

Report to the Legislature

Oral Health Equity Assessment

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Prevention and Community Health



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Executive Summary

The legislature passed a budget proviso as part of the 2021-2023 biennium operating budget (ESSB 5693, Sec.222(67)) that directed the Washington State Department of Health (DOH) to conduct an oral health equity assessment. The operating budget required the department to identify unmet oral health needs and develop recommendations to advance positive oral health outcomes while reducing inequities through increased access to community water fluoridation. The Department of Health conducted a study in partnership with the University of Washington School of Dentistry. Key findings include:

- 1. Communities disproportionately impacted by oral health disparities, including non-white and Hispanic or Latino communities, did not have greater access to fluoridated tap water.*
- 2. While most interviewees believed tap water was healthy and water fluoridation was acceptable, a substantial number of interviewees believed tap water was unhealthy.*
- 3. Substantial numbers of interviewees believed tap water fluoridation was unacceptable or had mixed views about it.*
- 4. Negative views about tap water and water fluoridation were more common among non-white participants.*
- 5. Indifference to tap water fluoridation was high among interviewees living in counties with low levels of tap water fluoridation.*
- 6. Most interviewees wanted to have a choice about fluoride being added to tap water.*
- 7. Many interviewees believed community-wide education could improve acceptability of fluoridated tap water.*

As a result of the study, DOH, in partnership with the University of Washington School of Dentistry, developed the following recommendations:

- 1. The state must focus efforts to improve tap water fluoridation in counties with low fluoridation levels and known oral health disparities.*
- 2. The state's public health efforts should focus on communicating that tap water is safe.*
- 3. Community-based education should focus on the value of water fluoridation.*
- 4. Additional research is needed to understand the views on tap water and fluoridation among communities disproportionately impacted by oral health disparities to help develop refined oral health equity strategies.*

Poor oral health, untreated oral disease, and loss of teeth directly impact quality of life and well-being. Additionally, known oral health inequities exist by race, ethnicity, and income level. While water fluoridation is an important community-based prevention strategy, there are additional ways to address oral health inequities.

Background

Tooth decay can result in pain, disfigurement, tooth loss, and loss of function. This preventable disease is caused by bacteria that feed off sugars from our diet. Over time these bacteria produce acids that cause holes or cavities in the teeth. Many of these cavities require dental treatment such as fillings, caps, root canals, or even removing teeth. Evidence shows that certain groups are more likely to get cavities and face barriers to accessing dental care. These groups (CDC Oral Health Report, 2019) include:

- People from low-income households
- Ethnic and racial minorities
- Other socioeconomically and medically vulnerable individuals

Youth Oral Health

The Department of Health's State Oral Health Program conducts the Washington State Smile Survey. The Smile Survey is a face-to-face data collection activity, designed to assess the oral health status and treatment needs of preschool and elementary school children throughout the state. In the 2016 Smile Survey, more than 1,400 preschool children from 47 Head Start and Early Childhood Education and Assistance programs, and more than 13,000 children in kindergarten, second, and third grades were viewed by specially trained licensed examiners. The survey found that by the third grade, more than 50% of children had treated or untreated cavities (a history of tooth decay). It also found inequities in oral health by income, race and ethnicity, and language spoken in the home. For example:

- By the third grade, children from lower income households were 60 percent more likely to experience tooth decay and were 60 percent more likely to need treatment than their more affluent peers.
- Children of color in second and third grades were 40 to 180 percent more likely to experience tooth decay than white children.
- Kindergarten and third-grade children who primarily spoke a language other than English at home were 50 percent more likely to need dental treatment than their peers who primarily spoke English at home.

Access to Dental Care

Washington residents enrolled in Medicaid often struggle to access dental services — despite coverage for these services for both children and adults enrolled in the program. In Washington, 38 of our 39 counties are federally designated as complete or partial Dental Health Professional Shortage Areas. Dental Health Professional Shortage Areas are designated by the federal Health Resources and Services Administration (HRSA) and are used to identify areas, population groups, or facilities within the United States that are experiencing a shortage in

health care professionals. With nearly all of Washington state's counties being designated as having a dental health workforce shortage, only 23 percent of the state's Medicaid eligible residents received any dental services in 2021. (Washington Health Care Authority, 2022). Only 55% of children under six on Medicaid visited a dentist. This is despite our state having one of the nation's longest-running programs to help Medicaid-enrolled babies, toddlers, and preschoolers access dental services (Craig et al., 2019).

There are approximately 74 dentists per 100,000 people in Washington (about 1,351 patients per dentist). The distribution of these dentists across counties is uneven. For example: King and Pierce Counties have approximately 1,000 and 1,600 patients per provider. Klickitat and Whitman County have 4,300 and 5,000 patients per provider. Uneven access to dentists means widening disparities and poorer quality of life in marginalized communities.

