WSSC WATER
DELIVERING THE ESSENTIAL

AGENDA CATEGORY: Finance Department

ITEM NUMBER: **DATE:** February 19, 2020

SUBJECT	Vote - Approve Transmittal of FY 2021 Proposed Budget
SUMMARY **SPECIAL COMMENTS**	This action transmits WSSC Water's Proposed FY 2021 Operating and Capital Budget to the County Executives of Prince George's and Montgomery Counties. Section 17-202 of the Public Utilities Article requires WSSC Water to prepare, and submit to the two County Executives, a Proposed Operating and Capital Budget by March 1 of each year.
CONTRACT NO./ REFERENCE NO.	Not Applicable
COSTS	Proposed Operating and Capital total is $1,462,911,814
AMENDMENT/ CHANGE ORDER NO. AMOUNT	Not Applicable
MBE PARTICIPATION	Not Applicable
PRIOR STAFF/ COMMITTEE REVIEW **PRIOR STAFF/ COMMITTEE APPROVALS**	Public Hearings January 27 and February 4, 2020 Carla A. Reid, General Manager/CEO Joseph F. Beach, Deputy General Manager Patricia A. Colihan, Chief Financial Officer Letitia Carolina-Powell, Budget Division Manager
RECOMMENDATION TO COMMISSION	Approve for transmittal to Prince George's and Montgomery Counties.
COMMISSION ACTION	

WSSC WATER
DELIVERING THE ESSENTIAL

Interoffice Memorandum

TO: COMMISSIONERS

FROM: CARLA A. REID
GENERAL MANAGER/CEO

DATE: FEBRUARY 19, 2020

SUBJECT: FY 2021 PROPOSED BUDGET

Your approval for transmittal of the Fiscal Year 2021 (FY 2021) Proposed Budget to the Montgomery and Prince George's County Executives is recommended. This budget, totaling $1.463 billion, is the same as the FY 2021 Preliminary Proposed Budget that was presented to the Commission on December 18, 2019.

It should be noted there are changes to Miscellaneous Fees and Charges and the Proposed Maximum Allowable System Development Charges (Table XI) from what was published in the Preliminary Proposed Budget document. The change to the Maximum Allowable System Development Charges does not impact the Proposed System Development Charges which remain the same as FY 2021.

The proposed budget document recommends a 7.0% average rate increase. This proposed increase is in accordance with the 7.0% Spending Affordability Guidelines approved by Prince George's and Montgomery Counties. The rate increase will add $4.42 per month or $13.26 per quarter to the bill of a customer who is using 165 gallons per day.

Also, attached for your information is a copy of the transmittal letter to both County Executives for signature; copies of written testimony received; and the Commission Chair's Proposed Budget letter for signature with tables showing Comparative Expenditures by Fund and Major Expense Category, Summary of Revenues & Expenditures, the Proposed Rate Impact, Annual Customer Bills at Various Consumption Levels, Proposed Water/Sewer Rate Schedules, Account Maintenance Fees, Infrastructure Investment Fees, and Proposed Changes to Miscellaneous Fees & Charges.

Note that this budget does not reflect a recent potential adjustment of up to $1.2 million in debt service requirements for the Blue Plains projects. We have briefed the County Councils' legislative staffs and the Offices' of Management and Budget staffs on these potential adjustments to the proposed budget.

As you are aware, Public Hearings were held on January 27, and February 4, 2020. The Commissioners will be provided with any additional written correspondence received during the comment period. Additionally, a copy of the transcripts from the hearings will be provided to the Commissioners' Office when available.

Attachments

TRANSMITTAL LETTERS

March 1, 2020

The Honorable Angela D. Alsobrooks
Prince George's County Executive
1301 McCormick Drive
Suite 4000
Largo, MD 20774

The Honorable Marc Elrich
Montgomery County Executive
Executive Office Building
101 Monroe Street - 2nd Floor
Rockville, MD 20850

Dear County Executive Alsobrooks and County Executive Elrich:

Pursuant to the provisions of Section 17-202, of the Public Utilities Article, WSSD Laws, Annotated Code of Maryland, transmitted herewith are the proposed capital and operating budgets for WSSC Water for the fiscal year commencing July 1, 2020. Public hearings were held on Monday, January 27 in Rockville, and Tuesday, February 4 in Largo.

Our Proposed Fiscal Year 2021 (FY 2021) Budget for all operating and capital funds totals $1.463 billion or $7.0 million (0.5%) more than the FY 2020 Approved Budget and includes a 7.0% average increase in water and sewer consumption rates. This proposed increase meets the Spending Affordability Guidelines as both Prince George's and Montgomery Counties recommended a 7.0% limit. The FY 2021 Proposed Operating Budget of $856.2 million represents an increase of $38.8 million (4.7%) over the FY 2020 Approved Budget. The primary cost drivers are the holistic rehabilitation of the Piscataway basin to help address excess flows at the Piscataway Water Resource Recovery Facility (WRRF) and help prevent permit violations; increased operating costs for this WRRF, and debt service on infrastructure renewal. When controlling for the non-discretionary increases in debt service and Piscataway related costs, WSSC Water's FY 2021 proposed operating budget is only 2.5% more than the FY 2020 approved operating budget. The FY 2021 Proposed Capital Budget of $606.7 million represents a decrease of $31.8 million (-5.0%) from the FY 2020 Approved Budget. It should be noted that this budget does not reflect a potential increase in debt service of up to $1.2 million related to the Blue Plains projects. We have briefed the County Councils' legislative staffs and the Offices' of Management and Budget staffs on these potential adjustments to the proposed budget.

WSSC Water rates continue to be favorable when compared to other comparable water and sewer utilities, and the average WSSC Water residential bill is approximately 1% of the median household income. The proposed budget document includes graphic representation of these comparisons. The impact of the rate increase will add approximately $4.42 per month or $13.26 per quarter to the bill of a customer using 165 gallons per day.

New technologies and tools are emerging to help WSSC Water better assess the condition of our existing water/sewer mains so we can improve our ability to target pipes in need of replacement. Because we are better able to identify pipes in poor condition, WSSC Water decreased the Water Reconstruction Program (rehabilitation of smaller water mains <16 inches in diameter) over the next few years from 45 miles in FY 2019 to 25 miles in FY 2020 and FY 2021. This strategic reduction frees up the resources required for WSSC Water to develop a more efficient and effective Water Reconstruction Program, enabling us to develop our enhanced pipe condition assessment program over the next several years. In addition, new water main rehabilitation technologies to help control costs while also minimizing disruption for our customers are being evaluated.

For large diameter water mains, the Pre-stressed Concrete Cylinder Pipe (PCCP) Program provides for the ongoing acoustic fiber optic (AFO) monitoring of over 100 miles of pipe, ongoing inspection, and rehabilitation and replacement of large diameter pipes. Inspection, rehabilitation and replacement of large valves continues at two per year. The PCCP program will begin the replacement of pipe with one-half mile projected for FY 2021, eventually building the program up to two miles per year. Replacement of ferrous pipes is projected to increase from four miles to six miles per year. Funding is also included for the continued compliance with all requirements of the WSSC Water Sanitary Sewer Overflow and Potomac Water Filtration Plant Consent Decrees.

In addition to our ongoing investments in WSSC Water's physical infrastructure, the FY 2021 budget invests in our organizational infrastructure. Strategic contributions from Fund Balance will be used to modernize our IT infrastructure and streamline our business processes and help lay the foundation for Advanced Metering Infrastructure project.

To keep the Councils apprised of the budget status, copies of this letter with the enclosures are being sent to Prince George's Council Chair Turner and Montgomery Council President Katz. If any additional information is needed, please contact us.

Sincerely,

Chris Lawson,
Chair

Enclosures

cc: The Honorable Todd M. Turner, Chair
Prince George's County Council

The Honorable Sidney Katz, President
Montgomery County Council

FOR INCLUSION IN BUDGET BOOK

March 1, 2020

The Honorable Angela D. Alsobrooks, Prince George's County Executive
The Honorable Marc Elrich, Montgomery County Executive
The Honorable Todd M. Turner, Chair, Prince George's County Council
The Honorable Sidney Katz, President, Montgomery County Council

Dear Ms. Alsobrooks, Mr. Elrich, Mr. Turner, and Mr. Katz:

We are hereby transmitting WSSC Water's Proposed Fiscal Year 2021 (FY 2021) Capital and Operating Budget document. This document is released and distributed on this date for review by interested customers, citizens, and elected officials.

This proposed budget reflects our continued mission to our customers to provide safe and reliable water, life's most precious resource, and return clean water to the environment, all in an ethical, sustainable, and financially responsible manner. The programs, goals, and objectives included in this budget seek to achieve the WSSC Water's mission through the following strategic priorities:

- Enhance Customer Experience
- Optimize Infrastructure
- Spend Customer Dollars Wisely
- Protect our Resources
- Transform Employee Engagement

FY 2021 PROPOSED CAPITAL AND OPERATING BUDGETS

The proposed budget for Fiscal Year 2021 for all operating and capital funds totals $1.463 billion or $7.0 million (0.5%) more than the Approved FY 2020 Budget. The proposed operating budget of $856.2 million represents an increase of $38.8 million (4.7%) over the FY 2020 Approved Operating Budget of $817.4 million. The primary cost drivers are the holistic rehabilitation of the Piscataway basin to help address excess flows at the Piscataway Water Resource Recovery

Facility (WRRF) and help prevent permit violations; increased operating costs for this WRRF, and debt service on infrastructure renewal. Other cost drivers include bio-solids hauling and additional funding to stabilize business operations using the new Customer-to-Meter (C2M) billing system stabilization. When controlling for the non-discretionary increases in debt service and Piscataway related costs, the FY 2021 Operating Budget is only 2.5% over the FY 2020 Approved Budget.

The proposed capital budget of $606.7 million represents a decrease of $31.8 million (-5.0%) from the FY 2020 Approved Capital Budget of $638.5 million. This decrease is due to construction progress on the Trunk Sewer Reconstruction Consent Decree work and some significant projects winding down such as the Brink Zone Water Storage Improvements and the Broad Creek Waste Water Pumping Station Augmentation projects.

The proposed budget calls for a combined 7.0% average increase in water and sewer consumption revenue. This proposed increase meets the Spending Affordability Guidelines (SAG) as both Prince George's and Montgomery counties recommended up to 7.0%. Even with this change, WSSC Water rates continue to be favorable when compared to many similar sized water and sewer utilities. The average WSSC Water customer's residential bill is 1% (Section 2) of the median household income. The rate increase will add approximately $13.26 (6.1% bill increase) per quarter to the bill of a customer using 165 gallons per day, the average per person consumption of 55 gallons per day for a 3-person household.

It is important to point out that WSSC Water's budget is capital intensive and driven by changes in the construction market, commodity prices and tariffs. It is not driven by the more commonplace consumer price index (CPI). Other investments drive our budget, including: compliance with the Sanitary Sewer Overflow (SSO) and the Potomac River Consent Decrees; environmental regulation directives; maintaining the security of our water infrastructure and for our employees working in the field; and Information Technology improvements to streamline our business processes. Many of these costs are legally mandated and not easily deferred or reduced.

CUSTOMER AFFORDABILITY

Like many utilities across the country, WSSC Water continues to face the challenge of balancing increasing costs for infrastructure and operations with affordability considerations for our customers. While the average costs to ensure access to clean, safe drinking water and efficient wastewater treatment compares favorably to other household utilities and expenses, there are still many residents who struggle to meet their monthly expenses. In response to this need, the Customer Assistance Program (CAP) was created in FY 2016 to help economically disadvantaged customers by providing financial assistance with water and sewer bills. There are currently 12,655 customers enrolled in CAP who will save $1.2 million in fixed fees in FY 2021. This budget includes funding for enhancements to customer service including programs that will provide conservation kits and plumbing inspections for qualifying customers.

In addition, in accordance with House Bill 408 enacted in the FY 2018 legislative session, the proposed budget includes $100,000 to fund the second year of the new Connection Pipe Emergency Replacement Loan Program which provides affordable financing of up to $5,000 per eligible customer.

SPENDING AFFORDABILITY GUIDELINE LIMITATIONS

In order to reconcile our Departments' initial FY 2021 budget requests with the Counties' Spending Affordability Guidelines, a funding gap of $25.8 million dollars was closed. Actions included limiting growth for certain programs and the very difficult decision not to reinstate important programs and functions that were removed in previous fiscal years. For the fourth consecutive year, this budget includes no new positions. Although this budget provides funding for critical improvements required in the Piscataway basin, the stabilization of C2M business operations as well as much needed maintenance at some WSSC Water facilities, we must continue to defer implementing some important improvements that would support and advance our strategic priorities including:

- Implementing a system-wide flushing program of our water distribution pipe network in order to reduce discolored water complaints and improve water quality;
- Testing all 43,000 fire hydrants in our service area on a ten-year cycle; a best practice recommended by the American Water Works Association; and
- Accelerating large water valve inspections from a four-year to a three-year cycle.

COST SAVING MEASURES

This budget reflects WSSC Water's continuing commitment to maintaining affordability through the active pursuit and implementation of cost savings measures. In addition to the reductions in the operating and capital budgets noted above, the agency has several ongoing strategies to identify more cost-effective ways of providing clean water to our customers including the following:

- Our efforts in the Supply Management project, which have been supported by the Commission and both Counties since FY 2013, have produced significant cost reductions in excess of $47.0 million in the operating and capital budgets since the inception of this program and cost avoidance savings of nearly $45.0 million during the same period. If not for these intensive efforts in contract negotiation and cost management, additional rate increases, or service reductions would have been necessary. During FY 2019, our efforts resulted in $8.8 million in cost reductions.
- By continually monitoring and revising our Group Insurance plan design we have identified $4.3 million in savings since FY 2017;
- There has been no net increase in the number of WSSC Water positions since FY 2017, and we have currently frozen the hiring of 30 to produce ongoing personnel cost savings;
- Changes to our Workers Compensation have resulted in the following:
    - 62% reduction in lost workday cases
    - 25% reduction in lost work days
    - 50% reduction in claims totals ($425,000)
- Our Innovation program has identified promising methods for identifying and remediating water system leakages as well as new approaches to wastewater treatment that may significantly reduce processing costs while improving our environmental stewardship efforts; and

- Changes made in monitoring and supervision of overtime costs have reduced these expenses by $3.0 million since FY 2017.

OPTIMIZE INFRASTRUCTURE

New technologies and tools are emerging to help WSSC Water better assess the condition of our existing water/sewer mains so we can improve our ability to target pipes in need of replacement. Because we are better able to identify pipes in poor condition, WSSC Water decreased the Water Reconstruction Program (rehabilitation of smaller water mains <16 inches in diameter) over the next few years from 45 miles in FY 2019 to 25 miles in FY 2020 and FY 2021. This strategic reduction frees up the resources required for WSSC Water to develop a more efficient and effective Water Reconstruction Program, enabling us to develop our enhanced pipe condition assessment program over the next several years. In addition, new water main rehabilitation technologies to help control costs while also minimizing disruption for our customers are being evaluated.

For large diameter water mains, the Pre-stressed Concrete Cylinder Pipe (PCCP) Program provides for the ongoing acoustic fiber optic (AFO) monitoring of over 100 miles of pipe, ongoing inspection, and rehabilitation and replacement of large diameter pipes. Inspection, rehabilitation and replacement of large valves continues at two per year. The PCCP program will begin the replacement of pipe with one-half mile projected for FY 2021, eventually building the program up to two miles per year. Replacement of ferrous pipes is projected to increase from four miles to six miles per year. Funding is also included for the continued compliance with all requirements of the WSSC Water Sanitary Sewer Overflow and Potomac Water Filtration Plant Consent Decrees.

INFORMATION TECHNOLOGY MODERNIZATION

In addition to our ongoing investments in WSSC Water's physical infrastructure, the FY 2021 budget invests in our organizational infrastructure. Strategic contributions from Fund Balance will be used to modernize our IT infrastructure and streamline our business processes and help lay the foundation for Advanced Metering Infrastructure project.

SPENDING AFFORDABILITY

WSSC Water, in cooperation with the Montgomery County and Prince George's County governments, continues to participate in the spending affordability process. The spending affordability process focuses debate, analysis, and evaluation on balancing affordability considerations against the provision of resources necessary to serve existing customers (including infrastructure replacement/rehabilitation), meet environmental mandates, maintain affordable rates, and maintain operating and capital budgets and debt service at prudent and sustainable levels. Last fall, the Montgomery County Council and Prince George's County Council approved resolutions establishing four limits on the WSSC Water's FY 2021 budget. As indicated in the following table, the proposed FY 2021 budget meets the spending affordability limits for New Water and Sewer Debt, Debt Service and Average Water/Sewer Rate Increase.

WSSC FY 2021 PROPOSED BUDGET VS. SPENDING AFFORDABILITY LIMITS
($ in Millions)

	FY 2021 Proposed Budget	Prince George's County Limit	Montgomery County Limit
New Water and Sewer Debt	$409.9	$409.9	$409.9
Total Water and Sewer Debt Service	$313.9	$313.9	$313.9
Total Water/Sewer Operating Expenses	$842.5*	$837.7	$837.7
Water/Sewer Rate Revenue Increase	7.0%	7.0%	7.0%

*Covered by offsetting non rate related funding sources

The proposed budget provides for:

- Implementing the first year of the FYs 2021-2026 Capital Improvement Program (CIP);
- Paying WSSC Water's share of operating ($58 million in FY 2021) and capital costs ($60 million in FY 2021; $443 million FYs 2021-2026) for the District of Columbia Water and Sewer Authority's (DC Water) Blue Plains Wastewater Treatment Plant;
- Initiating Advanced Metering Infrastructure (AMI) so customers can better track their water usage, which can significantly reduce their bills and save them money
- Paying debt service of $325.6 million - of which $313.9 million is in the Water and Sewer Operating Funds;
- Rehabilitating holistically the Piscataway basin to reduce infiltration and inflow;
- Funding additional operating costs at the Piscataway WRRF due to increased flows;
- Funding maintenance and repairs at critical facilities;
- Replacing 25 miles of water mains and 26 miles of sewer mains and lateral lines;
- Funding $67.9 million for large diameter pipe rehabilitation. This includes $32.9 million for PCCP inspection, repair, and acoustic fiber optic monitoring of the pipes' condition; $31.9 million for large diameter repairs and cathodic protection; $3.1 million for large valve inspections, replacement, and repairs;
- Complying with the Sanitary Sewer Overflow and the Potomac Plant Consent Orders;
- Operating and maintaining a system of 3 reservoirs impounding 14 billion gallons of water, 2 water filtration plants, 6 WRRFs, 5,900 miles of water main, and 5,700 miles of sewer main 24 hours a day, 7 days a week; and
- Proposing competitive salary enhancement considering the Counties' compensation proposals and collective bargaining agreements.

In addition to reviewing expenses and revenues for water and sewer services, we have analyzed the cost and current fee levels for other WSSC Water services. Based upon these analyses, and to better align fees with program costs, some new fees and adjustments to current fees are recommended (Section 2).

SYSTEM DEVELOPMENT CHARGE

State law provides that the System Development Charge (SDC), a charge to new applicants for WSSC Water service which is intended to recover growth costs, may be adjusted annually by the change in the Consumer Price Index for Urban Wage Earners and Clerical Workers (CPI-W) in the Washington, D.C. metropolitan area. Historically, we have adjusted the maximum allowable charge based on the change in the November CPI-W. We recommend the same this year.

BUDGET REVIEW PROCESS

The Proposed Budget is subject to the Counties' hearings, procedures, and decisions, as provided under Section 17-202 of the Public Utilities Article, of the Annotated Code of Maryland, before the final budget is adopted for the fiscal year beginning July 1, 2020.

Sincerely,

Chris Lawson
Commission, Chair

cc:
Members of Prince George's County Council
Members of Montgomery County Council
Members of the Maryland General Assembly

COMPARATIVE EXPENDITURES BY FUND

($ in Thousands)	FY 2017 Actual	FY 2018 Actual	FY 2019 Actual	FY 2020 Approved	FY 2021 Proposed	FY 2021 Over / (Under) FY 2020	% Change
Operating Funds							
Water Operating	$ 300,599	$ 320,088	$ 339,200	$ 352,472	$ 368,437	$ 15,965	4.5%
Sewer Operating	374,234	385,527	419,633	450,148	474,086	23,938	5.3%
General Bond Debt Service	15,557	19,108	18,847	14,773	13,660	(1,113)	-7.5%
Total Operating	690,390	724,723	777,680	817,393	856,183	38,790	4.7%
Capital Funds							
Water Supply	$ 263,569	$ 261,602	$ 210,783	$ 287,256	257,227	$ (30,029)	-10.5%
Sewage Disposal	280,632	190,058	152,891	334,377	308,386	(25,992)	-7.8%
General Construction	12,784	23,555	23,121	16,893	41,116	24,224	143.4%
Total Capital	556,985	475,215	386,795	638,526	606,729	(31,797)	-5.0%
Grand Total	**$ 1,247,375**	**$ 1,199,938**	**$ 1,164,475**	**$ 1,455,919**	**$ 1,462,912**	**$ 6,993**	**0.5%**

COMPARATIVE EXPENDITURES BY MAJOR EXPENSE CATEGORY

	FY 2019 Actual			FY 2020 Approved			FY 2021 Proposed		
($ in Thousands)	Capital	Operating	Total	Capital	Operating	Total	Capital	Operating	Total
Expense Categories									
Salaries & Wages	$ 27,293	$ 125,851	$ 153,144	$ 27,154	$ 130,134	$ 157,288	$ 29,080	$ 133,866	$ 162,946
Heat, Light & Power	-	19,683	19,683	-	19,444	19,444	-	20,431	20,431
Regional Sewage	-	54,809	54,809	-	59,000	59,000	-	58,000	58,000
Contract Work	202,735	14,263	216,998	383,332	15,167	398,499	353,066	22,446	375,512
Consulting Engineers	51,872	19,388	71,260	58,073	17,761	75,834	77,182	19,326	96,508
Debt Service	-	292,656	292,656	-	319,883	319,883	-	325,593	325,593
All Other	104,895	251,030	355,925	169,967	256,004	425,971	147,401	276,521	423,922
Grand Total	**$ 386,795**	**$ 777,680**	**$1,164,475**	**$ 638,526**	**$ 817,393**	**$1,455,919**	**$ 606,729**	**$ 856,183**	**$1,462,912**

FY 2020 - FY 2021 SUMMARY OF OPERATING REVENUE & EXPENSE BY BUDGET, MAJOR CATEGORY, AND FUND TYPE

($ in Thousands)	Water Operating FY 2020 Approved	Water Operating FY 2021 Proposed	Sewer Operating FY 2020 Approved	Sewer Operating FY 2021 Proposed	General Bond Debt Service FY 2020 Approved	General Bond Debt Service FY 2021 Proposed	Totals FY 2020 Total	Totals FY 2021 Total	% Chg
OPERATING REVENUES									
Water Consumption Charges	$ 280,997	$ 298,759	$ -	$ -	$ -	$ -	$ 280,997	$ 298,759	6.3%
Sewer Use Charges	-	-	377,902	396,952	-	-	377,902	396,952	5.0%
Front Foot Benefit & House Connections	-	-	-	-	12,507	10,378	12,507	10,378	-17.0%
Account Maintenance Fees	16,471	16,503	15,825	15,857	-	-	32,296	32,360	0.2%
Infrastructure Investment Fee	20,059	20,099	19,272	19,311	-	-	39,331	39,410	0.2%
Plumbing and Inspection Fees	7,470	8,380	5,430	6,090	-	-	12,900	14,470	12.2%
Rockville Sewer Use	-	-	3,000	3,000	-	-	3,000	3,000	0.0%
Miscellaneous	10,600	10,500	9,200	10,300	260	230	20,060	21,030	4.8%
Interest Income	2,000	1,000	3,500	9,000	500	600	6,000	10,600	76.7%
Subtotal Operating Revenues	337,597	355,241	434,129	460,510	13,267	11,208	784,993	826,959	5.3%
OTHER CREDITS AND TRANSFERS									
Use of Fund Balance	5,784	4,080	5,557	3,920	-	-	11,341	8,000	-29.5%
Other	-	-	-	-	11,600	9,500	11,600	9,500	-18.1%
Reconstruction Debt Service Offset	4,000	4,845	7,600	4,655	(11,600)	(9,500)	-	-	-
SDC Debt Service Offset	3,540	2,731	1,118	3,041	-	-	4,658	5,772	23.9%
Premium Transfer	1,337	692	1,563	808	-	-	2,900	1,500	-48.3%
Underwriter's Discount Transfer	-	848	-	1,152	-	-	-	2,000	100.0%
Miscellaneous Offset	214	-	181	-	-	-	395	-	-100.0%
Subtotal Other Credits and Transfers	14,875	13,196	16,019	13,576	-	-	30,894	26,772	-13.3%
Total Funds Available	**352,472**	**368,437**	**450,148**	**474,086**	**13,267**	**11,208**	**815,887**	**853,731**	**4.6%**
OPERATING EXPENSES									
Salaries & Wages	63,707	72,921	65,968	60,276	459	668	130,134	133,865	2.9%
Heat, Light, and Power	10,808	11,671	8,628	8,752	8	8	19,444	20,431	5.1%
Regional Sewage Disposal	-	-	59,000	58,000	-	-	59,000	58,000	-1.7%
All Other	131,218	140,872	125,967	145,150	730	1,256	257,915	287,278	11.4%
Subtotal Operating Expenses	205,734	225,464	259,563	272,178	1,197	1,932	466,494	499,574	7.1%
DEBT SERVICE									
Bonds and Notes Principal	84,505	72,416	111,564	104,606	10,182	8,796	206,251	185,818	-9.9%
Bonds and Notes Interest	48,711	60,588	61,527	76,255	3,394	2,932	113,632	139,775	23.0%
Subtotal Debt Service	133,216	133,004	173,091	180,861	13,576	11,728	319,883	325,593	1.8%
Total Operating Expenses & Debt Service	338,950	358,468	432,654	453,039	14,773	13,660	786,377	825,167	4.9%
OTHER TRANSFERS									
PAYGO	13,522	9,969	17,494	21,047	-	-	31,016	31,016	0.0%
Total Expenditures	**352,472**	**368,437**	**450,148**	**474,086**	**14,773**	**13,660**	**817,393**	**856,183**	**4.7%**
Net Revenue (Loss)	**-**	**-**	**-**	**-**	**(1,506)**	**(2,452)**	**(1,506)**	**(2,452)**	**62.8%**
Fund Balance - July 1	**$ 16,320**	**$ 10,536**	**$ 124,409**	**$ 118,852**	**$ 34,229**	**$ 21,123**			
Net Increase (Decrease) in Fund Balance	-	-	-	-	(1,506)	(2,452)			
Use of Fund Balance	(5,784)	(4,080)	(5,557)	(3,920)	(11,600)	(9,500)			
Fund Balance - June 30	**$ 10,536**	**$ 6,456**	**$ 118,852**	**$ 114,932**	**$ 21,123**	**$ 9,171**			

FY 2020 - FY 2021 CAPITAL FUNDING & COSTS BY BUDGET, MAJOR SOURCE CATEGORY, AND FUND TYPE

($ in Thousands)	Water Supply Bond FY 2020 Approved	Water Supply Bond FY 2021 Proposed	Sewer Disposal Bond FY 2020 Approved	Sewer Disposal Bond FY 2021 Proposed	General Construction Bond FY 2020 Approved	General Construction Bond FY 2021 Proposed	Totals FY 2020 Total	Totals FY 2021 Total	% Chg
FUNDS PROVIDED									
Bonds and Notes Issues/Cash on Hand	$ 254,490	$ 236,345	$ 278,305	$ 255,555	$ 16,012	$ 41,106	$ 548,807	$ 533,006	-2.9%
PAYGO	13,522	9,969	17,494	21,047	-	-	31,016	31,016	0.0%
Anticipated Contributions:									
Federal & State Grants	-	1,500	22,291	21,500	-	-	22,291	23,000	3.2%
System Development Charge	16,418	8,057	5,298	1,473	-	-	21,716	9,530	-56.1%
Others	2,826	1,356	10,990	8,811	880	10	14,696	10,177	-30.7%
Total Funds Provided	**287,256**	**257,227**	**334,378**	**308,386**	**16,892**	**41,116**	**638,526**	**606,729**	**-5.0%**
CONSTRUCTION COSTS									
Salaries & Wages	15,065	16,774	8,828	8,914	3,261	3,392	27,154	29,080	7.1%
Contract Work	163,664	143,327	219,668	206,567	-	3,172	383,332	353,066	-7.9%
Consulting Engineers	30,810	33,641	24,759	20,778	2,504	22,763	58,073	77,182	32.9%
All Other	77,717	63,485	81,123	72,127	11,127	11,789	169,967	147,401	-13.3%
Total Construction Costs	**$ 287,256**	**$ 257,227**	**$334,378**	**308,386**	**$ 16,892**	**$ 41,116**	**$ 638,526**	**$ 606,729**	**-5.0%**

PROPOSED RATES, FEES AND CHARGES

COMBINED WATER/SEWER OPERATING FUNDS – FY 2021 PROPOSED RATE IMPACT

7.0% Average Water and Sewer Rate Increase

Funding Sources	**FY 2021 Proposed**
Revenues at Current Rates	($ in Thousands)
Consumption Charges	$ 650,197
Account Maintenance Fee	32,360
Infrastructure Investment Fee	39,410
Miscellaneous Revenues	48,270
Subtotal	770,237
Use of Fund Balance	8,000
Reconstruction Debt Service Offset	9,500
System Development Charge Debt Service Offset	5,772
Premium Transfer	1,500
Underwriters Discount Transfer	2,000
Total Funding Sources	797,009
Requirements	
Expenditures	
Operating, Maintenance & Support Services Expenses	497,642
Debt Service	313,865
Debt Reduction (PAYGO)	31,016
Total Expenditures	842,523
Shortfall to be Covered by Rate Increase	$ (45,514)
Proposed Average Water and Sewer Rate Increase	**7.0%**

The Proposed FY 2021 budget calls for a combined 7.0% average increase in water and sewer consumption revenue. This proposed increase meets the 7.0% Spending Affordability Guidelines (SAG) limit recommended by both Prince George's and Montgomery Counties. Even with this change, WSSC Water rates remain favorable when compared to many other comparable water and sewer utilities and the average residential bill is 1.0% of the median household income as shown on page 2-5.

QUARTERLY CUSTOMER BILLS AT VARIOUS CONSUMPTION LEVELS

Meter Size	Average Daily Consumption (Gallons Per Quarter)	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
3/4" Residential Meter	100 (9,125 gal/qtr)	$ 119.53	$ 122.72	$ 127.01	$ 138.94	$ 146.69
3/4" Residential Meter	165 (15,056 gal/qtr)	200.09	206.12	213.95	217.83	231.09
3/4" Residential Meter	500 (45,625 gal/qtr)	789.94	816.40	851.99	794.66	848.58
2" Meter	1,000 (91,250 gal/qtr)	1,821.65	1,878.23	1,952.14	1,903.02	2,022.18
3" Meter	5,000 (456,250 gal/qtr)	8,881.75	9,169.19	9,552.44	9,736.92	10,378.03
6" Meter	10,000 (912,500 gal/qtr)	18,491.90	19,085.00	19,878.88	19,748.55	21,042.10

Quarterly customer bills include the Account Maintenance Fee and Infrastructure Investment Fee shown on pages 2-7 and 2-8.

WATER AND SEWER RATE SCHEDULES

Rate Schedule Proposed for Implementation July 1, 2020

Average Daily Consumption by Customer Unit During Billing Period (Gallons Per Day)	FY 2021 July 1, 2020 Proposed Water Rates (Per 1,000 Gallons)	FY 2021 July 1, 2020 Proposed Sewer Rates (Per 1,000 Gallons)	Total Combined
0 - 80.9999	$ 5.41	$ 7.31	$ 12.72
81 - 165.9999	6.10	8.13	14.23
166 - 275.9999	7.04	10.18	17.22
276 & Greater	8.25	13.44	21.69

Proposed Flat Rate Sewer Charge - $135.00 per quarter

Current Rate Schedule

Average Daily Consumption by Customer Unit During Billing Period (Gallons Per Day)	FY 2020 July 1, 2019 Approved Water Rates (Per 1,000 Gallons)	FY 2020 July 1, 2019 Approved Sewer Rates (Per 1,000 Gallons)	Total Combined
0 - 80.9999	$ 5.09	$ 6.80	$ 11.89
81 - 165.9999	5.74	7.56	13.30
166 - 275.9999	6.62	9.47	16.09
276 & Greater	7.76	12.50	20.26

Current Flat Rate Sewer Charge - $125.00 per quarter

ACCOUNT MAINTENANCE FEES – PROPOSED FOR IMPLEMENTATION JULY 1, 2020

Meter Size	FY 2020 Current Quarterly Charges	FY 2021 Proposed Quarterly Charges
Small Meters		
5/8" to 1"	$ 16.00	$ 16.00
Large Meters		
1-1/2"	16.00	16.00
2"	27.00	27.00
3"	66.00	66.00
4"	142.00	142.00
6"	154.00	154.00
8"	200.00	200.00
10"	246.00	246.00
Detector Check Meters		
2"	33.00	33.00
4"	177.00	177.00
6"	255.00	255.00
8"	461.00	461.00
10"	633.00	633.00
Fire Service Meters		
4"	182.00	182.00
6"	293.00	293.00
8"	452.00	452.00
10"	682.00	682.00
12"	989.00	989.00

This is a quarterly fee which is prorated based on the length of the billing cycle.

