared by the research and analysis section. (2013). http://live.laborstats.alaska.gov/pop/estimates/pub/12popover.pdf. Accessed 1 Nov 2018.

39. Centers for Medicare & Medicaid (CMS). Medicaid and CHIP in Alaska. https://www.medicaid.gov/medicaid/by-state/stateprofile.html?state=alaska. Accessed 1 Nov 2018.
40. Rugg-Gunn AJ, Do L. Effectiveness of water fluoridation in caries prevention. Commun Dent Oral Epidemiol. 2012;40:55–64. https://doi.org/10.1111/j.1600-0528.2012.00721.x.
41. Dye BA, Li X, Thorton-Evans G. Oral health disparities as determined by selected healthy people 2020 oral health objectives for the United States, 2009-2010. NCHS Data Brief. 2012;104:1–8.
42. Dental ADA. Claim form. (2012). http://www.ada.org/en/publications/cdt/ada-dental-claim-form. Accessed 1 Nov 2018.
43. Centers for Medicare & Medicaid (CMS). Research and data assistance center (ResDAC). (2012). https://www.cms.gov/Research-Statistics-Data-and-Systems/Research/ResearchGenInfo/ResearchDataAssistanceCenter.html. Accessed 1 Nov 2018.
44. Research Data Assistance Center. (ResDAC). CMS data request center. https://www.resdac.org/. Accessed 1 Nov 2018.
45. U.S Department of Health and Human Services, Office of the Assistant Secretary for Planning and Evaluation. HHS poverty guidelines. Federal Register, Vol. 3, No. 3018, 4154-4055. (2003). https://aspe.hhs.gov/2003-poverty-guidelines-federal-register-notice. Accessed 1 Nov 2018.
46. U.S Department of Health and Human Services, Office of the Assistant Secretary for Planning and Evaluation. HHS poverty guidelines. Federal Register, Vol. 77, No. 17, 4034-4035. (2012). https://aspe.hhs.gov/2012-hhs-poverty-guidelines#thresholds. Accessed 1 Nov 2018.
47. U.S. Department of Labor. Bureau of labor statistics, databases, tables & calculators by subject, CPI inflation calculator. (2017). https://www.bls.gov/data/inflation_calculator.htm. Accessed 1 Nov 2018.
48. O'Mullane DM, Baezz RJ, Jones S, Lennon MA, Petersen PE, Rugg-Gunn AJ, Whelton H, Whitford GM. Fluoride and oral health. Community Dent Health. 2016;33(2):69–99. https://www.cdhjournal.org/issues/33-2-june-2016/704-fluoride-and-oral-health. Accessed 1 Nov 2018.
49. Murray DM. Design and analysis of group randomized trials. New York: Oxford University Press; 1998.
50. Edelstein BL, Hirsch G, Frosh M, Kumar J. Reducing early childhood caries in a Medicaid population: a systems model analysis. J Am Dent Assoc. 2015; 146:224–32. https://doi.org/10.1016/j.adaj.2014.12.024.
51. O'Connell JM, Brunson D, Anselmo T, Sullivan PW. Costs and savings associated with community water fluoridation programs in Colorado. Prev Chronic Dis. 2005;2:A06. https://doi.org/10.1377/hlthaff.2016.0881.
52. State of Alaska. Department of Health and Social Services, Office of Disease Prevention and Health Promotion. Alaska 2007 Youth Risk Behavioral Health Survey. Published 2007. http://dhss.alaska.gov/dph/Chronic/Pages/yrbs/yrbs07.aspx. Accessed 1 Nov 2018.
53. State of Alaska. Department of Health and Social Services, Office of Disease Prevention and Health Promotion. Alaska 2013 Youth Risk Behavioral Health Survey. Published 2013. http://dhss.alaska.gov/dph/Chronic/Documents/School/pubs/2013YRBS_Highlights.pdf. Accessed 1 Nov 2018.
54. Bleich SN, Vercammen KA, Koma JW, Li Z. Trends in beverage consumption among children and adults, 2003-2014. Obesity. 2018;26:432–41. https://doi.org/10.1002/oby.22056.
55. Moynihan PJ, Kelly SA. Effect on caries of restricting sugars intake: systematic review to inform WHO guidelines. J Dent Res. 2014;93:8–18. https://doi.org/10.1177/0022034513508954.
56. Rozier RG, Adair S, Graham F, Iafolla T, Kingman A, Kohn W, et al. Evidence-based clinical recommendations on the prescription of dietary fluoride supplements for caries prevention: a report of the American Dental Association Council on Scientific Affairs. J Am Dent Assoc. 2010;141:1480–9. https://doi.org/10.14219/jada.archive.2010.0111.
57. Cho HJ, Jin BH, Park DY, Jung SH, Lee HS, Paik DI, et al. Systemic effect of water fluoridation on dental caries prevalence. Commun Dent Oral Epidemiol. 2014;42:341–8. https://doi.org/10.1111/cdoe.12091.

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Fluoride exposure and indicators of thyroid functioning in the Canadian population: implications for community water fluoridation

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ABSTRACT

Background There are concerns that altered thyroid functioning could be the result of ingesting too much fluoride. Community water fluoridation (CWF) is an important source of fluoride exposure. Our objectives were to examine the association between fluoride exposure and (1) diagnosis of a thyroid condition and (2) indicators of thyroid functioning among a national population-based sample of Canadians.

Methods We analysed data from Cycles 2 and 3 of the Canadian Health Measures Survey (CHMS). Logistic regression was used to assess associations between fluoride from urine and tap water samples and the diagnosis of a thyroid condition. Multinomial logistic regression was used to examine the relationship between fluoride exposure and thyroid-stimulating hormone (TSH) level (low/normal/high). Other available variables permitted additional exploratory analyses among the subset of participants for whom we could discern some fluoride exposure from drinking water and/or dental products.

Results There was no evidence of a relationship between fluoride exposure (from urine and tap water) and the diagnosis of a thyroid condition. There was no statistically significant association between fluoride exposure and abnormal (low or high) TSH levels relative to normal TSH levels. Rerunning the models with the sample constrained to the subset of participants for whom we could discern some source(s) of fluoride exposure from drinking water and/or dental products revealed no significant associations.

Conclusion These analyses suggest that, at the population level, fluoride exposure is not associated with impaired thyroid functioning in a time and place where multiple sources of fluoride exposure, including CWF, exist.

BACKGROUND

The objective of this study was to examine the association between fluoride exposure and thyroid functioning among a national population-based sample of Canadians. As described below, fluoride is one of the several factors that could be relevant to thyroid-related problems; however, existing human studies have yielded mixed findings.

Thyroid underactivity (hypothyroidism) is most commonly caused by an autoimmune disease known as Hashimoto's thyroiditis but can also occur due to the use of certain medications (eg, lithium) and both increased and decreased iodine intake. Thyroid overactivity (hyperthyroidism) is most commonly caused by an autoimmune disease known as Graves' disease but can also result from inflammation of the thyroid, excessive iodine intake and thyroid adenomas.[1] Risk factors for thyroid diseases include, but are not limited to sex (female), age (over 50), family history of thyroid disease, smoking cigarettes and radiation exposure to the head or neck.[2] Additionally, individuals with one autoimmune condition are more susceptible to developing other autoimmune conditions. For example, individuals with celiac disease have been found to have significantly higher risk of developing autoimmune thyroid diseases.[3]

Animal studies have indicated that high concentrations of fluoride impair thyroid function.[4] Decreases in triiodothyronine (T3) and thyroxine (T4), thyroid peroxidase and 3G-leucine were observed in laboratory animals administered fluoride at doses of 3–6 mg/kg/day. When iodine intake was low, larger effects on thyroid function were noted. Several mechanisms of action, such as lowered production of thyroid hormone, thyroid hormone transportation abnormalities in the blood and interference related to the conversion of T4–T3 in the peripheral tissues by deiodinases, have been proposed to explain these effects, but the mechanistic details have yet to be elucidated.[4]

Human studies investigating the relationship between fluoride exposure and thyroid functioning have mixed findings. Three studies conducted in India[5–7] and one in China[8] found evidence of at least one hormone derangement among those deemed as having 'high' fluoride exposure (defined in various ways), but the studies differed in terms of the hormone derangement patterns observed. For example, Michael *et al* (1996)[5] found no difference in the levels of thyroid-stimulating hormone (TSH) between those with low and high fluoride exposure (fluoride exposure was not clearly defined), whereas Lin *et al* (1991)[8] found that individuals residing in high fluoride areas (defined as areas with an average fluoride concentration of 0.88 parts per million (ppm) in drinking water) had significantly higher TSH levels than those residing in low fluoride areas (average fluoride concentration of 0.34 ppm in drinking water) ($p<0.01$). Conversely, a study by Hosur *et al* (2012)[9] did not detect altered levels of thyroid hormones (free T3, free T4 and TSH) in 65 individuals living in India with dental fluorosis (used as a proxy for high fluoride exposure), with the exception of one individual whose serum levels of TSH were elevated. The results

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of these small-scale human studies should be interpreted with caution in light of limited details regarding the study sample, unclear descriptions of fluoride exposure classification and lack of adjustment for other important covariates (eg, iodine status).[4] Importantly, none of these studies were conducted in the context of community water fluoridation (CWF), making their relevance to CWF and the Canadian population unclear.