Consequences of Poor Oral Health

Positive oral health outcomes matter because more than 51 million school hours are lost each year due to cavity-related pain and treatment in the U.S ([National Institute of Dental and Craniofacial Research, 2000](#)). The 2021 Washington State Healthy Youth Survey found:

- 8% of surveyed 8th graders missed school because of toothaches and dental treatment.
- 10th graders who missed school because of a toothache had lower grades (Cs, Ds, and Fs) than those who did not miss school (37% vs. 26%).
- Loss of teeth and ongoing, untreated tooth decay can have a direct effect on a person's physical, social, and psychological health. Examples include:
 - A person with missing, decayed, or broken teeth, or who experiences oral pain, may struggle to eat a balanced diet. A lack of adequate nutrients can lead to other health issues.
 - A person with missing or decaying teeth may have trouble obtaining or keeping employment, or fully participating in society because of bias against them. This can lead to increased financial costs for the person and Washington state.

In 2011, the Washington State Hospital Association (2010, p. 12) reported that dental pain was the number one reason uninsured Washington residents visited emergency departments.

Patients with Medicaid insurance and without any insurance rely on the emergency room for dental care due to lack of access to these services in their community. Emergency room visits such as these that could be better treated in primary care settings are a significant and costly public health problem. These visits lead to high costs to the patient and to the state.

Additionally, most emergency departments are not equipped to provide dental care and can only provide relief for the immediate pain but not address the patient's issues with oral health (Sun, 2015). Consequences of poor oral health for an individual affect both physical health and mental health. It affects how we grow, enjoy life, look, speak, chew, taste food, and socialize. Poor oral health impacts the state's workforce, increases costs to taxpayers due to increased medical needs, and widens health disparities.

Prevention through Water Fluoridation

Most preventive strategies focus on individuals, like improving access to dental care services. However, research shows that tap water fluoridation is one of the most effective and widely studied public health strategies that prevents tooth decay. Drinking tap water with fluoride is safe and cost-effective. Fluoridating tap water is one way to get fluoride to people who face barriers to seeing a dentist or accessing dental care. Thus, tap water fluoridation is an equity-based public health strategy that can be accessible to all.

Overview of Oral Health Equity Study

DOH and the University of Washington met with the Washington State Office of Equity to discuss health equity frameworks and methods of engaging communities before the study began. Together, we developed a community-based recruitment strategy to generate engagement with and participation from communities disproportionately impacted by poor oral health. We also discussed short-term study goals and long-term community-based strategies to promote oral health equity.

We analyzed publicly available data to examine access to fluoridated tap water for communities disproportionately impacted by oral health disparities. We recruited 122 interview participants from sites in six counties. Community-based recruitment sites included:

- Family Health Center, Okanogan County
- Douglas County Health Department
- Mid-Columbia Library, Kennewick
- Mid-Columbia Library, Othello
- Mid-Columbia Library, Pasco
- NeighborCare Health, King County
- Othello Food Bank
- Snohomish Public Library
- University of Washington

Key findings:

1. Communities disproportionately impacted by oral health disparities, including non-white and Hispanic or Latino communities, did not have greater access to fluoridated tap water.
2. While most interviewees believed tap water was healthy and water fluoridation was acceptable, a substantial number of interviewees believed tap water was unhealthy.
3. Substantial numbers of interviewees believed tap water fluoridation was unacceptable or had mixed views about it.
4. Negative views about tap water and water fluoridation were more common among non-white participants.

5. Indifference to tap water fluoridation was high among interviewees living in counties with low levels of tap water fluoridation.
6. Most interviewees wanted to have a choice about fluoride being added to tap water.
7. Many interviewees believed community-wide education could improve acceptability of fluoridated tap water.

There were some challenges and limitations in developing this study. One of the main limitations was the limited timeline. More time would have allowed for the recruitment of additional study participants, which may have increased participation from communities of color.

Recommendations

- 1. The state must focus efforts to improve tap water fluoridation in counties with low fluoridation levels and oral health disparities.**
Initial efforts to improve tap water fluoridation should begin in the highest-need communities. An emphasis should be made within certain counties, including counties with low levels of water fluoridation and communities with oral health disparities. Subsequent efforts could then focus on areas with less need. A need-based approach ensures that resources are initially devoted to communities that have the most to gain from prevention approaches.
- 2. The state's public health efforts should focus on communicating that tap water is safe.**
Discussions about tap water fluoridation tend to ignore whether communities are okay with tap water in general, much less the topic of fluoridation. Many survey participants expressed a level of distrust in the safety and quality of tap water. Future public health efforts should focus more general messaging about tap water being a healthy option. This may also mean addressing sources of contamination that exist in locations with old infrastructure (e.g., rusty water pipes). If community members do not believe tap water is safe, then fluoridating it becomes a moot topic.
- 3. Community-based education efforts should focus on the value of water fluoridation.**
Public health must educate communities on the benefits of tap water fluoridation including why tap water is fluoridated, how it prevents cavities, and how people benefit from it. Community leaders can help disseminate public health information. Community-based education needs to be reinforced by consistent messaging on the benefits of water fluoridation delivered by health care providers, including dentists, physicians, nurses, and other providers who have contact with patients.
- 4. Additional research is needed to understand the views on tap water and fluoridation among communities disproportionately impacted by oral health disparities to help**

develop refined oral health equity strategies.

A large percentage of interviewees were non-white or Hispanic/Latino. Our assessment indicates that oral health equity strategies focusing on tap water fluoridation may require different community-based approaches for different race and ethnicity subgroups. We were not able to survey enough people from different racial and ethnic subgroups to find what strategies might produce the best results. Additional assessment work is needed focusing exclusively on these populations to understand how they feel about both tap water consumption and fluoridation of tap water to optimize acceptability of both.