INFRASTRUCTURE INVESTMENT FEES – PROPOSED FOR IMPLEMENTATION JULY 1, 2020

Meter Size	FY 2020 Current Quarterly Charges	FY 2021 Proposed Quarterly Charges
Small Meters		
5/8"	$ 11.00	$ 11.00
3/4"	12.00	12.00
1"	14.00	14.00
Large Meters		
1-1/2"	90.00	90.00
2"	185.00	185.00
3"	585.00	585.00
4"	813.00	813.00
6"	1,265.00	1,265.00
8"	2,845.00	2,845.00
10"	4,425.00	4,425.00
Fire Service Meters		
4"	499.00	499.00
6"	616.00	616.00
8"	2,524.00	2,524.00
10"	2,714.00	2,714.00
12"	5,214.00	5,214.00

This is a quarterly fee which is prorated based on the length of the billing cycle.

MISCELLANEOUS FEES AND CHARGES – PROPOSED FOR IMPLEMENTATION JULY 1, 2020

The agency provides a number of services for which separate fees or charges have been established. Recent review of the costs required to provide these services indicates a need to change the amounts charged for some of the services. The fee and charge changes listed below are proposed to be effective July 1, 2020.

Inspections, Licenses, and Permits

Item	Current Charge	FY 2021 Proposed Charge	Charge Change
1 **Inspection Fees - Water/Sewer Connection Hookup, Well/Septic Hookup**			
Plumbing and Gasfitting Inspections			
New Single Family Detached Dwellings	$ 919	$ 1,011	Yes
New Attached Dwellings (townhouse/multiplex excluding apartments)	919	1,011	Yes
All Other Residential:			
Water/Well Hookup	120	132	Yes
Meter Yoke Inspection (meter only installation)	120	132	Yes
Water Hookup Converting from Well (includes 2 inspections)	240	264	Yes
Sewer/Septic Hookup	120	132	Yes
First Plumbing Fixture	120	132	Yes
Each Additional Fixture	46	53	Yes
SDC Credit Fixture Inspection (per fixture)	44	48	Yes
Minimum Permit Fee	220	242	Yes
Permit Reprocessing Fee	66	73	Yes
Long Form Permit Refund Fee (1B write-up form)	220	242	Yes
Long Form Permit Re-Issue Fee	220	242	Yes
All Non-Residential:			
Plan Review (without Permit Application)			
25 Fixtures or Less	499	534	Yes
26-200 Fixtures	1,772	2,038	Yes
Over 200 Fixtures	3,531	4,061	Yes
2nd or 3rd Review (with or without Permit Application)			
25 Fixtures or Less	173	187	Yes
26-200 Fixtures	397	457	Yes
Over 200 Fixtures	846	973	Yes
Water/Well Hookup	214	235	Yes
Meter Yoke Inspection (meter only installation)	214	235	Yes
Sewer/Septic Hookup	214	235	Yes
FOG Interceptor	214	235	Yes
First Plumbing Fixture	214	235	Yes
Each Additional Fixture	55	59	Yes
SDC Credit Fixture Inspection (per fixture)	44	48	Yes
Minimum Permit Fee	306	337	Yes
Permit Reprocessing Fee	65	73	Yes
Long Form Permit Refund Fee (1B write-up form)	320	352	Yes
Long Form Permit Re-Issue Fee	320	352	Yes

Inspections, Licenses, and Permits (Continued)

Item	Current Charge	FY 2021 Proposed Charge	Charge Change
2 License Fees for the Regulated Trades			
Reciprocal Master Plumber, Gasfitter:			
Initial Registration per type (for 2 years)	$ 112	$ 123	Yes
Registration Renewal all types (for 2 years)	96	106	Yes
Late Registration Renewal	57	63	Yes
Examined Master Plumber, Gasfitter:			
Initial Registration per type (for 4 years)	118	130	Yes
Registration Renewal all types (for 4 years)	118	130	Yes
Late Registration Renewal	57	63	Yes
Cross-connection Technician Registration	29	32	Yes
Sewer and Drain Registration and Renewal (for 2 years)	46	53	Yes
Sewer and Drain Late Renewal Fee	22	24	Yes
Journeyman License Registration:			
Initial Registration (for 2 years)	34	37	Yes
Registration Renewal (for 2 years)	34	37	Yes
Late Registration Renewal	23	25	Yes
License Transfer Fee	31	31	-
License Replacement Fee	17	18	Yes
Apprentice License Registration Renewal	12	13	Yes
3 Short Form Permit Fee (up to 3 fixtures) – Non-Refundable	103	113	Yes
4 Long Form Permit Transfer Fee (with Inspection)	176	194	Yes
5 Tapper License Fees			
Permit Fee	363	363	-
Duplicate	36	36	-
6 Watershed Use Permit Fees			
Boat Removal and Impoundment Fees			
Boat/Craft Removal and Removal Fee	103	103	-
Monthly Storage Fee for Removed Boats	82	82	-
Watershed Use Permit Fees			
Watershed Use Permit (January 1 - December 31)	72	72	-
Single Day Watershed Use Permit	6	6	-
Open Season Boat Mooring (March 15 – November 30)	82	82	-
Winter Boat Mooring (December 1 – March 14)	55	57	Yes
Rental for the Azalea Garden (4 hours)	77	77	-
Rental for the Bio-Brick Pavilion (4 hours)	77	77	-
Boarding Stable Entrance Permit	258	258	-
Adjacent Landowner Entrance Permit	82	82	-
Picnic Permit			
Picnic Permit - groups of 1-5 persons	6	6	-
Picnic Permit - groups of 6-10 persons	12	12	-
Picnic Permit - groups of 11-15 persons	19	18	Yes
7 Site Utility Inspection Fees (Non-Minor)			
Base Fee	1,133	1,133	-
Pipeline (per foot)	6	6	-

MISCELLANEOUS FEES AND CHARGES – PROPOSED FOR IMPLEMENTATION JULY 1, 2020

Discharge and Water Protection

Item	Current Charge	FY 2021 Proposed Charge	Charge Change
8 Septic Hauler Discharge Permit Fees			
Category I Residential & Septic Waste & Grease			
1 - 49 gallons (per vehicle)	$ 255	$ 257	Yes
50 - 799 gallons (per vehicle)	5,071	5,578	Yes
800 - 2,999 gallons (per vehicle)	14,464	15,910	Yes
3,000 - gallons and up (per vehicle)	34,307	34,754	Yes
January through June	50% of fee	50% of fee	-
Transfer and/or Replacement Permit Sticker	118	130	Yes
Industrial/Special Waste Disposal Fee (per 1,000 gallons)	355	366	Yes
Zero Discharge Permit Fee	118	130	Yes
Temporary Discharge Permit Fee	118 + Sewer Rate/1,000 gallons	130 + Sewer Rate/1,000 gallons	Yes
Sewer Rate - Hauled Waste	43/1,000 gallons of truck capacity	47/1,000 gallons of truck capacity	Yes
9 Industrial Discharge Control Program Fees By Category			
Industrial users subject to Categorical Pretreatment Standards			
Less than 5,000 gpd (double visit)	5,085	5,594	Yes
Greater than 5,000 gpd (double visit)	7,792	8,571	Yes
Non-discharging Categorical Industries (zero discharge)	1,370	1,507	Yes
Significant Industrial User			
Less than 25,000 gpd (single visit - priority pollutant sampling)	5,085	5,594	Yes
Greater than 25,000 gpd (double visit - priority pollutant sampling)	7,792	8,571	Yes
Penalty Charge for Late Fee Payment	5% of fee	5% of fee	-
10 Discharge Authorization Permit Fees			
Significant Industrial User – Initial Permit (for 4 years)	6,046	6,651	Yes
Significant Industrial User – Renewal (for 4 years)	2,963	3,259	Yes
Initial Zero-Discharge CIU Permit (for 4 years)	2,296	2,526	Yes
Reissued Zero-Discharge CIU Permit (for 4 years)	1,531	1,684	Yes
Temporary Discharge Permit (non – SIU)	6,046	6,651	Yes
11 Discharge Fees - Food Service Establishment (FSE)			
Full Permit FSE	537	537	-
BMP Permit FSE	152	152	-
12 Cross Connection Fees			
Test Report Fee (per report)	38	42	Yes
Base Fee for High Hazard Commercial Water Customer (per month)	16	18	Yes
Base Fee for All Other Commercial Water Customer (per month)	8	9	Yes

MISCELLANEOUS FEES AND CHARGES – PROPOSED FOR IMPLEMENTATION JULY 1, 2020

Meter Related Services and Fees

Item	Current Charge	FY 2021 Proposed Charge	Charge Change
13 **Small Meter Replacement (at Customer Request)**	$ 211	$ 215	Yes
14 **Meter Replacement Fees (Damaged or Stolen Meter)**			
5/8" w/ touch pad (inside w/remote)	150	152	Yes
5/8" w/ pit pad (outside w/o remote)	150	150	-
5/8 Meter - pad encoder	125	127	Yes
5/8" x 3/4" w/ touch pad (inside w/ remote)	126	129	Yes
3/4" w/ touch pad (inside w/ remote)	160	160	-
3/4" w/ pit pad (outside w/o remote)	151	157	Yes
1" w/ touch pad (inside w/ remote)	202	202	-
1" w/ pit pad (outside w/o remote)	196	199	Yes
1" Kamstrup Meter, UT	315	319	Yes
1 1/2" Badger Flanged Meter	561	567	Yes
1 1/2" Flanged Meter	750	750	-
1 1/2" Nipple Meter	725	739	Yes
2" Flanged Meter	1,100	1,100	-
2" 15 1/4 Flanged Meter	1,185	1,207	Yes
3" Compound Meter	3,190	3,190	-
4" Compound Meter	3,960	3,960	-
6" Compound Meter	5,830	5,830	-
Turbine, Horizontal 3" Neptune w/ pit pad	1,456	1,475	Yes
Turbine, Horizontal 4" Neptune w/ pit pad	1,952	1,975	Yes
2" Hersey MVR Turbine	1,210	1,210	-
3" Hersey MVR Turbine	2,296	2,296	-
4" Hersey MVR Turbine	3,216	3,216	-
6" Hersey MVR Turbine	4,970	4,970	-
2" Detector Check	4,562	4,615	Yes
4" Detector Check	3,195	3,275	Yes
6" Detector Check	3,761	3,850	Yes
8" Detector Check	4,876	4,986	Yes
10" Detector Check	6,224	6,350	Yes
12" Detector Check	21,946	22,211	Yes
4" Fire Service Meter	8,239	8,239	-
6" Fire Service Meter	9,874	10,037	Yes
8" Fire Service Meter	12,315	12,502	Yes
10" Fire Service Meter	14,225	14,389	Yes
12" Fire Service Meter	16,250	20,403	Yes
3" Octave UT L=24	3,050	3,095	Yes
4" Octave UT L=29/ L=33	4,034	4,095	Yes
6" Octave UT L=45	5,944	6,026	Yes
8" Octave UT L=53	9,528	9,677	Yes
10" Octave UT L=68	12,901	13,080	Yes
15 **Meter Testing Fees**			
5/8" to 1"	261	261	-
1-1/2"	424	424	-
2" and up	473	473	-

MISCELLANEOUS FEES AND CHARGES – PROPOSED FOR IMPLEMENTATION JULY 1, 2020

Meter Related Services and Fees (Continued)

Item	Current Charge	FY 2021 Proposed Charge	Charge Change
16 Sub-Meter Installation Fees			
One-time Sub-Meter Charge - Small	$ 261	$ 261	-
One-time Sub-Meter Charge - Large	528	528	-
One-time Inspection Fee	57	66	Yes
Minimum Permit Inspection Fee	200	220	Yes
17 Water Turn-Off, Turn-On Fees			
Small Meter Turn-Off	80	80	-
Small Meter Turn-On	97	100	Yes
Large Meter Turn-Off	203	203	-
Large Meter Turn-On	241	241	-
18 Call Back Fee (small meters, plumbers)	93	93	-
19 Call Back Fee (large meters, plumbers)	262	301	Yes
20 Missed Appointment Fees			
First Missed Appointment or Turn-On	97	97	-
Each Additional Missed Appointment	110	110	-
21 Meter Reinstallation Correction Fee	388	388	-
22 Sewer Meter Maintenance Fee (per year)	12,003	13,803	Yes
Quarterly Calibrations (per quarter)	3,001	3,451	Yes
23 Property Inspection Fee	115	119	Yes
24 Warehouse Restocking Fee	39	47	Yes

Fire Hydrant Services and Fees

	Item	Current Charge	FY 2021 Proposed Charge	Charge Change
25	**Temporary Fire Hydrant Connection Fees**			
	3/4" Meter - Deposit			
	2 Weeks or Less w/approved payment record	No fee	No fee	-
	Over 2 Weeks/Less than 2 weeks w/unapproved payment record	$ 379	$ 379	-
	3" Meter - Deposit			
	2 Weeks or Less w/approved payment record	No fee	No fee	-
	Over 2 Weeks/Less than 2 weeks w/unapproved payment record	2,420	2,420	-
	Service Charge			
	2 Weeks or Less (3/4" meter)	62	68	Yes
	2 Weeks or Less (3" Meter)	130	130	-
	Over 2 Weeks (3/4" and 3" Meters)	175	175	-
	Water Consumption Charge - 3/4" Meter	Approved rate for 1,000 gal ADC; $33 min.	Approved rate for 1,000 gal ADC; $36 min.	Yes
	Water Consumption Charge - 3" Meter	Approved rate for 1,000 gal ADC; $214 min.	Approved rate for 1,000 gal ADC; $229 min.	Yes
	Late Fee for Return of Meter (per day)	10	10	-
	Fee on Unpaid Temporary Fire Hydrant Meter Billings	1.5%/month	1.5%/month	-
	Loss/Destruction of Meter	Replacement cost	Replacement cost	-
	Loss/Destruction of Wrench	40	40	-
26	**Truck Inspection Fee w. Attached Fire Hydrant Meter (2 Years)**	52	52	-
27	**Fire Hydrant Inspection Fee (per hydrant)**	137	158	Yes
	Controlled Access Surcharge Fee	26	30	Yes
28	**Fire Hydrant Flow Test Fees**			
	No Current Test	693	693	-
	Current Test	83	83	-

MISCELLANEOUS FEES AND CHARGES – PROPOSED FOR IMPLEMENTATION JULY 1, 2020

Development Services

Item	Current Charge	FY 2021 Proposed Charge	Charge Change
29 Feasibility Review Fees (WSSC Water Built)			
Feasibility Submission Fee (Non-refundable)	$ 1,780	$ 1,956	Yes
Feasibility Review & Report Fee Deposit *(can be deferred as deficit when extension is completed)*	11,862	13,048	Yes
30 Construction Services Fee	9.3% of WSSC Water unit cost estimate or 12.0% of contractor's cost estimate	9.3% of WSSC Water unit cost estimate or 12.0% of contractor's cost estimate	-
31 Design Review			
Development is more than 10 Residential Units or Commercial	6,500	6,500	-
Development is 10 Residential Units or Less	3,250	3,250	-
32 Extra Review Fees			
<u>Per SEP Plan Review:</u>			
Minor Additional Reviews of Unsigned or Signed Plans (per review)	1,202	1,322	Yes
Major/Splitting Additional Reviews of Unsigned or Signed Plans (per review)	2,453	2,698	Yes
<u>Per Site Utility/Minor Utility Additional Signed or Unsigned Plan Review:</u>			
Site Utility (per review)	1,458	1,604	Yes
Minor Site Utility (per review)	379	417	Yes
<u>Per Hydraulic Planning Analysis/Systems Planning Forecast Application:</u>			
Additional Review of Required Data (per application)	822	904	Yes
33 Hydraulic Planning Analysis and System Planning Forecast			
Modeling and Re-Modeling Fee - Up to 3 parts	1,840	2,116	Yes
Modeling and Re-Modeling Fee - per part over 3	765	765	-
Pressure Sewer System Review Fee - per system	367	404	Yes
34 In-House Design Deposit	Deposit	Deposit	-
35 Partial Release for Service Fee	1,398	1,468	Yes
36 Off-Property Service Connection Reimbursement	Prevailing service connection fee	Prevailing service connection fee	-
37 Service Connection Application and Inspection Fee (per permit)	2,434 water and/or sewer connection	2,434 water and/or sewer connection	-
38 Government Referred Plan Review Fees			
Major Development – Over 10 Units	1,583	1,693	Yes
Minor Development – 10 or Less Units	791	791	-
Re-Review Fee for Major Development	791	791	-
Re-Review Fee for Minor Development	396	396	-

Development Services (Continued)

Item	Current Charge	FY 2021 Proposed Charge	Charge Change
39 Pre-Screen Fee All Plan Types	$ 365	$ 394	Yes
40 Site Utility (On-Site) Review Fees			
Base Fee	3,522	3,631	Yes
Additional Fee per 100 feet	332	352	Yes
Minor (Waived) Site Utility (On-Site) Fee	1,106	1,217	Yes
41 Name/Transfer of Ownership Change Fee	250	275	Yes
42 Variance Review Fee	1,238	1,362	Yes

MISCELLANEOUS FEES AND CHARGES – PROPOSED FOR IMPLEMENTATION JULY 1, 2020

Pipeline, Engineering, and Environmental Services

Item	Current Charge	FY 2021 Proposed Charge	Charge Change
43 Shut Down/Charge Water Main Fee	$ 1,177	$ 1,177	-
Shut Down/Complex Water Main Fee	2,144	2,144	-
44 Fees for Review and Inspection of Site Work Potentially Impacting WSSC Pipelines			
Simple Review	399	399	-
Complex Review / Non-DR Developer Review	2,615	3,138	Yes
Inspection for minor adjustment / Non-DR Developer (per inspection)	266	266	-
45 Relocation Fees			
Relocation Design Review Fee	6,500	DELETE	Yes
Inspection Fee for MOU Project (minimum charge up to 4 hours)	600	600	-
46 Connection Abandonment Fees			
County Roads (Except Arterial Roads) - Water	1,474	1,474	-
County Roads (Except Arterial Roads) - Sewer	1,873	1,873	-
State Roads and County Arterial Roads - Water	1,778	1,778	-
State Roads and County Arterial Roads - Sewer	2,200	2,200	-
47 Chlorination Confirmation Test Fee (per first test)	247	247	-
Re-Test or Additional Tests (per hour)	157	173	Yes
48 Re-Test or Additional Tests Chlorination and Pressure Test (per test)	157	173	Yes
Inspector Overtime (per hour)	206	206	-
49 Review Fee for Additional Reviews of Contract Documents and As-Builts (per hour)	206	206	-
50 Residential Outside Meter Housing Upgrade/Pipe Alteration	6,786	6,805	Yes
51 Utility Erosion and Sediment Control Permit Fees			
Minor Projects (less than 125 linear ft OR less than 42 in. deep and 20 in. width)	0.23	0.26	Yes
Major Projects (per linear foot)	0.34	0.39	Yes
Minimum for Major Projects	124	124	-
52 Right-of Way Release or Subordination Review Fee (per document)	1,236	1,335	Yes
53 Right-of-Way Acquisition and Condemnation for SEP Projects	Reimbursement	Reimbursement	-
54 Environmental Site Review Fee			
With Database Search Submitted by Applicant	331	381	Yes
55 Feasibility Report and Committee Review Fee for On-Site Takeover Projects	1,120	1,288	Yes

MISCELLANEOUS FEES AND CHARGES – PROPOSED FOR IMPLEMENTATION JULY 1, 2020

Publications and Administrative

Item	Current Charge	FY 2021 Proposed Charge	Charge Change
56 Fee for Sale of Copies of Plans, Plats, and 200' Reference Maps			
Xerographic bond paper copy (per sheet)	$ 6	$ 6	-
57 Fee for Sale of WSSC Plumbing and Fuel Gas Code (Plumbing Code)			
Sale of Plumbing Regulation (per book)	42	46	Yes
58 Fees for Sale of Contract Specifications, Contract Specification Books, Drawings, Design Manuals, Standard Details, and General Conditions			
<u>Construction Specifications/Drawings</u>			
Utility Contracts (up to $20)	11 - 20	11 - 20	-
Facility Contracts (up to $450)	40 - 450	40 - 450	-
Construction Standard Details	60	66	Yes
Construction General Conditions & Standard Specifications	53	61	Yes
SEP Construction General Conditions & Standard Specifications	53	61	Yes
<u>Procurement Specifications/Drawings/General Conditions</u>			
with Routine Specifications	No charge	No charge	-
with Complex/Voluminous Specifications (up to $200)	40 - 200	40 - 200	-
59 Charge for Photocopies of WSSC Water Documents			
Readily Available Source Material (per single sided page)	0.30	0.30	-
Certified Copy of Readily Available Source Material (per single sided page)	0.60	0.60	-
Scanning Documents (per single sided page) (A reasonable fee may be charged for time in excess of two hours expanded by WSSC Water in searching for requested records or preparing such records for inspection and copying.)	0.30	0.30	-
60 Fee for WSSC Pipeline Design Manual	90	90	-
61 Sale of WSSD Laws			
Bound Volume	83	83	-
Supplements	42	45	Yes
62 Facilities Design Guideline Fee	40	DELETE	Yes
63 Fee for Transcribed Tape of a Hearing or Meeting	Prevailing fee charged by vendor	Prevailing fee charged by vendor	-

Other Fees and Charges

Item	Current Charge	FY 2021 Proposed Charge	Charge Change
64 Patuxent Watershed Civil Citation Fee (State Mandated)			
First Offense	$ 150	$ 150	-
Each Additional Offense Within Calendar Year	300	300	-
65 Civil Citation Fees - Sediment Control, Theft of Service, and Plumbing Civil Citations (State Mandated)			
First Offense	250	250	-
Second Offense	500	500	-
Third Offense	750	750	-
Each Violation in Excess of Three	1,000	1,000	-
66 Lobbyist Registration Fee (Code of Ethics)	100	110	Yes
67 Dishonored Check Fee & Electronic Payment Fee	46	46	-
(Applies to all dishonored checks and dishonored electronic payments)			
68 Credit Card Surcharge	2% of amount charged	2% of amount charged	-
(Applies to customer payment of any fee/charge by credit card (MasterCard and Visa) other than water and sewer billing.)			
69 Protest Filing Fee	770	847	Yes
70 Preparation of Hold Harmless Agreement Fee	1,228	1,351	Yes
71 Connection Redemption Fee	44	44	-

SYSTEM DEVELOPMENT CHARGE – PROPOSED FOR IMPLEMENTATION JULY 1, 2020

	FY 2020 Current Charges	FY 2021 Proposed Charges	Current Maximum Allowable	Proposed Maximum Allowable
Apartment				
Water	$ 896	$ 896	$ 1,330	$ 1,346
Sewer	1,140	1,140	1,694	1,714
1-2 toilets/residential				
Water	1,344	1,344	1,998	2,022
Sewer	1,710	1,710	2,538	2,568
3-4 toilets/residential				
Water	2,240	2,240	3,328	3,368
Sewer	2,850	2,850	4,234	4,285
5 toilets/residential				
Water	3,135	3,135	4,658	4,714
Sewer	3,991	3,991	5,929	6,000
6+ toilets/residential (per fixture unit)				
Water	88	88	132	134
Sewer	115	115	173	175
Non-residential (per fixture unit)				
Water	88	88	132	134
Sewer	115	115	173	175

No increase is proposed for the System Development Charge for FY 2021 in any category. The maximum allowable charge is being adjusted pursuant to Division II, Section 25-403(c) of the Public Utilities Article of the Annotated Code of Maryland, based on the 1.2% change in the Consumer Price Index for Urban Wage Earners and Clerical Workers (CPI-W) for all items in the Washington, D.C. metropolitan area from November 2018 to November 2019.

WRITTEN TESTIMONY

SPEAKER'S SIGN-UP SHEET

WSSC PUBLIC HEARING
MONTGOMERY COUNTY

FISCAL YEAR 2021 PRELIMINARY PROPOSED BUDGET
MONDAY, JANUARY 27, 2020 @ 7:30 p.m.

PLEASE PRINT NAME	PLEASE PRINT ADDRESS	PLEASE PRINT REPRESENTING
Natalie Rosser	13114 Mica Court, Silver Spring MD 20904	Self
Robert Janko	11209 Trippon Court, North Potomac, MD 20878	Self
Jozef PLACHY	6104 Stonehenge Pl. 20852	Self
Cynthia Levin		
Jackie Copeland		
Jackie Hoglund	11 Russell Rd. Cabin John, MD 20818	Cabin John Gardens Inc
"	jhoglund1@yahoo.com	

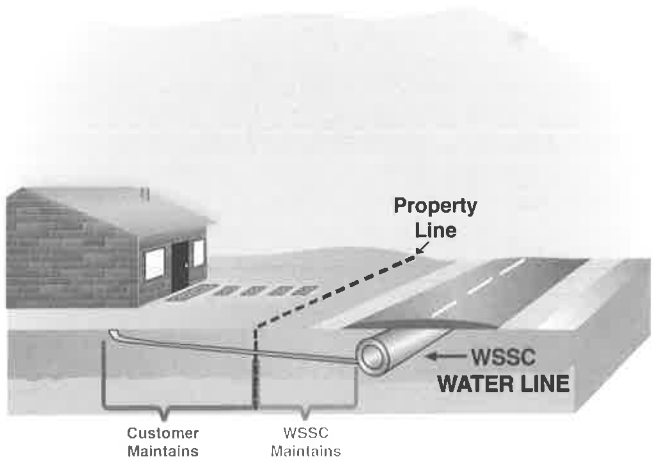
WSSC WATER
DELIVERING THE ESSENTIAL

Allow WSSC clients to collect their water meter data via their wired broadband service. The WSSC smart water meter should include both an Ethernet cable connector and a wireless connection or let the customer pick between a wired meter and a wireless meter. A wired connection would allow the customer to connect to FIOS and XFinite broadband services among others.

People are concerned about wireless transmission of data. These people want to opt out of wireless transmission of data. WSSC wants to reduce its cost for collecting water usage data. This win-win solution would allow WSSC clients to pick what form of data transmission they want to employ: a wired connection or over the air.

Robert C. JANKU
11209 TRIPPON CT.
NORTH POTOMAC, MD.
20878

Water service line disruptions: Here's How They May Affect Homeowners



The service line beyond the property boundary may be an additional responsibility of the homeowner, but it is not included in this coverage.

Replace water service line (26-100 ft.) **$2,585**
PLAN MEMBERS: NO CHARGE‡

Locate, excavate and repair leak **$798**
PLAN MEMBERS: NO CHARGE‡

‡National average repair costs within the HomeServe network as of March 2018. No charge for covered repairs.

Exclusions apply. See details in accompanying letter.

One of the most common misconceptions regarding water infrastructure is that the utility or the government will take care of the problem if there is a leak on private property, but the homeowner is primarily responsible for the service line that brings fresh water to their home. The bottom line is that homeowners should take steps today to prepare themselves and protect their finances from the costs and damages of water-line related home emergencies.

Homeowners are largely unaware that a leak on their own property is likely their responsibility to fix, often at significant cost. 61% of Americans are unaware that they are responsible for the line that runs from the street to their home.[1]

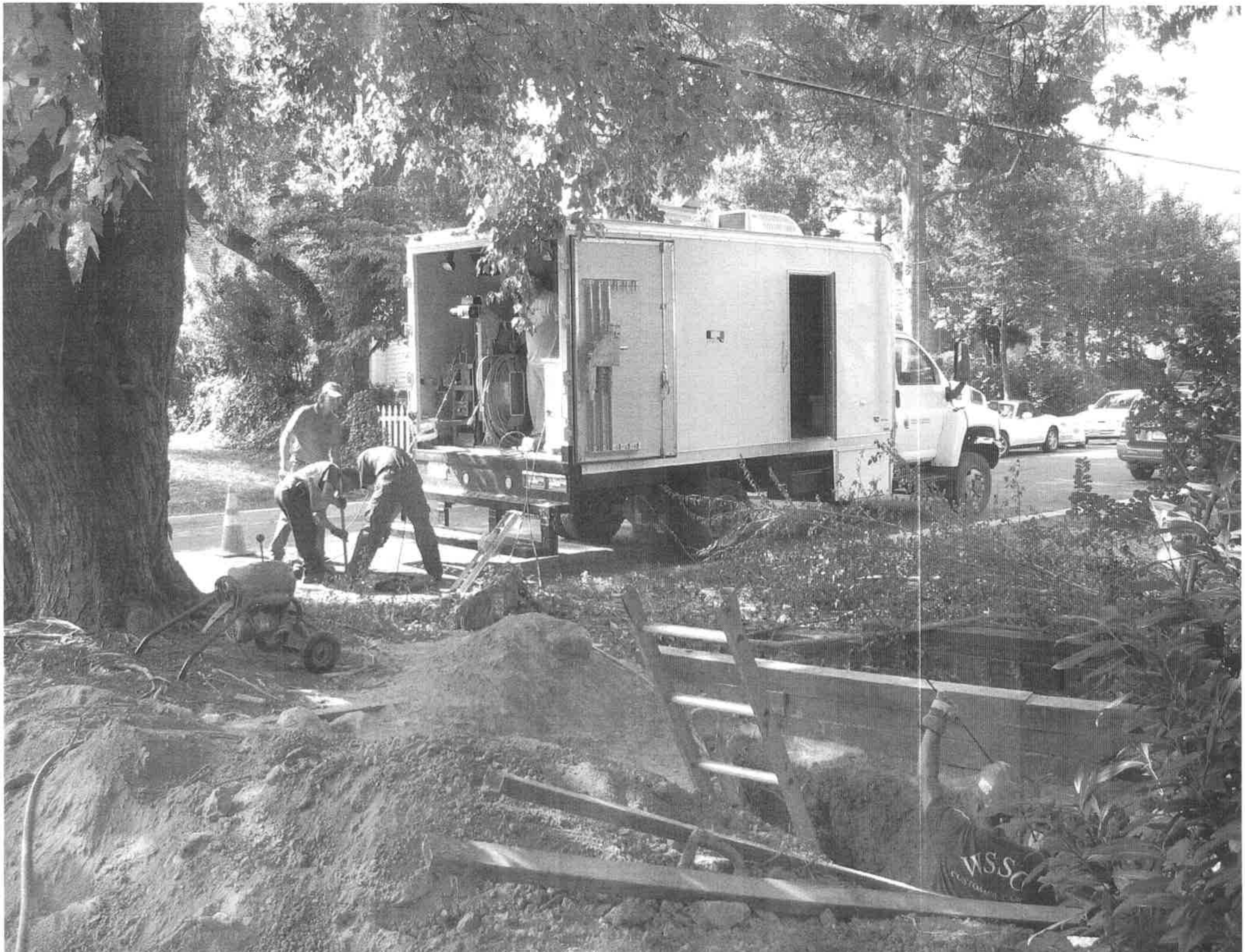
Many may mistakenly assume that the damage is covered by their homeowners insurance policy. Most basic homeowners insurance policies do NOT cover water line breaks due to normal wear and tear on a homeowner's property.

The price tag for replacing a water service line averages $2,500.[2] Homeowners can take steps today to prepare themselves and protect their water service lines and finances from the costs and damages of water-related home emergencies.