CWF is a public health intervention that functions to prevent tooth decay by adding a controlled quantity of fluoride to public drinking water supplies and represents an important source of fluoride exposure in fluoridated regions.[10] A Fluoride Expert Panel commissioned by Health Canada determined the optimal concentration of fluoride in public drinking water supplies to be 0.7 mg/L, as available evidence suggests that this concentration balances the protective dental benefits of fluoride with potential adverse health effects (eg, dental fluorosis).[11] However, concerns remain that the concentration of fluoride in drinking water supplies is still too high and could compromise thyroid functioning,[12] especially when multiple sources of fluoride exist (eg, fluoride-containing dental products).

The results of a recent cross-sectional study by Peckham, Lowery and Spencer (2015)[13] appear to add legitimacy to concerns regarding fluoride exposure from CWF and impaired thyroid functioning. Data on diagnosed hypothyroidism during 2012–2013 were obtained from all primary care physicians' offices in England and mapped to water supply zones and corresponding fluoride levels. Binary logistic regression was used to examine the association between high general practitioner (GP) practice level hypothyroidism prevalence (top tertile, 3.58%–8.48%) and fluoride concentrations in drinking water (low (≤0.3 ppm), medium (>0.3 to ≥0.7 ppm) and high (>0.7 ppm)), controlling for aggregate (GP practice level) gender, age and deprivation scores. Areas with high fluoride concentrations were 1.6 times more likely to have high GP practice level hypothyroidism prevalence than areas with low fluoride concentrations.[13]

Since Peckham *et al* (2015)[13] was the first population-level study to examine the relationship between CWF and thyroid problems (in particular, hypothyroidism), additional research is required to determine if these findings are consistent across different contexts, and when individual-level biomarkers of fluoride exposure are used.

The present study utilised high-quality Canadian survey data from a national population-based sample that includes individual-level estimates of fluoride exposure from urine and tap water samples, as well as measures of thyroid functioning. Our objectives were to examine the association between fluoride exposure and (1) the diagnosis of a thyroid condition and (2) indicators of thyroid functioning, specifically TSH and free T4 levels, among a population-based sample of Canadians.

METHODS

Data source and target population

The data source is Cycles 2 (2009–2011) and 3 (2012–2013) of Statistics Canada's Canadian Health Measures Survey (CHMS); specifically, the environmental urine subsample (n=2563) for Cycle 2 and the urine fluoride subsample (n=2671) for Cycle 3. Full survey details are available at www.statcan.gc.ca. Briefly, the CHMS is a nationally representative, cross-sectional survey that collects health information from individuals through an in-home interview followed by a clinical exam conducted in a mobile clinic. The target population is all Canadian residents age 3–79 years living in the ten provinces, excluding those who live in the three territories (Cycle 3 only), those who live on reserves and other Aboriginal settlements in the provinces, institutionalised residents, full-time members of the Canadian Forces and residents of certain remote regions. Cumulatively, these excluded groups represent about 4% of the target population.[14,15] Nationally representative samples were drawn using a stratified, multistage sampling strategy. The overall response rates were 55.5% (Cycle 2) and 51.7% (Cycle 3). Response rates were 54.4% for the environmental urine subsample (Cycle 2) and 55.6% for the urine fluoride subsample (Cycle 3).[14 15]

Variables of interest

Estimates of urinary fluoride from spot urine were available for a subsample of respondents. The fluoride content of urine samples was analysed using an Orion pH metre with fluoride ion selective electrode with a limit of detection of 20 µg/L (Cycle 2) and 10 µg/L (Cycle 3).[16 17] Analysis was performed under standardised operating procedures at the Human Toxicology Laboratory of the Institut National de Santé Publique du Québec (accredited under ISO 17025). Urinary fluoride has been shown to be sensitive to variations in fluoride exposure, including CWF,[18] and has been classified as a contemporary marker of fluoride exposure as opposed to recent (eg, hair and nails) or historic (eg, bone and teeth) markers.[19]

In Cycle 3 only, estimates of the fluoride concentration of tap water samples collected from randomly selected households were available. The subsample of households selected for tap water sample collection corresponded to the person-level urine fluoride subsample. Analysis of the fluoride concentration of tap water was performed using a basic anion exchange chromatography procedure, with a limit of detection of 0.006 mg/L.

Thyroid functioning was measured in three ways: (1) self-reported diagnosis of a thyroid condition (yes/no, based on a single item from the household survey in Cycles 2 and 3 asked to respondents aged 12 years and older: 'Do you have a thyroid condition?'), (2) TSH level (low/normal/high) for respondents aged 3–79 years in Cycle 3 only and (3) blood test results indicating primary hypothyroidism (yes/no) for respondents aged 3–79 years in Cycle 3 only.

Determination of TSH level and primary hypothyroidism status was based on the non-environmental lab full sample file of the CHMS (new for Cycle 3) which contained four biomarkers of thyroid health: (1) TSH, (2) free T4, (3) antithyroid peroxidase and (4) antithyroglobulin. We used TSH and free T4 because they had the largest sample sizes and greatest clinical significance in terms of the most common thyroid disorders.

Blood samples of TSH and free T4 were collected at the mobile clinic by a phlebotomist using a standardised venipuncture method. The amount of blood drawn was dependent on the respondent's age.[14 15] Quantification of TSH in serum was determined using a third-generation assay analyser that has a chemiluminescent detection system.[20] Serum levels of free T4 were analysed using a competitive chemiluminescent immunoassay.[21] The reference intervals of TSH and free T4 were 0.55–4.78 mIU/L and 11.5–22.5 pmol/L, respectively. Both TSH and free T4 samples were analysed at the Institut National de Santé Publique du Québec on the Siemens ADVIA Centaur XP analyser.[20 21]

Synthesised and secreted by the anterior pituitary gland, TSH stimulates the thyroid gland to produce T3 and T4, which play important roles in regulating metabolism.[20] Approximately, 99.95% of T4 circulates in the blood reversibly bound to transport proteins, while the small percentage that is unbound, known as free T4, is metabolically active.[21] Measuring blood levels of TSH is important in determining thyroid gland function. In primary hypothyroidism, a common thyroid disorder, TSH levels are significantly elevated. A reduced free T4 level also characterises primary hypothyroidism.[20] Accordingly, we classified respondents as having primary hypothyroidism if they had elevated TSH levels (>4.78 mIU/L) and low free T4 levels (<11.5 pmol/L).[20 21]

We adjusted for potential confounders (drawn from the household interview): sex, age, household education (highest attained education in the household: less than a Bachelor's degree vs Bachelor's degree or greater) and household income adequacy (low and middle income vs high income based on the total household income and household size). For analyses involving biomarkers of thyroid health (TSH and free T4), we excluded (1) pregnant women[22] and (2) respondents who reported taking a thyroid medication in the past month at either the household or clinic interview, as thyroid medications could artificially bring an abnormal thyroid biomarker into the normal range.

Finally, we considered variables that permitted some discernment of source(s) of fluoride exposure. Our reasoning was as follows: if we observed an association between fluoride and thyroid functioning among the full subsample, observing whether that association was also present (or was stronger) among the subset of participants would provide us with a sense about the role of the source of fluoride exposure. For both Cycles 2 and 3, following an approach used elsewhere,[23] we assigned each data collection site as 'fluoridated' or 'not fluoridated' using information obtained from a variety of sources (eg, municipal websites, water quality reports, news reports). The Office of the Chief Dental Officer, Public Health Agency of Canada, corroborated our classifications. Additionally, content from Cycle 2 allowed us to identify respondents who (1) identified tap water as their primary source of drinking water at home or away from home (vs bottled or other) and (2) indicated living in their current home for at least 3 years. New content related to water consumption for Cycle 3 allowed us to identify respondents who (1) reported using fluoride-containing products at home (eg, toothpaste, mouthwash) and (2) reported ever receiving fluoride treatments at the dentist (vs never).

Data analysis

First, we used logistic regression to regress self-reported diagnosis of a thyroid condition (yes/no) on urinary fluoride (µmol/L) for Cycles 2 and 3 and on fluoride concentration of tap water (mg/L) for Cycle 3, unadjusted and adjusted for covariates. Second, multinomial logistic regression was used to examine the relationship between fluoride exposure (from urine and tap water) and TSH (low/normal/high), unadjusted and adjusted for covariates. We intended to regress hypothyroidism status (yes/no) on urinary fluoride and fluoride concentration of tap water but Statistics Canada sample size requirements precluded these analyses. Instead, our third analysis was simple mean comparison of urinary fluoride and fluoride concentration of tap water between respondents with and without hypothyroidism.

We again intended to rerun the same analyses among a subset of respondents for whom we could discern source(s) of fluoride exposure but again, we were unable to do so due to sample size requirements set by Statistics Canada. Instead, we performed mean comparisons to examine whether fluoride (from urine and tap water) differed between those with and without thyroid diagnosis, and those with low, normal, and high TSH level, among the constrained fluoride urine subsample.

Data access and analysis took place at the Prairie Regional Research Data Centre at the University of Calgary. As directed by Statistics Canada, all models incorporated survey weights to permit generalisation of findings back to the Canadian population and bootstrap weights to ensure the appropriate computation of variance estimates. Stata (V.14.1) software was used for all analyses.[24] This study was exempt from formal ethics approval due to informed consent procedures in place at the time of data collection and integrity measures in place at the time of data analysis.

RESULTS

Descriptive statistics for Cycles 2 and 3 of the CHMS are presented in table 1. Missing data were less than 5% for all analyses and thus considered inconsequential.[25] One exception is income, which was reported by 71% (Cycle 2) and 77% (Cycle 3) of respondents. Statistics Canada imputed total household income so that values were available for all survey participants.[14 15]

Table 2a shows the results of logistic regression, with self-reported diagnosis of a thyroid condition (yes/no) regressed on urinary fluoride (µmol/L) for Cycles 2 and 3 and on fluoride concentration of tap water (mg/L) for Cycle 3, unadjusted and adjusted for covariates. None of the models show an association between the measures of fluoride exposure and self-reported diagnosis of a thyroid condition.