Conclusion

The Legislature tasked DOH to assess oral health equity focusing solely on water fluoridation. While water fluoridation is an important community-based prevention strategy, there are additional ways to address oral health inequities. Access to comprehensive dental care must be ensured for communities disproportionately impacted by oral health disparities, especially those enrolled in the state Medicaid program. Additionally, improvements must be made to address the known workforce shortage in dental professions. Public health can also implement policy interventions that increase access to and selection of healthier food options. Finally, it is important to note the serious gaps in oral health care in the state among certain populations and its detrimental effects to overall health. Access to oral health care remains one of the most challenging components to increasing health equity.

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Appendices

Appendix A: (2022) Engrossed Substitute Senate Bill 5693 §222(67)

(67) \$166,000 of the general fund—state appropriation for fiscal year 2023 is provided solely for the department to conduct an oral health equity assessment. The department must use available data and community needs assessments to identify unmet oral health needs and develop recommendations to advance positive oral health outcomes while reducing inequities through increased access to community water fluoridation. The department must consult with the state office of equity and may collaborate with public health oral health care providers and community-based organizations to conduct the assessment and develop recommendations. The department must submit the oral health equity assessment report and recommendations to the appropriate committees of the legislature by June 30, 2023.

Tap Water Fluoridation and Oral Health Equity in Washington State

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Summary

Background. Tap water fluoridation is a safe and cost-effective public health strategy to prevent tooth decay and achieve oral health equity. Unknown is whether access to fluoridated tap water is equitable and if perceptions about tap water fluoridation vary for vulnerable populations. The goals of this mixed methods study were to (a) examine if county-level water

fluoridation in Washington state is associated with vulnerability markers (e.g., race, ethnicity, poverty level, educational attainment); and (b) conduct interviews to assess community members' views on water fluoridation.

Methods. For the county-level quantitative analyses, we obtained demographic data from the U.S. Census Bureau to create four vulnerability markers (% of the population non-white, Hispanic or Latino, below the poverty level, not graduated from high school) and water fluoridation data from the Washington State Department of Health on the percent of the county receiving fluoridated tap water (<33%, 33%-66%, >66%). We evaluated associations between the four vulnerability markers and water fluoridation using Spearman's rank correlation coefficient and the Kruskal-Wallis rank sum test weighted by the county adult population size. For the qualitative analyses, a 14-item interview script was used to conduct interviews with 122 community members in six counties in Washington state (Adams, Benton, Franklin, King, Okanogan, Snohomish). Participants were recruited through social media, community organizations, and libraries. Interviews were conducted from December 2022 to March 2023. Data were analyzed inductively and classified into three domains: opinions about tap water, opinions about adding fluoride to tap water, and strategies for improving access to fluoridated tap water. Exploratory analyses were conducted to identify potential differences for individuals from vulnerable backgrounds which was defined as non-white, Hispanic or Latino ethnicity, living in a county with low water fluoridation, and reporting at least some degree of opposition to tap water fluoridation.

Results. At the county-level, a higher percentage of non-white individuals was associated with a significantly higher level of water fluoridation (correlation=0.55; 95% CI 0.29, 0.82; $p<0.001$) but a higher percentage of individuals living in poverty was associated with a significantly lower level of water fluoridation (correlation=-0.36, 95% CI -0.70, -0.03; $p=0.02$). Ethnicity and education were not significantly associated with county-level water fluoridation. Findings from the Kruskal-Wallis rank sum test were similar except that significantly larger percentages of more highly fluoridated counties were comprised of Hispanic or Latino individuals (7.6% Hispanic or Latino in counties with <33% water fluoridation compared to 9.8% and 8.9% Hispanic or Latino in counties with 33%-66% and >66% water fluoridation, respectively; $p=0.047$). Based on the interview data, 82% of participants believed tap water was healthy and viewed water fluoridation as acceptable. However, 58.2% participants believed tap water was unhealthy and viewed water fluoridation as unacceptable. About 41.8% had mixed views (good and bad). Negative views about tap water and water fluoridation were more common among non-white participants (compared to white participants). Indifference to water fluoridation was high among Hispanic or Latino participants. Participants expressed wanting to have a choice about adding fluoride to water and believed that community education could help improve acceptability of fluoridated tap water.

Conclusions. Individuals living in more racially and ethnically diverse communities in Washington state appear to have greater access to fluoridated tap water while those in lower-

income communities have poorer access. Efforts to achieve oral health equity through fluoridated tap water should employ community-based educational strategies to improve acceptability of tap water, address indifference to water fluoridation, and target water fluoridation ambivalence.

Background and Study Goals

Tooth decay is a significant public health challenge that disproportionately affects vulnerable and minoritized populations [1]. Untreated tooth decay can lead to pain, problems chewing food and sleeping, emergency department visits, hospitalizations, systemic infection, and, in rare cases, death. It is also linked to systemic health challenges and chronic diseases. Life-course consequences include school absences, low self-esteem, and difficulties finding employment.