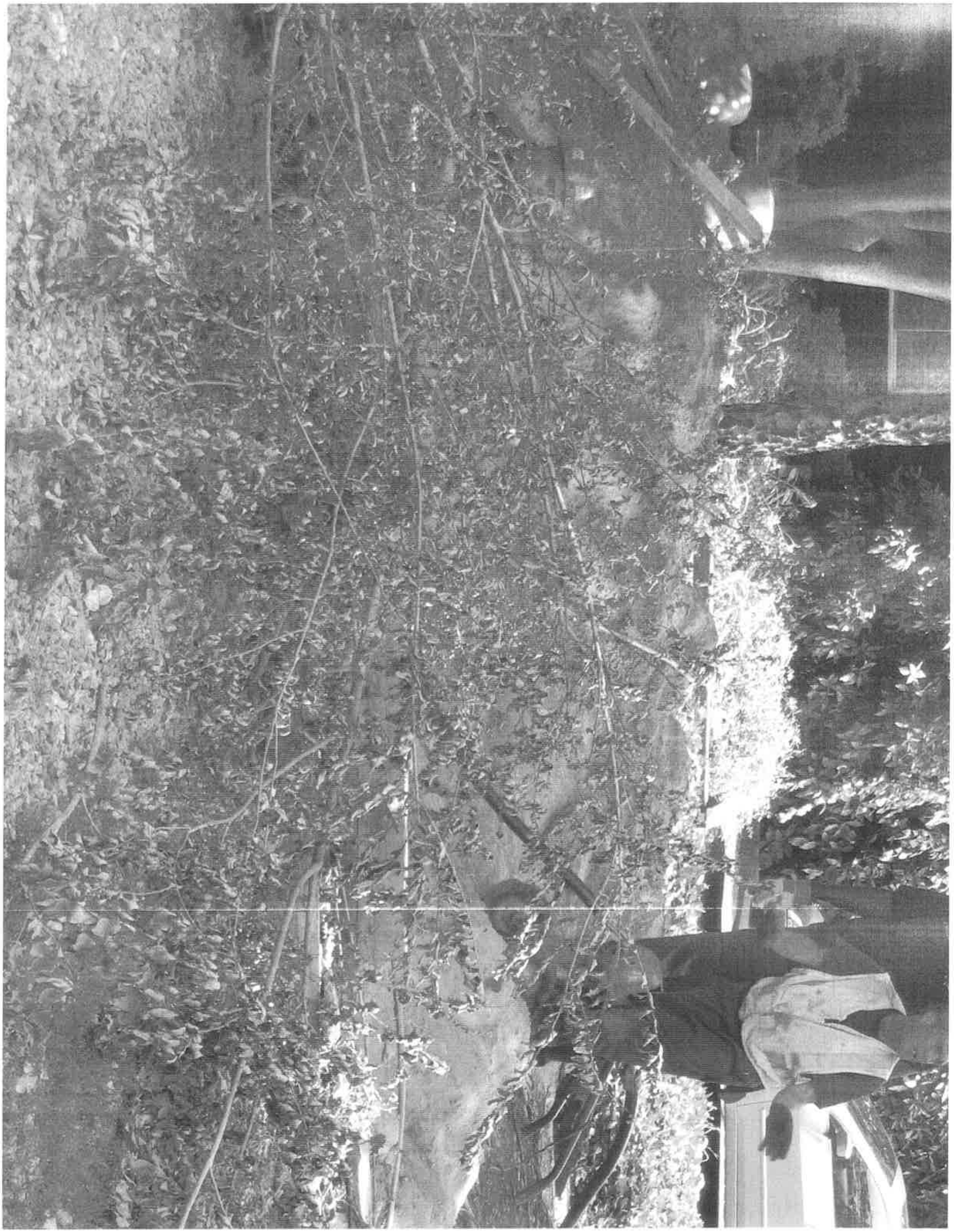
August 6, 2007

[1]Ipsos Public Affairs, 2012.
[2]Estimate based on national average repair costs within the HomeServe network, March 2018.

1902_WA_QR_INS


WSSC

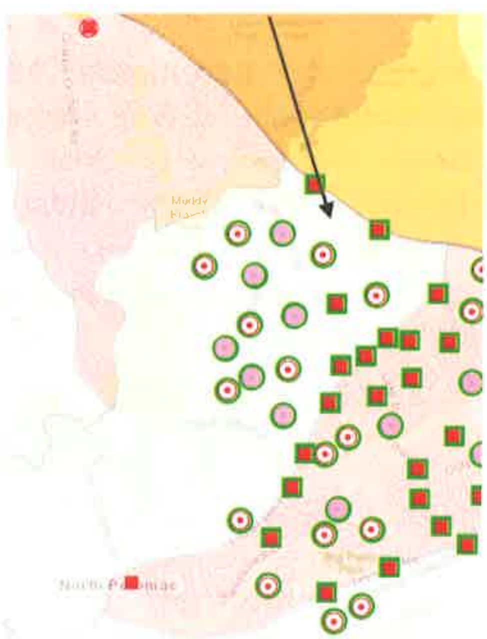
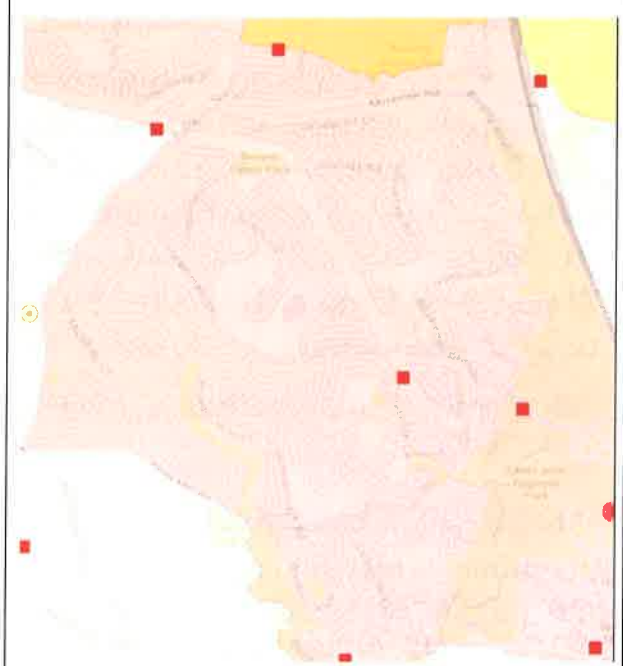

CAUTION



2) Comparing Population density

The location of small cell towers in Dufief, Flints Grove and Westleigh doesn't seem to be based on population density. It's arbitrary. It means we are getting cell towers when areas such as North Bethesda and Potomac are not.

The North Potomac area contains two different population densities. The population density in Dufief, Flints Grove and Westleigh is in light grey/tan, which means it's less dense than in North Bethesda in light pink and parts of Potomac in light pink.

Dufief, Flints Grove, Stonebridge and Westleigh in North Potomac	North Bethesda and Potomac
	

Health

Any health effects translate directly into decreased real estate value of our homes. I believe the county council is allowed to be concerned about decreased property values under the FCC rules.

1) DNA Damage found in NTP Study

This peer-reviewed scientific study "Evaluation of the genotoxicity of cell phone radiofrequency radiation in male and female rats and mice following subchronic exposure" was published in Environmental and Molecular Mutagenesis by National Toxicology Program (NTP) scientists of the National Institutes of Environmental Health Sciences."

https://ehtrust.org/cell-phone-radiation-is-associated-with-dna-damage-in-peer-reviewed-analysis-of-ntp-study/

Abstract

https://www.ncbi.nlm.nih.gov/pubmed/31633839

2) Ramazzini Institute Study

Fiorella Belpoggi Ph.D., Ramazzini Institute

"Our findings of cancerous tumors in rats exposed to environmental levels of RF are consistent with and reinforce the results of the US NTP studies on cell phone radiation, as both reported increases in the same types of tumors of the brain and heart in Sprague-Dawley rats. Together, these studies provide sufficient evidence to call for the International Agency for Research on Cancer (IARC) to re-evaluate and re-classify their conclusions regarding the carcinogenic potential of RFR in humans,"

https://ehtrust.org/worlds-largest-animal-study-on-cell-tower-radiation-confirms-cancer-link/

"I believer irresponsible to implement any new wireless technologies in neighborhoods where people would be continuously exposed before thorough evaluations are made of potential adverse health effects."
Ron Melnick, Ph.D.
https://www.youtube.com/watch?v=N9LLfFxJTVg&t=15m7s

3) National Toxicology Program (NTP)

"Scientific panel advises there is evidence for an association between both heart and brain cancers and cell phone radiation in large-scale animal study (Triangle Park, NC)." "Scientists concluded there is "clear evidence" linking cell phone radiation to the development of cancers in rats. The U.S.

government invited an expert panel to make a majority-rules declaration in response to the $25 million U.S. government National Toxicology Program (NTP) study of cell phone radiation in animals. After a three-day review of the study data, they voted to strengthen the conclusions that cell phone radiation caused health effects in the cell phone radiation exposed rats and mice."

https://ehtrust.org/clear-evidence-of-cancer-concludes-the-expert-panel-to-the-us-national-toxicology-program-on-cell-phone-radiation-study-findings/

4) Stunted Trees

Radiofrequency radiation injures trees around mobile phone base stations

Damage only on one side: The tree shows damage only on one side. The damage can be recognized with the naked eye.

Full text report

http://media.withtank.com/cf9ae35027/waldmann-selsam_2016_scitotenv572p554-569_rf_trees.pdf

Summary

http://scientists4wiredtech.com/oakland/radiofrequency-radiation-injures-trees-around-mobile-phone-base-stations/

Since we cannot worry about the growing evidence of a health risk to humans, maybe we can worry about the damage to trees.

5) Exposure limits are much greater than other countries

NATION	EXPOSURE LIMITS FROM WIRELESS TRANSMITTERS
USA standard	580 microwatts
Russia	10 microwatts
China	6 microwatts
Italy	5 microwatts
Switzerland	4.2 microwatts
Salzburg, Austria	.1 microwatt
Liechtenstein	.1 microwatt

6) More Health Studies

This site contains many links to health studies showing the negative effects of cellular signals

https://www.telecompowergrab.org/science.html

Land topography and terrain in Westleigh – Do not block cellular signals

The terrain of Dufief, Falls Grove and Westleigh in Montgomery County is on a hillside. Dufief Mill Road is at the top of the hill at 410 feet. The low point is farthest away from Dufief Mill road at 350 feet. This means that antennas on top of the power poles along Dufief Mill Road have an excellent view.

Crown Castle representative at Germantown meeting stated that terrain features blocked signals. However, I didn't find my signals being blocked. I get a constant 3 bars on my iPhone 4, which uses 3g when I visited 15 of 15 the proposed cell tower sites in Dufief, Falls Grove and Westleigh. I got 2 bars at proposed pole site, but 3 bars five fee away. See Signals section below on page 62.

January 27, 2020

Dear WSSC,

Thank you for your assistance in last year's WSSC public comment meeting in Rockville, and during our phone calls and meetings since. It has been a pleasure working with you.

I'm writing to you to repeat last year's testimony on behalf of Cabin John Gardens, Inc. As you may recall, I was asking for the elimination of the Ready to Serve charges as we are directly paying for the maintenance and repair of our on-site infrastructure, and feel that the combination of both WSSC fees and the necessary co-op fees amounts to a hardship to our members.

I know that you know what it entails to manage the thousands of miles of infrastructure to manage the water and manage our sewage needs of Montgomery and Prince George's counties, but imagine the economies of scale for our neighborhood managing that same work:

- Replace water and sewer lines as needed
- Fix water main breaks, repair the streets after the water main breaks
- Flush the sewer lines on a regular basis
- Maintain the sewer lines against tree root damage
- Repair laterals (not in the WSSC's domain, but it is in ours)
- Pay for any water lost due to a water main break
- Pay for hydrant repair, replacement, and testing
- Pay an employee to manage the infrastructure, including being on call for emergencies
- Ask an all volunteer board to manage the infrastructure projects

This does not come cheap: the water/sewer repair report for our budget from 2001-2018 (not including street repairs, manager salary, or water bill) shows $713,000 in work. This does include a number of lateral replacements, but that is a small percentage of the outlay.

To look at the numbers, the entire co-op is serviced by a single 8" Fire Service meter, with one monthly bill paid by the corporation. The 2018 Ready to Serve charges for an 8" Fire Service Meter are:

Account Maintenance Fee:	$452/quarter, $1808 per year
Infrastructure Maintenance Fee:	$2,524/quarter, $10,096 per year
Total annual fees:	$11,904
Per household:	$119.04

In contrast, the Ready to Serve charges for a typical fee simple house with a ¾" water line connection is:

Account Maintenance Fee:	$16/quarter, $64/year
Infrastructure Maintenance Fee:	$12/quarter, $48
Total annual fees:	$112

At first glance, the costs seem proportional. But consider...the WSSC has a single account with CJG, and CJG pays a single bill. And we have a single point of contact for our water and for our sewer. But for the same fee in an area of fee simple homes, the WSSC has to maintain 100 separate accounts, 100 separate water line connections, 100 lateral connections, all of the water/sewer mains connecting them, the hydrants, and has to handle emergency calls 24x7.

A second point is the discrepancy in infrastructure charges for the various sizes of fire service meters. There is a discrepancy in charges per square inch of pipe size between the various sizes – see attached chart.

I look forward to hearing from you.

Regards,
Jackie Hoglund
Treasurer, Cabin John Gardens, Inc.
301-661-6916
Jackie_hoglund@cjgardens.org

② mistake

	Per Quarter	Annually	Per household
Account Maintenance Fee	452.00	1,808.00	18.08
Infrastructure Maintenance Fee	2,524.00	10,096.00	100.96
Totals		**11,904.00**	**119.04**

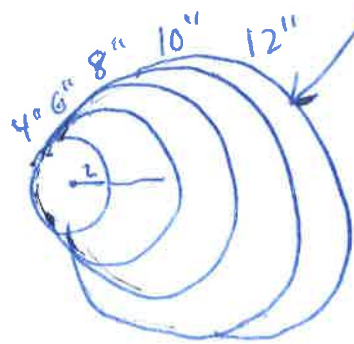
Account Maintence Fees

Fire Service Meters	Per Quarter	Radius	Area	Cost / sq in
4"	182	2	12.56	14.4904459
6"	293	3	28.26	10.3680113
8"	452	4	50.24	8.99681529
10"	682	5	78.5	8.68789809
12"	989	6	113.04	8.74911536

Infrastructure Fees

Fire Service Meters	Per Quarter	Radius	Area	Cost / sq in
4"	499	2	12.56	39.7292994
6"	616	3	28.26	21.7975938
8"	2524	4	50.24	50.2388535
10"	2714	5	78.5	34.5732484
12"	5214	6	113.04	46.1252654

Area



February 17, 2019

To WSSC Commissioners:

T. Eloise Foster, Chair
Chris Lawson, Vice Chair
Fausto R. Bayonet
Omar M. Boulware
Howard A. Denis
Thomasina V. Rogers

RE: WSSC AMI Smart Water Meter Roll-Out

Dear Commissioners:

I understand you are having a meeting on Wednesday, February 20th at 10:00 a.m. to discuss the AMI smart water meter roll-out, among other items. I have decided to write to you to share those concerns and I hope that you genuinely listen to them and consider them. I hope that you consider providing an "opt out" feature to the smart meters to allow individuals who may not want them to not have such a meter forced upon them and consider appropriate "opt out" fees or no fee options as well.

Listed below are some of the major concerns with these meters. I have provided source documentation below each for your information:

(1) Accountability: Radio Frequency radiation (RF) emitted by the smart meters is the same as from a cell phone and tower which have been identified several years ago by the World Health Organization as a Class 2B "possible carcinogen" and on Sept. 6, 2018 a peer review suggested such RF be upgraded to a "known human carcinogen" Group 1. Providers of towers and cell phones and other RF emitting devices acknowledge, and have for years, that their products have been linked to health concerns including cancer. They also acknowledge they are unable to maintain adequate insurance coverage to cover losses associated with something like this.

The same goes for providers of smart meters. Below is an excerpt from the Annual Report to Shareholders of Itron, a large manufacturer of smart meters:

> The safety and security of the power grid and natural gas and water supply systems, the accuracy and protection of the data collected by meters and transmitted via the smart grid, concerns ***about the safety and perceived health risks of using radiofrequency communications,*** and privacy concerns of monitoring home appliance energy usage have been the focus of recent adverse publicity. Unfavorable publicity and consumer opposition may cause utilities or their regulators to delay or modify planned smart grid initiatives. Smart grid projects may be, or may be perceived as, unsuccessful [⋯..]
>
> ***We may be subject to claims that there are adverse health effects from the radio frequencies utilized in connection with our products. If these claims prevail, our customers could suspend implementation or purchase substitute products, which could cause a loss of sales***.
>
> Source: https://www.sec.gov/Archives/edgar/data/780571/000078057118000013/itri10k12312017.htm

Similar to the dialogue with cell tower providers, smart meter providers offer no real compliance or maintenance programs to regularly check to ensure the RF emitting from their towers/meters meets any sort of safety standards. The Federal Communication Commission ("FCC"), the regulator of RF emissions, states on its website it does not have capacity to determine if cell towers complying with RF emissions – certainly it would not be able to inspect these other devices.

(2) Privacy: cybersecurity concerns can increase in homes with wireless networks. Read recent articles showing concern over new technologies such as 5G which is relevant here. See below.

Source:

https://www.inverse.com/article/48293-5g-future-cybersecurity-risks

(3) Health: Smart meters emit RF and contribute to cancer and other health problems including raising blood sugar levels with people who are diabetics. Some people are electrically hypersensitive and develop symptoms, such as cognitive, neurological, and sleep problems from RF. But EVERYONE is affected by RF even if you can't feel it – see the study below on diabetes. People should be able to opt out at no cost to preserve their health. The health issues of smart meters and cell towers, both products emitting RF, has been getting national attention for years. Most recently, please see the letter that Senator Blumenthal (CT) sent to FCC Commissioner Carr on the health effects of 5G and RF generally asking that it study this area as people are being exposed to dramatically increased amounts of RF in their daily lives. The FCC last considered RF safety limits (and it considered them largely for workers as people were not exposed to the extent they are today) in 1996 and their standards were based on data from the 1980s. A link to this letter and a press release on it from the National Institute of Science, Law and Public Policy are below. Also below (smart grid awareness) is a letter by the Department of Interior stating the FCC's regulations are outdated.

Sources: https://www.businesswire.com/news/home/20181203006017/en/Blumenthal-Presses-FCC-Commissioner-Brendan-Carr-Disclose

http://electromagnetichealth.org/wp-content/uploads/2018/12/IMG_20181203_0002.pdf

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4661664/

https://smartgridawareness.org/2014/03/23/can-we-protect-birds-and-people/ (U.S. Department of Interior Declares FCC Standards "Out of Date" and Inapplicable)

(4) Litigation: If you are set on launching a program deploying smart meters, does it make sense to not have an "opt out" option which may result in public outcry and litigation. Several states have free opt outs for "smart" radiating meters, and when states do not, lawsuits have resulted in forcing an opt out as is exemplified recently in Iowa by a recent court decision that cites the fact that the companies are aware but not enforcing the RF safety instructions on their products and some meters do not even comply with the very outdated FCC safety requirements.

Sources:

https://ehtrust.org/wp-content/uploads/Final-ruling.pdf (Iowa case)

https://ehtrust.org/wp-content/uploads/Lipman-Matara-Post-Hearing-Brief-PUBLIC.pdf (RF safety instructions; non-compliance with FCC p.7)

(5) Trends Toward No-Fee Opt-Out: Many localities have no fees for opting out. For example, Indiana (Duke Energy) makes it free IF you sign up for the Read-Your-Own Meter Program. In California, opt out

fees are no longer collected after 3 years. They are "sunsetted." New Mexico, Oregon, Tennessee, Vermont, Los Angeles, California, New York/Central Hudson have no fee. North Carolina has no fee if for health reasons. Texas offers low-income fee option. Below is a chart of opt out states but does not readily distinguish between fee-based or no charge opt outs but ***the ability to "opt out" of having a smart meter is overwhelmingly the trend***.

Source: https://www.ehs.group/smart-meter-opt-out-chart.php

(6) Discriminatory Effects of Meter Placement: Localities, like the Montgomery County Council, have labored over the issue of safe distances from cell towers as the wireless industry pushes its "5G small cells" into residential areas as close as 30 feet from homes in public rights of way. Larger towers must be 300 feet from a home. Think then about smart meters – some homes have them 30-40 feet away from a living space while some homes have them 1-2 feet (opposite wall) of a living space and some apartment or townhome complexes may have "bank" of meters on a single wall in close proximity to one residence. How can you standardize this so that ALL individuals are allowed a safe distance from a meter. Would WSSC be amenable to re-locating water meters should a customer request so that customer would be allowed the maximum distance from their own water meter. Have those costs been considered and/or estimated by WSSC if it chooses not allow an individual to "opt out."

The smart meters themselves disclose that people should not be closer than 20 cm to them. Remember also that they are basing this on FCC data over 30 years old! Please see the Iowa Legal Brief section on "IPL has not met its burden to show that the transmitting module in the Sensus Stratus meter and other meters are FCC compliant." The legal brief details how providers of these meters are aware of the safety distance but do not tell customers.

Source: https://ehtrust.org/wp-content/uploads/Lipman-Matara-Post-Hearing-Brief-PUBLIC.pdf

(7) Cost Efficiency. The cost savings of smart meters is debatable. Evidence is showing that smart meter systems may not significantly curtain U.S. electricity use. One example, in 2011 a pilot program across the country showed little or no savings and the Connecticut Attorney General announced the pilot program results shows no beneficial impact on the state and the benefits of advanced meters would not merit the $500 million cost of implementation. Studies also suggest that smart meters themselves use more energy to perpetually signal the "mesh" system. Further, a Consumer Digest report states that "what is discouraging about the all-but-mandatory dynamics of the smart-meter transition is that it's appealing only if you are willing to pay a lot of money to save a little electricity … if the success of the smart meter transition is based on consumers saving money and energy in the long run, we can't help but imagine that it could take decades for that to happen – if it ever does."

Query if the removal of perfectly working analog meters contributes to environmental waste. If cost is a factor having drivers quarterly read out meters – and our driver is wonderfully nice – could he not have an electric car or hybrid to save money; wouldn't that reduce the carbon footprint at a much reduced cost while maintaining the contact with the end-user. Sometimes seeing a face to WSSC and seeing their car come in shows that you are in touch with the consumers you are serving and is not a bad thing. Further, wouldn't components of the current meters need to be replaced since RF would not penetrate iron? The AMI smart meters would also use batteries which would create waste and require disposal and, from what I understand, the meters themselves may have a shorter shelf life than their current forms.

Source: https://www.manchesterjournal.com/stories/smart-meter-interference,71235

"Why Smart Meters Might be a Dumb Idea" W. Kelly, *Consumer Digest*, January 2011

My neighborhood in Potomac, MD has 85 homes and there are several just on my street that “opt out” from PEPCO smart meters for a variety of reasons. This is something people want. We have had HOA meetings on the PEPCO opt out and on legislation that would have allowed small cell towers in residential communities so we are active on these issues and some of us have testified on them. Those who have opted out do so for a variety of reasons. My family – my husband and I don’t want the exposure to RF and choose not to use wi fi in our home and greatly limit our children’s use of cell phones; my neighbor is more concerned on technology and risk of “hacking” of his personal information and another neighbor has a young child who is in remission from leukemia and completely re-did her home to remove potential irritants like mold, among others, and takes seriously the data on RF health effects. **We are relying on WSSC to provide the ability for families and individuals that DO NOT want smart meters installed to be able to “opt out.”**

Thank you for your consideration,

Cyndie Baughman,

Resident of Potomac, MD, Montgomery County and a long-time WSSC customer.

ADA approves $500,000 to promote fluoridation

(this is just social media budgeting, it does not include the rest of their PR

In response to reports from dentists and dental associations nationwide of escalating anti-fluoridation messages reaching their communities, the ADA House of Delegates approved a resolution calling for the ADA to implement a proactive social media campaign to promote the safe and positive effects of optimal water fluoridation. Delegates approved Res. 101H-2014, which allocates $500,000 for marketing and advertising via Facebook, YouTube and other social media platforms and optimizing search engines to help ensure that ADA information is prominent in Internet searches. The Association will use a portion of the funding to bolster the staff of the ADA Council on Access, Prevention and Interprofessional Relations, which assists members and dental societies with fluoridation campaigns and information.

"The campaign will help communities in a struggle very often waged against anti-fluoridation groups that are very media savvy," said Dr. Maxine Feinberg, ADA president. "The delegates were willing to make an investment that shows the resolve to put prevention first and give it the attention it deserves as an important aspect of the ADA's Action for Dental Health movement."

The resolution was introduced by the ADA's 1st District, said Dr. Jeffery Dow, 1st District trustee...

National Toxicology Program

U.S. Department of Health and Human Services

Proposed NTP Evaluation on Fluoride Exposure and Potential for Developmental Neurobehavioral Effects

November 19, 2015

Office of Health Assessment and Translation (OHAT)

Division of the National Toxicology Program

National Institute of Environmental Health Sciences

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PROPOSED NTP EVALUATION ON FLUORIDE EXPOSURE AND POTENTIAL DEVELOPMENTAL NEUROBEHAVIORAL EFFECTS

Project Leader:
Kristina Thayer, Office of Health Assessment and Translation (OHAT), DNTP

Summary: The National Toxicology Program (NTP) proposes to conduct an evaluation of the published literature to determine whether exposure to fluoride is associated with effects on neurodevelopment, specifically learning, memory, and cognition. This evaluation will use systematic review methods and include an examination of data from human (epidemiological), experimental animal, and mechanistic studies. Previous evaluations have found support for an association between fluoride exposure and impaired cognition; however, many of the studies included exposure to high levels of fluoride. Most of the human evidence was from fluoride-endemic regions having high background levels of fluoride, and the animal studies typically included exposure during development to relatively high concentrations of fluoride (>10 mg/L) in drinking water. Thus, the existing literature is limited in its ability to evaluate potential neurocognitive effects of fluoride in people associated with the current U.S. Public Health Service drinking water guidance (0.7 mg/L). In order to facilitate this literature-based evaluation, NTP is planning laboratory studies in experimental animals to address identified research needs and provide data useful for understanding effects of fluoride at water concentrations relevant to current human exposures. The findings from these studies will be included in the literature-based NTP evaluation of fluoride exposure and neurodevelopment.

BACKGROUND

EXPOSURE

Sources of fluoride exposure include drinking water, foods, beverages, dental products (toothpaste, mouth rinses), supplements, industrial emissions, pharmaceuticals, and pesticides (e.g., cryolite and sulfuryl fluoride). Soil ingestion is another source of exposure in young children (US Environmental Protection Agency 2010b).

In 2010, the US Environmental Protection Agency conducted a relative source contribution analysis and concluded that drinking water, beverages, food, and toothpaste are the major contributors to fluoride exposure (Table 1). The relative source contribution from drinking water intake was 40 to 60% after the age of 1 year and 70% in children less than 1 year old.

Table 1. Representative Values for Fluoride Intakes Used in Calculation of the Relative Source Contribution from Drinking Water

Age group (years)	DWI[a] (mg/day)	BI (mg/day)	FI (mg/day)	TI (mg/day)	SuF (mg/day)	SI (mg/day)	Total (mg/day)	RSC (%)
0.5 - <1	0.84	--	0.25[b]	0.07	0.03	0.02	1.2	70
1 - <4	0.63	0.36	0.16	0.34	0.05	0.04	1.58	40
4 - <7	0.82	0.54	0.35	0.22	0.06	0.04	2.03	40
7 - <11	0.86	0.60	0.41	0.18	0.07	0.04	2.16	40
11-14	1.23	0.38	0.47	0.20	0.09	0.04	2.41	51
>14	1.74[b]	0.59	0.38	0.10[c]	0.08	0.02	2.91	60

From Table 7-2 (US Environmental Protection Agency 2010b)
[a] Consumers only; 90th percentile intake except for >14 years. The >14 year value is based on the Office of Water policy of 2 L/day. [b] Includes foods, fluoride in powdered formula, and fruit juices; no allocation for other beverages. [c] Assumed. 50% of the 11-14 year old age group. DWI = Drinking Water Intake; BI = Beverage Intake; FI = Food Intake (Solid Foods); TI = Toothpaste Intake; SuF = Sulfuryl Fluoride Intake; SI = Soil Intake; RSC = Relative Source Contribution.

EPA has proposed a reference dose (RfD) of 0.08 mg/kg/day for protection against pitting of the tooth enamel (severe dental fluorosis) and this value is also considered protective against fractures and skeletal effects in adults (US Environmental Protection Agency 2010a). The RfD is the estimate of the daily exposure that is likely to be without harmful effect during a lifetime. A RfD of 0.08 is equivalent to a daily dose of 5.6 mg for a 70 kg person or 1.6 mg for a 20 kg child.

USE OF FLUORIDE TO PREVENT TOOTH DECAY

Fluoride from community water fluoridation, mouth rinses, gels and toothpastes is intended to prevent dental caries primarily through topical remineralization of tooth surfaces. Community water fluoridation and fluoride toothpaste are the most common sources of non-dietary fluoride in the United States (U.S. DHHS Federal Panel on Community Water Fluoridation 2015). Because fluorine is the 13th most abundant element in the earth's crust, fluoride is also naturally occurring in water, and is present even in non-fluoridated water systems.

Although other fluoride-containing products and sources are available (e.g., mouth rinses, dietary supplements, professionally applied fluoride compounds), community water fluoridation has been identified as the most cost-effective method of delivering fluoride to all members of the community regardless of age, educational attainment, or income level. Consuming fluoridated water and beverages, and foods prepared or processed with fluoridated water throughout the day maintains a low concentration of fluoride in saliva and plaque that enhances remineralization. Community water fluoridation to minimize the occurrence and severity of tooth decay began in 1945 and by 2012 had reached 67% of the U.S. population. About 25 countries practice community water fluoridation (Iheozor-Ejiofor et al. 2015) and many more countries provide fluoride through other means such as salt. In 2012, an estimated 200 million people in the U.S. were served by 12,341 community water systems that added fluoride to water or purchased water with added fluoride from other systems (U.S. DHHS Federal Panel on Community Water Fluoridation 2015).

The U.S. Public Health Service (PHS) first recommended communities add fluoride to drinking water in 1962. PHS guidance is advisory, not regulatory, which means that while PHS recommends community water fluoridation as an effective public health intervention, the decision to fluoridate water systems is made by state and local governments. For community water systems that add fluoride, PHS now recommends a fluoride concentration of 0.7 milligrams/liter (mg/L)[1] based on the optimal concentration of fluoride in drinking water. This recommended level provides the best balance of protection from dental caries while limiting the risk of dental fluorosis, a condition marked by changes in the appearance of tooth enamel most commonly appearing as lacy white markings (U.S. Department of Health and Human Services Federal Panel on Community Water Fluoridation 2015). Dental fluorosis may result when children regularly consume fluoride from birth through 8 years of age -- the time that their permanent teeth (with the exception of the third molars) are developing.

Under the Safe Drinking Water Act, the U.S. Environmental Protection Agency (EPA) sets standards for drinking water quality. Currently, the enforceable standard is set at 4.0 mg/L to protect consumers from exposure to drinking water sources with naturally high occurrence of fluoride against severe skeletal fluorosis (i.e., a condition caused by excessive fluoride intake for a long period of time that in advanced stages can cause pain and/or crippling damage to bones and joints). EPA also has a secondary drinking water standard of 2.0 mg/L to protect against moderate to severe dental fluorosis, which is not enforceable but requires systems to notify the public. The EPA is in the process of reviewing the current drinking water standards for fluoride (US EPA 2013).

Concerns for Potential Fluoride Toxicity

The NTP received a nomination in June 2015 from the public to conduct an analysis of fluoride developmental neurobehavioral toxicity in June 2015. Concerns for possible adverse health effects of fluoride were also raised in public comments received on the Proposed Recommendation for Fluoride Concentration in Drinking Water for the Prevention of Dental Caries published in 2011 (U.S. DHHS Federal Panel on Community Water Fluoridation 2015). Commonly cited health concerns raised in the public comments included bone fractures and skeletal fluorosis, IQ and other neurological effects, and

[1] For many years most community water fluoridated systems used fluoride concentrations ranging from 0.8 to 1.2 mg/L (U.S. Department of Health and Human Services Federal Panel on Community Water Fluoridation 2015)

neurodevelopment at levels of fluoride in drinking water. However, neither of these reviews used systematic review methodology and neither was comprehensive in identifying and describing relevant animal studies. A 2015 systematic analysis of the human literature conducted for the Republic of Ireland's Department of Health (Sutton et al. 2015) concluded that there was no evidence of an association with lowered IQ in studies of community water fluoridation areas based primarily on an analysis of a prospective cohort study in New Zealand (Broadbent et al. 2015). For fluoride-endemic areas, there was a strong suggestion that high levels of naturally occurring fluoride in water (> 1.5 ppm) may be associated with negative health effects, including lowering of IQ. In general, these studies were considered of low quality because they did not fully account for other factors that could also cause a lowering of IQ e.g., nutritional status, socioeconomic status, iodine deficiency, other chemicals in the ground water (arsenic or lead). The conclusions of Sutton et al. (2015) are consistent with findings of a 2012 meta-analysis of 27 epidemiology studies that supported the possibility of an adverse effect of "high" fluoride exposure[3] on children's neurodevelopment, specifically for lowered IQ; although the 2012 meta-analysis also identified study quality limitations, mostly related to reporting quality, that limited the strength of conclusions that could be reached (Choi et al. 2012).