The results from multinomial logistic regression with TSH levels (low/normal/high) regressed on urinary fluoride (µmol/L) and on fluoride concentration of tap water (mg/L), unadjusted and adjusted for covariates are presented in table 2b. Neither urinary fluoride nor fluoride concentration of tap water was associated with an abnormal (low or high) TSH level compared with a normal TSH level.

Based on mean comparisons, urinary fluoride (µmol/L) did not differ between individuals classified as having primary hypothyroidism (mean=31.78 µmol/L, SE=10.28 µmol/L, 95% CI 11.63 to 51.93 µmol/L) versus not (mean=29.23 µmol/L, SE=1.66 µmol/L, 95% CI 25.97 to 32.49 µmol/L). Similarly, fluoride concentration or tap water (mg/L) did not differ between individuals classified as having primary hypothyroidism (mean=0.36 mg/L, SE=0.11 mg/L, 95% CI 0.16 to 0.57 mg/L) versus not (mean=0.22 mg/L, SE=0.04 mg/L, 95% CI 0.15 to 0.30 mg/L).

In table 3a and b, we consider the subsample for which we could discern sources of fluoride exposure from drinking water and/or dental products. Neither the means of urinary fluoride (µmol/L) nor the means of fluoride concentration of tap water (mg/L) appear to differ between those who self-reported being diagnosed with a thyroid condition versus those who did not based on widely overlapping 95% CIs, in this constrained subsample (table 3a). Similarly, individuals with low, normal and high TSH levels did not appear to differ in mean urinary fluoride (µmol/L) or fluoride concentration of tap water (mg/L), in this constrained subsample (table 3b). Those who were pregnant and/or taking a thyroid medication (n=37) were not excluded from this analysis due to Statistics Canada sample size requirements, but these individuals comprised less than 5% of the total sample (n=~820).

DISCUSSION

We did not detect any association between fluoride exposure (from urine and tap water) and (1) self-reported diagnosis of a thyroid condition or (2) abnormal (low or high) TSH levels, among a large, representative sample of the Canadian

Table 1 Descriptive statistics for Cycles 2 and 3 of the Canadian Health Measures Survey (weighted and bootstrapped). The sample sizes presented at the top of the table reflect the full available sample; however, in some cases, the sample sizes in the cells are lower due age exclusions (primary reason) and missing data (less than 5% in all cases). See notes below

	Cycle 2—full sample (n=6395)	Cycle 2— fluoride urine subsample (n=2530)	Cycle 2— constrained urine fluoride subsample* (n=649)	Cycle 3—full sample (n=5785)	Cycle 3—fluoride urine subsample (n=2671)	Cycle 3—constrained urine fluoride subsample† (n=852)
Predictors						
Urinary fluoride (μmol/L)	–	33.55 (95% CI 30.71 to 36.39)	40.46 (95% CI 34.45 to 46.46)	–	29.81 (95% CI 26.51 to 33.10)	35.15 (95% CI 28.10 to 42.20)
Fluoride concentration of tap water (mg/L)	–	–	–	–	0.22 (95% CI 0.15 to 0.30)	0.35 (95% CI 0.21 to 0.49)
Outcomes						
Self-reported thyroid condition diagnosis‡ (yes)	5.67% (95% CI 4.72 to 6.62)	3.43% (95% CI 1.77 to 5.08)	5.51% (95% CI 1.29 to 9.74)	6.85% (95% CI 4.87 to 8.83)	5.62% (95% CI 3.64 to 7.60)	6.02% (95% CI 3.09 to 8.95)
Thyroid-stimulating hormone level (low/normal/high)	–	–	–	3.33% (95% CI 1.93 to 4.73)	2.83% (95% CI 1.43 to 4.23)	4.14% (95% CI 1.83 to 6.44)
	–	–	–	93.15% (95% CI 91.20 to 95.09)	94.95% (95% CI 93.01 to 96.90)	93.34% (95% CI 88.72 to 97.96)
	–	–	–	3.52% (95% CI 2.64 to 4.41)	2.22% (95% CI 1.33 to 3.10)	2.52% (95% CI 0.00 to 5.47)
Hypothyroidism (yes)	–	–	–	0.49% (95% CI 0.00 to 1.60)	0.80% (95% CI 0.00 to 1.90)	Not releasable
Covariates						
Sex (females)	50.06%	44.91% (95% CI 40.82 to 49.00)	45.30% (95% CI 36.79 to 53.80)	50.06%	48.70%	48.63% (95% CI 42.07 to 55.19)
Age (years) (cont)	38.57 (95% CI 38.35 to 38.80)	32.55 (95% CI 31.32 to 33.77)	35.12 (95% CI 32.26 to 37.97)	39.05 (95% CI 38.40 to 39.70)	35.69 (95% CI 35.04 to 36.34)	35.33 (95% CI 33.73 to 36.93)
Household Income adequacy‡ (lower and middle income)	49.54% (95% CI 43.88 to 55.19)	47.60% (95% CI 42.76 to 52.44)	44.02% (95% CI 36.14 to 51.90)	51.79% (95% CI 42.76 to 60.82)	45.34% (95% CI 36.31 to 54.37)	42.75% (95% CI 27.72 to 57.78)
Highest attained education in the household (less than bachelor's degree)	63.97% (95% CI 57.32 to 70.62)	64.97% (95% CI 56.98 to 72.96)	64.26% (95% CI 52.25 to 76.27)	59.26% (95% CI 48.75 to 69.77)	54.83% (95% CI 44.31 to 65.34)	56.46% (95% CI 41.63 to 71.28)
Variables related to sources of fluoride exposure						
Respondent from a fluoridated collection site (yes)	54.92% (95% CI 40.00 to 69.87)	54.96% (95% CI 40.26 to 69.67)	–	54.54% (95% CI 28.43 to 80.66)	53.73% (95% CI 27.62 to 79.85)	–
Length of time in current home (≥3 years)	71.15% (95% CI 68.50 to 73.80)	70.69% (95% CI 67.55 to 73.83)	–	–	–	–
Primary source of drinking water (tap water)	65.56% (95% CI 62.41 to 68.72)	63.48% (95% CI 59.48 to 67.48)	–	–	–	–
Uses fluoride-containing dental products at home (yes)	–	–	–	84.21% (95% CI 80.55 to 87.87)	84.34% (95% CI 80.68 to 88.00)	–
Ever received fluoride-treatments at the dentist (yes)	–	–	–	80.95% (95% CI 78.03 to 83.86)	81.29% (95% CI 78.37 to 84.20)	–

*For Cycle 2, the constrained fluoride urine subsample refers to respondents who: 1) attended a fluoridated data collection site, 2) identified tap water was their primary source of drinking water at home or away from home and, 3) lived in their current home for three or more years.
†For Cycle 3, the constrained fluoride urine subsample refers to respondents who: 1) attended a fluoridated data collection site, 2) reported using fluoride-containing dental products at home and, 3) reported ever receiving fluoride treatments at the dentist.
‡Survey question regarding self-reported diagnosis of a thyroid condition was only asked to respondents age 12 and older
§Only 71% and 77% of respondents reported their total household income for Cycle 2 and Cycle 3 of the CHMS, respectively. Accordingly. Statistics Canada developed a regression model to impute total household income for all respondents for both Cycles.

Table 2a Results from logistic regression where self-reported diagnosis of a thyroid condition was regressed on urinary fluoride (Cycles 2 and 3) and fluoride concentration of tap water (Cycle 3)

	Cycle 2 of CHMS		Cycle 3 of CHMS			
Predictor variable	Unadjusted† estimates for fluoride urine subsample (OR, 95% CI)	Adjusted‡ estimates for fluoride urine subsample (OR, 95% CI) (n=1466)	Unadjusted† estimates for fluoride urine subsample (OR, 95% CI)	Adjusted‡ estimates for fluoride urine subsample (OR, 95% CI) (n=1570)	Unadjusted† estimates for fluoride tap water subsample (OR, 95% CI)	Adjusted‡ estimates for fluoride tap water subsample (OR, 95% CI) (n=1564)
Urinary fluoride (µmol/L) (cont)	0.98 (0.94 to 1.03)	0.98 (0.95 to 1.02)	1.00 (0.99 to 1.02)	1.00 (0.99 to 1.01)	–	–
Fluoride concentration of tap water (mg/L) (cont)	–	–	–	–	0.92 (0.22 to 3.94)	0.98 (0.28 to 3.45)
Sex (ref: male)	6.36* (1.52 to 26.68)	6.31* (1.29 to 30.89)	4.09* (1.27 to 19.52)	4.20* (0.90 to 19.53)	4.00* (1.02 to 15.72)	4.13* (0.94 to 18.21)
Age (years) (cont)	1.04** (1.02 to 1.07)	1.05** (1.02 to 1.08)	1.05** (1.03 to 1.08)	1.06** (1.03 to 1.09)	1.05** (1.03 to 1.08)	1.06** (1.03 to 1.09)
Household income adequacy (ref: lower and middle income)	0.95 (0.39 to 2.35)	1.09 (0.29 to 4.07)	0.78 (0.23 to 2.61)	1.23 (0.30 to 5.03)	0.77 (0.22 to 2.64)	1.20 (0.30 to 4.83)
Highest attained education in the household (ref: less than bachelor's degree)	1.67 (0.84 to 3.28)	2.03 (0.81 to 5.10)	0.40*** (0.15 to 1.10)	0.37*** (0.11 to 1.22)	0.41*** (0.15 to 1.11)	0.38 (0.12 to 1.26)

†Column contains bivariate associations between predictor variable and the outcome (self-reported diagnosis of a thyroid condition).
‡Column contains associations from single model containing all predictor variables (age, sex, household income adequacy and highest attained education in the household).
*p<0.05, **p<0.01, ***p<0.1.
Note: these models were rerun using creatinine-adjusted urinary fluoride (µmol/mmol) and no significant observations were detected (data not shown).
CHMS, Canadian Health Measures Survey; RRR, relative risk ratio; TSH, thyroid-stimulating hormone.