The main causes of tooth decay are excess added sugar intake and inadequate fluoride exposure [2,3]. The latter can be addressed at the individual level (e.g., toothbrushing with fluoridated toothpaste, topical fluoride treatment) or through public health strategies like fluoridated tap water. According to the U.S. Centers for Disease Control and Prevention (CDC), 73% of the U.S. population in 2018 was served by a fluoridated water system [4]. Tap water fluoridation is cost-effective and safe [5,6]. While tap water fluoridation is thought to contribute to oral health equity by addressing barriers to fluoride that disproportionately affect vulnerable populations, it is unknown whether socioeconomically vulnerable and minoritized individuals have equitable access to fluoridated tap water. Furthermore, there is a dearth of studies focusing on strategies to improve access to fluoridated tap water for vulnerable communities.

The goals of this mixed methods study were to (a) examine the quantitative relationships between county-level vulnerability markers (e.g., race, ethnicity, poverty level, educational attainment) and water fluoridation in Washington state and (b) conduct qualitative interviews in Washington state to assess community members' views on water fluoridation, with an emphasis on identifying strategies to improve access to fluoridated tap water for individuals from vulnerable backgrounds.

Quantitative Methods

The quantitative study focused on the 39 counties in Washington state. We identified the most current county-level tap water fluoridation data (2000-2015) available from the Washington State Department of Health. Each county was classified into one of three categories based on the percentage of the county receiving fluoridated tap water: <33%, 33%-66%, >66% [7]. We developed four vulnerability markers based on 2015 county-level demographic data from the U.S. Census Bureau: % of the population non-white, % Hispanic or Latino, % below the poverty level, and % not graduated from high school

[8]. Spearman's rank correlation coefficient was used to evaluate associations between the four vulnerability markers and county-level water fluoridation ($\alpha=0.05$). We calculated the median

and interquartile range (IQR) of the vulnerability markers at each level of fluoridated tap water and used the Kruskal-Wallis rank sum test to test for differences. All calculated statistics were weighted for the size of the adult population in the county. No Institutional Review Board (IRB) approval was necessary to analyze these publicly available data.

Qualitative Methods

For the qualitative analyses, we selected counties in Washington state using data from the quantitative study to ensure variation on county-level water fluoridation level (high and low) and geography (Eastern and Western Washington) as well as sufficient county-level racial and ethnic diversity. The six study counties were Adams, Benton, Franklin, King, Okanogan, and Snohomish. The study team developed, pilot tested, refined, and finalized a 14-item semi-structured interview script (Appendix Figure 1). Participants were recruited through social media (e.g., Facebook, Twitter), public bulletin boards, email listservs, community organizations, and libraries. We also sought word-of-mouth referrals from community organizations (e.g., Access to Baby and Child Dentistry Program Coordinators, Women, Infant, and Children clinic staff, churches) and recruited participants through snowball sampling. One-time interviews were conducted with a purposive sample of 122 community members from across the six counties until we reached saturation. After obtaining verbal consent, interviews were conducted by phone or in-person from December 2022 to March 2023 by trained staff. Participants received a \$20 gift card as a thank you. All interviews were digitally recorded, transcribed, and verified for accuracy. Six trained coders unitized the data. The unitized data were analyzed inductively and classified into categories that were further organized into three domains: opinions about tap water, opinions about tap water fluoridation, and strategies on improving access to fluoridated tap water. Counts and percentages were generated to report relative frequencies for each domain and category. Additional exploratory analyses were conducted to identify potential differences in category frequencies for individuals from vulnerable backgrounds, which was defined as non-white (based on self-reported race), Hispanic or Latino (based on self-reported ethnicity), living in a county with low water fluoridation (based on Washington State Department of Health category), or reporting some degree of tap water fluoridation opposition (defined as a response of ≥ 2 for the question: People differ in how strongly they are opposed to fluoride being added to their tap water. On a scale of 1 to 10, with “1” being not opposed at all and “10” being totally opposed, how opposed are you to fluoride being added to your tap water?). The University of Washington IRB approved the qualitative study procedures.

Quantitative Results

Based on the weighted Spearman’s rank correlation coefficient, we found that a higher percentage of non-white individuals was associated with a significantly higher level of water fluoridation (correlation=0.55; 95% CI 0.29, 0.82; $p < 0.001$) (Appendix Table 1). A higher percentage of individuals living in poverty was associated with a significantly lower level of water fluoridation (correlation=-0.36, 95% CI -0.70, -0.03; $p = 0.02$). Ethnicity and education were

not significantly associated with county-level water fluoridation. Findings from the Kruskal-Wallis rank sum test were similar except that significantly larger percentages of more highly fluoridated counties were comprised of Hispanic or Latino individuals (7.6% Hispanic or Latino in counties with <33% water fluoridation compared to 9.8% and 8.9% Hispanic or Latino in counties with 33%-66% and >66% water fluoridation, respectively; $p=0.047$) (Appendix Table 2).

Qualitative Results

Among the 122 interviewed participants, the mean age was 43.2 ± 12.2 years (range: 18 to 85), 60.7% were female, 41.8% were non-white, 30.3% were Hispanic or Latino, and 26.3% completed high school or less. About 69% of participants lived in Eastern Washington. About 58.1% of participants reported some degree of opposition to tap water fluoridation with the remaining 39.3% reporting no opposition (mean opposition level: 4.4; standard deviation: 3.4).