The NTP has recently completed a systematic review of fluoride and neurobehavioral outcomes in animal studies that included consideration of adult and developmental exposure and a broad range of behavioral outcomes, including learning and memory, motor and sensory function, depression and motor endurance, anxiety and motor activity. This report is currently undergoing peer-review and expected to be finalized early in 2016. A total of 61 studies were considered relevant (Appendix A), and 44 of these addressed learning and memory. For evidence synthesis, 14 of the learning and memory studies were excluded based on serious concern for risk of bias (internal validity), leaving a total of 30 studies considered in an analysis of learning and memory in rats and mice. Draft conclusions found evidence of potential detrimental effects on learning and memory, but confidence in the conclusions was limited due to study design and reporting issues and there was also concern for potential confounding of the learning and memory assessments by deficits in motor function or fear responses. Most of the studies reporting effects treated animals with doses >10 ppm. Few studies tested dose levels of less than 5 ppm (Zhang et al. 1999; Xu and Shen 2001; Gao et al. 2008; Gao et al. 2009; Liu et al. 2009; Liu et al. 2010; Liu et al. 2011; Zhu et al. 2012; Liu et al. 2014) and none of these assessed the impacts of exposure during development (Appendix A). Further, levels of fluoride in vehicle controls in the lower dose studies (<10 ppm) ranged from 0.15 to 0.7 ppm, at or only slightly lower than the current PHS guidance (Chioca et al. 2008; Gao et al. 2008; Gui et al. 2010; Jiang et al. 2014; Wei et al. 2014). For these reasons, the animal literature on learning and memory following developmental exposure is not considered sufficient to assess effects at dose levels relevant to current water fluoridation practices in the US. The draft report concludes that additional studies are required to have higher confidence in the specificity of the responses as learning or memory impairments and in quantitative measures such as identification of No Observed Effect Level (NOEL) or Lowest Observed Effect Level doses, or parameters for benchmark dose analysis. The NTP is currently pursuing experimental studies in rats to address key data gaps, starting with pilot studies that address limitations of the current literature with respect to study design (e.g., randomization, blinding, control for litter effects), and assessment of motor and sensory function to assess the degree to which impairment of movement may impact performance in

[3] "High" was defined based on drinking water concentration, evidence of fluorosis, exposure related to coal-burning activities, and urine levels.

learning and memory tests. If justified, follow-up studies would address potential developmental effects using lower dose levels more applicable to human intakes.

Given the number of studies published since the 2006 NRC and 2011 SCHER evaluations, there appears to be sufficient rationale to justify conducting an evaluation that integrates evidence from epidemiological, experimental animal, and mechanistic[4] data to reach an NTP hazard identification conclusion with respect to developmental neurobehavioral toxicity. However, an analysis of the existing literature would likely be limited in its ability to reach conclusions about potential cognitive effects in people associated with the current drinking water guidance (0.7 mg/L). For this reason, the timing of the analysis will be structured to include the results of the experimental animal studies currently being initiated by the NTP. This should enable a more complete interpretation of the animal data with respect to understanding potential neurocognitive effects at water concentrations relevant to current human exposure levels.

With respect to evaluations of cancer and non-thyroid endocrine outcomes, separate analyses are proposed to determine the amount of evidence available and merit of pursuing systematic reviews given factors such as the extent of new research published since previous evaluations, and whether these new reports address or correct the deficiencies noted in the literature (National Research Council 2006; California Office of Environmental Health Hazard Assessment (OEHHA) 2011; Scientific Committee on Health and Environmental Risks (SCHER) 2011).

Objective and Specific Aims

The overall objective of this evaluation is to undertake an integrated analysis of evidence from human, animal, and mechanistic studies to develop hazard identification conclusions about whether fluoride is a developmental neurobehavioral toxicant. The evaluation will be implemented by developing a protocol based on guidance in the OHAT Handbook for Systematic Review and Evidence Integration (NTP 2015).

Steps in the process and specific aims:

- Identify literature reporting the effects of exposure to fluoride and developmental neurological outcomes in humans, non-human mammals, or in applicable *in vitro* and *in silico*[5] model systems.
- Extract data on health outcomes from relevant studies.
- Assess the internal validity ("risk of bias") of individual human and non-human mammalian studies.

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[4] Mechanistic data come from a wide variety of studies and are generally not intended to identify a disease phenotype. This source of experimental data includes *in vitro* and *in vivo* laboratory studies directed at identifying the cellular, biochemical, and molecular mechanisms that are related to chemicals that produces particular adverse effects. These studies increasingly take advantage of new "-omics" tools, such as proteomics and metabolomics, to identify early biomarkers of effect. Another broad class of mechanistic data relates to the toxicokinetics of a chemical (NRC 2014).

[5] *In silico* refers to computer-based models

- Summarize the extent and types of evidence available.

The following specific aims will depend on the extent and nature of the available evidence (i.e., number and similarity of studies):

- Synthesize the evidence, including performance of quantitative meta-analyses if appropriate, and evaluate sources of heterogeneity.
- Rate confidence in the body of evidence for neurological effects for human and non-human mammalian studies separately according to one of four statements: (1) High, (2) Moderate, (3) Low, or (4) Very Low/No Evidence Available.
- Translate confidence ratings into level of evidence of health effects for human and non-human mammalian studies separately according to one of four statements: (1) High, (2) Moderate, (3) Low, or (4) Inadequate.
- Combine the level of evidence ratings for human and non-human mammalian data and consider the degree of support from mechanistic data to reach one of five possible hazard identification conclusions: (1) Known, (2) Presumed, (3) Suspected, (4) Not classifiable, or (5) Not identified to be a hazard to humans.
- Describe findings in the context of human exposure levels, describe limitations of the analysis, and identify data gaps and key research needs.

DRAFT PECO STATEMENT

A PECO (Population, Exposure, Comparators and Outcomes) statement (Table 2) is used as an aid to focus the research question(s), search terms, and inclusion/exclusion criteria in a systematic review (Higgins and Green 2011). The draft PECO statement was based on a series of problem formulation steps that included: (1) review of the nomination, (2) discussion with staff at Federal agencies and the nominator; (3) consultation with an evaluation design team[6] with expertise in neurotoxicology, epidemiology, toxicology, systematic review and evidence integration, and information science; and (4) consideration of information received from a public request for information in the Federal Register [80 FR 60692 (October 7, 2015) 60692 -60693].

[6] The evaluation team is composed of NIEHS/NTP staff, staff from other US Federal agencies, and contractor staff who are involved in the entire systematic review process. As needed, OHAT will also engage non-federal technical advisors, who are screened for potential conflicts of interest. Contractor staff members are also screened for potential conflicts of interest.

Table 2. Draft PECO (Population, Exposure, Comparators and Outcomes) statement	
PECO Element	**Evidence**
Population	Humans, non-human mammalian animal species (whole organism, *ex vivo*), and *in vitro or in silico* model systems.
Exposure	Forms of fluoride (CASRN): Sodium fluoride (7681-49-4, the most common form used in toxicology studies), soluble fluorine (7782-41-4), fluorosilicic acid (16961-83-4), or sodium fluorosilicate (16893-85-9). **Humans and non-human mammalian animal species:** Fluoride exposure or treatment that includes a developmental life-stage, i.e., during fetal life, infancy, childhood (i.e., ≤18 years in humans; up to post-natal day 30 in rodent species). There are no restrictions based on dose level (in order to help assess shape of dose response). In vitro/in silico models: Fluoride treatment with no restrictions on life-stage of model system.
Comparators	Humans: A comparison group exposed to no or lower levels compared to more highly exposed participants. Non-human mammalian animal species: Experimental study that includes a vehicle-only control treatment. In vitro/in silico models: Experimental tissue, cell, or cell component study that includes a vehicle-only control treatment for *in vitro* studies; comparison group not required for in silico models.
Outcomes	Humans and non-human mammalian animal species: *Primary outcomes:* Neurobehavioral outcomes related to cognition *Secondary (mechanistic) outcomes:* Brain-related cellular, morphometric or histological endpoints; thyroid hormone-related measures; toxicokinetic data. In vitro/in silico models: *Secondary (mechanistic) outcomes:* Brain-related endpoints in studies of neuronal cells, neurotransmitters, and/or receptors.

CONSIDERATIONS FOR PROTOCOL DEVELOPMENT AND ANALYSIS

After considering public comments on the draft concept document, a detailed protocol will be developed following guidance outlined in the OHAT Handbook for Systematic Review and Evidence Integration (NTP 2015). The protocol will be posted on the OHAT website. Any revisions during the course of the evaluation will be noted. The following section is intended to highlight key issues that will be considered when developing the study protocol. The protocol and draft report will be developed by NTP staff, other members of the evaluation design team, and technical advisors (as needed) who have been screened for conflict of interest.

LITERATURE SEARCH STRATEGIES

Literature search strategies will be developed to identify published evidence on the effects of fluoride on neurological outcomes by using index terms and text words based on key elements of the research question. Six electronic databases[7] will be searched:

- BIOSIS (Thomson Reuters)
- EMBASE (Elsevier)
- PsycINFO (APA PsycNet)
- PubMed (NLM)
- Scopus (Elsevier)
- Web of Science (Thomson Reuters; Web of Science indexes the journal Fluoride)

No publication date or language restrictions will be applied.

The reference lists of included studies, reviews related to neurological effects of fluoride, and the other compilations of studies related to fluoride (e.g., received through public comments, Fluoride Action Network database) will be searched for additional relevant publications. The list of included (and excluded) studies will be posted on the OHAT website prior to release of a draft report as an additional strategy to identify potentially relevant studies that may have been missed during the literature search.

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[7] The National Library of Medicine's Toxline database is not included in the search because recent changes have resulted in significant reductions in search functionality that limits running the search strings for this topic. The other databases proposed for searching are very likely to identify relevant published and peer-reviewed animal studies. In addition, three other databases were searched in a prior NTP report ("Systematic Review on the Neurobehavioral Effects of Fluoride in Animal Studies," currently under internal review) and no relevant records were identified, thus they will not be searched in the current project: European Chemicals Agency (ECHA) Registration dossiers ("REACH"); Organization for Economic Co-operation and Development (OECD) Existing Chemicals Screening Information Data Sets (SIDS); USEPA HPV Challenge Program Robust Summaries and Test Plans.

Selection Criteria for the Evidence

In order to be eligible for inclusion, studies will need to comply with the criteria specified by the PECO statement (Table 2). Studies that do not meet the PECO criteria will be excluded. In addition, the following exclusion criteria will be applied:

- Studies do not contain original data, such as reviews, editorials, or commentaries.
    - Reference list of reviews were reviewed to identify potentially relevant articles.
- Studies not containing sufficient detail to undergo peer-review (e.g., conference abstracts, unpublished data described in technical reports, databases, working papers from research groups or committees, and white papers).
- Unpublished or non-peer-reviewed data that cannot be made publically available (see below for guidance).

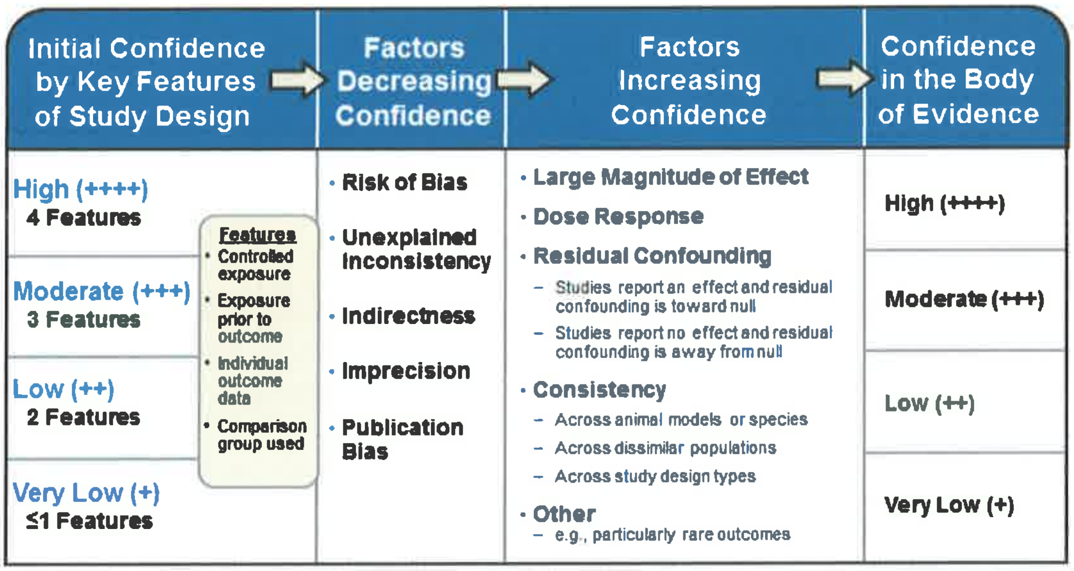
Unpublished or non-peer-reviewed data

NTP only includes publicly accessible information in its evaluations. This information is typically based on studies published in peer-reviewed journals. However, NTP can consider unpublished data or data presented in the grey literature (e.g., theses/dissertations, technical reports, white papers) that has not undergone peer-review provided the owners of the data are willing to have the study details and results made publicly accessible. Peer-review of this data would be accomplished using standard procedures in the OHAT handbooks to evaluate the quality of the information with the option to utilize topic specific technical advisors as needed. Study sponsors and researchers are invited to submit unpublished data during the course of an evaluation, although the ability to use the information depends on the timing of submission relative to release of a draft monograph. Unpublished data from personal author communication can supplement a peer-reviewed study, as long as the information is made publicly available.

Assessment of Confidence in the Body of Evidence

In more complete description of the process and guidance used to implement the analysis is outlined in the OHAT Handbook for Systematic Review and Evidence Integration (NTP 2015). In brief, the quality of evidence for each outcome will be graded using the GRADE system for rating the confidence in the body of evidence (Guyatt et al 2011) as adapted by OHAT for observational human studies and animal studies (NTP 2015). Under the GRADE system, the overall confidence in the body of evidence for an outcome is categorized as high, moderate, low or very low. An initial confidence rating for the body of evidence (for a specific outcome) is determined by the ability of the study design to ensure that exposure preceded and was associated with the outcome (Figure 1, column 1). This ability is reflected in the presence or absence of four key study design features used to delineate the studies for initial confidence ratings: (1) the exposure to the substance is experimentally controlled, (2) the exposure assessment demonstrates that exposures occurred prior to the development of the outcome (or concurrent with aggravation/amplification of an existing condition), (3) the outcome is assessed on the individual level (i.e., not through population aggregate data), and (4) an appropriate comparison group is included in the study. The first key feature, "controlled exposure," reflects the ability of experimental studies in humans and animals to largely eliminate confounding by randomizing allocation of exposure. Therefore, these studies usually have all four features and receive an initial rating of "High Confidence." Observational studies do not have controlled exposure and are differentiated by the presence or absence of the three remaining study design features. For example, prospective cohort studies usually have all three remaining features and receive an initial rating of "Moderate Confidence". Next, a series of adjustments ("downgrades" or "upgrades") may be made to the initial ranking based on the characteristics of the studies constituting the body of evidence after considering factors such as risk of bias across studies, unexplained inconsistency, indirectness, imprecision, publication bias, magnitude of the effect, dose response, and consistency across different model systems and study designs (Figure 1). Studies conducted in mammalian model systems are assumed relevant for humans (i.e., not downgraded for indirectness) unless compelling evidence to the contrary exist.

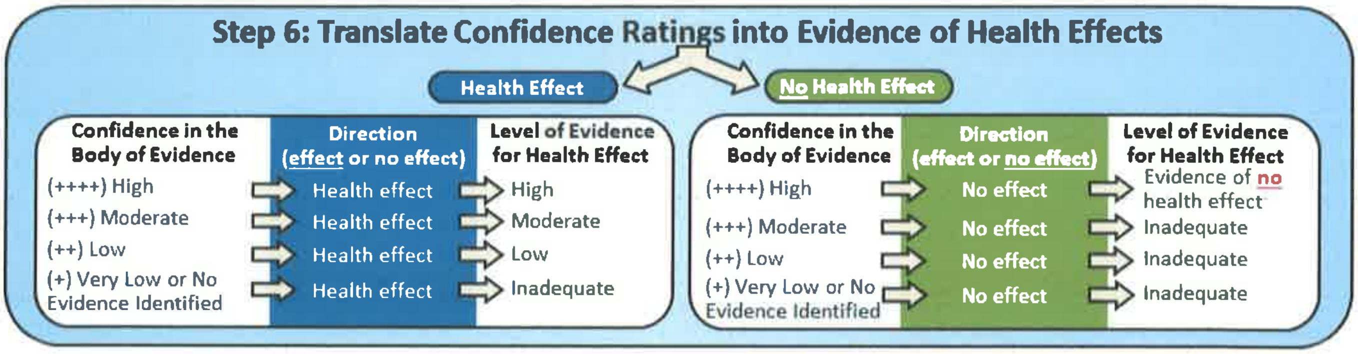
Figure 1. Assessing Confidence in the Body of Evidence



PREPARATION OF LEVEL OF EVIDENCE CONCLUSIONS

The confidence in the body of evidence conclusions from Figure 1 are translated into draft statements of health effects for human and animal data, seperately, according to one of four statements: 1. High, 2. Moderate, 3. Low, or 4. Inadequate (Figure 2, labeled as Step 6 in OHAT's process for systematic review and evidence integration). The descriptor "evidence of no health effect" is used to indicate confidence that the substance is not associated with a health effect. Because of the inherent difficulty in proving a negative, the conclusion "evidence of no health effect " is only reached when there is high confidence in the body of evidence.

Figure 2. Translate Confidence Ratings into Evidence of Health Effect Conclusions



Evidence Descriptors	Definition
High Level of Evidence	There is high confidence in the body of evidence for an association between exposure to the substance and the health outcome(s).
Moderate Level of Evidence	There is moderate confidence in the body of evidence for an association between exposure to the substance and the health outcome(s).
Low Level of Evidence	There is low confidence in the body of evidence for an association between exposure to the substance and the health outcome(s), or no data are available.
Evidence of No Health Effect	There is high confidence in the body of evidence that exposure to the substance is not associated with the health outcome(s).
Inadequate Evidence	There is insufficient evidence available to assess if the exposure to the substance is associated with the health outcome(s).

INTEGRATE EVIDENCE TO DEVELOP HAZARD IDENTIFICATION CONCLUSIONS

For determining the appropriate hazard identification category, the evidence streams for human studies and animal studies, which have remained separate through the previous steps, are integrated along with other relevant data, such as supporting evidence from *in vitro* studies.

Integration of human and animal evidence

Hazard identification conclusions are initially reached by integrating the highest level-of-evidence conclusion for a health effect(s) from the human and the animal evidence streams. On an outcome basis, this approach applies to whether the data support a health effect conclusion or provide evidence of no health effect. The five hazard identification conclusion categories are as follows:

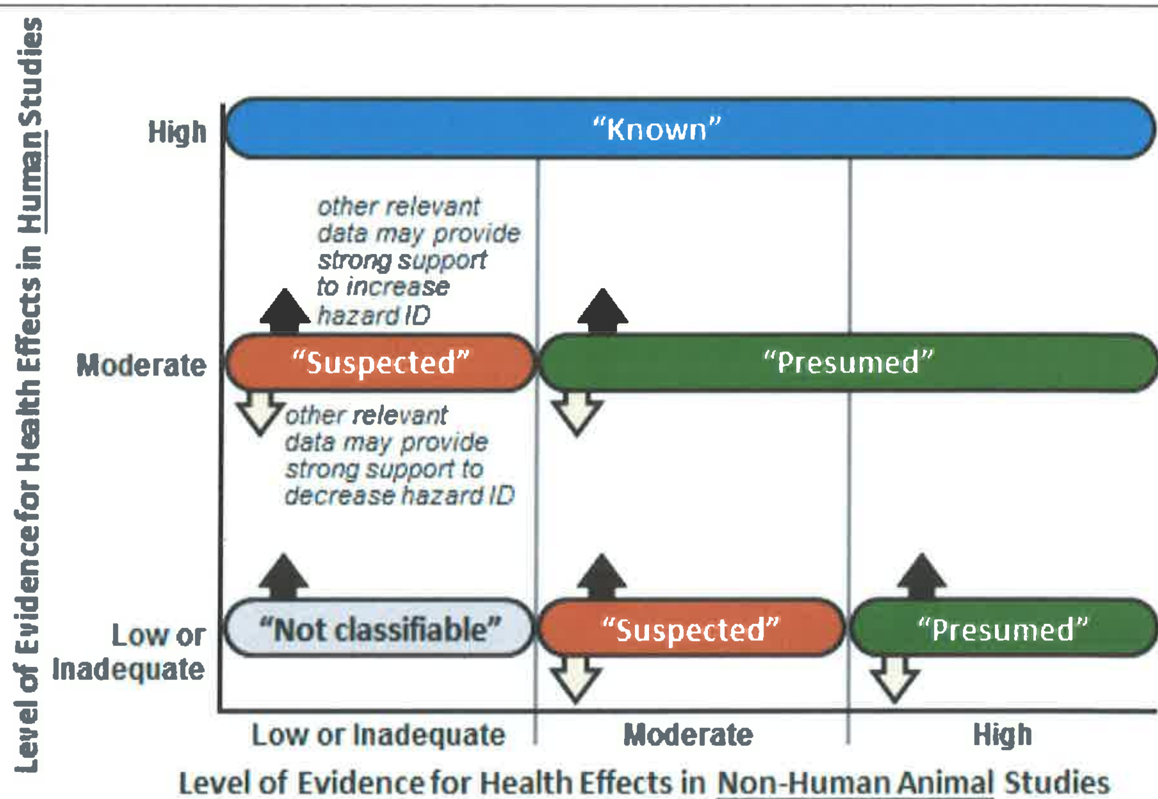
- Known to be a hazard to humans
- Presumed to be a hazard to humans
- Suspected to be a hazard to humans
- Not classifiable as a hazard to humans
- Not identified as a hazard to humans

When the data support a health effect, the level-of-evidence conclusion for human data from Step 6 is considered together with the level of evidence for non-human animal data to reach one of four hazard identification conclusions (Figure 3, labeled as Step 7 in OHAT's process for systematic review and evidence integration). If one evidence stream (either human or animal) is characterized as "Inadequate Evidence," then conclusions are based on the remaining evidence stream alone (which is equivalent to treating the missing evidence stream as "Low" in Step 7).

Consideration of mechanistic data

The NTP does not require mechanistic or mode-of-action data in order to reach hazard identification conclusions, although when available, this and other relevant supporting types of evidence may be used to raise (or lower) the category of the hazard identification conclusion. If mechanistic data provide strong support for biological plausibility of the relationship between exposure and the health effect, the hazard identification conclusion may be upgraded (indicated by black "up" arrows in the Step 7 graphic in Figure 3) from the one initially derived by considering the human and non-human animal evidence together.

Figure 3. Hazard Identification Scheme



Identification and Evaluation of Most Relevant Mechanistic Studies

Human and experimental animal data will be interpreted in conjunction with evidence from mechanistic data to evaluate the biological plausibility of any associations between fluoride and developmental neurological effects. Relevant mechanistic evidence will be identified and evaluated using an iterative approach adapted from the US EPA Handbook of Procedures for Systematic Review In support of Integrated Risk Information System (IRIS) Toxicological Reviews (presented at November 17-18, 2015 National Academy of Sciences meeting "Unraveling Low Dose Toxicity: Case Studies of Systematic Review of Evidence").

- **Identification and categorization of mechanistic literature:** *In vitro* or *in silico* studies identified in the initial neurotoxicity-focused literature search will be tagged to develop a "bin" for mechanistic studies. Full-text review of studies in humans and non-human mammalian animal species will be conducted to determine if they also contain mechanistic data. Studies in non-mammalian animal species (e.g., fish, *C. elegans*) will be considered supportive information to assess biological plausibility and categorized as mechanistic.
- **Identification of proposed mechanism of action (MOAs) or mechanistic hypotheses from published literature:** The evaluation team will review the bibliographic information gathered from the literature survey of human, animal and *in vitro* studies to identify emerging patterns of potential neurotoxicity. These patterns will inform hypothesized mechanistic events. Additional targeted literature search protocols may be conducted to identify other potentially relevant mechanisms if needed.
- **Prioritization of mechanistic studies for analysis:** Once neurological effects of interest are identified from the human and animal studies, the evaluation team will evaluate the mechanistic data to focus on the studies and outcomes that are most informative for those outcomes. The protocol will be updated to indicate which types of mechanistic studies are considered most relevant.
- **Evaluation:** After prioritization, the most relevant set(s) of experimental studies will be evaluated. For topics with large evidence base, reviews by others may be used. Studies should be grouped by assay and/or endpoint type to facilitate analysis of support for biological plausibility.

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APPENDIX A. STUDY FLOW AND OVERVIEW OF INCLUDED STUDIES IN DRAFT NTP SYSTEMATIC REVIEW ON THE NEUROBEHAVIORAL TOXICITY OF FLUORIDE IN ANIMAL STUDIES

Figure S1. Study Flow

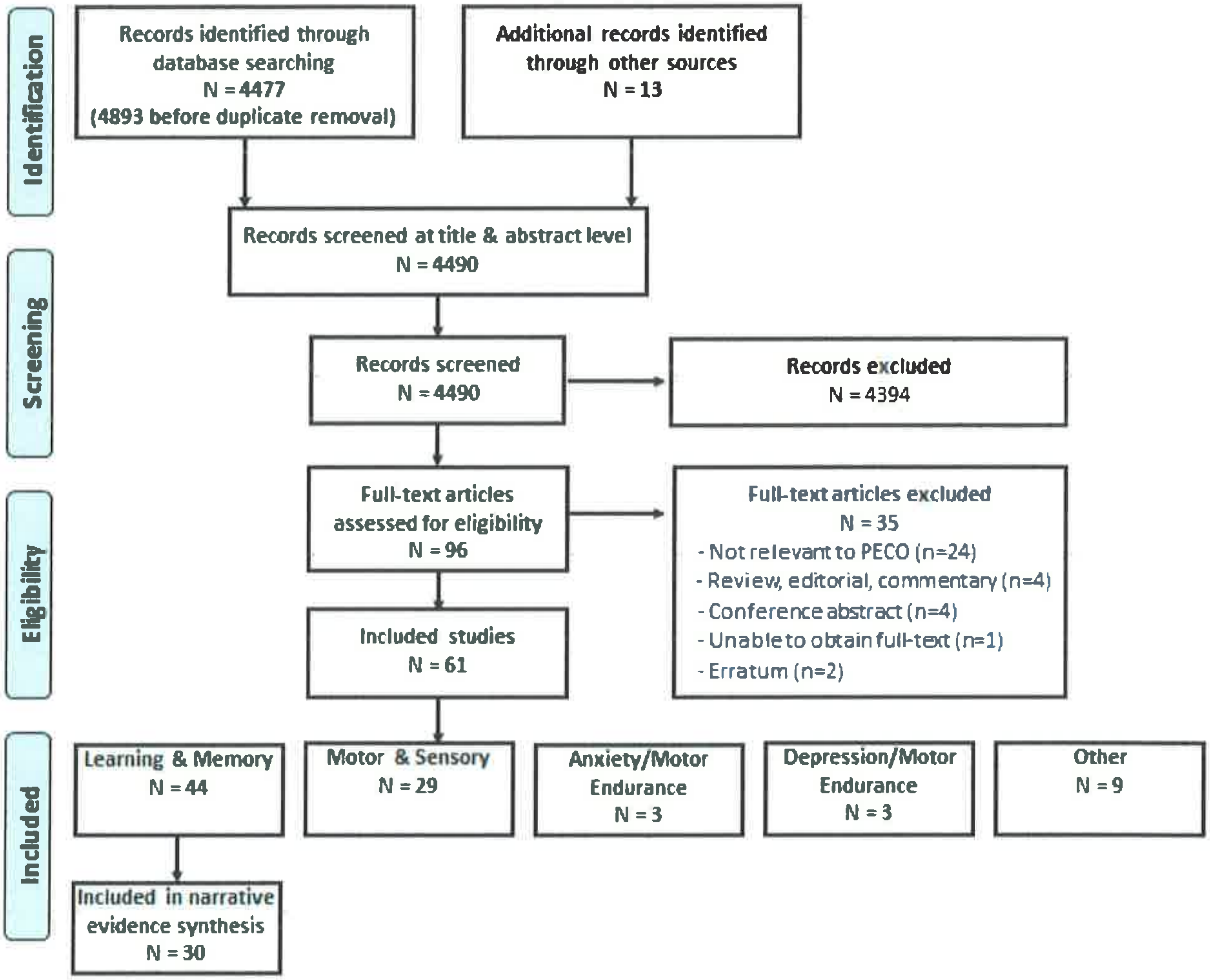

Table S1. Description of relevant studies	Learning and Memory	Motor and Sensory Function	Depression/Motor Endurance	Anxiety/Motor Activity	Other
Number of studies	44	29	3	3	9
Non-English	15 (34%)	6 (21%)	0 (0%)	0 (0%)	0 (0%)
Species					
rats	35	22	0	1	7
mice	9	7	3	2	2
Life-stage of exposure*					
adult	29	20	3	2	5
developmental	15	10	0	1	5
Doses tested*					
range (ppm, F equivalents)	0.9 - 272	0.9 - 226	0.9 - 90	0.9 - 90	1 - 136
≤10 ppm	17	6	1	1	3
developmental	3	4	--	--	2
11-25 ppm	17	11	0	0	4
developmental	7	6	--	--	4
>25 ppm	29	20	2	2	6
developmental	11	4	--	--	1
Studies with very serious risk of bias					
total	14	9	0	0	3
developmental	9	5	0	0	2
≤10 ppm	3 (100%)	3 (75%)	--	--	2 (100%)
11-25 ppm	4 (57%)	3 (50%)	--	--	2 (50%)
>25 ppm	6 (55%)	2 (50%)	--	--	0
Studies used for evidence synthesis					
total	30				
developmental	6				
≤10 ppm	0				
11-25 ppm	3				
>25 ppm	5				
adult	24				
≤10 ppm	11				
11-25 ppm	9				
>25 ppm	14				

*Numbers may not total because studies often tested multiple dose levels and some studies evaluated effects in multiple lifestages of exposure.

Phila July 31, 1786 (To Benjamin Vaughan) Dear Friend,

I recollect that when I had the great Pleasure of seeing you at Southampton, now a 12 month since, we had some Conversation on the bad Effects of Lead taken inwardly; and that at your Request I promis'd to send you in writing a particular Account of several Facts I then mention'd to you, of which you thought some good Use might be made. I now sit down to fulfil that Promise.

The first Thing I remember of this kind, was a general discourse in Boston when I was a Boy, of a Complaint from North Carolina against New England Rum, that it poison'd their People, giving them the Dry Bellyach, with a Loss of the Use of their Limbs. The Distilleries being examin'd on the Occasion, it was found that several of them used leaden Still-heads and Worms, and the Physicians were of the Opinion that the Mischief was occasion'd by that Use of Lead. The Legislature of the Massachusetts thereupon pass'd an Act prohibiting under severe Penalties the Use of such Still-heads & Worms thereafter. Inclos'd I send you a Copy of the Act, taken from my printed Law book.

In 1724, being in London, I went to work in the Printing-House of Mr. Palmer, Bartholomew Close as a Compositor. I there found a Practice I had never seen before, of drying a Case of Types, (which are wet in Distribution) by placing it sloping before the Fire. I found this had the additional Advantage, when the Types were not only dry'd but heated, of being comfortable to the Hands working over them in cold weather. I therefore sometimes heated my Case when the Types did not want drying. But an old Workman observing it, advis'd me not to do so, telling me I might lose the Use of my Hands by it, as two of our Companions had nearly done, one of whom that us'd to earn his Guinea a Week could not then make more than ten Shillings and the other, who had the Dangles, but Seven & sixpense. This, with a kind of obscure Pain that I had sometimes felt as it were in the Bones of my Hand when working over the Types made very hot, induc'd me to omit the Practice. But talking afterwards with Mr. James, a Letter-founder in the same Close, and asking him if his People, who work'd over the little Furnaces of melted Metal, were not subject to that Disorder; he made light of any Danger from the Effluvia, but ascrib'd it to Particles of the Metal swallow'd with their Food by slovenly Workmen, who went to their Meals after handling the Metal, without well-washing their Fingers, so that some of the metalline Particles were taken off by their Bread and eaten with it. This appear'd to have some Reason in it. But the Pain I had experienc'd made me still afraid of those Effluvia.