Table 2b Results from multinomial logistic regression with TSH levels (low/normal/high) regressed on fluoride exposure from urine and tap water (Cycle 3 only). Pregnant women and those taking a thyroid medication were excluded from analyses

		Cycle 3 of CHMS			
Predictor variable		Unadjusted† estimates for fluoride urine subsample (RRR, 95% CI)	Adjusted‡ estimates for fluoride urine subsample (RRR, 95% CI) (n=2008)	Unadjusted† estimates for fluoride tap water subsample (RRR, 95% CI)	Adjusted‡ estimates for fluoride tap water subsample (RRR, 95% CI) (n=2000)
Urinary fluoride µmol/L) (co;nt)	Low TSH	1.01 (0.99 to 1.04)	1.01 (0.99 to 1.04)	–	–
	Normal TSH (ref)	–	–		
	High TSH	0.99 (0.97 to 1.02)	0.99 (0.97 to 1.02)		
Fluoride concentration of tap water (mg/L) (cont)	Low TSH	–	–	1.77 (0.20 to 15.86)	1.38 (0.08 to 24.49)
	Normal TSH (ref)			–	–
	High TSH			1.38 (0.07 to 27.00)	1.20 (0.14 to 10.08)
Sex (ref: male)	Low TSH	1.04 (0.28 to 3.85)	1.03 (0.26 to 4.06)	1.03 (0.28 to 3.79)	0.98 (0.24 to 3.92)
	Normal TSH (ref)	–	–	–	–
	High TSH	0.97 (0.15 to 6.36)	0.89 (0.11 to 7.03)	0.96 (0.14 to 6.31)	0.91 (0.13 to 6.36)
Age (years) (cont)	Low TSH	1.01 (0.99 to 1.04)	1.01 (0.98 to 1.05)	1.01 (0.99 to 1.04)	1.02 (0.99 to 1.05)
	Normal TSH (ref)	–	–	–	–
	High TSH	0.99 (0.97 to 1.00)	0.99 (0.97 to 1.01)	0.99 (0.97 to 1.00)	0.99 (0.96 to 1.01)
Household income adequacy (ref: lower and middle income)	Low TSH	1.87 (0.71 to 4.89)	1.97 (0.65 to 5.97)	1.89 (0.72 to 4.97)	1.98 (0.64 to 6.11)
	Normal TSH (ref)	–	–	–	–
	High TSH	1.66 (0.30 to 9.02)	1.94 (0.26 to 14.50)	1.67 (0.30 to 9.16)	1.88 (0.26 to 13.46)
Highest attained education in the household (ref: less than bachelor's degree)	Low TSH	0.84 (0.31 to 2.28)	0.70 (0.22 to 2.16)	0.85 (0.31 to 2.31)	0.71 (0.23 to 2.19)
	Normal TSH (ref)	–	–	–	–
	High TSH	0.99 (0.10 to 10.22)	0.80 (0.07 to 9.61)	1.00 (0.10 to 10.39)	0.82 (0.07 to 9.21)

†Column contains bivariate associations between predictor variable and the outcome (TSH level (low/normal/high)).
‡Column contains associations from single model containing all predictor variables (age, sex, household income adequacy and highest attained education in the household).
*p<0.05, **p<0.01, ***p<0.1.
Note: these models were rerun using creatinine-adjusted urinary fluoride (µmol/mmol) and no significant observations were detected (data not shown).
CHMS, Canadian Health Measures Survey; RRR, relative risk ratio; TSH, thyroid-stimulating hormone.

Table 3a Mean comparisons of urinary fluoride (Cycles 2 and 3) and fluoride concentration of tap water (Cycle 3) between those with and without a self-reported diagnosis of a thyroid condition among the constrained fluoride urine subsample (weighted and bootstrapped)

	Cycle 2 of CHMS	Cycle 3 of CHMS	
	Mean urinary fluoride (µmol/L) for the constrained fluoride subsample* (n=~390)	Mean urinary fluoride (µmol/L) for the constrained fluoride subsample† (n=~590)	Mean fluoride concentration of tap water (mg/L) for the constrained fluoride subsample† (n=~590)
Has not been diagnosed with a thyroid condition	41.61 (34.50 to 48.72)	34.18 (26.30 to 42.06)	0.35 (0.20 to 0.49)
Has been diagnosed with a thyroid condition	38.60 (30.12 to 47.00)	39.58 (29.27 to 49.89)	0.33 (0.16 to 0.51)

*For Cycle 2, the constrained fluoride urine subsample refers to respondents who: 1) attended a fluoridated data collection site, 2) identified tap water was their primary source of drinking water at home or away from home and, 3) lived in their current home for three or more years.
†For Cycle 3, the constrained fluoride urine subsample refers to respondents who: 1) attended a fluoridated data collection site, 2) reported using fluoride-containing dental products at home and, 3) reported ever receiving fluoride treatments at the dentist.
CHMS, Canadian Health Measures Survey; TSH, thyroid-stimulating hormone.

Table 3b Mean comparisons of urinary fluoride and fluoride concentration of tap water (Cycle 3) between those with and with low, normal and high TSH levels among the constrained fluoride urine subsample (weighted and bootstrapped)

	Cycle 3 of CHMS	
	Mean urinary fluoride (µmol/L) for the constrained fluoride subsample* (n=~820)	Mean fluoride concentration of tap water (mg/L) for the constrained fluoride subsample* (n=~820)
Low TSH (<0.55 mIU/L)	40.01 (24.35 to 55.67)	0.34 (0.16 to 0.51)
Normal TSH (0.55 to 4.78 mIU/L)	33.92 (26.79 to 41.05)	0.35 (0.21 to 0.49)
High TSH (>4.78 mIU/L)	30.76 (17.89 to 43.63)	0.38 (0.19 to 0.57)

*For Cycle 3, the constrained fluoride urine subsample refers to respondents who: 1) attended a fluoridated data collection site, 2) reported using fluoride-containing dental products at home and, 3) reported ever receiving fluoride treatments at the dentist.
CHMS, Canadian Health Measures Survey; TSH, thyroid-stimulating hormone.

population. The absence of association applied to both the full fluoride urine subsample and the constrained fluoride urine subsample for which we could discern some source(s) of fluoride exposure from drinking water and/or use of dental products. Taken together, these findings suggest that, at the population level in Canada, fluoride exposure does not contribute to impaired thyroid functioning during a time where multiple sources of fluoride exposure, including CWF, exist.

Our findings appear to contradict the conclusions of the only other population-level study conducted on this topic to-date, by Peckham *et al* (2015).[13] These opposing findings could reflect: (1) differences in country-specific recommendations for optimal concentration of artificial fluoride added to drinking water (1 ppm in England vs 0.7 ppm in Canada),[11 13] (2) differences in the methods used (ie, individual-level measures used here vs ecological measures used by Peckham *et al* (2015))[13] and/or (3) differences in factors related to hypothyroidism within the underlying populations of both studies. One example is prescription medication use. Although beyond the scope of this discussion, it is important to acknowledge that several prescription medications can interfere with thyroid function tests or induce thyroid diseases,[26] and the use of these medications may differ between countries. Another potentially important factor is iodine intake. Data from the Iodine Global Network indicates that the population iodine status for Canada is 'adequate', whereas the population iodine status for the UK is 'mild deficiency'.[27] This could reflect that Canada adopted mandatory iodisation of all food-grade salt in 1949, whereas the UK has never had recommended or mandatory iodised salt programme.[28 29] A recent study estimated the weighted availability of iodised salt in UKs' supermarkets to be 21.5%, which the authors conclude is unlikely to confer adequate protection against iodine deficiency.[29]

Some limitations of our study include: (1) possible reporting bias related to self-reported diagnosis of a thyroid condition; because one's level of fluoride exposure is unlikely to influence their reporting of thyroid outcomes, the resulting non-differential misclassification could have diluted the reported associations, (2) information on some potentially important covariates such as family history of thyroid disease were not available in the CHMS and (3) spot urine samples used to measure urinary fluoride are susceptible to fluctuations.[30] Additionally, we are not able to discern causality due to the cross-sectional nature of the survey data. Major strengths of this study include: (1) the large, representative nature of the sample, (2) extensive data validation and quality control measures and (3) individual-level estimates of both fluoride exposure and biomarkers of thyroid health.

In conclusion, findings suggest that current levels of fluoride exposure do not increase susceptibility to impaired thyroid functioning at the population-level in Canada. These findings may be broadly relevant to other countries with similar populations and CWF schemes and provide an important complement to existing clinical and/or basic science studies on fluoride exposure and thyroid outcomes. Decision-makers can consider the results of the present research in addition to the larger body of scientific literature on risks, benefits, economic evaluations, etc., when determining if fluoride concentrations in their municipality's water supply need to be altered. These results can also contribute to informed public debate surrounding CWF.