We identified 14 mutually exclusive categories that were organized into three domains. Below we summarize the domains and corresponding categories along with frequencies and percentages. Exemplary quotes are provided in Appendix Table 3.

Domain 1. Having opinions about tap water (N=117)

Most participants felt that tap water was good for drinking and cooking, but a substantial number of participants felt that tap water was unhealthy or bad. A substantial number of participants had mixed feelings about tap water – indicating that tap water was both good and bad.

Category 1. Feeling tap water is good (n=100; 82.0%)

Participants spoke about drinking and cooking with tap water regularly because they felt it was healthy, clean, free, and available. They also shared that their family and friends chose tap water over bottled water.

Category 2. Feeling tap water is unhealthy (n=71; 58.2%)

Participants shared their thoughts about tap water not being safe for drinking or for cooking. They believed tap water contained chemicals like chlorine and lead, bacteria, and other contaminants. They also felt tap water had an odor and tasted bad. Some identified poorly maintained pipes and filtration systems as reasons tap water was unsafe.

Category 3. Having mixed feelings about tap water (n=51; 41.8%)

Participants expressed feelings indicating that tap water was both good and unhealthy (category 1 and category 2).

Domain 2. Having opinions about fluoride being added to tap water (N=121)

Most participants felt strongly that fluoridated tap water was not harmful, necessary for oral health, and an easy source of fluoride. Others felt strongly that it was unhealthy and dangerous to both oral and general health. Some participants had mixed feelings. Others did not have

strong feelings about fluoridated tap water, stating that fluoridated tap water was not something they discussed with others. Some felt that fluoride in tap water was not necessary as it was overused and available in other oral health products. Many participants wanted to have a choice about having fluoride added to their water.

Category 4. Thinking fluoridated tap water is acceptable (n=91; 74.6%)

The positive aspects of fluoride and fluoridated tap water were enumerated by participants and included improving overall oral health, preventing and reducing cavities, and building stronger teeth especially for children. Some also shared what their friends, family, and neighbors thought regarding the benefits of fluoridated tap water.

Category 5. Thinking fluoridated tap water is not acceptable (n=64; 52.5%)

Participants voiced their own opposition to fluoridated tap water in addition to objections they heard from others. They thought fluoridated tap water was harmful and shared their worries about the impact of fluoride on dental and overall health, including long-term effects. They repeatedly spoke about fluoride being a carcinogen or a poisonous chemical.

Category 6. Having mixed feelings about fluoridated tap water (n=43; 35.2%)

Participants expressed feelings indicating that fluoridated tap water was both acceptable and not acceptable (category 4 and category 5).

Category 7. Not having strong feelings about fluoridated tap water (n=41; 33.6%)

Participants talked about not having strong feelings one way or the other about fluoride being added to tap water. They spoke about having heard positive and negative things about fluoridated water and feeling that they did not know enough to have a strong opinion one way or the other about fluoridated tap water.

Category 8. Fluoridated tap water never being a topic of discussion (n=35; 28.7%)

Participants said they had not had conversation with family, friends or neighbors about adding fluoride to tap water, it was not a concern, and they never thought about it.

Category 9. Feeling it is unnecessary to add fluoride to tap water (n=43; 35.2%)

Participants thought fluoride was an unnecessary chemical to add to water; that it is already available at the dentist, in toothpaste, and other oral hygiene products; that fluoride is overused; and putting it in tap water was a waste of money.

Category 10. Wanting a choice about adding fluoride to tap water (n=99; 81.1%)

Participants expressed wanting to have a choice about fluoride being added to their tap water. A few spoke of a voting process to reach a decision; others felt the decision would be made for them by government authorities based on scientific evidence. Several participants felt that the community needed to be educated about the pros and cons of fluoridated tap water so when it was put to a vote, people would be informed when they made their choice.

Domain 3. Making fluoridated tap water more acceptable (N=120)

A lack of information and knowledge about fluoride among community members was common. Some shared their opinions about the need to regulate and monitor the levels of fluoride in tap water. Many participants sought information to learn more about fluoride. Participants felt targeted strategies were needed to educate the community about the pros and cons of fluoride to gain support for fluoridated tap water.

Category 11. Lacking knowledge about fluoride (n=63; 51.6%)

Participants spoke about not having much knowledge about the benefits and potential harm of fluoride. Many reported not having done any research on fluoride and reported beliefs that fluoride was added to tap water to purify and cleanse it.

Category 12. Regulating water fluoridation is necessary (n=55; 45.1%)

Participants spoke about the benefits of adding fluoride to tap water being dependent on the pre-existing level of fluoride in the water. They talked about keeping the level of fluoride in tap water at recommended levels to prevent harm and questioned the amount already being consumed through other sources like toothpaste and fluoride from the dentist.

Category 13. Accessing information on fluoride (n=113; 92.6%)

Participants had a variety of resources they accessed to look for information on water fluoridation. Many spoke of doing online Google searches while others said they would go to scientific journals and consult with medical and dental professionals.