Being in Derbishire at some of the Furnaces for Smelting of Lead Ore, I was told that the Smoke of those Furnaces was pernicious to the neighboring Grass and other Vegetables. But I do not recollect to have heard any thing of the Effect of such Vegetables eaten by

Animals. It may be well to make the Enquiry.

In America I have often observed that on the Roofs of our shingled Houses where Moss is apt to grow in northern Exposures, if there be any thing on the Roof painted with white lead, such as Balusters, or Frames

of dormant Windows, &c. there is constantly a streak on the Shingles from such Paint down to the Eaves, on which no Moss will grow, but the Wood remains constantly clean & free from it.--We seldom drink Rain Water that falls on our Houses; and if we did, perhaps the small Quantity of Lead descending from such Paint, might not be sufficient to produce any sensible ill Effect on our Bodies. But I have of a Case in Europe, I forgot the Place, where a whole Family was afflicted with what we call the Dry-Bellyach, or Colica Pictonum, by drinking Rain Water. It was at a Country Seat, which being situated too high to have the Advantage of a Well, was supply'd with Water from a Tank which receiv'd the Water from the leaded Roofs. This had been drank several Years without Mischief; but some young Trees planted near the House, growing up above the Roof, and shedding their Leaves upon it, it was suppos'd that an Acid in those Leaves had corroded the Lead they cover'd, and furnish'd the Water of that Year with its baneful Particles & Qualities.

When I was in Paris with Sir John Pringle in 1767, he visited La Charite, a Hospital particularly famous for the Cure of that Malady, and brought from thence a Pamphlet, containing a List of the Names of Persons, specifying their Professions or Trades, who had been cured there. I had the Curiosity to examine that List, and found that all the Patients were of Trades that some way or other use or work in Lead; such as Plumbers, Glasiers, Painters, &c. excepting only two kinds, Stonecutters and Soldiers. These I could not reconcile to my Notion that Lead was the Cause of that Disorder. But on my mentioning this Difficulty to a Physician of that Hospital, he inform'd me that the Stonecutters are continually using melted Lead to fix the Ends of Iron Balustrades in Stone; and that the Soldiers had been emply'd by Painters as Labourers in Grinding of Colours.

This, my dear friend, is all I can at present recollect on the Subject. You will see by it, that the Opinion of this mischievous Effect from Lead, is at least above Sixty Years old; and you will observe with Concern how long a useful Truth may be known, and exist, before it is generally receiv'd and practis'd on.

-- I am, ever,
Yours most affectionately B. Franklin

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Full length article

Association of water fluoride and urinary fluoride concentrations with attention deficit hyperactivity disorder in Canadian youth

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ABSTRACT

Background: Exposure to fluoride has been linked with increased prevalence of attention deficit hyperactivity disorder (ADHD) in the United States and symptoms of inattention in Mexican children. We examined the association between fluoride exposure and attention outcomes among youth living in Canada.

Method: We used cross-sectional data collected from youth 6 to 17 years of age from the Canadian Health Measures Survey (Cycles 2 and 3). Urinary fluoride concentration adjusted for specific gravity (UFSG) was available for 1877 participants. Water fluoride concentration measured in tap water samples was available for 980 participants. Community water fluoridation (CWF) status was determined by viewing reports on each city's website or contacting the water treatment plant. We used logistic regression to test the association between the three measures of fluoride exposure and ADHD diagnosis. Linear regression was used to examine the relationship between the three measures of fluoride exposure and the hyperactivity/inattention score on the Strengths and Difficulties Questionnaire (SDQ).

Results: UF_{SG} did not significantly predict ADHD diagnosis or hyperactive/inattentive symptoms. A 1 mg/L increase in tap water fluoride level was associated with a 6.1 times higher odds of an ADHD diagnosis (95% CI = 1.60, 22.8). A significant interaction between age and tap water fluoride level ($p = .03$) indicated a stronger association between tap water fluoride and hyperactivity/inattention symptoms among older youth. A 1 mg/L increase in water fluoride level was associated with a 1.5 SDQ score increase (95% CI: 0.23, 2.68, $p = .02$) for youth at the 75th percentile of age (14 years old). Similarly, there was a significant interaction between age and CWF. At the 75th percentile of age (14 years old), those living in a fluoridated region had a 0.7-point higher SDQ score (95% CI = 0.34, 1.06, $p < .01$) and the predicted odds of an ADHD diagnosis was 2.8 times greater compared with youth in a non-fluoridated region (aOR = 2.84, 95% CI: 1.40, 5.76, $p < .01$).

Discussion: Exposure to higher levels of fluoride in tap water is associated with an increased risk of ADHD symptoms and diagnosis of ADHD among Canadian youth, particularly among adolescents. Prospective studies are needed to confirm these results.

1. Introduction

Fluoride is beneficial in the prevention of dental caries (Health Canada, 2010). It can naturally occur in water, but often at levels that are too low to prevent tooth decay. In the middle of the 20th century, the concept of adding fluoridation chemicals (usually hexafluorosilicic acid) to water supplies was introduced. Currently, approximately 38% of Canadians on public water supplies receive community water fluoridation (CWF; Public Health Agency of Canada, 2017) compared with 74% of Americans and only 3% of Europeans (Centers for Disease Control and Prevention, 2014). Consumption of optimally fluoridated water (i.e., 0.7 mg fluoride per liter of water) accounts for approximately 40 to 70% percent of daily fluoride ingestion (United States Environmental Protection Agency, 2010).

Fluoride has been classified as a developmental neurotoxin (Grandjean and Landrigan, 2014) – a claim that is uncontested at high exposure levels, but remains debated at the exposure levels associated with water fluoridation. Epidemiological studies conducted in endemic fluorosis areas (i.e., naturally occuring water fluoride concentrations > 1.5 mg/L) have reported a negative association between fluoride concentrations in drinking water and intellectual ability in children (Das and Mondal, 2016; Rocha-Amador et al., 2007; Seraj

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et al., 2012; Xiang et al., 2003; Zhao et al., 1996). A *meta*-analysis of 27 studies concluded that children who lived in areas with high fluoride exposure had IQ scores that were approximately seven points lower than those who lived in low-exposure areas (Choi et al., 2012). Most of the studies included in this review were cross-sectional and had deficient reporting of key information; however, the consistency of their findings supports the potential for fluoride-mediated developmental neurotoxicity at elevated levels of exposure. Recently, three longitudinal birth cohort studies addressed these limitations by examining the associations between maternal fluoride exposure indicators in pregnancy and offspring cognitive abilities. These prospective studies reported a negative association between prenatal fluoride exposure and cognitive development in infants (Jiménez et al., 2017), children living in Mexico (Bashash et al., 2017), and children living in Canada (Green et al., 2019).

Experimental and epidemiologic studies have also reported an association between early-life fluoride exposure and adverse behavioural outcomes. One study demonstrated that prenatal fluoride exposure caused greater hyperactivity in male rat pups whereas females were more sensitive to postnatal exposures (Mullenix et al., 1995). In an ecological study, higher prevalence of water fluoridation was associated with increased prevalence of Attention Deficit Hyperactivity Disorder (ADHD) diagnoses among youth in the United States (Malin and Till, 2015). In a cohort study, higher levels of fluoride exposure during pregnancy were associated with more inattentive symptoms and total ADHD symptoms in Mexican children aged 6 to 12 years (Bashash et al., 2018). In contrast, a study using data from the Canadian Health Measures Survey (CHMS; Statistics Canada, 2013; 2015) did not report an association between urinary fluoride corrected for dilution and a diagnosis of a learning disability in children aged 3 to 12 years (Barberio et al., 2017).

We examined the relationship between urinary and tap water fluoride concentrations and attention-related outcomes in a national sample of Canadian youth aged 6 to 17 years. We hypothesized that higher levels of urinary and water fluoride would be associated with increased odds of an ADHD diagnosis and more symptoms of hyperactivity and inattention.

2. Methods

2.1. Data source and participants

We used data from Cycle 2 (2009–2011) and Cycle 3 (2012–2013) of the CHMS collected by Statistics Canada. All aspects of the CHMS were reviewed and approved by Health Canada's Research Ethics Board (Day et al., 2006); the current study was approved by the York University Research Ethics Board.

The CHMS randomly selected participants aged 3 to 79 years who lived in private households across Canada. A total of 6395 people participated in Cycle 2 of the CHMS, with 2520 people providing urine samples analyzed for fluoride concentration. Among those who provided urine samples, 909 (36%) were between 6 and 17 years of age. For Cycle 3, a total of 5785 people were enrolled, with 2667 people providing urine samples analyzed for fluoride concentration; 968 (36%) were between 6 and 17 years of age. In Cycle 3 only, 980 youth ages 6 to 17 were selected to provide a tap water sample to be analyzed for fluoride content. Full details about the survey can be found at www.statcan.gc.ca.

Approximately half of the sites included in Cycles 2 and 3 received CWF, which was determined by viewing reports on each city's website or contacting the water treatment plant (see Supplemental Table 1). In total, 13 of 25 sites received CWF (eight from Cycle 2 and five from Cycle 3), corresponding to approximately 1400 (51.9%) of 2700 participants included in the study (rounded due to Statistics Canada data release requirements). Nine additional sites were considered to have mixed fluoridation status, corresponding to approximately 650 (24.0%) participants. A site was classified as mixed for one of five reasons: unclear site boundaries (n = 150), having some municipalities within the site add fluoride while others did not (n = 250), and stopping CWF during the period spanning CHMS data collection (n = 50). We excluded all mixed sites from any analysis using city fluoridation status as a variable. We also excluded sites which were labeled as fluoridated or non-fluoridated, but had an average water fluoride level that was either 2.5 times lower (n = 100) or higher (n = 100) than other fluoridated or non-fluoridated sites, respectively.

We utilized three participant samples for our analyses; see Fig. 1 for a participant flow chart. The first sample, collapsed across both cycles, included 1877 youth ages 6 to 17 who had urinary fluoride measurements. The second sample categorized 1722 youth who were on a municipal water system (instead of a well) as either living in a fluoridated region (n = 932; 54.1%) or a non-fluoridated region (n = 790; 45.9%). This sample only included youth who primarily drank tap water (instead of bottled water), did not have a home filtration system that removes fluoride (i.e., reverse osmosis or distillation), and have lived in their current residence for three or more years. The third sample consisted of 710 youth from Cycle 3 who primarily drank tap water (instead of bottled water) and had fluoride levels measured in their tap water.

2.2. Measurement of urinary fluoride concentration

Urine spot samples were collected under normal (non-fasting) conditions and were not standardized with respect to collection time. Fluoride concentrations in spot urine samples were analyzed using an Orion PH meter with a fluoride ion selective electrode after being diluted with an ionic adjustment buffer (Statistics Canada, 2013). Urinary analyses were performed at the Human Toxicology Laboratory of the Institut National de Santé Publique du Québec (INSPQ; accredited under ISO 17025) under standardized operating procedures (Statistics Canada, 2013; 2015). The precision and accuracy of the fluoride analyses, including quality control measures and quality assurance reviews, are described in previous publications (Health Canada, 2015). The limit of detection (LoD) for urinary fluoride was 20 µg/L for Cycle 2 and 10 µg/L for Cycle 3 (Health Canada, 2015). No urinary fluoride values in the Cycle 2 or Cycle 3 samples were below the LoD. Urinary fluoride concentrations were adjusted for specific gravity (UF_{SG}; mg/L); specific gravity shows no systematic variation within a day and is less dependent on body size, age, and gender than creatinine (Barr et al., 2005; Nermell et al., 2008; Moriguchi et al., 2005; Suwazono et al., 2005).

2.3. Measurement of water fluoride concentration

Tap water samples were collected at respondents' homes and were available for Cycle 3 only. Samples were analyzed for fluoride concentrations (mg/L) via a basic anion exchange chromatography procedure with a LoD of 0.006 mg/L. Concentrations at the LoD were assigned a missing value code by Statistics Canada, and these values were subsequently replaced with an imputed value of $LoD/\sqrt{2}$ (Hornung and Reed, 1990); 150 of 980 (16%) water samples had fluoride levels below the LoD.

2.4. Measurement of attention-related outcomes

Primary outcomes included the hyperactivity/inattention subscale score from the Strengths and Difficulties Questionnaire (SDQ; Goodman, 2001) and a physician-made diagnosis of ADHD; these outcomes were measured in both Cycles 2 and 3. Data are presented for youth ages 6 to 17 because the SDQ was only administed to youth under age 18 and 90% of youth with ADHD are diagnosed after age 6 (Kessler et al., 2005). For children aged 6 to 11 years, information about ADHD diagnosis and SDQ ratings were provided by parents or guardians, whereas youth aged 12 to 17 years completed the questionnaire

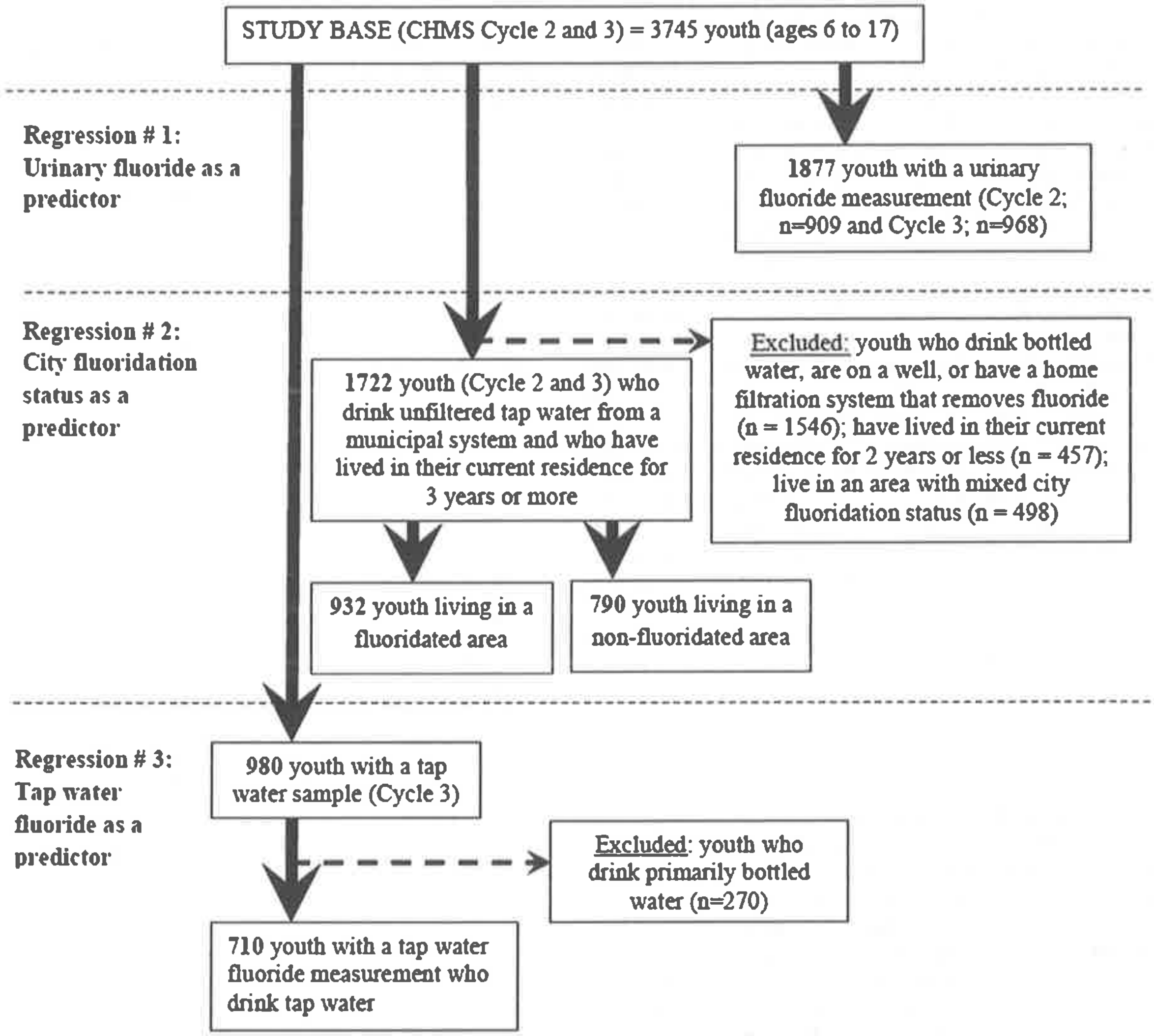

Fig. 1. Subject inclusion in each regression analysis.

themselves, including the question about having a diagnosis of ADHD.

The SDQ consists of 25 items with a 3-point response scale (0 = *not true*, 1 = *somewhat true*, and 2 = *certainly true*). These items are divided among five subscales: emotional problems, conduct problems, hyperactivity-inattention, peer problems, and prosocial behaviour. Possible scores on each subscale range from 0 to 10. The five-item hyperactivity-inattention subscale was used in the current study to test the association between fluoride and ADHD-like symptoms.

The item pertaining to a physician-made diagnosis of ADHD differed between Cycles 2 and 3. In Cycle 2, respondents were asked *Do you have a learning disability?*, and if they responded *yes*, they were asked to specify the type of learning disability from among four options: (1) Attention Deficit Disorder, no hyperactivity [ADD]; (2) Attention Deficit Hyperactivity Disorder [ADHD]; (3) Dyslexia; and (4) Other. In Cycle 3, parents of children aged 6 to 11 were asked directly whether their child had ADHD, and if so, which subtype. Similarly, youth age 12 or older were asked whether they have received a physician-diagnosis of ADHD, and if so, which subtype. Across both cycles, all subtypes were combined into a single dichotomous variable of ADHD diagnosis (*no* = 0, *yes* = 1) as per current diagnostic classification schemes (American Psychiatric Association, 2013).

2.5. Covariates

Covariates related to ADHD diagnosis and to fluoride metabolism were selected based on literature review and consultation with an ADHD expert. The following covariates were included in each regression model: sex, age of child at household interview, ethnicity (white or ethnic minority), Body Mass Index (BMI), highest level of education obtained by either parent (less than a bachelor's degree vs. bachelor's degree or greater), total household income (Canadian dollars), exposure to cigarette smoke inside the home (yes or no), and $\log_{10}$-transformed value of concurrent level of blood lead (μg/dL).

2.6. Statistical analysis

Outliers that had high Studentized residuals, leverage, or Cook's distance values were removed from all analyses with UF_{SG} as a predictor; these outliers (0.27% of values) represented individuals with urinary fluoride levels that were over 30 times the mean UF_{SG} level, likely representing an acute fluoride ingestion (e.g., swallowing toothpaste). Further, individuals with the highest incomes were identified as extreme observations; these values were replaced with the next highest income value (only 0.01% of income values were adjusted).

We used robust logistic regression to examine the associations between each fluoride exposure measure (UF_{SG}, CWF status, tap water fluoride) and ADHD diagnosis with the same set of covariates in each model. Box-Tidwell tests were used to check the linearity of the relationship between the log-odds of the dependent variable (ADHD diagnosis) and all continuous predictors; none of the non-linear terms were significant. Next, we used robust linear regression models with the same set of covariates to examine the associations between the three measures of fluoride exposure and the SDQ hyperactivity/inattention subscale score. Because the regression models produced heteroscedastic and non-normal residuals, all significance tests and confidence intervals were based on robust Huber-White standard errors. No issues with multicollinearity were detected from variance inflation factor (VIF) statistics. All regression analyses tested interactions between age and fluoride and between sex and fluoride, as hyperactivity is more common in younger boys and sex-dependent fluoride effects have been previously reported (Mullenix et al., 1995; Green et al., 2019). If an interaction with age was significant, we probed the interaction by calculating the predicted association between fluoride and the outcome at the 25th and 75th percentiles of age. When a tested interaction was non-significant, the model was re-estimated without the interaction term and the overall associations were interpreted. Finally, we conducted sensitivity analyses to test whether the associations between the fluoride exposure variables and ADHD diagnosis differed between cycles given that the question about ADHD diagnosis was posed differently across the two cycles. A two-tailed $\alpha = 0.05$ was used as the threshold for statistical significance.

3. Results

3.1. Descriptive statistics

Of all variables included in the CHMS, missing data were highest for household income (missing among 29% and 23% of CHMS respondents in Cycle 2 and 3, respectively); however, Statistics Canada provided imputed estimates for all participants missing the household income variable. Across Cycle 2 and 3 combined, most demographic variables (including sex, age, ADHD diagnosis, SDQ score, and length of residence) had less than 2% missing data. For highest household education, 2.6% of data were missing, and 7.4% of participants did not report their height or weight, which are needed to calculate BMI.

Table 1 presents descriptive statistics for the different samples used for the regression models. Among the 1877 youth in Cycles 2 and 3 with a urinary fluoride measurement, 51.2% were male, 72.6% were white, and 47.0% had at least one parent with a university degree or higher. In this sample, 137 (7.3%) reported having received a diagnosis of ADHD; the mean for the SDQ Hyperactivity-Inattention subscale score was 2.7 ($SD = 2.7$; range: 0 to 10) with 201 (11.4%) youth having scores in the clinical range (i.e., above 90th percentile; Goodman, 2001). As expected, participants with an ADHD diagnosis had significantly higher scores on the SDQ Hyperactivity-Inattention subscale ($M = 6.5$, $SD = 2.5$) than those without a diagnosis ($M = 2.5$, $SD = 2.4$), $t = 24.8$, $p < .01$. Table 2 provides descriptive statistics for the 1877 youth aged 6 to 17 years with and without an ADHD diagnosis.

3.2. Fluoride measurements

The mean UF_{SG} concentration was 0.61 mg/L ($Mdn = 0.51$; $SD = 0.39$; 10th to 90th percentile range = 0.27–1.06 mg/L) among the 1877 youth from Cycles 2 and 3. Mean UF_{SG} concentration was significantly higher among youth who lived in communities with fluoridated drinking water ($M = 0.82$ mg/L, $SD = 0.54$) than among youth who lived in communities without fluoridated drinking water ($M = 0.46$ mg/L, $SD = 0.32$), $t = 15.1$, $p < .01$. The mean water fluoride concentration was 0.23 mg/L ($Mdn = 0.12$; $SD = 0.24$; 10th-90th percentile = 0.01–0.65 mg/L) among the 710 youth for whom tap water measures were available, excluding those who reported drinking bottled water as their main source of water. As expected, water fluoride levels were significantly higher among those living in a fluoridated region ($M = 0.49$ mg/L, $SD = 0.22$) than non-fluoridated region ($M = 0.04$ mg/L, $SD = 0.06$), $t = 34.9$, $p < .01$. Table 3 presents the urinary fluoride and water fluoride levels across demographic characteristics, fluoride exposure variables, and attention outcomes.

Table 1
Demographic characteristics, fluoride exposure variables, and attention outcomes for youth included in the three different samples.

Variable	Participants in Cycles 2 and 3 with:		Participants in Cycle 3 with:
	Urinary fluoride Mean (SD) or %	CWF status[†] Mean (SD) or %	Water fluoride Mean (SD) or %
N	1877	1722	710
Child sex			
Male	51.2	50.8	52.7
Female	48.8	49.2	47.3
Child age at interview (years)	11.3 (3.4)	11.3 (3.3)	11.2 (3.5)
Ethnicity			
White	72.6	67.6	69.0
Non-white	27.3	32.5	31.0
Parental Education			
High School/College	53.0	43.4	44.9
University or higher	47.0	56.6	55.1
Smoking in the home			
Yes	11.5	7.7	8.3
No	88.5	92.4	91.7
Household Income (per $1000 CDN)	91.7 (82.7)	97.3 (70.6)	104.0 (134.6)
Body Mass Index	19.8 (4.7)	19.7 (4.7)	19.6 (4.6)
Blood lead (μg/dL)	0.83 (0.41)	0.83 (0.41)	0.83 (0.41)
Lived in residence			
2.99 years or less	19.2	Excluded	21.1
3.00 years or more	80.8	100.0	78.9
Fluoride measures			
UF_{SG} (mg/L)	0.61 (0.39)	0.64 (0.45)	0.62 (0.48)
Water fluoride (mg/L)	0.23 (0.24)	0.26 (0.26)	0.23 (0.24)
Site adds fluoride			
Yes	50.9	53.3	53.7
No	48.1	46.7	46.3
Outcome Variables			
Diagnosis of ADHD	7.3	5.5	6.3
SDQ H/I Subscale Score	2.8 (2.7)	2.6 (2.6)	2.9 (2.6)

Abbreviations: ADHD = Attention Deficit Hyperactivity Disorder; BMI = Body Mass Index; SD = standard deviation; UF_{SG} = urinary fluoride adjusted for specific gravity; SDQ H/I = Strengths and Difficulties Questionnaire Hyperactivity Inattention.

[†] Youth who drink tap water and have a stable residence.

3.3. Association between fluoride exposure and ADHD diagnosis

No planned interactions were significant in the logistic regression of ADHD diagnosis on UF_{SG} concentration; thus, the final model did not include interaction terms. UF_{SG} did not significantly predict an ADHD diagnosis (adjusted Odds Ratio [aOR] = 0.96; 95% CI: 0.63, 1.46, $p = .84$) adjusting for covariates (Table 4). In the regression of ADHD diagnosis on CWF, there was a significant interaction between age and CWF ($B = 0.19$, $p = .02$), such that the association between CWF and the odds of an ADHD diagnosis was stronger among older youth. Specifically, at the 75th percentile of age (14 years old), the predicted odds of an ADHD diagnosis was 2.8 times greater among youth in a fluoridated region compared with youth in a non-fluoridated region (aOR = 2.84, 95% CI: 1.40, 5.76, $p < .01$), whereas among youth at the 25th percentile of age (9 years old), the predicted odds of an ADHD

Table 2
Comparison of youth with a urinary and water fluoride measurement with and without a diagnosis of ADHD.

Variable	ADHD Diagnosis (n = 137) *Mean (SD)/%*	No ADHD Diagnosis (n = 1740) *Mean (SD)/%*
Sex		
Male	69.7	49.6
Female	30.3	50.4
Ethnicity		
White	85.1	72.4
Non-white	14.9	27.6
Parental Education		
High School/College	68.7	53.1
University or higher	31.3	46.9
Smoking in the home		
Yes	26.9	10.0
No	73.1	90.0
Age	12.0 (3.2)	11.2 (3.5)
Household income (per $1000 CND)	70.6 (54.1)	97.9 (95.4)
BMI	19.4 (4.1)	19.9 (4.8)
Blood lead (µg/dL)	0.83 (0.41)	0.83 (0.41)
Fluoride measures		
Tap water fluoride concentration[†] (mg/L)	0.29 (0.28)	0.22 (0.24)
UF_{SG} (mg/L)	0.57 (0.32)	0.62 (0.45)
Site adds fluoride – Yes	47.1	52.8
Site adds fluoride – No	52.9	47.2
Outcome		
SDQ H/I Subscale Score	6.74 (2.5)	2.51 (2.4)

ADHD = Attention Deficit Hyperactivity Disorder; BMI = Body Mass Index; SD = standard deviation; UF_{SG} = urinary fluoride adjusted for specific gravity concentration; SDQ H/I = Strengths and Difficulties Questionnaire Hyperactivity-Inattention.
[†] Cycle 3 only.

diagnosis was similar across CWF status (aOR = 0.91, 95% CI: 0.41, 1.99, $p = .81$; Table 4). Finally, tap water fluoride concentration was significantly associated with having an ADHD diagnosis, adjusting for covariates; this effect did not significantly interact with sex or age. Specifically, a 1 mg/L increase in tap water fluoride was associated with a 6.1 times higher odds of ADHD diagnosis (95% CI: 1.60, 22.8, $p < .01$; Table 4).

Estimating the models with UF_{SG} and CWF for Cycle 2 and 3 separately showed a similar pattern (Supplemental Table 2). For the regression with CWF, the interaction with age was not significant using Cycle 2 data only ($B = 0.12$, $p = .35$), but was significant using data from Cycle 3 only ($B = 0.30$, $p = .03$).

3.4. Association between fluoride exposure and SDQ hyperactive/inattentive scores

No planned interactions were significant in the regression of SDQ hyperactive/inattentive subscale scores on UF_{SG} concentration; thus, the final model did not include interaction terms. UF_{SG} did not significantly predict SDQ hyperactive/inattentive subscale scores ($B = 0.31$, 95% CI = −0.04, 0.66, $p = .08$; Table 4).

Next, there was a significant interaction between age and CWF status ($B = 0.11$, $p = .01$) such that the association between CWF and hyperactivity/inattention scores was stronger among older youth. Specifically, the regression model predicted that for youth at the 75th percentile of age (14 years old), living in a fluoridated region was associated with a 0.7-point higher SDQ hyperactivity/inattention score (95% CI = 0.34, 1.06, $p < .01$). In contrast, among youth at the 25th percentile of age (9 years old), CWF status was not significantly associated with SDQ hyperactivity/inattention scores ($B = 0.04$, 95% CI = −0.38, 0.46, $p = .85$).

Table 3
Urinary fluoride and tap water fluoride levels across binary demographic characteristics and fluoride exposure variables.

Variable	UF_{SG} (mg/L) Mean (SD)	Water fluoride (mg/L) Mean (SD)
Child sex		
Male	0.61 (0.36)	0.23 (0.24)
Female	0.63 (0.51)	0.23 (0.24)
Ethnicity		
White	0.60 (0.42)	0.21 (0.23)
Non-white	0.68 (0.51)	0.28 (0.26)
Parental Education		
High School/College	0.62 (0.49)	0.21 (0.23)
University or higher	0.61 (0.38)	0.24 (0.25)
Smoking in the home		
Yes	0.57 (0.36)	0.17 (0.21)
No	0.63 (0.45)	0.24 (0.24)
Lived in residence		
2.99 years or less	0.64 (0.50)	0.23 (0.24)
3.00 years or more	0.61 (0.42)	0.23(0.24)
Type of water consumed		
Tap water	0.62 (0.44)	0.23 (0.24)
Bottled water	0.62 (0.45)	0.22 (0.23)
Source of water		
Municipal water system	0.63 (0.45)	0.25 (0.25)
Private well	0.54 (0.34)	0.13 (0.13)
Fluoride measures		
Site adds fluoride		
Yes	0.82 (0.54)	0.49 (0.22)
No	0.46 (0.32)	0.05 (0.06)

Abbreviations: ADHD = Attention Deficit Hyperactivity Disorder; SD = standard deviation; UF_{SG} = urinary fluoride adjusted for specific gravity.

Table 4
Adjusted Odds Ratio (aOR) and effect estimates for the association between fluoride exposure, ADHD diagnosis, and attention symptoms.

	ADHD diagnosis		SDQ H/I subscale score	
	aOR[a]	95% CI	aOR[a]	95% CI
UF_{SG} (mg/L)[b]	0.96	0.63, 1.46	0.31	−0.04, 0.66
Fluoride in tap water (mg/L)[c]	6.10*	1.60, 22.8	0.31*	0.04, 0.58
75th percentile age	–[d]	–	1.52*	0.23, 2.80
25th percentile age	–	–	−0.33	−1.51, 0.84
CWF status[e]	1.21*	1.03, 1.42	0.11*	0.02, 0.20
75th percentile age	2.84*	1.40, 5.76	0.70*	0.34, 1.06
25th percentile age	0.91	0.41, 1.99	0.04	−0.38, 0.46

Abbreviations: ADHD = Attention Deficit/Hyperactivity Disorder; CWF = community water fluoridation; aOR = adjusted odds ratio; SDQ H/I = Strengths and Difficulties Questionnaire Hyperactivity-Inattention.
* $p < .05$.
[a] Adjusted for child's sex, age at interview, ethnicity (white or other), body mass index, highest level of parental education, total household income, exposure to cigarette smoke inside the home (yes/no), concurrent blood lead level (log_{10}-transformed).
[b] Non-significant main effect of urinary fluoride level predicting ADHD diagnosis ($B = -0.04$, $p = .84$) or SDQ subscale score ($B = 0.31$, $p = .08$).
[c] Interaction between age and water fluoride level predicting SDQ subscale score ($B = 0.31$, $p = .03$).
[d] Since the interaction between age and water fluoride was not significant, only the main effects are presented for the logistic regression predicting ADHD diagnosis from fluoride in tap water (mg/L).
[e] Significant interaction between age and CWF status predicting ADHD diagnosis ($B = 0.19$, $p = .03$) and SDQ subscale score ($B = 0.11$, $p = .01$).