Future research should utilise this rich, high-quality data source to explore relationships between fluoride exposure and other potential harms. We also recommend that future cycles of the CHMS collect data on fluoride biomarkers that capture *recent* fluoride exposure (eg, hair samples or fingernail clippings), rather than, or in addition to, those that measure *contemporary* fluoride exposure (urine), so that exposure may be more accurately defined.[19]

What is already known on this subject

- Concerns exist that community water fluoridation could compromise thyroid functioning. A recent population-level study from England appears to add credibility to this concern as a positive association between the fluoride concentration in drinking water and hypothyroidism prevalence was found. It is important to investigate whether this observed association is consistent among different populations and settings.

What this study adds

- Using newly released, nationally representative Canadian survey data, we did not detect an association between individual-level fluoride exposure (from urine and tap water) and impaired thyroid functioning, as measured by self-reported diagnosis of a thyroid condition or abnormal thyroid-stimulating hormone level. Future research should utilise this rich data source to explore relationships between fluoride exposure and other potential harms.

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Contributors All the authors provided substantial input to the study design, the acquisition, analysis and interpretation of the data, writing the manuscript and revising it critically and provided final approval of the version of the manuscript to be published. All the authors agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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REFERENCES

1 Hall JE. *Guyton and hall textbook of medical physiology*: Elsevier Health Sciences, 2015.
2 Manji N, Carr-Smith JD, Boelaert K, *et al*. Influences of age, gender, smoking, and family history on autoimmune thyroid disease phenotype. *J Clin Endocrinol Metab* 2006;91:4873–80.
3 Elfström P, Montgomery SM, Kämpe O, *et al*. Risk of thyroid disease in individuals with celiac disease. *J Clin Endocrinol Metab* 2008;93:3915–21.
4 National Research Council. *Fluoride in drinking water: a scientific review of EPA's standards*. Washington DC, USA: The National Academies Press, 2006.
5 Michael M, Barot VV, Chinoy NJ. Investigations of soft tissue functions in fluorotic individuals of North Gujarat. *Fluoride* 1996;29:63–71.
6 Susheela AK, Bhatnagar M, Vig K. Excess fluoride ingestion and thyroid hormone derangements in children living in Delhi. *India Fluoride* 2005;38:98–108.
7 Singh N, Verma KG, Verma P, *et al*. A comparative study of fluoride ingestion levels, serum thyroid hormone & TSH level derangements, dental fluorosis status among school children from endemic and non-endemic fluorosis areas. *Springerplus* 2014;3:7–5.
8 Lin FF, Aihaiti HX, Zhao J, *et al*. The relationship of a low iodine and high-fluoride environment to subclinical cretinism in Xinjiang. *IDD Newsletter* 1991;7:24–5.
9 Hosur MB, Puranik RS, Vanaki S, *et al*. Study of thyroid hormones free triiodothyronine (FT3), free thyroxine (FT4) and thyroid stimulating hormone (TSH) in subjects with dental fluorosis. *Eur J Dent* 2012;6:184–90.
10 Sutton M, Kiersey R, Farragher L, *et al*. *Health effects of water fluoridation*. Dublin, Ireland: Health Research Board, 2015.
11 Health Canada. *Findings and recommendations of the fluoride expert panel*, 2008.
12 Podgorny PC, McLaren L. Public perceptions and scientific evidence for perceived harms/risks of community water fluoridation: an examination of online comments pertaining to fluoridation cessation in Calgary in 2011. *Can J Public Health* 2015;106:e413–e25.
13 Peckham S, Lowery D, Spencer S. Are fluoride levels in drinking water associated with hypothyroidism prevalence in England? A large observational study of GP practice data and fluoride levels in drinking water. *J Epidemiol Community Health* 2015;69:619–24.
14 Statistics Canada. *Canadian Health Measures Survey (CHMS). Data user guide: Cycle 2*, 2013.
15 Statistics Canada. *Canadian Health Measures Survey (CHMS). Data user guide: Cycle 3*, 2015.
16 Institut National de Santé Publique du Québec (INSPQ): Centre de toxicology. Analytic Method for the Determination of Fluoride in Urine (M-186)-Condensed Version for CHMS. 2009.
17 Health Canada. Second Report on Human Biomonitoring of Environmental Chemicals in Canada: Results of the Canadian Health Measures Survey Cycle 2 (2009-2011). Ottawa, ON: Health Canada. 2013.
18 Marthaler TM, Schulte AG. Monitoring salt fluoridation programs through urinary excretion studies. *Schweiz Monatsschr Zahnmed* 2005;115:679–84.
19 Mehta A. Biomarkers of fluoride exposure in human body. *Indian J Dent* 2013;4:207–10.
20 Health Canada. *Analytic procedure manual: Third Generation Ultra THYROID STIMULATING HORMONE (TSH3-UL) on ADVIA Centaur XP*: Division. CRLNR, 2012.
21 Health Canada. *Analytic procedure manual: free thyroxine (FT4) on ADVIA Centaur XP*: CHMS Reference Laboratory: Nutrition Research Division, 2012.
22 American Thyroid Association website. Thyroid disease and pregnancy, 2016. http://www.thyroid.org/thyroid-disease-pregnancy/ (accessed Jul 2016).
23 McLaren L. Fluoridation exposure status based on location of data collection in the Canadian health measures survey: is it valid? *J Can Dent Assoc* 2016;82:1–7.
24 StataCorp. Stata Statistical Software: release 14.1. College Station TX, USA: StataCorpLP. 2015.
25 Schafer JL. Multiple imputation: a primer. *Stat Methods Med Res* 1999;8:3–15.
26 Dong BJ. How medications affect thyroid function. *West J Med* 2000;172:102–6.
27 Iodine Global Network. http://www.ign.org/ (accessed Jun 2017).
28 Canadian Public Health Association. Food fortification with vitamins and minerals. http://www.cpha.ca/en/programs/history/achievements/09-shf/fortification.aspx (accessed Jun 2017).
29 Bath SC, Button S, Rayman MP. Availability of iodised table salt in the UK: is it likely to influence population iodine intake? *Public Health Nutr* 2014;17:450–4.
30 Federal-Provincial-Territorial Committee on Drinking Water. *Guidelines for Canadian drinking water quality: guideline technical document – fluoride*. Ottawa, ON Health Canada, 2010.

Fluoridation of Public Drinking Water

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I. Introduction

Communities throughout the United States have utilized the fluoridation of drinking water supplies for over 60 years as a strategy to reduce tooth decay (dental caries) [1-4]. The observed decline in national averages for the prevalence and severity of dental caries since the initiation of the program in 1945 has been deemed one of the greatest modern public health successes of the 20th century[1, 5, 6]. Despite these gains, a debate exists concerning the potential health risks of water fluoridation versus the observed benefit of the intervention[1]. As a result, Public Health Madison & Dane County occasionally receives phone calls, emails, and letters from residents expressing concern about the fluoridation of local water supplies. Therefore, this document was produced to provide a brief overview of the current status of public concerns and a review of the scientific literature.

II. Overview

Naturally occurring fluoride is found in all water supplies across the United States; the concentration is dependent upon the geology of the water body and the occurrence of fluoride-bearing minerals and materials[1, 7]. The discovery of the potential health applications of fluoride in the early 1930s led to the development of the first clinical trial of artificial fluoridation of community water supplies in Grand Rapids, MI in 1945. The trial was designed to last for 15 years prior to any potential recommendation for the expansion of water fluoridation to other communities; however, the popularity of the program led to its initiation in other cites the following year[1]. The City of Madison, Wisconsin began the fluoridation of drinking water supplies in 1948.

Effectiveness of Water Fluoridation to Prevent Dental Caries

Opponents of water fluoridation of community water supplies cite two major issues to question the effectiveness of the program; a comparable reduction in dental caries in non-fluoridated communities and the improved availability of fluoride-containing products make the treatment of community drinking water unnecessary.

Research has demonstrated that differences in the rate of dental caries in fluoridated and non-fluoridated communities have gradually decreased since the inception of water fluoridation programs. Related research has reported that communities that end fluoridation both have and have not observed increases in dental caries[1, 7-8]. A survey involving over 39,000 children conducted in the United States from 1986-1987 evaluating this issue indicated that the benefit to fluoridated compared to non-fluoridated communities amounted to an estimated 0.6 fewer decayed tooth surfaces per child[8]. However, this argument ignores the diffusion effect of fluoride containing products including food, beverages, dietary supplements, and dental products that were manufactured in fluoridated communities and sold in non-fluoridated areas[1, 7]. Therefore, the non-fluoridated communities also experience an indirect benefit derived from water fluoridation programs resulting in the comparable reduction of dental caries observed in these areas. This argument also ignores the benefit repeatedly reported when the study populations are classified by income level; larger benefits are observed at lower income levels[3, 9].

Oral hygiene has gradually improved in the United States over the past several decades, including the increased use of fluoride-containing dental products such as rinses, toothpaste, and topical gels[8, 9]. However, disparities in use of and access to products and services promoting oral health remain, especially among low socioeconomic status and ethnic populations. The use of water fluoridation has provided an effective and cost efficient method to deliver preventative services to promote oral health to all residents within a community served by municipal water supplies, regardless of socioeconomic status or access to care[6]. Currently, over 200 million Americans are served by drinking water supplies that contain the accepted levels of fluoride to reduce dental caries; the Healthy People 2020 initiative calls for an expansion of this coverage to 79.6% of the population receiving drinking water from public water systems[5, 10, 11].