Category 14. Educating and informing the community about fluoride (n=99; 81.1%)

Participants spoke about education as key to making the community aware of the benefits of fluoride. They recommended that information be provided by local community leaders (e.g., elected officials, religious figures), and they specifically wanted to know about the research being done on the pros and cons of fluoridated tap water.

There were notable differences in the frequencies of categories for individuals from vulnerable backgrounds (e.g., non-white participants, Hispanic or Latino participants, those living in counties with low water fluoridation levels, those opposed to water fluoridation) (**Appendix Table 4**). Negative views about tap water and water fluoridation were more common among non-white participants compared to white participants. For instance, 64.7% of non-white participants felt tap water was unhealthy (category 2) and 60.8% thought fluoridated tap water was unacceptable (category 5), compared to 53.0% and 47.0% of white participants, respectively. Conversely, the proportions of non-white participants who felt good about tap water and fluoridated tap water were lower than for white participants. Views on tap water being unhealthy and indifference to fluoridated tap water were highest among Hispanic or Latino participants (78.4% and 75.7%, respectively). Indifference to water fluoridation (category 7) was higher among participants living in counties with low levels of water fluoridation than for participants living in counties with high levels of water fluoridation (42.2% and 24.1%,

respectively). Indifference was also higher among participants opposed to fluoridated tap water.

Discussion

In this study, we examined the relationship between county-level vulnerability markers (e.g., race, ethnicity, poverty level, educational attainment) and water fluoridation in Washington state and conducted interviews to assess community members' views on water fluoridation. There are two main findings.

The first finding is that individuals living in more racially and ethnically diverse communities in Washington state appear to have greater access to fluoridated tap water while those in lower-income communities have poorer access. There are no existing studies to which these findings can be compared. One of the perceived benefits of tap water fluoridation is that it removes barriers to fluoride, especially for socioeconomically vulnerable and minoritized populations. Additional studies are needed to assess the degree to which vulnerable populations have equitable access to fluoridated water.

The second finding is that most participants had positive views about tap water and water fluoridation, but there were substantial numbers of individuals who had negative, mixed, or indifferent views, which were especially common among participants from vulnerable backgrounds. These results are consistent with findings from community surveys administered in Canada, England, and New Zealand [9-11]. Participants in our study believed that community-level education has an important role in promoting access to water fluoridation. However, it may not be possible for broad public health education strategies to address all the reasons members of a community are opposed to water fluoridation [12]. Community-based educational interventions aimed at improving water fluoridation need to account for the underlying characteristics of the community, especially for diverse communities, if the goal is to achieve oral health equity. For example, programs should be developed by trusted community members, incorporate local feedback prior to and during implementation, and be made available in multiple languages to ensure cultural appropriateness. In addition, it may be that fluoridation is acceptable but concerns center on tap water, which suggests the need to educate and reassure populations about water safety.

There were five main study limitations. First, this was an observational study. We are unable to draw causal conclusions. Second, the study findings are generalizable to Washington state and to participants from counties included in the qualitative analyses. We focused on a purposive sample of counties and participants, but conducted interviews until we reached saturation. Third, we recruited a relatively large proportion of non-white and Hispanic or Latino participants. However, future intervention approaches may need to be tailored to the needs of vulnerable population subgroups (by attributes like race, ethnicity, and income) to achieve oral health equity through principles of targeted universalism [13]. Fourth, the quantitative analyses are likely to be underpowered because of the small number of counties in Washington state, but we were still able to detect differences. Larger studies would address this limitation. Fifth,

our measure of county-level water fluoridation was from 2015 and was a categorical variable. Up-to-date, continuous measures of water fluoridation levels would provide for more accurate quantitative modeling.

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Appendix

Figure 1

Semi-Structured Script Used to Interview Participants of a Study on Tap Water Fluoridation in Washington State

Interview Questions

1. People differ in how strongly they are opposed to fluoride being added to their tap water. On a scale of 1 to 10, with "1" being not opposed at all and "10" being totally opposed, how opposed are you to fluoride being added to your tap water?
2. When you think of tap water, what are three things that come to mind? (If they cannot answer, ask to come up with 3 words) (Prompt: Is it Good/Bad/Indifferent?)
3. How often do you drink tap water at your home?
4. How often do you prepare or cook food with tap water at your home?
5. Now we are going to shift to a question about fluoride. Tell me about what you think fluoride does, good or bad.
6. Now we are going to talk about fluoride being added to tap water. When you think about fluoride being added to your tap water, what are 3 things that come to mind? (PAUSE. WAIT 10 seconds to give them time to think).
7. Tell me why you think fluoride is added to tap water.
8. How necessary do you think it is to have fluoride added to tap water?
9. How harmful do you think it is to have fluoride added to tap water?
10. How much choice do you think people in your community should have in whether fluoride is added to tap water?
11. What do your friends, neighbors, and family members think about fluoride being added to tap water?
12. If you were looking for information about the safety of adding fluoride to tap water, where would you go for this information?
- 13a. [For highly fluoridated counties] More than 66% of your county (King, Snohomish, Franklin) has fluoridated tap water, which is relatively high for Washington state. How would you feel if a decision was made to stop adding fluoride to the tap water in your county?
- 13b. [For low fluoridated counties] Less than 33% of your county (Adams, Benton, Okanogan) has fluoridated tap water, which is relatively low for Washington state. How would you feel if a decision was made to start adding fluoride to the tap water in your county?
14. What are ways to get more people in your community to support adding fluoride to tap water?
 - a. What are other ways to improve oral health?