Finally, the interaction between age and tap water fluoride level was also significant ($B = 0.31$, $p = .03$) such that the association between tap water fluoride and SDQ hyperactivity/inattention score was stronger among older youth. In particular, among youth at the 75th percentile of age (14 years old), an increase of 1 mg/L in water fluoride level was associated with a 1.52 increase in the SDQ hyperactivity/inattention subscale score (95% CI: 0.23, 2.68, $p = .02$). However, for youth at the 25th percentile of age (8 years old), the association between water fluoride level and SDQ hyperactivity/inattention subscale score was not significant ($B = -0.33$, 95% CI: −1.51, 0.84, $p = .58$).

4. Discussion

We found that Canadian youth exposed to higher tap water fluoride levels had a higher risk of receiving an ADHD diagnosis and reported more symptoms of hyperactivity and inattention. Specifically, an increase of 1.0 mg/L in water fluoride concentration was associated with a 6.1 times higher odds of an ADHD diagnosis after accounting for potential confounding variables, such as exposure to second-hand smoke, household income, and blood lead level. Likewise, water fluoride concentration was positively associated with hyperactive/inattentive symptoms, especially among older youth. To contextualize these results, the difference in water fluoride concentration between cities with and without fluoridation is approximately 0.5 mg/L. Our finding of a 1.5-point increase in the SDQ hyperactive/inattentive symptom subscale for each increase of 1 mg/L in water fluoride level implies a 0.75-point increase per 0.5 mg/L water fluoride; this result is remarkably consistent with our finding of a 0.7-point increase on the SDQ's hyperactivity/inattention subscale observed among older youth living in a fluoridated versus non-fluoridated region.

In contrast, urinary fluoride levels were not significantly associated with a diagnosis of ADHD or hyperactive/inattentive symptoms. Water fluoride concentration and CWF status may be more strongly associated with attention-related outcomes than urinary fluoride levels because fluoride concentrations in municipal water supplies vary within a limited range and therefore may serve as a proxy for early-life and chronic fluoride exposure. In contrast, urinary fluoride levels in spot samples are more likely to fluctuate due to the rapid elimination kinetics of fluoride. Additionally, urinary fluoride values may capture acute exposures due to behaviours that were not controlled in this study, such as professionally applied varnish, consumption of beverages with high fluoride content (e.g., tea), or swallowing toothpaste prior to urine sampling. Finally, the association between urinary fluoride and attention-related outcomes could be obscured due to reduced fluoride excretion (i.e., increased fluoride absorption) during a high growth spurt stage (Jha et al., 2011; World Health Organization, 1997). Despite these limitations, use of individualized biomarkers is considered an improvement over past ecologic studies (Malin and Till, 2015) examining the association between ADHD and fluoride exposure and it has the advantage of examining all sources of fluoride exposure, not just from drinking water.

Our findings are consistent with earlier studies showing a relationship between fluoride exposure and ADHD. In particular, Malin and Till (2015) found that a 1% increase in community water fluoridation prevalence in 1992 was associated with approximately 67,000 to 131,000 additional ADHD diagnoses from 2003 to 2011 among children and adolescents in the United States. Conversely, Barberio and colleagues (2017) did not find a significant relationship between fluoride exposure and learning disabilities (including ADHD) using data from the CHMS Cycles 2 and 3. A direct comparison of our results to the results found by Barberio and colleagues is challenged by the differences in how the data were analyzed between the two studies. Our sample included youth between ages 6 and 17, whereas Barberio and colleagues restricted their sample to youth ages 3 to 12. Further, Barberio and colleagues included participants with learning disabilities instead of selecting only those with a diagnosis of ADHD. Finally, the current study accounted for whether youth in both Cycles 2 and 3 drank unfiltered municipal tap water. It may be that the effects of fluoride exposure are most pronounced in older youth, or that fluoride is specifically associated with ADHD-related behaviours as opposed to learning disabilities. Finally, inclusion of learning disabilities may also introduce selection bias due to differences in how learning disabilities and ADHD are diagnosed in Canada.

Our findings showed that age modified the association between fluoride exposure and the likelihood of ADHD diagnosis and symptoms of hyperactivity and inattention, such that the associations were stronger among older youth. The method used in the CHMS may not be as sensitive for young children who are at risk of an ADHD diagnosis but have not yet been diagnosed; given that 90% of youth with ADHD are diagnosed after age 6 (Kessler et al., 2005), we restricted our minimum age to 6 years. Cumulative exposure to fluoride over time may also impact neurobehavioural development such that youth show more symptoms as they age. Alternatively, because the developing brain is highly sensitive to environmental toxins (Grandjean and Landrigan, 2006; 2014) and because gene expression later in life is impacted by epigenetic changes that occur earlier in development (Roth, 2012), changes produced by early exposure to environmental toxins may manifest later in development.

While ADHD is known to have a strong genetic component with an estimated heritability of 70% to 80% (Larsson et al., 2014), environmental risk factors are also believed to contribute to the development of ADHD. Prenatal substance exposures, heavy metal and chemical exposures, and nutritional factors have been proposed to contribute to the rise in ADHD in the United States (Xu et al., 2018; Sciberras et al., 2017) and an increase in behavioural difficulties as assessed by the SDQ (Philippat et al., 2017; Oulhote et al., 2016; Luk et al., 2018). A recent systematic review (Donzelli et al, 2019) reported a significant association between lead exposure and risk of ADHD in 12 out of 17 studies; the adjusted odds ratios ranged from 1.09 to 7.25, which is within the range of the current study findings. Although the precise mechanism by which fluoride affects neurodevelopment is unclear, several possible mechanisms have been proposed. Animal studies have shown alterations in acetylcholine or cholinergic receptors due to fluoride exposure (Chouhan et al., 2010; Liu et al., 2010; Reddy et al., 2014). In particular, both nicotinic acetylcholine receptors and cholinesterase expression appear to play a role in attentional processes (Levin et al., 2011). Other studies have shown morphological changes in neurons (Bhatnagar et al., 2011), mitochondria (Zhao et al., 2019), increased catalase immunoreactivity (Güner et al., 2016), more oxidative stress (Zhang et al., 2015), and increases in apoptotic neurons and abnormal mitochondrial dynamics (Lou et al., 2013, 2014). Further, some studies have suggested that fluoride may suppress thyroid function (Trabelsi et al., 2001); subclinical hypothyroidism during pregnancy has been linked with increased risk for attention disorders (Modesto et al., 2015; Päkkilä et al., 2014).

Our study has some limitations. First, tap water fluoride was measured in Cycle 3 only, which decreased the sample size for analyses using this predictor. However, we were able to determine CWF status for participants in both Cycle 2 and 3, which permitted examining the concordance between the effects associated with tap water fluoride level, CWF status, and urinary fluoride level. Second, use of exposure metrics obtained at the same time as the outcome of interest (cross-sectional data) is limited for making conclusions about the causal association between fluoride and attention-related outcomes. Exposure misclassification may have occurred for some participants due to changes in a city's water fluoridation status over the youth's lifetime. Tap water samples were collected between 2012 and 2013 when approximately 37.4% of Canadians had access to fluoridated water as compared with 42.6% in 2007 (Public Health Agency of Canada, 2017). Thus, water fluoride measures obtained at the time of CHMS data collection may not be consistent with water fluoride levels that were antecedent to the outcomes in our study. Because the CHMS only measured postnatal fluoride exposure, we were not able to distinguish the effects of fluoride exposure during different developmental periods (e.g., prenatal versus postnatal). Recent studies have identified pregnancy as a critical period during which fluoride exposure is linked to lowered IQ (Bashash et al., 2017; Green et al., 2019) and attention-related behaviours (Bashash et al., 2018) in offspring. Third, the method used by CHMS may not completely capture true ADHD prevalence. Because of the way that the CHMS items were phrased, the Cycle 2 sample may identify youth with a comorbid learning disability and ADHD, but not those who have ADHD and no learning disability. Nonetheless, the prevalence of ADHD in the current study (7.3%) is similar to the prevalence rate found in other studies. A *meta*-analysis including 175 studies from across the world obtained an overall ADHD prevalence rate of 7.2% (Thomas et al., 2015). In a 2012 sample of Canadian youth under age 24, the prevalence of ADHD was 5.4% (Hauck et al., 2017). Relatedly, the number of youth with ADHD in our study was relatively small, ranging from approximately 45 to 140 depending on the sample used for a given analysis, which limited statistical power and precision. Finally, the SDQ relies on youth or parent perceptions of symptoms. Future studies would benefit from prospective designs and more rigorous symptom assessment, particularly a structured diagnostic interview that assesses DSM-5 criteria for ADHD.

In conclusion, we found that higher tap water fluoride levels and fluoridation of municipal water supplies were associated with a higher risk of an ADHD diagnosis as well as increased symptoms of hyperactivity and inattention, especially among adolescents. These findings, which point to a potential cumulative effect of fluoride exposure, highlight the need for further investigation of the potential for fluoride-mediated developmental neurotoxicity in populations with water fluoridation.

Declaration of Competing Interest

None.

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Appendix A. Supplementary material

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SPEAKER'S SIGN-UP SHEET

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FISCAL YEAR 2021 PRELIMINARY PROPOSED BUDGET TUESDAY, FEBRUARY 4, 2020 @ 7:30 p.m.		
PLEASE PRINT **NAME**	PLEASE PRINT **ADDRESS**	PLEASE PRINT **REPRESENTING**
Cynthia Erville	905 Buckingham Drive, Silver Spring, MD 20901	"The public"
PAUL MAHER	10644 Weymouth Dr. Bethesda, MD 20814	Public
~~Chris Lawson~~		
BARUCH YEHUDAH		
KATHERINE KATZIN		

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From: **Cynthia Erville** ervillec@aol.com
Subject: Fluoride's Harm to the Developing Brain
Date: February 2, 2020 at 12:06 AM
To: Paul Petini ppitino@cityofarcata.org

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Fluoride Action Network

Fluoride's Harm to the Developing Brain: Recent Science

"Several experts equated the harm found from fluoride to that from childhood lead poisoning."

The past year has seen unprecedented new science from Canada and the USA showing fluoride harms the developing brain from exposures due primarily to artificial water fluoridation.

Two of the published studies found clear associations between water fluoridation and substantial loss of IQ, both from prenatal and infant exposures. Equally worrisome is a third study that found children in fluoridated areas have a 284% higher risk of ADHD compared to those in non-fluoridated areas. Finally, a fourth study found harm in adolescence as well, with altered sleep patterns. Three of these high-quality studies were funded by the US National Institute of Environmental Health Sciences.

The wave began in 2017

This wave of new studies actually started in 2017 with two mother-child cohort studies of IQ loss in Mexico [Valdez-Jimenez 2017 and Bashash 2017]. These two high-quality studies confirmed the evidence of fluoride's neurotoxicity that had been accumulating over 30 years in China, India, and elsewhere consisting of 60 human studies

The high quality fluoride-IQ studies in 2017 were followed in 2018 with a study showing an association between fluoride and ADHD [Bashash 2018] and another showing an association between fluoride and reduced thyroid function (hypothyroidism) which was exacerbated by iodine deficiency [Malin 2018]. Hypothyroidism in pregnant women is a known cause of lowered IQ in their children.

The four studies published in 2019 are the strongest ever and are undeniably relevant to the levels of fluoridation in the USA. I will discuss these in turn.

1) Green 2019: in JAMA Pediatrics. Substantial IQ loss in Canadian children from prenatal exposure to fluoride from water fluoridation.

This year's first major study was from a research group based in Canada and published in the prestigious journal *JAMA Pediatrics* [Green 2109]. It received widespread media coverage, with articles in The Washington Post, CNN, NPR, Time Magazine, etc. The editors of JAMA Pediatrics even went so far as to say that the study reversed their previous (mis)conception that fluoridation was perfectly safe and only crazy people claimed it could be neurotoxic. The editor-in-chief said if his wife were pregnant he would advise her to avoid fluoridated water [JAMA Pediatrics Christakis podcast]. Several experts equated the harm found from fluoride to that from childhood lead poisoning.

2) Riddell 2019: found almost 3 times higher risk of ADHD for those living in fluoridated areas in national sample of Canadian children.

This study, also from Canada, found a strong association between home water fluoride concentration and much higher risk of ADHD diagnoses in children [Riddell 2019]. The data came from a government sponsored nationwide survey of health and nutrition (Canadian Health Measures Survey). The study found that children living in areas with fluoridated water had a 284% higher risk of having a diagnosis of ADHD as those who lived in non-fluoridated areas. This study confirmed two previous studies linking fluoride to ADHD from Mexico and the USA [Bashash 2018, Malin 2015] confirmed two previous studies linking fluoride to ADHD from Mexico and the USA [Bashash 2018, Malin 2015].

3) Till 2020: *(published ahead of print in Nov 2019)* **Children who were formula-fed and lived in fluoridated areas as babies have dramatically lower IQ compared to those who lived in non-fluoridated areas.**

This study is arguably the most worrisome finding yet. Till and co-workers found that formula-fed infants in fluoridated areas had much lower IQ than formula-fed infants in non-fluoridated areas.

Formula-fed babies (with most of the powdered formula reconsitututed with tap water) in fluoridated areas averaged 4 IQ points lower compared to formula-fed babies in non-fluoridated areas. Tests of non-verbal IQ showed even more dramatic effects, with an average loss of 9 points in the non-verbal component of IQ tests. When translated to typical water fluoridation levels in the USA of 0.7 mg/L the Till 2020 findings suggest a loss of non-verbal IQ of 13 points for infants in fluoridated areas compared to those with low levels of fluoride in the water. This study was in a carefully monitored cohort followed from before birth through age 4 years. The study authors controlled for many factors. When they also adjusted for mothers' fluoride exposure during the pregnancy, that only accounted for a small part of the IQ loss. Thus, infancy may be at least as susceptible a period for neurotoxic harm as the prenatal period and exposure during both developmental periods may produce additive harm. Not just pregnant women should be advised to avoid fluoridated water, their children should as well.

These three studies were all within Canada, where the average water fluoridation level is 0.6 mg/L, while the current average in the USA is 0.7 mg/L (and in some communities still up to 1.2 mg/L). These studies are also relevant to the USA because socio-economic and other factors in Canada are arguably as similar to the USA as can be found anywhere.

A fourth study, published just last week, bursts any remaining quibbles about relevance to the USA because it studied children in the USA [Malin 2019].

4) Malin 2019: Altered sleep patterns in adolescents linked to levels of fluoride in the drinking water in the USA.

This study used data from the rigorous, nationally representative, NHANES health and nutrition surveys conducted by the CDC. The authors found that in adolescents age 16-19 years with fluoridated water, there was a doubling of symptoms indicative of sleep apnea, compared to those with low fluoride water. There were also significantly later bed times and waking times in the adolescents with higher water fluoride levels. The link between fluoride and sleep disturbances may be through fluoride's effect on the pineal gland. This gland, situated in the brain, regulates sleep-wake cycles through the hormone melatonin. The pineal gland accumulates high levels of fluoride, and previous studies in animals suggested fluoride may alter melatonin levels [Luke 1997]. Alteration of sleep patterns may be a neurotoxic effect of fluoride separate from the loss of IQ and increased risk of ADHD due to earlier life exposures.

It bears repeating that all four of these 2019 studies were performed in Canada or the USA where the majority of fluoride exposure comes from artificially fluoridated water. In other words, harm was found in children with average intakes of fluoride.

The oft-repeated claim of fluoridation proponents, that studies finding neurotoxic harm are only from areas with "irrelevant" high fluoride levels, can now be roundly dismissed.

Just one study!

Another criticism from fluoridation proponents that the JAMA pediatrics study was "just one study" has been false for at least 30 years, since the first of now over 60 fluoride-IQ studies was published in China in the 1980s [FAN 64 IQ studies webpage]. Almost 15 years ago the US National Research Council's comprehensive review noted several human neurotoxicity studies and many animal studies as clear evidence that fluoride could harm the brain [NRC 2006].

Conclusion

The scientific evidence can now be considered overwhelming. This may be a big surprise to those were never aware of the many studies because they simply accepted the claim that fluoridation was "safe and effective". It may be a shock to fluoridation promoters who have tried to ignore or deny each accumulating piece of evidence. But the science is now undeniable. We don't know how long it will take for this truth to sink in to mainstream science, medicine, and public health. It will likely take more hard work on the part of scientists conducting even more studies, and by individuals and groups like FAN reaching ordinary people and government officials.

An analogy to the history of "low-level" lead neurotoxicity can offer insights. Several experts have said that it now looks like fluoride poses a similar risk for the developing brain as lead poisoning. In fact, back when leading researchers first started voicing concern that "low-level" lead was causing neurobehavioral harm in children, about 30 years ago, the existing

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Patterns of dental caries following the cessation of water fluoridation

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Maupomé G, Clark DC, Levy SM, Berkowitz J. Patterns of dental caries following the cessation of water fluoridation. Community Dent Oral Epidemiol 2001; 29: 37–47. © Munksgaard, 2001

Abstract – *Objectives:* To compare prevalence and incidence of caries between fluoridation-ended and still-fluoridated communities in British Columbia, Canada, from a baseline survey and after three years. *Methods:* At the baseline (1993/4 academic year) and follow-up (1996/7) surveys, children were examined at their schools. Data were collected on snacking, oral hygiene, exposure to fluoride technologies, and socio-economic level. These variables were used together with D1D2MFS indices in multiple regression models. *Results:* The prevalence of caries (assessed in 5927 children, grades 2, 3, 8, 9) decreased over time in the fluoridation-ended community while remaining unchanged in the fluoridated community. While numbers of filled surfaces did not vary between surveys, sealed surfaces increased at both study sites. Caries incidence (assessed in 2994 life-long residents, grades 5, 6, 11, 12) expressed in terms of D1D2MFS was not different between the still-fluoridating and fluoridation-ended communities. There were, however, differences in caries experienced when D1D2MFS components and surfaces at risk were investigated in detail. Regression models did not identify specific variables markedly affecting changes in the incidence of dental decay. *Conclusions:* Our results suggest a complicated pattern of disease following cessation of fluoridation. Multiple sources of fluoride besides water fluoridation have made it more difficult to detect changes in the epidemiological profile of a population with generally low caries experience, and living in an affluent setting with widely accessible dental services. There are, however, subtle differences in caries and caries treatment experience between children living in fluoridated and fluoridation-ended areas.

Key words: caries; epidemiology; fluoridation; incidence; prevalence

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In the last 30 years, oral health in North America has improved dramatically (1, 2), although there are still significant oral health needs in some subgroups (3, 4). Much of the improvement in dental caries is attributed to the widespread use of fluorides (5, 6). Despite this generally held opinion, the literature fails to provide good current estimates for the effectiveness of water fluoridation, either alone or when used in conjunction with the many other available fluoride technologies (7–9). During the 1980s and 1990s, considerable attention has been paid to the safety and effectiveness of fluorides (5–11). This renewed scientific concern is being driven by the fragmented but constantly-present opposition to water fluoridation (12, 13), the changing trends of caries (2, 3, 14, 15), the complex exposures and ingestion patterns of fluoride (16–18), the need to balance fluorosis risk through adjusting the total amount of fluoride ingested from numerous sources (12, 19–23), the (still poorly-understood) effects of fluoride on bone (11), and the paucity of current data on fluorides (6, 8, 19, 24). Accordingly, there is still a need to estimate the caries-preventive benefits from fluoridated water (25). Considerably less attention has been devoted to the issue of cessation of fluoridation.

C Erville comments : No rain permitted on their parade !

Event ***for state and national leaders*** *will commemorate* ***75th year*** *of community water fluoridation*

January 14, 2020, By David Burger

75TH ANNIVERSARY

COMMUNITY WATER FLUORIDATION CELEBRATION

ADA

The ADA National Fluoridation Advisory Committee is inviting dentists and others who promote the adoption and continuation of adding an optimal amount of fluoride to water to celebrate this year.

The year 2020 marks the 75th anniversary of community water fluoridation in the United States.

Part of celebrating this event will be a National Fluoridation Symposium at ADA Headquarters in Chicago.

Attendees at the invitation-only event can expect an educational symposium with special guest speakers, expert panels and sessions on practical aspects to understanding, promoting and retaining community water fluoridation, said Dr. Leon E. Stanislav, chair of the committee, a component of the ADA Council on Advocacy for Access and Prevention.

The symposium will be recorded and available to members after the event, with four continuing education courses available.

"I cannot convey how proud I am of the members of the committee, the ADA and all the other organizations and institutions that have rallied over the years in the fight to promote better oral health via one of the most cost-effective and safe methods that reaches so many people regardless of age, ethnicity and socioeconomic status," Dr. Stanislav said.

Members of the **National Fluoridation Advisory Committee** will present at the symposium. Dr. Stanislav said t**he committee was created in 1970 to combat opponents of community water fluoridation**.

"From the beginning, there has always been opposition to the practice, which continues today," Dr. Stanislav said. "In fact, antifluoridation efforts were frequent enough that the ADA decided to organize an expert group to provide evidence based-fluoridation assistance to the membership and public at large. This early group of stakeholders were to form what we now have as the National Fluoridation Advisory Committee. **This is the core of what has been the go-to resource to respond to misinformed anti-fluoridation efforts** and to assist community water fluoridation startups in communities across the U.S."

In 1945, Grand Rapids, Michigan, became the first city to institute community water fluoridation.

Dr. Stanislav said, "It was so successful that many communities did not wait for the studies to be completed before starting their own fluoridation efforts. By 1950, it had the full support of the ADA." For additional community water fluoridation information or symposium information contact Tooka Zokaie, manager of ADA fluoridation and preventive health activities, at zokaiet@ada.org. ADA.org/fluoride.

Is Water Fluoridation Effective?

According to most major sources, estimates of fluoridation effectiveness amount to at most a reduction of only one-half cavity per child. Low end estimates find **no significant reduction at all**. Children aged 6-17 average 2.1 cavities in their permanent teeth[1]:

- Cochrane Collaboration[2] (2015): 26% (**0.5 cavity per child**)
- CDC[3] (2018): 25% (**0.5 cavity per child**)
- Iowa Fluoride Study[4] (2018): **No significant reduction**
- World Health Organization data[5] (2005): **No evidence of fluoridation's effectiveness**

There is already a consensus including CDC, Cochrane Collaboration, the Iowa Fluoride Study and others that fluoride's effectiveness in preventing cavities is mainly topical (not swallowed).

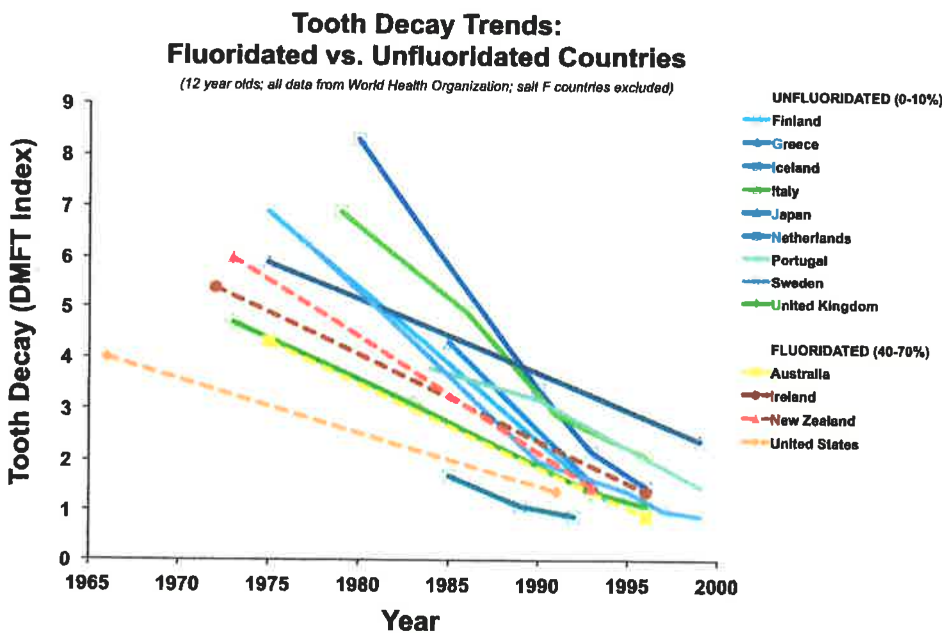
The Cochrane Collaboration is considered the gold standard of evaluating effectiveness. It said the cavity reduction referenced above was *"**based predominantly on old studies and may not be applicable today**."*

> *"Over 97% of the 155 studies were at a high risk of bias, which reduces the overall quality of the results… We did not identify any evidence… to determine the effectiveness of water fluoridation for preventing caries in adults… There is insufficient evidence to determine whether water fluoridation results in a change in disparities in caries levels across socio-economic status."*

The Iowa Fluoride Study (IFS), funded by the National Institutes of Health, is the most comprehensive, ongoing research project in the U.S., the only one measuring all sources of fluoride ingestion. The 2018 study from IFS referenced above found no significant correlation between ingested fluoride and cavity reduction, further validating a 2009 study[6] from IFS that stated:

> *" … achieving a caries-free status may have relatively little to do with fluoride **intake** (emphasis in the original) … recommending an 'optimal' fluoride intake is problematic."*

Finally, World Health Organization data show cavity rates in children (age 12) have dropped as much in nations that don't fluoridate (darker solid lines) as in nations that do (red/yellow dotted lines). *(See graph)*



1. Slade et al. 2018. Journal of Dental Research
2. Cochrane Collaboration, 2015
3. CDC, 2018
4. Curtis et al. 2018. Journal of Public Health Dentistry
5. Neurath, 2005, Fluoride
6. Warren et al. 2009. Journal of Public Health Dentistry

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THE WORLD-WIDE MOVEMENT AGAINST WATER FLUORIDATION

In stark contrast to the Center for Disease Control's claim that fluoridation is one of the top ten public health achievements of the 20th century, it is **one of the most widely rejected health interventions in the world.**

Out of 196 nations, only 24 have any fluoridation, and only 10, like the U.S., for more than half their population. Over 95% of the world's population is fluoridation-free. The U.S. fluoridates as many people as the rest of the world combined.

None of the largest Asian nations, including China, India and Japan, fluoridate. Out of 54 countries in Africa, only one fluoridates – Libya, and only for a small percent of its population. In Europe, only four out of 48 countries fluoridate (less than 2% of the population). A few have fluoridated salt, but only as a consumer choice.

France, Germany, Belgium, the Netherlands, Denmark, Norway and Sweden have all prohibited fluoridation, many citing the ethical problem of putting any drug in drinking water.

For dozens of nations that haven't banned it, thousands of major cities and smaller towns don't fluoridate, including **Athens, Barcelona, Budapest, Geneva, Helsinki, London, Madrid, Prague, Rome, Vienna and Warsaw**. Ireland is the only European nation mandating fluoridation. But despite the mandate, 13 town and county councils, including Dublin and Cork, have voted for its immediate cessation.

Many organizations still support fluoridation, but **those opposing it grows year by year**. They include:

• American Academy of Environmental Medicine • Center for Health, Environment and Justice
• Children's Health Defense • Eau Secours (Canadian coalition of 234 groups promoting clean, safe water)
• Council of Canadians • Environmental Working Group • Food and Water Watch
* Institute of Neurotoxicology & Neurological Disorders • International Academy of Biological Dentistry and Medicine
• International Academy of Oral Medicine and Toxicology • League of United Latin American Citizens
• Moms Against Fluoridation • Organic Consumers Association

In addition, **many organizations once endorsing fluoridation have pulled back**, no longer taking a position. They include the Alzheimer's Association, American Academy of Allergy, Asthma and Immunology, Center for Science in the Public Interest, Consumers Union (Consumer Reports), National Association of Social Workers, National Down Syndrome Congress, National Down Syndrome Society and National Kidney Foundation.

The trend is clear. And as the scientific data accumulate, more and more nations, cities and organizations are challenging the safety, efficacy, costs and ethics of fluoridation.

References at fluoridealert.org/references1

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Risk Factors for Fluoride Toxicity in the Black Community

Numerous studies, including a national survey by the Centers for Disease Control (CDC), have found that black children suffer significantly higher rates of dental fluorosis than white children. (Martinez-Mier 2010; Beltran-Aguilar 2005; Kumar 2000, 1999; Williams 1990; Butler 1985; Russell 1962).

Not only do black children suffer higher rates of fluorosis, they suffer the most severe forms of the condition which are marked by dark brown staining and deterioration of the enamel. While the reasons for this increased rate of fluorosis have yet to be definitively determined, there are several risk factors for fluoride toxicity that are present at elevated rates in the black community. These risk factors include:

1. Reduced nutrient intake;
2. Higher levels of lead exposure;
3. Higher prevalence of health conditions (e.g., kidney disease and diabetes) that render the body more vulnerable to fluoride intake; and
4. Higher intakes of fluoride.

1.) Reduced Nutrient Intake

Voluminous research spanning back to the 1930s shows that populations with nutrient deficiencies are harmed by fluoride exposures otherwise safe for the general population. A 1952 study in the *Journal of the American Dental Association* warned:
"The data from this and other investigations suggest that malnourished infants and children, especially if deficient in calcium intake, may suffer from the effects of water containing fluorine while healthy children would remain unaffected...Thus low levels of fluoride ingestion which are generally considered to be safe for the general population may not be safe for malnourished infants and children. Therefore, the nutritional status must be carefully assessed and guarded in areas with endemic fluorosis. Nutritional studies should be included in any comprehensive program of fluoridation of water with special attention to chronically ailing infants and children...When an individual or a population group shows mottling beyond the degree expected, the health and nutritional status of that group should be investigated." (Massler & Schour 1952).

Research has repeatedly shown that black Americans have lower nutrient intakes than caucasians. (Fulgoni 2007, Goolsby 2006; Sharma 2004). As summarized in a recent review:
"As a group, African-Americans consume a diet that is lower in recommended nutrients and meet fewer of the national recommendations than the average American. In comparison to national recommendations, the African-American diet is more likely to be low in vitamins and minerals, including calcium, and higher in fat. Additionally, the food pattern in the African-American diet includes more meat and fats, while being lower in fruits, vegetables and dairy foods." (Byers 2005).

One reason for the lower nutrient intake in the black community is the higher prevalence of lactose intolerance that is known to exist. (Byers 2005). Due to this high rate of lactose tolerance, black children consume significantly less milk than white children. Since milk is an important source of calcium, and since calcium is important for reducing fluoride's toxic effects on mineralized tissues (bones and teeth), lower milk consumption could be an important reason for the increased fluorosis rate in the black community. Indeed, recent research has specifically found that **milk consumption is associated with reduced severity of fluorosis in areas with high levels of fluoride in water. (Rango 2012).**

Another reason for the reduced nutrient intake in the black community is the scarcity of fresh grocery stores in low-income urban areas. Recent studies have found that the lack of grocery stores in low-income black neighborhoods severely limits access to fresh fruits and vegetables (a major source of anti-oxidants). (Kolker 2008; Burt 2006; Tellez 2006). Consistent with this, the level of anti-oxidants in the blood of otherwise healthy black adults has been found to be significantly lower than the anti-oxidant levels in white adults. (Watters 2007). This is important because **research has repeatedly shown that fluoride increases the level of** oxidative stress **in the body and, as a result, anti-oxidants play a critical role in defending the body from fluoride toxicity**. (Barbier 2010).

2) Lead Exposure

Research has found that the black community has higher levels of lead intake than the white community. (Bernard 2003; Lanphear 1996; Brody 1994). This has been demonstrated through studies of lead levels in both blood and bone. (Jones 2009; Theppeang 2008). This is significant because, according to recent animal research, heightened exposure to lead can exacerbate the toxicity of fluoride exposures. (Leite 2011; Niu 2009). In one animal study, rats with both fluoride and lead exposure had more severe forms of fluorosis than rats with fluoride exposure alone. (Leite 2011). Thus, the higher lead exposure in the black community may help to explain the greater severity of dental fluorosis found in the black community.