Potential Health Concerns

The beneficial health effects of exposure to low concentrations of fluoride result from its ability to reduce tooth enamel solubility, decrease acid production of plaque-producing organisms, and promote the remineralization of the enamel[1]. Efforts to prevent or remove community water fluoridation are most commonly motivated by concerns of fluorosis of teeth and bone, increased risk of hip fracture among the elderly, and cancer.

1. Acute fluoride toxicity
   This condition has been reported when fluoridated drinking water supplies reach a level of 30ppm[7]. Due to the utilization of well-designed fail-safe equipment, proper maintenance and calibration, and appropriate operating procedures these overdosing incidents are rare in the United States. Symptoms normally occur within hours of exposure and include skin irritation, nausea, vomiting, diarrhea, and muscle weakness. Depending upon severity, observable symptoms resolve quickly following cessation of exposure; approximately. In severe cases, fluoride poisoning may result in cardiac arrest.[12-14].

2. Dental and skeletal fluorosis
   These conditions are well-documented results of prolonged exposure to excess fluoride[1, 7-8]. The development of dental fluorosis and skeletal fluorosis are attributed to the toxicokinetic properties of fluoride following exposure. Following ingestion, 75-90% of the compound is absorbed and readily distributed throughout the body[7]. Approximately 35-48% of the absorbed fluoride is retained by the body; an estimated 99% of the compound body burden is stored in the calcium rich areas of the bones and teeth (dentine and enamel)[7, 15]. This pattern of distribution and storage may lead to adverse impacts on the teeth and skeletal systems of individuals chronically exposed to excess natural and/or introduced levels of fluoride in public drinking water supplies[1, 7, 8, 15].

Dental fluorosis is characterized by the staining and disruption of normal enamel formation of the teeth; the markings can range from unnoticeable in very mild cases (most common) to brown stains and pitting of the enamel in severe cases (rare) [1, 7, 15, 16]. Although severe cases can lead to brittle teeth and more teeth wear, all forms of dental fluorosis are considered by the United States Centers for Disease Control and Prevention (CDC) and the Department of Health and Human Services (DHHS) to be a cosmetic concern rather than an adverse health effect[16]. Reported cases of dental fluorosis have increased in the United States since the widespread initiation of water fluoridation. Prior to the adoption of the program, the prevalence of dental fluorosis was 12-15%; modern rates of this condition have shown reported increases[17-18]. A study conducted by the CDC reported that an estimated 23% of persons aged 6 to 39 years had a very mild or greater dental fluorosis while approximately 32% of children and adolescents aged 6 to 19 years were reported with the condition. The risk of dental fluorosis development is limited to children 8 years of age or younger; tooth development occurs during this age range and the enamel has not matured and is susceptible to the effects of fluoride when chronically exposed to levels of fluoride larger than 2 ppm; the current optimal level of fluoride recommended for drinking water sources is 0.7 ppm. Children older than 8 years, adolescents, and adults are not susceptible to dental fluorosis[3].

Skeletal fluorosis is a disease that is characterized by increased density and brittleness of the skeletal system; the disease occurs in a range of severity dependent upon the level and duration of fluoride exposure. The mildest form of the disease can lead to arthritis-like symptoms including painful joints, limitations in movement, and reduced flexibility. Continual exposure to fluoride concentrations of 5ppm or greater may lead to osteosclerosis[1, 7]. In the most severe cases, skeletal fluorosis can be a crippling disease, confining a patient to a wheelchair. The condition is extremely rare in the United States with only 5 confirmed cases reported in the last 35 years; each of these cases occurred in areas where natural fluoride levels were greater than 20ppm[1].

3. Hip fracture
   Both excessive and inadequate intake of fluoride has been associated with an increased risk of hip fracture among the elderly[1, 7-8]. However, two recent studies reported no difference in the rates of hip fracture between fluoridated and non-fluoridated communities at recommended levels of fluoride additive to water supplies[20-21].

4. Cancer
   According to the World Health Organization (WHO), a large number of studies exploring the issue demonstrate no consistent evidence of any association between the consumption of controlled fluoridated drinking water with an increased risk of cancer[7].

   The majority of the concern about a potential cancer risk associated with the exposure to fluoridated drinking water is the development of osteosarcoma; a rare type of bone cancer typically diagnosed in children and teens in the United States. Similar to other types of cancers, the body of evidence does not display a consistent association between the consumption of drinking water fluoridated at recommended levels and the risk of osteosarcoma. For example, research performed by the Harvard School of Public Health in

2006 reported that water fluoridation was associated with a higher risk of osteosarcoma in males but not females. However, early results from the second half of this investigation did not match the initial findings and the researchers advised caution in interpreting the results. The second part of the Harvard study was published in 2011 and found no association between water fluoridation and osteosarcoma risk[22, 23].

Two additional recent studies compared rates of osteosarcoma in areas of higher versus lower levels of water fluoridation in the United States and Ireland; neither study reported an increased risk in areas of water fluoridation[22].

III. Fluoridation Compound Sources and Potential Contaminates

There are three basic compounds that are utilized for water fluoridation; sodium fluoride, sodium fluorosilicate, and fluorosilicic acid. Each of these compounds is derived from phosphorite rock, a source that is primarily used in the production of phosphate fertilizer[21]. Phosphorite contains a mixture of calcium phosphate, calcium carbonate (limestone), and apatite; the mineral apatite contains approximately 3 to 7% fluoride overall and is considered the primary source of the fluoride used in water treatment[1, 11]. The association of water fluoridation additives and the production of phosphate fertilizer have led to safety concerns by opponents of the intervention[1]. The majority of these concerns center on potential impurities entering the drinking water supply as a result of the water fluoridation; specifically lead, arsenic, and radionucleotides[8, 11].

Regulatory processes are in place to protect community water supplies that either restricts and/or prevents the introduction of impurities from the fluoridation of drinking water. The U.S. Environmental Protection Agency (EPA) is responsible for the regulation of drinking water and to assure its safety in accordance with the Safe Drinking Water Act (SDWA). The SDWA requires that all additives used in water treatment plants, including fluoride additives, must meet strict regulatory standards in regards to their production, maintenance, and application. Each additive is subject to a system of standards, testing, and certification by the American Water Works Association (AWWA) and the National Sanitation Foundation/ American Standards Institute (NSF/ ANSI). Testing by the NSF for water quality has demonstrated that the vast majority of fluoride additive samples do not have detectable levels of arsenic derived from the addition of these compounds; water samples that do test positive are much lower than the EPA allowable levels. Other impurities, including lead and radionucleotides, are typically reported at levels lower than the detected arsenic levels[11]. Aside from the testing of impurities, the recommended optimum fluoride concentration is 0.7 ppm; these levels are monitored to ensure appropriate concentrations are maintained in communities that fluoridate drinking water supplies[5, 11].

The water fluoridation program for the City of Madison currently utilizes hydrofluorosilicic acid as its primary source for the fluoridation of community drinking water supplies. The compound is obtained from Hawkins Chemical, Inc. via an annual renewable contract. In addition to the federal requirements to ensure water quality, the City of Madison Water Utility has also designed and initiated additional safe guards to maintain safe water supplies. Standard operating procedures (SOPs) were designed in cooperation with Public Health Madison and

Dane County to govern the operation of water fluoridation, routine maintenance of all equipment associated with the fluoridation process, and the daily monitoring of the water fluoride levels to ensure optimal recommended levels of fluoridation. Impurities, including potential impurities introduced by water fluoridation are also monitored in order to ensure that water quality standards are in accordance with regulatory policies; samples are derived from water entering the distribution center which occurs after fluoridation to ensure the accurate reporting of water quality[24].

IV. Summary and Recommendations

The occurrence of dental caries has been substantially reduced in the United States in recent decades, predominately through the widespread use of fluoride. Unfortunately, disparities among low socioeconomic status and ethnic populations are still quite prevalent[2, 5, 7]. This trend has also been reported in Wisconsin. In an oral health screening survey of third grade children conducted for the state during 2001 – 2002, the results demonstrated that these underserved populations reported a disproportionate number of dental caries; racial/ ethnic minority populations were particularly impacted. In this study, the oral health status comparisons demonstrated that approximately 57% of white children sampled during this survey had a history of dental caries while 65% of African American children, 84% of Asian children, and 80% of American Indian children displayed similar findings[25].

To reach children and other at-risk populations for dental caries, water fluoridation is still the most efficient method of delivering safe and effective levels of fluoride. Therefore, Public Health Madison and Dane County supports and recommends water fluoridation using the optimum fluoride concentration of 0.7 ppm as recommended by the United States Department of Health and Human Services[5, 10, 26]. However, it should be recognized that drinking water fluoridation is a complex process that must be well monitored and controlled.

Careful review of the scientific literature and consultation with local and national experts has identified no evidence for adverse health effects associated with water fluoridation at recommended levels. While not a health concern, dental fluorosis is, for some, a cosmetic concern. Increased rates of dental fluorosis are due to increased exposure to fluoride containing products found in general US society and are noted in both fluoridated and non-fluoridated communities. This fact and the continued high prevalence of dental caries and associated pain, expense and potentially serious medical consequences make the continuation and expansion of well controlled drinking water fluoridation in the United States a public health imperative.

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V. References

1. Ananian, A, Solomowitz, BH, and Dowrich, IA. (2006). Fluoride: a controversy revisited. *New York State Dental Journal*, 72(3), 14-18.