Table 1

Weighted Spearman’s Rank Correlation Coefficients for Associations between Four Vulnerability Markers and County-Level Tap Water Fluoridation in Washington State

Vulnerability Marker	Correlation	Lower 95% CI	Upper 95% CI	p-value
% Non-white	0.55	0.29	0.82	<0.001
% Hispanic or Latino	-0.31	-0.67	0.04	0.11
% Below poverty line	-0.36	-0.70	- 0.04	0.02
% Not graduated from high school	-0.05	0.41	0.32	0.77

CI, confidence interval.

Spearman’s rank correlation coefficients weighted for county adult population size

Table 2

Weighted Median and Interquartile Range of Vulnerability Markers for All Counties and Stratified by County-Level Tap Water Fluoridation

County-Level Tap Water Fluoridation

Vulnerability Markers	All Counties	<33% N = 221	33-66% N = 71	>66% N = 101	p-value ²
% Non-white	15.8 (10.7, 26.1)	10.1 (6.92, 12.2)	14.3 (18.0, 18.0)	22.5 (16.6, 26.1)	0.006
% White	78.4 (68.1, 84.8)	85.2 (82.6, 89.0)	73.0 (74.7, 81.0)	68.1 (68.1, 78.8)	0.004
% Hispanic or Latino	9.05 (8.5, 9.8)	7.6 (5.6, 16.1)	9.8 (10.0, 10.0)	8.9 (9.3, 9.4)	0.047
% Non-Hispanic or Latino	90.6 (90.4, 91.6)	91.6 (88.8, 94.9)	75.1 (90.0, 90.2)	90.6 (90.7, 90.7)	0.046
% Below poverty line	10.9 (11.2, 15.9)	15.5 (12.8, 16.0)	11.1 (12.7, 14.5)	10.7 (11.2, 11.2)	0.003
% At or above poverty line	88.6 (84.6, 88.8)	84.0 (84.0, 87.6)	86.1 (87.3, 87.3)	86.8 (88.8, 88.8)	0.04
% Not graduated from high school	8.05 (7.7, 9.0)	6.9 (6.73, 11.2)	8.8 (9.0, 10.5)	7.6 (7.7, 8.6)	0.06
% Graduated high school	91.5 (90.9, 92.3)	92 (88.9, 93.4)	89.4 (90.9, 90.9)	91.9 (91.6, 92.3)	0.05

¹Median (Interquartile Range)

²Weighted Kruskal-Wallis rank sum test weighted for county adult population size

Table 3

Exemplary Quotes from Participants in a Qualitative Study to Assess Community Member Views on Water Fluoridation in Washington State

Domain	Category-Level Exemplary Quote	Participant Characteristics
1. Having opinions about tap water	Category 1. Feeling tap water is good	
	<i>"I think that here in the Pacific Northwest, we're so fortunate to have Mother Nature provide us with some of the best water in the world, which translates to what comes out of our tap."</i>	74-year-old non-Hispanic white male, fluoride opposition level: 1/10
	Category 2. Feeling tap water is unhealthy	
	<i>"I think it's [tap water] bad...because of the lead content and pharmaceuticals in tap water...It's just the contaminants in the [tap] water."</i>	66-year-old non-Hispanic American Indian/Alaska Native female, fluoride opposition level: 10/10

	Category 3. Having mixed feelings about tap water	
	See category 1 and category 2	-
2. Having opinions about fluoride being added to tap water	Category 4. Thinking fluoridated tap water is acceptable	
	<i>"I don't see any reason to think [fluoride is] bad... fluoride is associated with...good or oral hygiene... promotes healthy gums or healthy teeth...I don't think it would do any harm."</i>	53-year-old non-Hispanic Black/African American male, fluoride opposition level: 6/10
	Category 5. Thinking fluoridated tap water is not acceptable	
	<i>"I don't even care if [fluoride] prevents cavities or not. I'm much more concerned about if it's a carcinogen, or if it causes birth defects or diseases. You can recover from a cavity a lot easier than you can from cancer."</i>	59-year-old non-Hispanic White female, fluoride opposition level: 9/10
	Category 6. Having mixed feelings about fluoridated tap water	
	See category 4 and category 5	-
	Category 7. Not having strong feelings about fluoridated tap water	
	<i>"Does added fluoridization [in tap water] help us or would that...I don't know if there's any bad side effects...I'm still on the fence about."</i>	39-year-old non-Hispanic American Indian/Alaska Native male, fluoride opposition level: 5/10
	Category 8. Fluoridated tap water never being a topic of discussion	
	<i>"[I] have not talked about fluoride [with my neighbors]...[the] last time I asked a neighbor about how safe our water was, we never mentioned fluoride."</i>	32-year-old Hispanic white female, fluoride opposition level: 5/10
Category 9. Feeling it is unnecessary to add fluoride to tap water		
<i>"It's [fluoride] a chemical. It's not necessary...Adding it to a population of people just because they're poor...is that worth the risk of what fluoride as a chemical could do to everything else and everybody else?"</i>	47-year-old non-Hispanic white female, fluoride opposition level: 1/10	
Category 10. Wanting a choice about adding fluoride to tap water		
<i>"I think that if it is something that we can vote...something that we can be more educated on the consequences of and then giving us that choice [about adding fluoride to tap water]."</i>	41-year-old Hispanic female, fluoride opposition level: 2/10	