3) Fluoride Intake

Some studies have found that black children consume more fluoride from water and beverages than white children. (Sohn 2001). This may be the result of increased lactose intolerance which leads to the substitution of milk with water and other processed beverages. **In addition, studies have found that black children are less likely to be breast-fed than other racial groups. (Robinson 2009)**. A recent national survey by the CDC, for example, found that "**non-Hispanic blacks had a lower prevalence of breastfeeding initiation than non-Hispanic whites in all but two states.**" (CDC 2010). **This is significant because infants consuming formula made with fluoridated water can ingest up to 70 times more fluoride (at the level WSSC is adding at**

0.7 mg/L than a breast fed infant, (breast milk is 0.01), even if he mother is drinking fluoridated tap water . Thus, infants given fluoridated water have been found to be at greater risk of developing dental fluorosis in their permanent teeth. (Hong 2006).

In the review , *Developmental fluoride neurotoxicity; an updated review*, Philippe Grandjean, Environmental Health, 2019 18:110- *which I have sent to you* - Grandjean cited three Chinese studies which, instead of measuring fluoride in wells, **correlated dental fluorosis , DF, in teeth to reduced IQ as compared to no presence of dental fluorosis.** (references 97, 103, 107.

A department of federal health statistics, HANES, examines a sample of children every ten years and reports on the incidence of DF they find. Every ten years, the incidence goes up; I think the last report said 46% nationally. (they dry the teeth and look at back teeth; it is not always visible on front teeth that show. Broken down by race, black children always had a greater incidence of any dental fluorosis. When the DF was ranked from mild to severe, black children also presented the most severe cases.

4.) Health Conditions

Fluoride's toxicity is significantly exacerbated by health conditions, **including kidney disease and diabetes, that are significantly more prevalent among communities of color.**
Black Americans, for example, are over two times as likely to develop chronic kidney disease and nearly four times as likely to experience kidney failure as caucasians. (Muntner 2012; US Renal Data System, 2005). to develop kidney failure than caucasians, **and nearly twice as likely to suffer from diabetes than are whites.** (Katzmarzyk 2012).

Some diabetics and kidney patients who have full upper and lower dental plates (false teeth) can not possibly benefit from dental fluoride - you should not aggravate their conditions by adding fluoride to drinking water.

Cynthia writing :The National Research Council said in 2006 that diabetics and renal patients were sub -populations at risk of getting too much fluoride. Sometimes diabetics drink more water, even though their compromised kidneys can not efficiently rid the body of fluoride. ***I hypothesize that fluoridated water eventually sends more people with diabetes to dialysis centers,*** *than if diabetics had access to fluoride free water, fluoride free soda, and fluoride free beer. (Bottlers use whatever water is provided in that city, and do not remove fluoride as reverse osmosis is expensive to install and maintain.)*

I found this at fluoride alert.org after I put "environmental justice" in the search box, then modified it for WSSC.

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(Cynthia found this at fluoridealert.org by putting "environmental justice" in the search box, then modified it for WSSC

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Environmental Health

REVIEW

Open Access

Developmental fluoride neurotoxicity: an updated review

Philippe Grandjean[1,2]

Abstract

Background: After the discovery of fluoride as a caries-preventing agent in the mid-twentieth century, fluoridation of community water has become a widespread intervention, sometimes hailed as a mainstay of modern public health. However, this practice results in elevated fluoride intake and has become controversial for two reasons. First, topical fluoride application in the oral cavity appears to be a more direct and appropriate means of preventing caries. Second, systemic fluoride uptake is suspected of causing adverse effects, in particular neurotoxicity during early development. The latter is supported by experimental neurotoxicity findings and toxicokinetic evidence of fluoride passing into the brain.

Method: An integrated literature review was conducted on fluoride exposure and intellectual disability, with a main focus on studies on children published subsequent to a meta-analysis from 2012.

Results: Fourteen recent cross-sectional studies from endemic areas with naturally high fluoride concentrations in groundwater supported the previous findings of cognitive deficits in children with elevated fluoride exposures. Three recent prospective studies from Mexico and Canada with individual exposure data showed that early-life exposures were negatively associated with children's performance on cognitive tests. Neurotoxicity appeared to be dose-dependent, and tentative benchmark dose calculations suggest that safe exposures are likely to be below currently accepted or recommended fluoride concentrations in drinking water.

Conclusion: The recent epidemiological results support the notion that elevated fluoride intake during early development can result in IQ deficits that may be considerable. Recognition of neurotoxic risks is necessary when determining the safety of fluoride-contaminated drinking water and fluoride uses for preventive dentistry purposes.

Keywords: Cognitive disorder, Dental caries, Drinking water, Fluoridation, Fluoride poisoning, Intellectual disability, Neurotoxic disorder, Prenatal exposure delayed effects

Background

In 2006, the U.S. National Research Council (NRC) evaluated the fluoride standards of the Environmental Protection Agency (EPA) and concluded that fluoride can adversely affect the brain through both direct and indirect means, that elevated fluoride concentrations in drinking-water may be of concern for neurotoxic effects, and that additional research was warranted [1]. At the time, and continuing through today, the EPA's Maximum Contaminant Level Goal (MCLG) for fluoride was 4.0 mg/L that aimed at protecting against crippling skeletal fluorosis, which is still considered to be the critical adverse health effect from fluoride exposure [2]. Following the NRC review, evidence has accumulated that the developing human brain is inherently much more susceptible to injury from neurotoxic agents, such as fluoride, than is the adult brain [3]. A review and meta-analysis published in 2012 [4] assessed a total of 27 research reports, all but two of them from China, on elevated fluoride exposure and its association with cognitive deficits in children. All but one study suggested that a higher fluoride content of residential drinking water was associated with poorer IQ performance at school age. Only a couple of these studies had been considered by regulatory agencies [1, 5]. As much additional evidence has emerged since then, it seems appropriate

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fetal tissues, including brain [37, 38]. Also, fluoride concentrations in maternal and cord serum correlate well [39], cord blood showing slightly lower concentrations, apparently about 80% of the concentrations in maternal serum [40], though depending on gestational age [17]. Fetal blood sampling techniques have allowed documentation of elevated fluoride concentrations in the fetal circulation after administration of sodium fluoride to the mother [41]. Accordingly, assessment of fluoride in maternal samples during pregnancy may be used as indicator of fetal exposure.

Due to a well-established dose-response relationship between early-life fluoride exposure and the degree of dental fluorosis [6, 20, 42], this abnormality can serve as a useful biomarker of developmental fluoride exposure. When water fluoridation was first introduced in the middle of the twentieth century, U.S. health authorities estimated that less than 10% of children in fluoridated communities (at 1 mg/L water) would develop dental fluorosis, and only in its mildest forms [43]. Subsequent epidemiological studies have demonstrated prevalence and severity of fluorosis much higher than predicted [9, 44, 45]. Increased occurrence of dental fluorosis has also been recorded in fluoridated areas in the United Kingdom [46]. This increase may be related to the widened use of fluoridated water for beverages and food products for general consumption and for formula preparation for infants [19, 21], as well as increased usage (and ingestion) of fluoride-containing toothpastes among preschoolers [47].

Experimental neurotoxicity

In vitro studies have documented fluoride toxicity to brain cells, most of the studies using high fluoride concentrations, though some effects have been demonstrated at lower, more realistic levels [48, 49]. In the low-dose studies, 0.5 μmol/L (10 μg/L) was sufficient to induce lipid peroxidation and result in biochemical changes in brain cells [48], while 3 μmol/L (57 μg/L) induced inflammatory reactions in brain cells [49]. These concentrations are similar to the upper ranges of serum-fluoride levels reported in the general population [6]. In addition, fluoride can negatively affect brain development in rats at levels below those that cause dental lesions [50].

Utilizing computerized surveillance of rat behavior, a landmark study showed signs of neurotoxicity at elevated fluoride exposure [51], and more recent studies have reported fluoride-induced neurochemical, biochemical, and anatomic changes in the brains of treated animals, although often at doses much above human exposure levels. Among possible mechanisms of developmental neurotoxicity is toxicity to the thyroid gland [52], a mechanism relevant in regard to several neurotoxicants [53, 54]. Thus, the NRC concluded that fluoride is an endocrine disrupter that can affect thyroid function at intake levels as low as 0.01 to 0.03 mg/kg/day in individuals with iodine deficiency [1].

A 2016 review by the National Toxicology Program (NTP) focused on fluoride neurotoxicity in regard to learning and memory [55]. At water concentrations higher than 0.7 mg/L, NTP found a low-to-moderate level of evidence. The evidence was the strongest (moderate) in animals exposed as adults and weaker (low) in animals exposed during development, where fewer studies were available at relevant exposure levels. Most experimental studies had used concentrations exceeding the levels added to water in fluoridation programs, but the NTP recognized that rats require about five times more fluoride in their water to achieve the same serum-fluoride concentrations as humans [55].

Subsequently, several additional developmental studies have been published, including two that reported impaired learning/memory in rats consuming water with fairly low fluoride concentrations [56, 57]. However, not all studies have reported adverse effects [58], perhaps due in part to strain or species-related differences in vulnerability to fluoride. In addition, most animal studies used subchronic exposure scenarios and, due to the lack of fluoride transfer into milk, neonatal exposure was not considered, thereby likely underestimating the effect from early-life exposure. Overall, the experimental evidence of developmental neurotoxicity appears to be strengthened and to provide plausibility to the potential occurrence of neurodevelopmental effects in humans.

Methods

Publications on fluoride neurotoxicity in humans were identified from the PubMed data base by using "fluoride" along with search terms "neurotoxic*", "neurologic", and "intelligence". The searches were narrowed by limiting to "human," "most recent 10 Years," and "English." Additional searches using "fluoride" also included search terms "prenatal exposure delayed effects"[MeSH] or "neurotoxicity syndrome"[MeSH]. Secondary searches used combinations of fluoride with "maternal exposure" or "academic disorder, developmental".

Supporting literature from earlier years was obtained by using the terms "occupational exposure" or "endemic disease". References cited in the publications and in recent review reports [55, 59–61] were also retrieved, as were publications listed by PubMed under "Similar articles". Because these articles may not represent an exhaustive list of relevant studies, separate searches included the web site of the journal *Fluoride* (http://www.fluorideresearch.org/) and the site (http://oversea.cnki.net/kns55/default.aspx) that covers many Chinese-language journals not included in PubMed. Full-text originate primarily from coal burning, which may have contributed other, undocumented contaminants.

Additional community studies in adults have focused on cognitive problems and neurological symptoms in subjects with skeletal fluorosis. Using neuropsychological tests, including the Wechsler scale, 49 adult fluorosis patients were compared with controls and showed deficits in language fluency, recognition, similarities, associative learning, and working memory [79]. Further, cognitive impairment in elderly subjects from a waterborne fluorosis area was found to be much more common than in less-exposed controls [80]. Dementia diagnosis in North Carolina was more common at higher water-fluoride concentrations [81], and similar findings for fluoride (and aluminum) have recently been reported from Scotland [82]. Excess occurrence of neurological symptoms (i.e., headaches, insomnia, and lethargy) have also been recorded in both adults and children from waterborne fluorosis areas [83]. However, these studies are hard to evaluate due to uncertainty about past fluoride exposure levels and the possible influence of other risk factors. The literature search did not reveal any other recent studies that added important evidence in this regard.

Cross-sectional studies of children in exposed communities

Most studies that have investigated fluoride's impact on childhood IQ are from locations in China with elevated exposure to fluoride, within and outside of known endemic areas [1, 4, 84]. When water supplies derive from springs or mountain sources, small or large pockets of increased exposures may be created near or within similar areas of lower exposures, thus representing useful epidemiology settings. The fluoride exposure from the household water would then represent the only or major difference between nearby neighborhoods. At the time, children in rural China had very little exposure to fluoridated dental products [85]. The local water-fluoride concentration can then serve as a feasible and appropriate exposure parameter, and some studies emphasized that the children were born in the particular study area, and/or had been using the same water supply since birth. Reliable exposure assessment then becomes possible when rural families remain for a long time at the same residence. Any deviation from stable exposure would result in exposure misclassification and thereby a likely underestimation of the toxicity [86]. Thus, the consistency of study findings supports the likelihood that developmental fluoride exposure causes cognitive deficits [4]. Although the study designs are technically cross-sectional, many of the settings allowed consideration of the current exposure as an indicator also of a longer-term exposure level.

Most study reports have not been widely disseminated and considered in literature reviews. Four studies from China that were published in English [87–90] were cited in the 2006 NRC report [1], while the World Health Organization (WHO) considered only two [87, 90] in its revised Environmental Health Criteria document on fluoride from 2002 [26]. A meta-analysis from 2007 included five studies [91], four of which were not in a subsequent review [84]. The latter review was cited by the EU Scientific Committee on Health and Environmental Risks (SCHER) working group in 2010 [5] in support of a conclusion that the evidence of neurotoxicity was insufficient.

A meta-analysis from 2012 was based on a collaboration with Chinese experts on fluoride toxicity and covered 27 cross-sectional studies reporting associations between children's intelligence and their fluoride exposure [4]. Overall, children who lived in areas with high fluoride exposure had lower IQ scores than those who lived in low exposure or control areas, the average difference being close to 7 IQ points. These findings were consistent with an earlier review [84], but included nine more studies and more systematically addressed study selection, exclusion information, and bias assessment.

Two of the 27 studies that we included in the analysis were conducted in Iran [92, 93], while all other study populations were from China. Two cohorts were exposed to fluoride from coal burning [94, 95], but otherwise the study populations were exposed to fluoride through drinking water contaminated from soil minerals. Due to the use of different cognitive tests, normalized data were used to estimate the possible effects of fluoride exposure on intelligence. The results were materially unchanged in various sensitivity analyses, as were analyses that excluded studies with possible concerns about co-factors, such as iodine deficiency and arsenic toxicity, or non-water fluoride exposure from coal burning [4].

Among the 27 studies, all but one showed random-effect standardized mean difference (SMD) estimates that indicated an inverse association, ranging from -0.95 to -0.10 (one study showed a slight, non-significant effect in the opposite direction). The overall random-effects SMD estimate (and 95% confidence interval, CI) was -0.45 (-0.56, -0.34). Given that the standard deviation (SD) for the IQ scale is 15, an SMD of -0.45 corresponds to a loss of 6.75 IQ points. Although substantial heterogeneity was present among the studies, there was no clear evidence of publication bias [4]. Given the large number of studies showing cognitive deficits associated with elevated fluoride exposure under different settings, the general tendency of fluoride-associated neurotoxicity in children ($p < 0.001$) seems robust.

Recent cross-sectional studies of children

The present study presents an updated literature search that revealed 14 new studies on the association between early-life fluoride exposure and IQ in children (Table 1). All 14 studies reported apparent associations between elevated fluoride exposure and reduced intelligence, although one did not reach statistical significance. The several new Chinese-language studies showed similar associations between fluoride exposure and reduced IQ [96, 101–103, 105, 107, 108], although often published as short reports in national journals and according to the standards of science at the time. Similar findings were reported from India [98, 100, 110] and Africa [104, 106]. As with the previous reports, most of these newer studies suffer from limitations of covariate reporting, which limited the opportunity to assess possible bias. Also, a variety of outcomes have been employed, such as neuropsychological tests and Raven-based intelligence scales. Of note, fluoride exposure was accompanied by other contaminants from coal burning in some studies [96, 99, 101, 102]. Four studies used the degree of dental fluorosis as exposure parameter, and three of them reported a clear negative association with IQ [100, 103, 107], although statistical significance was not reached in one study [102]. The water-fluoride concentrations tended to be somewhat lower than in previous studies and thus more relevant to exposures occurring outside of endemic areas.

To ascertain the validity of the methodology used in Chinese studies of fluoride neurotoxicity, my colleagues and I carried out a small study in Sichuan using methods commonly applied in Western neurobehavioral epidemiology [97]. The 51 children examined had lived in their respective communities all their life, i.e., at least since conception. All three measures of fluoride exposure showed negative associations for cognitive function tests. One exposure parameter was the known water-fluoride concentration at the residence where the child was born, another was the child's morning urine-fluoride after having ingested fluoride-free water the night before (neither measure reached formal statistical significance as predictor of cognitive deficits). The strongest and statistically significant association was seen with the degree of dental fluorosis that served as a marker of the child's early-life fluoride exposure. Other recent studies (Table 1) also found dental fluorosis to be a useful risk indicator. While one previous study in the U.S. failed to observe a relationship between dental fluorosis and behavior (parental assessment by the Child Behavior Checklist) [111], a dose-response relationship between urinary fluoride concentrations (range, 0.24–2.84 mg/L) and reduced IQ was reported in a population without any severe dental fluorosis [112].

A recent meta-analysis of waterborne fluoride exposures [60] covered 18 studies with water-fluoride concentrations below 4 mg/L; clear IQ reductions were observed at water-fluoride concentrations of about 1 mg/L and above. In addition, four cross-sectional studies reported linear relationships between urinary fluoride (one study also included plasma-fluoride) and IQ among children living in areas with mean water-fluoride contents of 1.4 mg/L, 1.5–2.5 mg/L, 1.4 mg/L, and 0.5–2.0 mg/L [99, 107, 109, 113].

Although meta-analysis of studies has previously been carried out [4, 60], the heterogeneity of the new studies and differences in exposure assessment and cognitive tests suggested that a joint analysis would require too many assumptions to provide useful evidence on the dose-dependence of neurotoxicity. The information summarized in Table 1 therefore serves as qualitative documentation that elevated fluoride exposure during early development is associated with cognitive deficits. Although the presence of confounding bias cannot be excluded, the fairly uniform findings under different study conditions would argue against any serious bias. The largest study, by far, reported an IQ loss of 4.29 (95% CI, 0.48–8.09) and 2.67 (0.68–4.67) for each increase by 0.5 mg/L in the fluoride concentration in water and urine, respectively [107]. A recent study with individual exposure data [109] reported lower losses of 0.79 (0.28–1.30) and 0.61 (0.22–0.99) IQ points for each increase by 0.5 mg/L in fluoride in water and urine, respectively. Of note, the ranges of exposures in these studies overlap with concentrations commonly reported from regions without endemic disease.

Prospective studies

More weight must be placed on prospective studies that include assessment of individual levels of fluoride exposures in early life (Table 2). Two prospective studies from New Zealand explored the possible neurobehavioral consequences of community water fluoridation. The first study reported no association between behavioral problems and residence in a fluoridated community during the first 7 years of life [114]. However, like the subsequent study, the authors had no access to individual measurements of fluoride exposure, and the exposure status relied solely on residence in a fluoridated community and its duration, where age at the time of residence was apparently not considered.

A more comprehensive study was based on a birth cohort established in Dunedin, New Zealand from births in 1972–1973 [115]. The 1037 children were recruited at age 3 years, and IQ tests were administered at ages 7, 9, 11 and 13 years, and again at age 38; the average IQ result for 992 subjects was used for comparison between residents in areas with and without water fluoridation. No significant differences in IQ in regard to fluoridation status were noted, and this finding was independent of potential confounding variables that included sex, socioeconomic status, breastfeeding, and birth weight. Prenatal fluoride exposure was not considered. The average difference in childhood exposure between fluoridated vs. non-fluoridated areas was estimated to be 0.3 mg/day [117].

However, the 93 cohort subjects who did not live in a fluoridated area may well have received fluoride supplements, as was the case for a total of 139 children in the study, thereby impacting on the exposures [20]. A further concern is that formula may have contributed substantial fluoride exposure [19, 21], and it is therefore interesting that breastfeeding – and thus avoidance of formula – in the fluoridated areas contributed an advantage that averaged 6.2 IQ points at age 7–13 years, while the advantage was less (4.3) in the non-fluoridated areas [115]. Subsequently, the authors estimated the average total fluoride intake up to age 5 years, including tablets, toothpastes, and dietary sources, without finding any IQ difference [118]. However, information on maternal tea consumption during pregnancy was not obtained, although tea has long been recognized as an important source of fluoride in New Zealand [119]. Lead exposure in this cohort was later reported to cause IQ deficits [120], but control for the blood-lead concentration at age 9 years showed no change in the results for fluoride [117]. Despite the shortcomings, this study has been hailed as evidence that fluoridated water is "not neurotoxic for either children or adults, and does not have a negative effect on IQ" [121]. This conclusion seems rather optimistic [122], given the fact that the exposure assessment was imprecise (especially for prenatal exposure) and that the statistical power was probably insufficient to allow identification of any important IQ deficit.

More recent studies provide more robust evidence. In a prospective study from an area in Mexico with elevated levels of fluoride in drinking water, maternal pregnancy urine-fluoride (corrected for specific gravity) was examined for its association with scores on the Bayley Scales among 65 children evaluated at age 3–15 months [24]. The mothers in the study had average urine-fluoride concentrations at each of the three trimesters of pregnancy of 1.9, 2.0, and 2.7 mg/L (higher than the following study). The fluoride exposure indicators during first and second trimesters were associated with significantly lower scores on the Bayley Mental Development Index score after adjustment for covariates [24].

The existence of the ELEMENT (Early Life Exposure in Mexico to Environmental Toxicants) birth cohort allowed longitudinal measurements of urine-fluoride in pregnant mothers and their offspring and their associations with measures of cognitive performance of the children at ages 4 and 6–12 years [63]. The cohort had been followed to assess developmental lead neurotoxicity, and biobanked urine samples were available for fluoride analysis and adjustment for creatinine and density. Most of the mothers provided only one or two urine samples, thereby introducing some imprecision in the exposure estimate. Child cognitive function was determined by the General Cognitive Index (GCI) of the McCarthy Scale at age 4 years in 287 children, and IQ by an abbreviated Wechsler scale (WASI) at age 6–12 years in 211 children. Urinary fluoride (mg/L) in the mothers averaged 0.90 (s.d., 0.35) and, in the children, 0.82 (s.d., 0.38). Covariates included gestational age, birth weight, sex, parity, age at examination, and maternal characteristics, such as smoking history, marital status, age at delivery, maternal IQ, and education. After covariate adjustment, an increase in maternal urine-fluoride by 1 mg/L during pregnancy was associated with a statistically significant loss of 6.3 (95% CI, − 10.8; − 1.7) and 5.0 (95% CI, − 8.2; − 1.2) points on the GCI and IQ scores, respectively. These associations remained significant, and the effect sizes appeared to increase, in sensitivity analyses that controlled for lead, mercury, and socioeconomic status.

Although adjustment could not be made for iodine deficiency or arsenic exposure, any residual confounding was judged to be small in this population. Important strengths are that the cohort was followed from birth with meticulous documentation for lead exposure and other neurobehavioral risks. This study also ascertained the childhood fluoride exposure at the time of IQ testing (6–12 years) and found no indication of adverse impact on the IQ in the cross-sectional analysis [63].

Between 2008 and 2011, 2001 pregnant women were recruited into the Maternal-Infant Research on Environmental Chemicals (MIREC) cohort in Canada. A subset of 601 of their children were examined at age 3–4 years, slightly less than half of them residing in fluoridated communities [116]. Maternal spot urine samples were obtained from each of the three semesters of pregnancy, and results were analyzed for those 512 mother-child pairs where urine was available from all three semesters, so that the overall average urine-fluoride could be used as an exposure biomarker, with adjustment for specific gravity and creatinine. Information was obtained on food and beverage intakes, including tea (assuming a fluoride content of 0.52 mg in each cup of black tea). Intellectual abilities were assessed using the age-appropriate Wechsler scale that provided a full-scale IQ. Covariate adjustment included exposures to other neurotoxicants and other relevant covariates, such as sex, age at examination, and maternal exposure to indirect smoking, race, and education [116]. As had been shown by the same research group in a previous study of a larger population [11], women residing in fluoridated communities had higher urine-fluoride concentrations (0.69 vs 0.40 mg/L) and also higher calculated daily fluoride intakes from water and other beverages (0.93 vs. 0.30 mg/day). Regression analyses showed that an increase in *urine*-fluoride of 1 mg/L was associated with a statistically significant loss in IQ of 4.49 points in boys, though not in girls. An increase of 1 mg/L of fluoride in *water* and conditions and therefore add little weight to the information otherwise available on fluoride neurotoxicity in children.

Dose-dependence and benchmark doses

The studies reviewed show dose-dependent fluoride neurotoxicity that appears to be statistically significant at water concentrations of or below 1 mg/L, but the studies themselves do not identify a likely threshold. Regulatory agencies often use benchmark dose calculations to develop non-cancer health-based limits for dietary intakes, such as drinking water [62, 131]. One recent report [132] used this approach to generate benchmark results from a study of more than 500 children in China [89]. The authors used a high BMR of 5 IQ points, but results were also given for a more appropriate BMR of 1 IQ point. For the latter, the BMDL was calculated to be a daily intake level of 0.27 mg/day [132]. Using the average water intake of 1.24 L/day in non-pregnant women [133], the BMDL corresponds to a water concentration of 0.22 mg/L. The report did not provide data for urine-fluoride concentrations.

As described in the Methods section, the regression coefficients and their standard deviations, as provided in the published reports [63, 116], were applied to estimate tentative BMD values. Assuming linearity and Gaussian distributions, the right-hand columns of Table 3 show the calculated results for the two prospective studies with the maternal urine-fluoride concentration as the exposure parameter in regard to the cognitive function measures (both boys and girls). For the ELEMENT study, results for the larger number of children with CGI outcomes are also shown. Overall, the BMDL results appear to be in agreement.

The Table 3 results also appear to be reliable, given that the studies provide ample coverage of subjects with lower-level exposures close to the BMDL. The Canadian children had lower prenatal exposures than the Mexican study subjects, and along with the apparent lack of fluoride effects in girls, the BMD results are higher than in the ELEMENT study, although the greater uncertainty results in a fairly low BMDL. The results suggest a BMDL of about 0.2 mg/L or below, a level that is similar to the result calculated from the study in China [89, 132] and clearly below commonly occurring exposure levels, even in communities with drinking water fluoridation.

Plausibility and implications

The present review updates the conclusions from a 2012 meta-analysis of cross-sectional studies of intellectual deficits associated with elevated fluoride exposure [4]. Subsequent epidemiological studies have strengthened the links to deficits in cognitive functions, several of them providing individual exposure levels, though most of the new studies were cross-sectional and focused on populations with fluoride exposures higher than those typically provided by fluoridated water supplies. Prospective studies from the most recent years document that adverse effects on brain development happen at elevated exposure levels that occur widely in North America and elsewhere in the world, in particular in communities supplied with fluoridated drinking water [24, 63, 116, 123]. These new prospective studies are of very high quality and, given the wealth of supporting human studies and biological plausibility, leave little doubt that developmental neurotoxicity is a serious risk associated with elevated fluoride exposure, especially when this occurs during early brain development. While evidence on the neurotoxic impact of early postnatal exposure remains limited [21, 123], other neurotoxicity evidence suggests that adverse effects are highly plausible [124].

Research on laboratory animals confirms that elevated fluoride exposure is toxic to the brain and nerve cells, as already indicated by the NRC review [1]. The evidence today is substantially more robust. The NTP review placed more confidence in fluoride impairing learning in *adult* animals due to fewer experimental studies being available on developmental exposure [55]. Still, not all studies are in agreement [58], perhaps due to species or strain differences in vulnerability. However, fluoride is known to pass the placental barrier and to reach the brain, and the animal studies bear out the importance of the prenatal period for fluoride neurotoxicity. Toxicant exposures in early life can have much more serious consequences than exposures occurring later in life, and the developing brain is known to be particularly vulnerable [69]. Thus, the vulnerability of early brain development supports the notion that fluoride neurotoxicity during early life is a hazard of public health concern [134].

Dental fluorosis has been dismissed as a "cosmetic" effect only [6, 135, 136], but the association of dental changes with intellectual deficits in children [95, 97, 100, 103, 107, 112]

Table 3 Adjusted differences in cognitive outcomes per mg fluoride per liter maternal urine (U-fluoride) during pregnancy, and benchmark dose results (boys and girls) in regard to maternal urinary fluoride excretion (mg/L urine adjusted for creatinine)

Study	Reference	Number	Outcome	U-fluoride (median)	Estimate	95% CI	BMD	BMDL
ELEMENT	[63]	287	GCI	0.84	−6.3	−10.8; − 1.7	0.16	0.10
ELEMENT	[63]	211	IQ	0.82	−5.0	−8.2; − 1.2	0.20	0.13
MIREC	[116]	512	IQ	0.51	−2.0	− 5.2; 1.3	0.51	0.21

elements that cause neurodevelopmental damage. Thus, although fluoride is neurotoxic, it appears to be much less potent than elements that occur at much lower concentrations in the Earth's crust. Although substances that occur naturally in the biosphere may be thought to be innocuous, or even beneficial as in the case of fluoride, the anthropogenic elevations in human exposures may well exceed the levels that human metabolism can successfully accommodate [150].

Perhaps dentistry interests in promoting water fluoridation have affected the risk assessment and reduced the regulatory attention to fluoride toxicity. Thus, reports on fluoride toxicity have been disregarded under a heading referring to "Anti-Fluoridation Activities" [121], and our review article [4] was said to rely on "selective readings" [115], with IQ deficits occurring at high fluoride concentrations "up to 11.5 mg/L" [151], although most of the studies related to concentrations that were only slightly elevated. Further, an ecological study without individual exposure data [115] that failed to identify an association with IQ was considered as strong support of the safety of water fluoridation and more relevant to fluoridation policy than other evidence on neurotoxicity [121].

While water fluoridation continues to be recommended [9], the benefits appear to be minimal in recent studies of caries incidence [152]. Perhaps due to modern use of topical fluoride products, especially fluoridated toothpaste, countries that do *not* fluoridate the water have seen drops in dental cavity rates similar to those observed in fluoridated countries [153]. This finding is in agreement with the observation that fluoride's predominant benefit to dental health comes from topical contact with the surface of the enamel, not from ingestion, as was once believed [154, 155]. Already in 2001, the U.S. Centers for Disease Control (CDC) concluded that fluoride supplementation during pregnancy did not benefit the child's dental health [156]. Consensus has since then been building on the lack of efficacy of water fluoridation in preventing caries [152].

It therefore appears that population-based increase of systemic fluoride exposure may be unnecessary and, according to the evidence considered in this review, counterproductive. The focus should therefore shift from population-wide provision of elevated oral fluoride intake to consideration of the risks and consequences of developmental neurotoxicity associated with elevated fluoride exposure in early life. The prospective studies suggest that prevention efforts to control human fluoride exposures should focus on pregnant women and small children. In addition to drinking water, attention must also be paid to other major sources of fluoride, such as black tea [13]. Thus, excessive tea-drinking is known to potentially cause skeletal fluorosis [12], and the possible impact of tea drinking deserves to be considered along with other possible sources that may affect pregnant women and small children.

The evidence on fluoride neurotoxicity in the general population is fairly recent and unlikely to represent the full toxicological perspective, including adverse effects that may occur at a delay, as has been seen with many developmental neurotoxicants in the past [134]. While some ecological studies failed to identify clear evidence for fluoride neurotoxicity, they cannot be relied on as proof that elevated fluoride exposure is safe, in particular regarding early brain development. Recent prospective studies with individual exposure assessments provide strong evidence, and the large number of cross-sectional studies from populations with stable and well-characterized exposures provide additional support.

Conclusions

Previous assessment of neurotoxicity risks associated with elevated fluoride intake relied on cross-sectional and ecological epidemiology studies and findings from experimental studies of elevated exposures. The evidence base has greatly expanded in recent years, with 14 cross-sectional studies since 2012, and now also three prospective studies of high quality and documentation of individual exposure levels. Thus, there is little doubt that developmental neurotoxicity is a serious risk associated with elevated fluoride exposure, whether due to community water fluoridation, natural fluoride release from soil minerals, or tea consumption, especially when the exposure occurs during early development. Even the most informative epidemiological studies involve some uncertainties, but imprecision of the exposure assessment most likely results in an underestimation of the risk [86]. Thus, the evidence available today may not quite reflect the true extent of the fluoride toxicity. Given that developmental neurotoxicity is considered to cause permanent adverse effects [69], the next generation's brain health presents a crucial issue in the risk-benefit assessment for fluoride exposure.