2. Centers for Disease Control and Prevention. (2008). CDC statement on the 2006 National Research Council (NRC) report on fluoride in drinking water. Retrieved on June 4, 2014 from: http://www.cdc.gov/Fluoridation/safety/nrc_report.htm

3. Centers for Disease Control and Prevention (2014). Safety. Retrieved on June 4, 2014from: http://www.cdc.gov/fluoridation/safety/index.htm

4. Yeung, CA. (2007). Fluoride prevents caries among adults of all ages. *Evidence Based Dentistry*, 8(3), 72-73.

5. Centers for Disease Control and Prevention. (2013). 2012 water fluoridation statistics. Retrieved on June 04, 2014 from: http://www.cdc.gov/fluoridation/statistics/2012stats.htm

6. Centers for Disease Control and Prevention. (1999). Ten great public health achievements – United States, 1900-1999. *Morbidity and Mortality Weekly Report*, 48(12), 241-243.

7. Fawell, J, Bailey, K, Chilton, J, Dahi, E, Fewtrell, L, and Magara, Y. (2006). Fluoride in drinking water. The World Health Organization. IWA Publishing: London, UK.

8. Connett, P, Connett, E, and Connett, M. (2001). Fluoridation: time for a second look? Retrieved on June 4, 2014 from: http://fluoridealert.org/news/fluoridation-time-for-a-second-look/

9. American Dental Association. (2005). Study shows oral health improvements but disparities remain. Retrieved on December 17, 2008 from: http://dev.ada.org/4333.aspx

10. Centers for Disease Control and Prevention (2013). Fluoridation basics. Retrieved on June 04, 2014 from: http://www.cdc.gov/fluoridation/basics/index.htm

11. Centers for Disease Control and Prevention (CDC). (2013). Community water fluoridation. Retrieved on June 02, 2014 from: http://www.cdc.gov/fluoridation/statistics/index.htm

12. Hoffman, R, Mann, J, Calderone, J, Trumbull, J, and Burkhart, M. (1980). Acute fluoride poisoning in a New Mexico elementary school. *Pediatrics*, 65(5), 897-900.

13. Vogt, RL and Witherell, L. (1982). Acute fluoride poisoning associated with an on-site fluoridator in a Vermont elementary school. *American Journal of Public Health*, 72, 1168-1171.

14. Gessner, BD, Beller, M, Middaugh, JP, and Whitford, GM. (1994). Acute fluoride poisoning from a public water system. *New England Journal of Medicine*, 330(2), 95-99.

15. Garg, VK and Singh, B. (2007). Fluoride in drinking water and fluorosis. Retrieved on June 4, 2014 from: http://www.eco-web.com/edi/070207.html

16. United States Department of Health and Human Services. (1991). Review of fluoride: Benefits and risks, report of the ad hoc subcommittee on fluoride of the committee to coordinate health and related programs. Retrieved on June 4, 2014 from: http://www.health.gov/environment/ReviewofFluoride/

17. Clark, DC. (1994). Trends in prevalence of dental fluorosis in North America. *Community Dentistry and Oral Epidemiology*, 22(3), 148-152.

18. Heller, KE, Eklund, SA, and Burt, BA. (1997). Dental caries and dental fluorosis at varying water concentrations. *Journal of Public Health Dentistry*, 58(3), 136-143.

19. Centers for Disease Control and Prevention. (2005).Surveillance for dental caries, dental sealants, tooth retention, edentulism, and enamel fluorosis- United States, 1988 – 1994 and 1999-2002. *Morbidity and Mortality Weekly Report*, 54(03), 1-44.

20. Park, EY, Hwang, SS, Kim, JY, and Cho, SH. (2008). Effects of long-term fluoride in drinking water on risks of hip fracture of the elderly: an ecologic study based on database of hospitalization episodes. *Journal of Preventative Medicine and Public Health*, 41(3), 147-152.

21. Phipps, K. (1995). Fluoride and bone health. *Journal of Public Health Dentistry*, 55(1), 53-56.

22. American Cancer Society. (2014). Water fluoridation and cancer risk. Retrieved on June 4, 2014 from: http://www.cancer.org/cancer/cancercauses/othercarcinogens/athome/water-fluoridation-and-cancer-risk

23. National Cancer Institute. (2012). Fluoridated water. Retrieved on June 4, 2014 from: http://www.cancer.gov/cancertopics/factsheet/Risk/fluoridated-water

24. Personal conversation with Joseph Grande, Water Quality Manager, City of Madison Water Utility.

25. Wisconsin Department of Health and Family Services. (2002). Make your smile count survey. Retrieved on June 4, 2014 from: http://www.dhs.wisconsin.gov/publications/P4/P40001.pdf

26. City of Madison Water Utility. (2014). Chlorine and fluoride. Retrieved on June 4, 2014 from: http://www.cityofmadison.com/water/waterquality/chlorine.cfm

Community Water Fluoridation

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What is Community Water Fluoridation?

Community water fluoridation is the process of adjusting the amount of fluoride in drinking water to a level recommended for preventing tooth decay. [1] More than 75 years of research and experience shows that community water fluoridation is a safe and healthy practice. [2]

Community water fluoridation is recommended by nearly all public health, medical, and dental organizations. It is recommended by the American Dental Association, American Academy of Pediatrics, US Public Health Service, and World Health Organization.

Sources:

1. Centers for Disease Control and Prevention. Community Water Fluoridation website: https://www.cdc.gov/fluoridation/basics/index.htm Accessed 3/25/2020
2. US Department of Health and Human Services. Oral Health in America: A Report of the Surgeon General. Rockville, MD: US Department of Health and Human Services, National Institute of Dental and Craniofacial Research, National Institutes of Health, 2000. https://www.nidcr.nih.gov/research/data-statistics/surgeon-generalexternal icon. Accessed February 20, 2020

Quick History of Community Water Fluoridation

- In the 1930s, scientists examined the relationship between tooth decay in children and naturally occurring fluoride in drinking water. The study found that children who drank water with naturally high levels of fluoride had less tooth decay
- In 1945, Grand Rapids Michigan was the first to add fluoride into its city water system
- As of 2016, nearly 73% of the United States served by community water systems had access to fluoridated water
- Because it is so beneficial, the United States has a national goal for 77% of Americans to have water with enough fluoride to prevent tooth decay by 2030

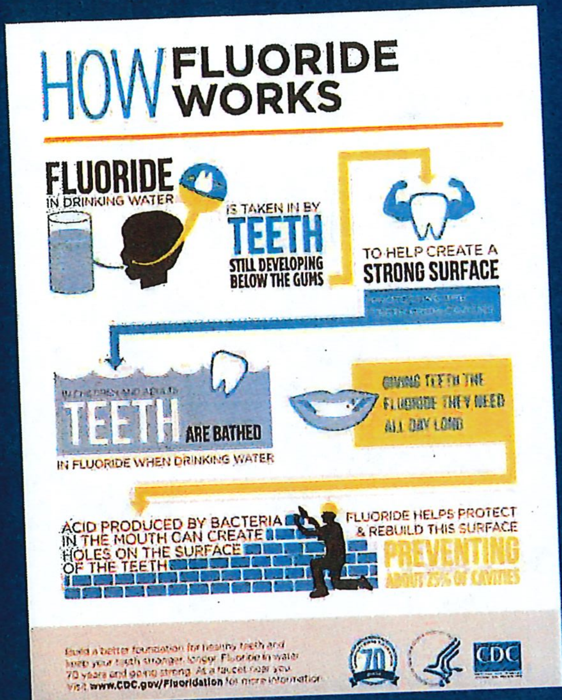
The CDC named community water fluoridation as 1 of 10 great public health achievements of the 20th century.

Three Types of Fluoridation

Community water systems in the United States use one of three additives for water fluoridation. Decisions on which additive to use are based on cost of product, product-handling requirements, space availability, and equipment.

1. Fluorosilicic Acid
   a. A water-based solution used by most water systems in the United States.
2. Sodium Fluorosilicate
   a. A dry salt additive, dissolved into a solution before being added to water
3. Sodium Fluoride
   a. A dry salt additive, typically used in small water systems, dissolved into a solution before being added to water

What type of fluoridation does Waterloo use?



Why Does it work?

The **mineral** fluoride occurs naturally. All water contains some fluoride. Fluoride has been proven to **protect teeth from decay**.

Bacteria in the mouth produce acid when a person eats sugary foods. This acid eats away minerals from the tooth's surface, making the tooth weaker and increasing the chance of developing cavities. Fluoride helps to rebuild and strengthen the tooth's surface, or enamel.

More importantly, when Fluoride is ingested during tooth development, it is incorporated into the growing teeth to make them more resistant to cavities.

Source:

https://www.cdc.gov/fluoridation/basics/index.htm

Cost/Benefit

- A recent 2016 economic analysis found that for communities of 1,000 or more people, the savings associated with water fluoridation exceeded estimated program costs, with an average annual savings of $20 per dollar invested. [1]
- Consistent with prior analyses, this study supports the finding that community water fluoridation remains one of the most cost-effective methods of delivering fluoride to all community members regardless of age, educational attainment, or income level.

Source:

1. Source: O'Connell JM, Rockwell J, Ouellet J, Tomar SL, Maas W. Costs and Savings Associated with Community Water Fluoridation in the United States. Health Affairs. 2016 ;135(12):2224-2232.

Community Water Fluoridation Studies

"Few public health topics have been researched as thoroughly as community water fluoridation. In fact, the database maintained by the U.S. National Library of Medicine contains more than 56,000 studies or research papers on fluoride. And the Library's records include more than 6,400 studies that focus specifically on water fluoridation"

-American Fluoridation Society

- Quick search on the Pub Med website revealed 70,396 articles on the subject of fluoride.