3. Making fluoridated tap water more acceptable	Category 11. Lacking knowledge about fluoride	
	<i>"I don't know if the average person like myself knows...how much fluoride you should be taking in and implications of it being in tap water."</i>	33-year-old non-Hispanic Asian female, fluoride opposition level: 5/10
	Category 12. Regulating water fluoridation is necessary	
	<i>"It is not harmful [to have fluoride added to tap water] if we have the correct amount of fluoride...if there is too much fluoride in drinking water, it can cause...issues."</i>	50-year-old Hispanic female, fluoride opposition level: 10/10
	Category 13. Accessing information on fluoride	
	<i>"I might start with a web search [to get information on fluoride safety]...then look through a list of articles...and read why did they put fluoride in water or, when did they start putting fluoride in water?...how safe is it?"</i>	66-year-old non-Hispanic white female, fluoride opposition level: 1/10
Category 14. Educating and informing the community about fluoride		
<i>"Just informing them what it [fluoride] is [to get more community members in support of fluoride]... A lot of people don't understand that things are there to help you... And knowing that it won't harm them would be."</i>	24-year-old non-Hispanic Black/African American female, fluoride opposition level: 1/10	

Table 4

Frequencies and Percentages of Domains and Categories* across General Study Population and for Individuals from Vulnerable and Non-Vulnerable Backgrounds

	General Study Population (N=122)	Race		County Water Fluoridation Level		Opposition to Water Fluoridation	
		Non-White (n=51)	White (n=66)	Low (n=64)	High (n=58)	Opposed (n=71)	Not Opposed (n=48)
Domain 1. Having opinions about tap water	117 (95.9)	49 (96.0)	58 (87.9)	63 (98.4)	55 (94.8)	68 (95.8)	46 (95.8)
Category 1. Feeling tap water is good	100 (82.0)	39 (76.5)	55 (83.3)	49 (76.6)	52 (89.7)	53 (74.6)	45 (93.8)
Category 2. Feeling tap water is unhealthy	71 (58.2)	33 (64.7)	35 (53.0)	35 (54.7)	36 (62.0)	48 (67.6)	19 (39.6)
Category 3. Having mixed feelings about tap water	51 (41.8)	22 (43.1)	26 (39.4)	23 (35.9)	30 (51.7)	33 (46.5)	16 (33.3)
Domain 2. Having opinions about fluoride being added to tap water	121 (99.1)	50 (98.3)	66 (100.0)	64 (100.0)	57 (98.2)	71 (100.0)	47 (97.9)

Category 4. Thinking fluoridated tap water is acceptable	91 (74.6)	35 (68.6)	50 (75.8)	45 (70.3)	46 (79.3)	45 (63.4)	45 (93.8)
Category 5. Thinking fluoridated tap water is not acceptable	64 (52.5)	31 (60.8)	31 (47.0)	25 (39.0)	39 (67.2)	45 (63.4)	18 (37.5)
Category 6. Having mixed feelings about fluoridated tap water	43 (35.2)	18 (35.3)	22 (33.3)	15 (23.4)	28 (48.27)	25 (35.2)	17 (35.4)
Category 7. Not having strong feelings about fluoridated tap water	41 (33.6)	12 (23.5)	27 (40.9)	27 (42.2)	14 (24.1)	31 (43.7)	9 (18.8)
Category 8. Fluoridated tap water never being a topic of discussion	35 (28.7)	13 (25.5)	17 (25.8)	20 (31.2)	14 (24.1)	20 (28.2)	12 (25.0)
Category 9. Feeling it is unnecessary to add fluoride to tap water	43 (35.2)	19 (37.2)	20 (30.3)	22 (34.3)	21 (36.2)	34 (47.9)	8 (16.7)
Category 10. Wanting a choice about adding fluoride to tap water	99 (81.1)	31 (60.8)	60 (90.0)	56 (87.5)	44 (75.9)	61 (85.9)	36 (75.0)
Domain 3. Making fluoridated tap water more acceptable	120 (98.4)	49 (96.0)	65 (98.5)	64 (100.0)	55 (94.8)	71 (100.0)	46 (95.8)
Category 11. Lacking knowledge about fluoride	62 (50.8)	27 (52.9)	28 (42.4)	35 (54.7)	28 (48.3)	36 (50.7)	23 (47.9)
Category 12. Regulating water fluoridation is necessary	55 (45.1)	26 (50.9)	27 (40.9)	27 (42.2)	28 (48.3)	30 (42.2)	21 (43.8)
Category 13. Accessing information on fluoride	113 (92.6)	43 (84.3)	61 (92.4)	61 (95.3)	53 (91.3)	64 (90.1)	43 (89.6)
Category 14. Educating and informing the community about fluoride	99 (81.1)	37 (72.5)	55 (83.3)	55 (85.9)	43 (74.1)	54 (76.0)	39 (81.2)