Response 1: Water Logic Article, "No Significant Benefits"

"[Recent data] ... <u>indicates no significant benefit from water fluoridation, but a significant association with dental fluorosis, a situation that will not be avoided by fluoridating all cities at 0.7.mg/L ...</u> At the very least, even if dental fluorosis is considered only a cosmetic problem, it takes money to treat to improve a person's appearance and perhaps his or her self-esteem... A growing number of studies indicate associations between dental fluorosis and increased risk of various health problems. Considerable evidence indicates that water fluoridation is an unsafe and unethical practice, with little or no real benefit."

- Dr. Kathy Thiessen, Director and Senior Scientist at the Oak Ridge Center for Risk Analysis in Tennessee

<u>Counter Point:</u>

- Study 1: 2022 out of Alaska
  (Meyer J, Margaritis V, Jacob M. The Impact of Water Fluoridation on Medicaid-Eligible Children and Adolescents in Alaska. J Prev (2022). 2022 Feb;43(1):111-123. doi: 10.1007/s10935-021-00656-x. Epub 2022 Jan 20. PMID: 35048263.)
- Study 2: 2020 - Economic Evaluations in water-fluoridation
  "All studies concluded that water fluoridation was a cost-effective strategy when it was compared with non-fluoridated communities, independently of the perspective, time horizon or discount rate applied. Most of the studies reported a caries (cavity)reduction effects between 25 and 40%"

Response 2: Concerns About Toxicology

Article: "What Are the Pros and Cons of Fluoride in Drinking Water?"
-South Florida Caribbean News December 2, 2020

Concerns:

1. Fluoride can cause cognitive impairments
2. Fluoride can negatively impact IQ
3. Fluoride negatively affects the thyroid

Counter Point:

1. 2018 Study from the National Toxicology program - "found no link between elevated levels of fluoride and cognitive harms"
2. 2015 study from the Journal of Public Health that found no link between fluoridation and IQ scores
3. Fluoride exposure and indicators of thyroid functioning in the Canadian population: implications for community water fluoridation

Barberio AM, Hosein FS, Quiñonez C, McLaren

At 0.7mg/L (the recommended dose for CWF)...

It would take...

- 85 glasses of water per day for an adult to develop chronic Fluorosis for average adult
- 1600 glasses of water to die due to Fluoride poisoning (A human would die from hyper hydration if they consume ~100 glasses of water in a day)

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What type of fluoridation does Waterloo use?

Summary

1. We believe that the benefits of public water fluoridation outweigh the potential risks.
2. Cost/benefit analysis for the Waterloo Community greatly favors public water fluoridation.
3. Health risks associated with fluoride are negligible which is supported by 70+ years of research and public usage across the United States.
4. There are new methods coming out that will further bring down cost of public water fluoridation.
    a. New article from the American Dental Association (June 13, 2022)- "New fluoridation tablet system to be deployed across US"
    b. System uses sodium fluorosilicate tablets and dispenser system. (See handout)

Waterloo

Find Your Path Here

Where do we go from here?

1.27 2017

Resources for Powerpoint on Community Water Fluoridation

1. Centers for Disease Control and Prevention. Community Water Fluoridation website: https://www.cdc.gov/fluoridation/basics/index.htm. Accessed 3/25/2020.
2. US Department of Health and Human Services. Oral Health in America: A Report of the Surgeon General. Rockville, MD: US Department of Health and Human Services, National Institute of Dental and Craniofacial Research, National Institutes of Health; 2000. https://www.nidcr.nih.gov/research/data-statistics/surgeon-generalexternal icon. Accessed February 20, 2020.
3. https://www.cdc.gov/fluoridation/basics/index.htm
4. Source: O'Connell JM, Rockwell J, Ouellet J, Tomar SL, Maas W. Costs and Savings Associated with Community Water Fluoridation in the United States. Health Affairs. 2016. 1;35(12):2224-2232.
5. Meyer J, Margaritis V, Jacob M. The Impact of Water Fluoridation on Medicaid-Eligible Children and Adolescents in Alaska. J Prev (2022). 2022 Feb;43(1):111-123. doi: 10.1007/s10935-021-00656-x. Epub 2022 Jan 20. PMID: 35048263.
6. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7164347/
7. https://www.ncdental.org/about-us/ncds-newsroom/2018/06/19/ntp-study-strengthens-evidence-showing-fluoridated-water-is-a-safe-way-to-prevent-tooth-decay-but-critics-ignore-the-study-they-once-welcomed
8. https://pubmed.ncbi.nlm.nih.gov/28839078/
9. https://www.ada.org/publications/ada-news/2022/may/new-fluoridation-tablet-system-about-to-be-deployed-across-us#:~:text=New%20fluoridation%20tablet%20system%20to%20be%20deployed%20across%20US&text=Advance%3A%20The%20feeder%20system%20works,is%20distributed%20into%20swimming%20pools.

KWIK TRIP INC.

Legal

PHONE 608-781-8988
FAX 608-793-6120

1626 Oak St., P.O. Box 2107
La Crosse, WI 54602

www.kwiktrip.com

RECEIVED
AUG 3 2 2022
CITY OF WATERLOO

August 18, 2022

Deputy Clerk
City of Waterloo
136 N. Monroe St.
Waterloo, WI 53594-1198

RE: Appointment of Agent
Kwik Trip 366
115 Portland Rd.

Dear Deputy Clerk:

A new manager, Matthew McIlquham, has been assigned to take over leadership responsibilities of Kwik Tr 366. Therefore, we would like to appoint Matt as the agent of the store.

Enclosed please find the completed Appointment of Agent and Auxiliary Questionnaire forms along with $10 for the administrative fee for this service. I respectfully request that you include this item on the agenda of your City Council meeting for consideration.

Please contact me at (608) 793-6262 or DHafner@kwiktrip.com if you require anything further. Thank you in advance for your assistance with this matter

Yours truly,

Deanna

Deanna Hafner
Licensing Agent

Enclosures

Schedule for Appointment of Agent by Corporation / Nonprofit Organization or Limited Liability Company

Submit to municipal clerk.

All corporations/organizations or limited liability companies applying for a license to sell fermented malt beverages and/or intoxicating liquor must appoint an agent. The following questions must be answered by the agent. The appointment must be signed by an officer of the corporation/organization or one member/manager of a limited liability company and the recommendation made by the proper local official.

To the governing body of: ☐ Town ☐ Village ☑ City of Waterloo County of Jefferson

The undersigned duly authorized officer/member/manager of KWIK TRIP, INC.
(Registered Name of Corporation / Organization or Limited Liability Company)

a corporation/organization or limited liability company making application for an alcohol beverage license for a premises known as

Kwik Trip 366
(Trade Name)

located at 115 Portland Rd., Waterloo, WI 53594

appoints Matthew A. McIlquham
(Name of Appointed Agent)

311 N. Monroe St., Watertown, WI 53098
(Home Address of Appointed Agent)

to act for the corporation/organization/limited liability company with full authority and control of the premises and of all business relative to alcohol beverages conducted therein. Is applicant agent presently acting in that capacity or requesting approval for any corporation/ organization/limited liability company having or applying for a beer and/or liquor license for any other location in Wisconsin?

☐ Yes ☑ No If so, indicate the corporate name(s)/limited liability company(ies) and municipality(ies).

Is applicant agent subject to completion of the responsible beverage server training course? ☐ Yes ☑ No

How long immediately prior to making this application has the applicant agent resided continuously in Wisconsin? Since 2004

Place of residence last year 311 N. Monroe St., Watertown, WI 53098

For: KWIK TRIP, INC.
(Name of Corporation / Organization / Limited Liability Company)

By: [signature]
(Signature of Officer / Member / Manager)

Any person who knowingly provides materially false information in an application for a license may be required to forfeit not more than $1,000.

ACCEPTANCE BY AGENT

I, Matthew A. McIlquham, hereby accept this appointment as agent for the
(Print / Type Agent's Name)

corporation/organization/limited liability company and assume full responsibility for the conduct of all business relative to alcohol beverages conducted on the premises for the corporation/organization/limited liability company.

X [signature] *(Signature of Agent)* X 7/25/2022 *(Date)* Agent's age 31

311 N. Monroe St., Watertown, WI 53098 Date of birth 10/23/1990
(Home Address of Agent)

APPROVAL OF AGENT BY MUNICIPAL AUTHORITY
(Clerk cannot sign on behalf of Municipal Official)

I hereby certify that I have checked municipal and state criminal records. To the best of my knowledge, with the available information, the character, record and reputation are satisfactory and I have no objection to the agent appointed.

Approved on ________ *(Date)* by ________ *(Signature of Proper Local Official)* Title ________ *(Town Chair, Village President, Police Chief)*

Date: September 1, 2022

To: Common Council Members

From: Police Chief Denis P. Sorenson *Chief Denis P. Sorenson*

Subject: Class A and B Intoxicating Liquor and Beer License Applications

The following Class A, B and C License applications have been reviewed and are following the regulations, ordinances, and laws of the City of Waterloo Municipal Code.

NAME OF INDIVIDUAL/PARTNERSHIP/LLC **AGENT NAME** **ADDRESS OF APPLICANT** **TRADE NAME** **PREMISE LOCATION** **PREMISE DESCRIPTION**	"Class B" Intoxicating Liquor License	Class "B" Beer License	Class "A" Beer License	"Class A" Intoxicating Liquor License	"Class A" Intoxicating Liquor License (Cider Only)	"Class C" Wine License	Cigarette License
Kwik Trip #366 Matthew Mcilquham, Agent 115 Portland Road Waterloo, WI 53594			X	X			C

Council Approval