Abbreviations

ADHD: Attention-Deficit/Hyperactivity Disorder; BMD: Benchmark dose; BMDL: Benchmark dose level; BMR: Benchmark response; BSDI-II: Bayley Scale of Infant Development II; CBRS: Connors Behavior Rating Scales; CHMS: Canadian Health Measures Survey; CI: Confidence interval; CRT-RC: Combined Raven's Test-The Rural in China; DAP: Draw-A-Person; EFSA: European Food Safety Authority; ELEMENT: Early Life Exposures in Mexico to Environmental Toxicants; EPA: Environmental Protection Agency; GCI: General Cognitive Index; IQ: Intelligence Quotient; MCLG: Maximum Contaminant Level Goal; MeSH: Medical Subject Headings (PubMed); MIREC: Maternal-Infant Research on Environmental Chemicals; MSCA: McCarthy Scales of Children's Abilities; NRC: National Research Council; NTP: National Toxicology Program; RBS: Rutter Behavior Rating Scales; RCPM: Raven's Colored Progressive Matrices; RSPM: Raven's Standardized Progressive Matrices; SD: Standard Deviation; SMD: Standardized Mean Difference; TSH: Thyroid Stimulating Hormone; WASI: Wechsler Abbreviated Scale of Intelligence; WISC-IV: Wechsler Intelligence Scale for Children-Revised; WPPSI-III: Wechsler Preschool and

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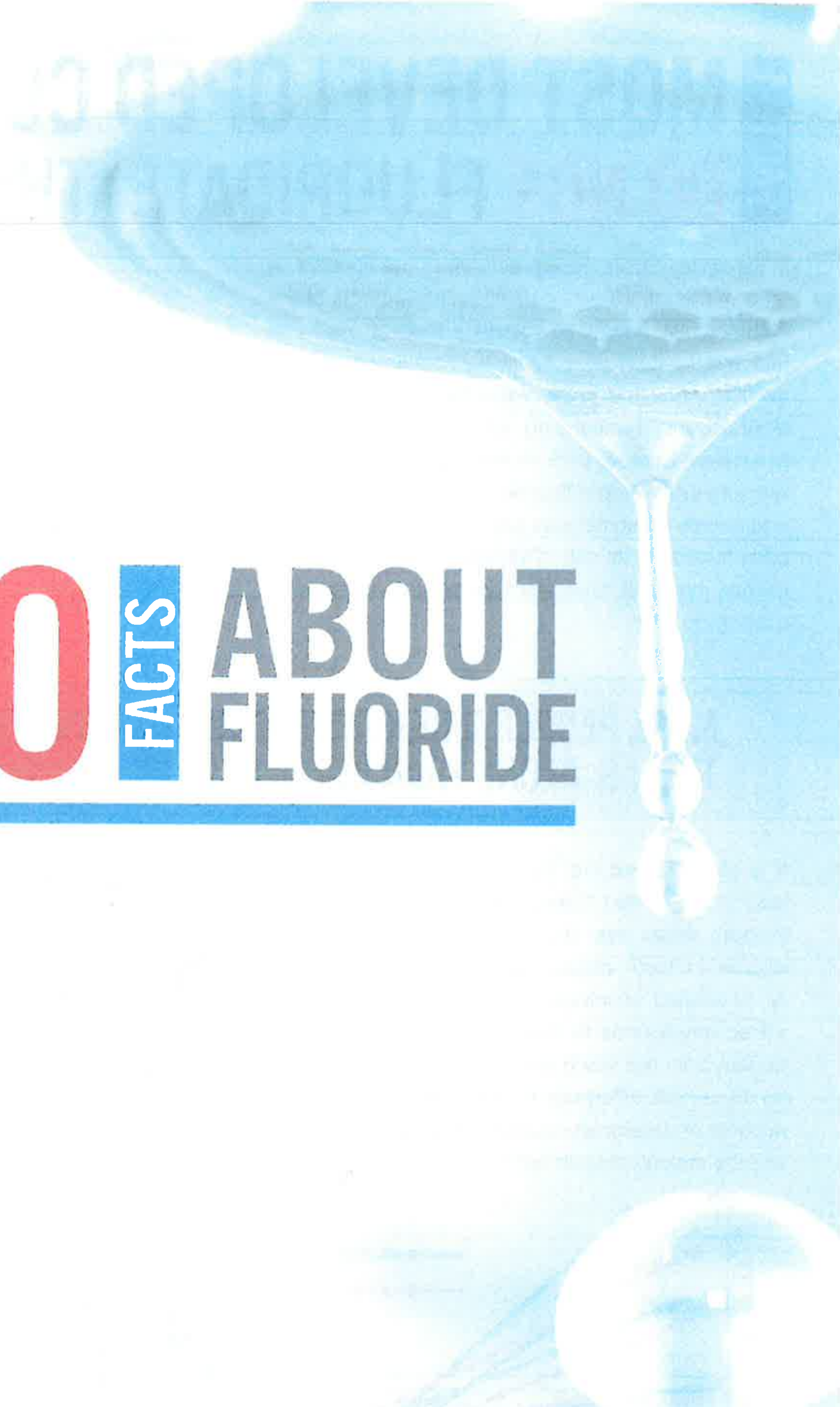


10 FACTS ABOUT FLUORIDE

FLUORIDEALERT.ORG
Fluoride Action Network

FACT 3 FLUORIDE AFFECTS MANY TISSUES IN THE BODY BESIDES THE TEETH

Fluoridation advocates have long claimed that the safety of fluoridation is beyond scientific debate.[6] However, according to the well-known toxicologist, Dr. John Doull, who chaired the National Academy of Science's review on fluoride, the safety of fluoridation remains "unsettled" and "we have much less information than we should, considering how long it has been going on."[7] In 2006, Doull's committee at the NAS published an exhaustive 500-page review of fluoride's toxicity.[8] The report concludes that fluoride is an "endocrine disruptor" and can affect many things in the body, including the bones, the brain, the thyroid gland, the pineal gland, and even blood sugar levels.[9]

Far from giving fluoride a clean bill of health, the NAS called upon scientists to investigate if current fluoride exposures in the United States are contributing to chronic health problems, like bone disorders, thyroid disease, low intelligence, dementia, and diabetes, particularly in people who are most vulnerable to fluoride's effects.[10] These recommendations highlight that—despite 60 years of fluoridation—many of the basic studies necessary for determining the program's safety have yet to be conducted.

DID YOU KNOW?

"It is apparent that fluorides have the ability to interfere with the functions of **the brain**."

"The possibility has been raised by studies conducted in China that fluoride can lower **intellectual abilities**."

"Fluoride is an **endocrine disruptor**."

"Several lines of information indicate an effect of fluoride exposure on **thyroid function**."

"Sufficient fluoride exposure appears to . . . increase the severity of some types of **diabetes**."

"The relationship between **fertility** and fluoride requires additional study."

"Further research on a possible effect of fluoride on **bladder cancer** risk should be conducted."

"These changes have a bearing on the possibility that fluorides act to increase the risk of developing **Alzheimer's disease**."

SOURCE: National Research Council. (2006). Fluoride in Drinking Water: A Scientific Review of EPA's Standards. National Academies Press, Washington D.C.

FACT 4 FLUORIDATION IS NOT A "NATURAL" PROCESS

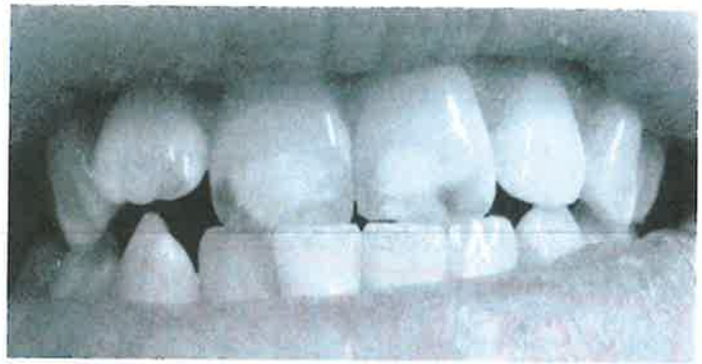
Fluoridation advocates often say that "nature thought of fluoridation first." By this, they mean that fluoride occurs at naturally high levels in some water supplies.[11] Lots of toxic substances, however, like arsenic, and even some medicines, like lithium, can occur at naturally high levels. This doesn't mean they're safe.[12] Further, the level of fluoride added in artificial fluoridation programs is far higher than the level of fluoride that occurs in the vast majority of (unpolluted) fresh surface waters.[13]

Also the main fluoride chemical (fluorosilicic acid) that is added to water is not what most people would call

Fact 5 continued

And there are other sources of fluoride as well, including processsed beverages/foods,[23] fluoride pesticides,[24] tea,[25] Teflon pans,[26] and some fluorinated pharmaceuticals.[27] The concern today, therefore, is not just the safety of fluoridated water by itself, but the safety of fluoridated water in combination with all the other sources to which we're now exposed.

Dental Fluorosis >
Photograph by Hardy Limeback, DDS, PhD



DID YOU KNOW?

36 STUDIES HAVE FOUND A CORRELATION BETWEEN FLUORIDE AND LOWER IQ

FACT 6

FOR INFANTS, FLUORIDATED WATER PROVIDES NO BENEFITS, ONLY RISKS

Up until the 1990s, health authorities advised parents to give fluoride to newborn babies. This is no longer the case. Today, the Institute of Medicine recommends that babies consume a minuscule 10 micrograms of fluoride per day.[28] This is roughly the equivalent of what babies ingest from breast milk, which contains virtually no fluoride.[29]

Infants who consume formula made with fluoridated tap water consume up to 700 to 1,200 micrograms of fluoride, or about 100 times more than the recommended amount. According to the CDC, these early spikes of fluoride exposure during infancy provide no known advantage to teeth.[30] These spikes can, however, produce harm.

Recent studies show that babies who are given fluoridated water in their formula develop significantly higher rates of dental fluorosis.[31] Because of this, a number of prominent dental researchers now advise that parents should not add fluoridated water to baby formula.[32]

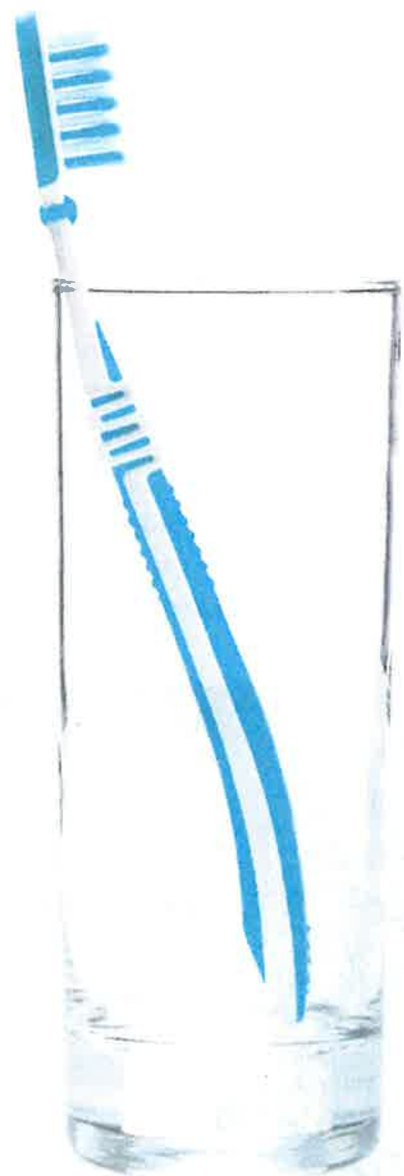
And teeth are not the only concern. In July of 2012, scientists from Harvard University warned that **the developing brain may be another target for fluoride toxicity.**[33] The Harvard team based their warning on a large number of studies from China that have found reduced IQ scores among children exposed to elevated fluoride during their early years of life. Twelve of the studies the Harvard team reviewed found IQ loss at fluoride levels deemed safe in the U.S. and a study sponsored by UNICEF found IQ loss in iodine-deficient children at the so-called "optimal" fluoridation level.[34] The possibility that fluoridated water can reduce IQ is a matter that "definitely deserves concern."[35]

iodine, for example, our thyroid gland won't function properly. Although fluoride advocates sometimes claim that fluoride is a "nutrient," the National Academy of Sciences has repeatedly confirmed that this is not the case.[40] Because fluoride is not a nutrient, the FDA has defined fluoride as a medicine when used to prevent disease.[41] Since tooth decay is a disease, adding fluoride to water to prevent tooth decay is -- as a matter of logic -- a form of medication. This is one of the reasons why most European nations have rejected fluoridation: because, in their view, the water supply is an inappropriate way to deliver medicine.[42] **With other medicines, it is the patient, not the doctor, who has the right to decide** which drug to take.[43] Fluoridation denies people this right.

> "Fluoridation goes against all principles of pharmacology. It's obsolete."
>
> *- Dr. Arvid Carlsson, Nobel Laureate in Medicine/Physiology.*

FACT 9

SWALLOWING FLUORIDE PROVIDES LITTLE BENEFIT TO TEETH



When water fluoridation first began back in the 1940s, the medical profession believed fluoride needed to be ingested to be most effective in preventing cavities.[44] This was why fluoride was added to water and pills—because these are things that people swallow. Today, however, it is now widely recognized that fluoride's main benefit does not actually come from ingestion, it comes from fluoride's **topical contact** with teeth[45]—a fact that even the CDC has now acknowledged.[46] So, not only does fluoridation add a medicine to water, it adds a medicine that does not actually need to be swallowed.

REFERENCES:

NOTES FOR FACT 1: "MOST DEVELOPED COUNTRIES DO NOT FLUORIDATE THEIR WATER"

1) See data at: www.fluoridealert.org/content/bfs-2012/
2) See data at: www.fluoridealert.org/content/water_europe/
3) For data on the number of countries in Europe that allow fluoridated salt, see: Gotzfried F. (2006). *Schweiz Monatsschr Zahnmed* 116: 371–75. Unlike water fluoridation (which applies fluoride to an entire water supply), salt fluoridation in Europe is limited to household salt that people have the option to purchase. In two of the five European countries that allow salt fluoridation, only 6% to 10% of household salt is actually fluoridated). Salt fluoridation is thus a far less intrusive application of fluoride than water fluoridation.

NOTES FOR FACT 2: FLUORIDATED COUNTRIES DO NOT HAVE LESS TOOTH DECAY THAN NON-FLUORIDATED COUNTRIES

4) See extensive compilation of published research and data at: www.fluoridealert.org/studies/caries01/
5) World Health Organization Collaborating Centre for Education, Training, and Research in Oral Health, Malmö University, Sweden. Data available at http://www.mah.se/CAPP/ (accessed on March 30, 2013).

NOTES FOR FACT 3: FLUORIDE AFFECTS MANY TISSUES IN THE BODY BESIDES THE TEETH

6) A representative example of this viewpoint was expressed by Dr. Robert Kehoe in 1957: "The question of the public safety of fluoridation is non-existent from the viewpoint of medical science."
7) In a January 2008 article published in *Scientific American*, Dr. Doull was quoted as saying: "[W]e've gone with the status quo regarding fluoride for many years—for too long, really—and now we need to take a fresh look. In the scientific community, people tend to think this is settled. I mean, when the U.S. surgeon general comes out and says this is one of the 10 greatest achievements of the 20th century, that's a hard hurdle to get over. But when we looked at the studies that have been done, we found that many of these questions are unsettled and we have much less information than we should, considering how long this has been going on. I think that's why fluoridation is still being challenged so many years after it began."
   See: www.fluoridealert.org/researchers/nrc/panelists/
8) National Research Council. (2006). Fluoride in drinking water: a scientific review of EPA's standards. National Academies Press, Washington D.C. Available online at: www.nap.edu/catalog.php?record_id=11571
9) See excerpts of NAS's findings at: www.fluoridealert.org/researchers/nrc/findings/
10) See excerpts of NAS's recommendations at: www.fluoridealert.org/researchers/nrc/recommendations/

NOTES FOR FACT #4: FLUORIDATION IS NOT A "NATURAL" PROCESS

11) Most fresh surface waters (e.g., lakes/streams) contain very little fluoride. When fluoride is obtained from deep ground water supplies, however, fluoride contamination can become a significant problem. See *infra* note 13.
12) High levels of naturally occurring fluorides have wreaked havoc on tens of millions of people's health around the world, particularly in developing countries where water shortages force many rural communities to obtain water from deep in the ground. Consumption of fluoride-laden well water causes serious health ailments, including tooth loss, bone disease, ulcers, brain damage, heart disease, and thyroid disease. See: www.fluoridealert.org/issues/health/. Because of this, international organizations like UNICEF assist developing nations in finding ways of removing fluoride from the water. For a review by UNICEF on the worldwide scope of fluoride poisoning, see: www.fluoridealert.org/uploads/UNICEF-1999.pdf
13) In Canada, the average level of fluoride in fresh surface water is just 0.05 ppm, which is 14 to 24 times less fluoride than added to water in fluoridation programs. See: Environment Canada. (1993). *Inorganic Fluorides: Priority Substances List Assessment Report.* Government of Canada, Ottawa. p. 14. Fresh vegetables, fruits, milk, and eggs contain even lower levels of fluoride (unless they're sprayed with fluoride pesticides). See:n www.fluoridealert.org/content/fresh_foods/. In the rare circumstance where rivers or ponds contain the same level of fluoride that is added to tap water, salmon and frogs have been found to suffer serious harm, including bone disease, changes in behavior, and increased mortality. See: Shaw SD, et al. (2012). Journal of Zoo & Wildlife Medicine 43(3):549-65; Damkaer DM, Dey DB. (1989). North American Journal of Fisheries Management. 9: 154-162.
14) As noted by the U.S. Environmental Protection Agency, "By recovering by-product fluosilicic acid from fertilizer manufacturing, water and air pollution are minimized, and water authorities have a low-cost source of fluoride available to them."
   See: www.fluoridealert.org/uploads/hanmer1983.pdf.
15) In 20th century, fluoride pollution caused more harm to livestock than any other pollutant. In Polk County, Florida (the capital of America's phosphate industry), cattle downwind of the phosphate industry suffered "mass fluoride poisoning." Between 1953 and 1960, "the cattle population dropped 30,000 head," and "an estimated 150,000 acres of cattle land were abandoned." As one farmer explained, "Around 1953 we noticed a change in our cattle… We watched our cattle become gaunt and starved, their legs became deformed; they lost their teeth. Reproduction fell off and when a cow did have a calf, it was also affected by this malady or was a stillborn." For discussion and documentation, see: www.fluoridealert.org/articles/phosphate01/
16) See: Weng C, et al. (2000). Treatment chemicals contribute to arsenic levels. Opflow (AWWA), October, p. 6-7. Available at: http://www.fluoridealert.org/uploads/opflow-2000.pdf
17) Hirzy JW, et al. (2013). Environ. Sci. Policy http://dx.doi.org/10.1016/j.envsci.2013.01.007. On the lead/neurotoxic risk, see: Coplan MJ, et al. (2007). Neurotoxicology 28(5):1032-42; Maas RP, et al. (2007). Neurotoxicology 28(5):1023-31.

47) In Maryland, 84% of dentists do not accept Medicaid patients. Similar rates exist in other states, including Alabama (82%), Colorado (79%), and Ohio (72%). As a result, most low-income children are not able to receive treatment from a dentist. See data and reports at: www.fluoridealert.org/content/dental-care/
48) See: www.fluoridealert.org/issues/sources/ej/
49) Beltran-Aguilar ED et al. (2005). MMWR Surveillance Summaries 54(3): 1-44. For a discussion of other studies that have found racial disparities in fluorosis rates, see: www.fluoridealert.org/studies/dental_fluorosis02/
50) See: www.fluoridealert.org/issues/ej/statements/
51) For a compilation of reports, see: www.fluoridealert.org/studies/caries07/.
52) See: www.fluoridealert.org/news/cincinnatis-dental-crisis/
53) Allowing access to dental therapists represents an important strategy for expanding dental care services to underserved populations. Dental therapists are specially trained to provide dental care, such as tooth cleanings and fillings. According to a recent review, "the quality of technical care provided by dental therapists (within their scope of competency) was comparable to that of a dentist, and in some studies was judged to be superior." Nash D, et al. (2012). *A Review of the Global Literature on Dental Therapists*. W.K. Kellogg Foundation. p. 6. Despite these findings, dental trade associations (such as the American Dental Association) are vigorously lobbying against efforts to allow dental therapists to serve underprivileged populations. See: Levine D. (2011). *Why Are Dentists Opposing Expanded Dental Care?* Available at: www.governing.com/topics/health-human-services/gov-why-are-dentists-opposing-expanded-dental-care.html
54) Ismail AI, et al. (2006). Severity of dental caries among African American children in Detroit. Presentation at ADEA/AADR/CADR Conference, March 11. Abstract available at: http://iadr.confex.com/iadr/2006Orld/techprogram/abstract_73168.htm
55) Albert DA, et al. (2002). *Dental caries among disadvantaged 3- to 4-year-old children in northern Manhattan.* Pediatric Dentistry 24:229-33.
56) Bridge to Healthy Smiles. Cook County Oral Health Crisis. Available at: http://www.bridgetohealthysmiles.com/ISDSBrochure.pdf
57) Bexar County Head Start Dental Screenings Program. See data at: www.fluoridealert.org/uploads/san_antonio_caries.pdf
58) Centers for Disease Control. (1999). Behavioral Risk factor Surveillance System. Data summarized at: http://drc.hhs.gov/report/4_3.htm
59) For a discussion of these tragic outcomes, see: Carrie Gann, *Man Dies from Toothache, Couldn't Afford Meds,* ABC News, Sept. 11, 2011, and Laura Owings, *Toothache Leads to Boy's Death*, ABC News, March 5, 2007.

STATEMENTS ON FLUORIDATION FROM CIVIL RIGHTS LEADERS

"I am most deeply concerned for poor families who have babies: if they cannot afford unfluoridated water for their babies' milk formula, do their babies not count? Of course they do. This is an issue of fairness, civil rights, and compassion. We must find better ways to prevent cavities, such as helping those most at risk for cavities obtain access to the services of a dentist."

-Andrew Young

"I support the holdings of Fluoridegate hearings so we can learn why we haven't been openly told that fluorides build up in the body over time, why our government agencies haven't told the black community openly that fluorides disproportionately harm black Americans, and why we've been told that decades of extensive research show fluoridation to be safe, when the National Research Council in 2006 listed volumes of basic research that has never been done."

-Rev. Gerald Durley

"This is a civil rights issue. No one should be subjected to drinking fluoride in their water, especially sensitive groups like kidney patients and diabetics, babies in their milk formula, or poor families that cannot afford to purchase unfluoridated water. Black and Latino families are being disproportionately harmed."

-Alveda King

End Water Fluoridation Now

- Paul D. Maher, MD MPH
- February 4th, 2020

Sodium Fluoride for dental caries

- Sodium Fluoride has been added to water for the indication of treating dental caries
- Fluoride has not been approved by the FDA for this indication.
- Fluoride has not been evaluated by the FDA for this indication
- This drug is given to patients en masse, without the person's consent, something unheard of outside of urgent matters of life and death.

Is Sodium Fluoride Toxic? Yes.

Sodium Fluoride was evaluated by the United States E.P.A in 1964 and again in 2007 for its registration as a fungicide and wood preservative. (1) These are the only official federal evaluations and pronouncements on fluoride toxicity currently available. On a scale of I to IV with I being most toxic and IV being least toxic, the reviewers conclude:

"For the technical grade active ingredient, sodium fluoride has a high order of toxicity via the oral route of exposure (Toxicity Category II) and a moderate order of toxicity via the dermal and inhalation routes of exposure (Toxicity Category III). Primary eye irritation studies classify sodium fluoride as corrosive (Toxicity Category I)" (page 6)

EPA Evaluation of Fluoride Toxicity: Continued

- Regarding carcinogenicity, the reviewers stated that per the report of the National Academy of Sciences (NAS) there was inadequate evidence of carcinogenicity In a subsequent comment an author of the NAS report stated the reviews interpretation of their report was incorrect and the data showed fluoride to be a "possible carcinogen".(2)
- Also from the EPA review,

> *"Positive mutagenicity results have been reported in mouse lymphoma assays, in chromosome aberration assays, in unscheduled DNA synthesis assays, and in in vitro sister chromatid exchange assays" (page 7)*

EPA Evaluation of Fluoride Toxicity: Continued

- Evaluated for toxicity as a fungicide/pesticide by the U.S. federal government fluoride was found to have the second highest grade of toxicity per the route of oral exposure, was mutagenic in all assays and is a possible carcinogen.
- If proposed as a treatment for dental caries it is a reasonable question whether any Institutional Review Board would allow this drug to be given to patients on even an experimental basis.

Fluoride Formulation

- In some instances water suppliers do not use pharmaceutical grade sodium fluoride as a water additive but rather fluoride based industrial byproducts. In such case quality control is clearly inadequate and composition of the product uncertain.
- In summary, fluoride is unapproved for its indication, unevaluated for its indication, documented to be toxic, we do not know the composition of the drug being added and it is given without consent.

Dosage in Water does not Capture Total Exposure to Fluoride

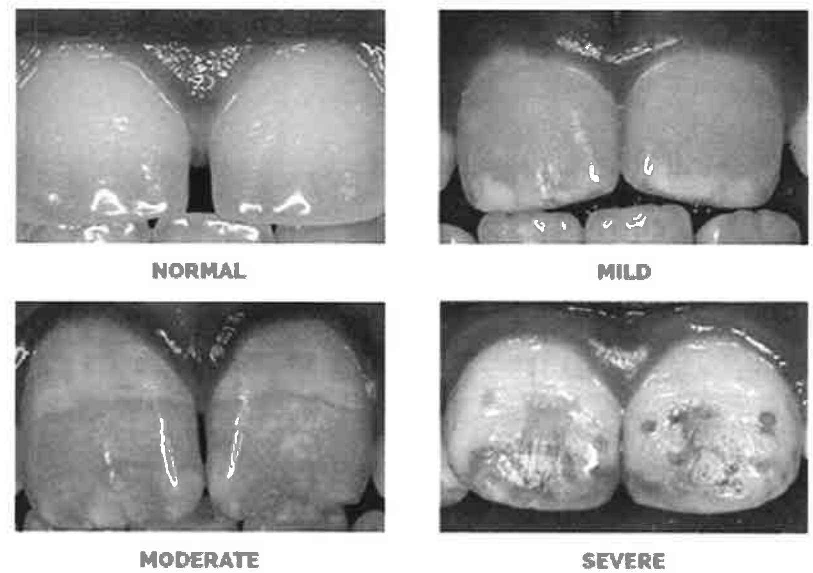
- While a dosage of fluoride for the unevaluated indication of prevention of dental caries may be set, the total exposure of the population is higher.
- Food processing using fluoridated water concentrates fluoride. i.e. a condensed can of soup with half the water boiled off does not lead to any of the fluoride being boiled off and hence has a concentration of fluoride twice that of the tap water, the problem is compounded when the soup is reconstituted with fluoridated water. Same problem with cereals, instant coffee, tea etc.

Infants and Children Receive Disproportionately High Doses of Fluoride.

- As a consequence of the higher skin surface area to body volume in infants and children as compared to adults, this group must drink more water to replace evaporative losses. Infants and children have the highest exposure to fluoride from water fluoridation.
- While required for a drug to be used in this population, no studies to date have been published on the toxicity of fluoride in the infant and pediatric populations.

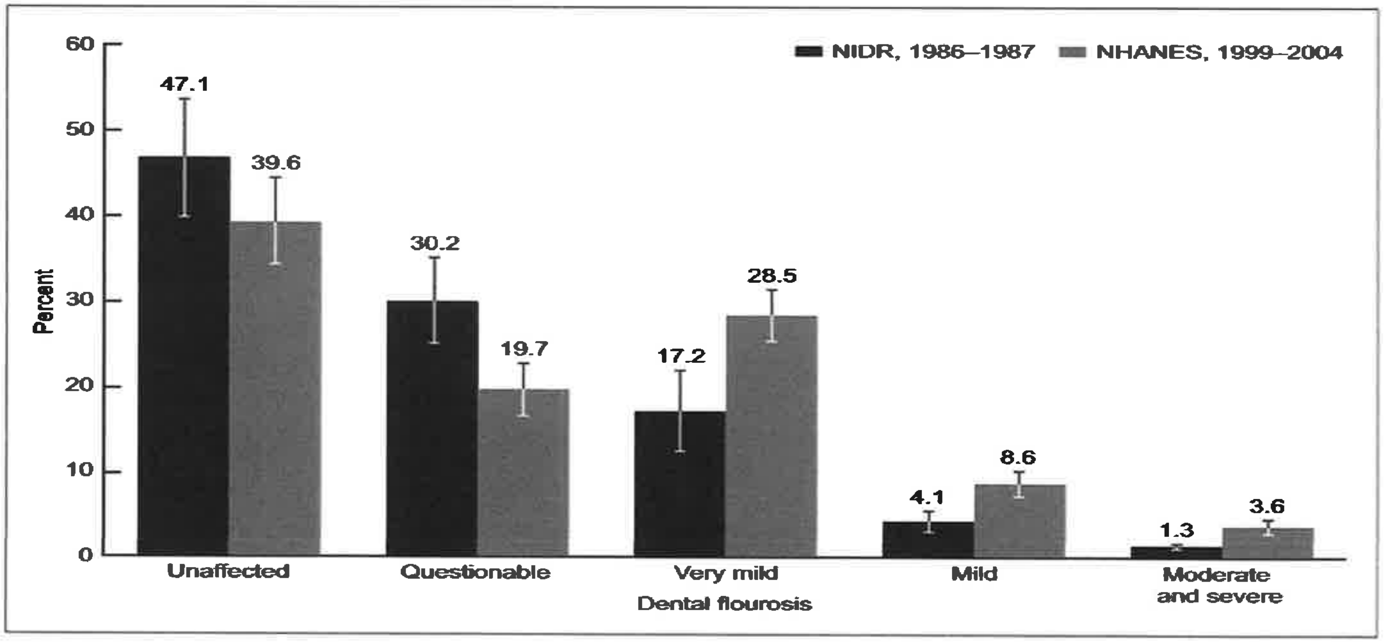
Toxicity leads to Disease.

- Skeletal Fluorosis: Painful, debilitating, pathologic bone changes often seen in areas of India with contamination of drinking water by fluoride. (3)
- Dental Fluorosis: (4)



Toxicity leads to Disease: Dental Fluorosis (5)

Figure 3. Change in dental fluorosis prevalence among children aged 12–15 participating in two national surveys: United States, 1986–1987 and 1999–2004



NOTES: Dental fluorosis is defined as having very mild, mild, moderate, or severe forms and is based on Dean's Fluorosis Index. Percentages do not sum to 100 due to rounding. Error bars represent 95% confidence intervals.

SOURCES: CDC/NCHS, National Health and Nutrition Examination Survey, 1999–2004 and National Institute of Dental Research, National Survey of Oral Health in U.S. School Children, 1986–1987.

Toxicity leads to Disease: Dental Fluorosis,

- 40.6 % of all children aged 12-15 in the United States now have the disease of dental fluorosis, this figure is up from 22.6% of children aged 12-15 having dental fluorosis in 1986-87. (5)
- This what we add to water to improve dental hygiene?

Toxicity leads to Disease: Behavioral Changes, Endocrine Disruption

- Dr. Phyllis Mullenix in the 1990s exposed rats to sodium fluoride and documented both neurotoxicity and behavioral changes. (6) More recently Dr. Mullenix has assayed fluoride added to water from various suppliers and found variable levels of additional contaminants to include, lead, aluminum, barium and arsenic. (7)
- Multiple studies have found fluoride interferes with proper parathyroid gland function. (8,9)
- A recent rat study of the effect of fluoride on the thyroid gland concluded: *"Our study showed that long-term low-dose exposure to Na–F affects the thyroid structure and function, leading to hypothyroidism."* (10)

Toxicity leads to Disease: Brain Function

- Multiple epidemiological studies out of China found decreased IQ in children with high water levels of fluoride as compared to areas without fluoride contamination. (11,12)
- There are now too many studies to briefly discuss documenting fluoride interferes with brain function and decreases IQ. To cite one, in 2019 Green et al, “Association Between Maternal Fluoride Exposure During Pregnancy and IQ Scores in Offspring in Canada.” published in the Journal of the American Medical Association. (13)
- JAMA is one of the, if not the, most prestigious and mainstream medical journals in the world.

How did we get here?

- When medical experts get things wrong, we have a history of not always getting things slightly wrong but oft times, stupendously and horrifyingly wrong.
- Ignaz Semmelwies, now the “Father of Antisepsis” published clear convincing research that physicians washing their hands in disinfecting lyme cut the incidence of fatal maternal child bed fever from ~10 percent in many hospitals to less than 1 percent. This was before the advent of Pasteur and the germ theory, and Semmelweis research was dismissed as both wrong and insulting. It would take a ½ century and 100s of thousands of maternal deaths before his findings were accepted and adopted.
- It was not that long ago the medical community had no problem with smoking.

How did we get here?

- While not delving into possible motivation, fluoride is necessary for atomic weapons production. The Atomic Energy Commission's toxicologist Harold Hodge was one of the most vocal and prominent early advocates of water fluoridation. It has since come to light that Dr. Hodge was also involved with injecting patients without their knowledge or consent with varying doses of radioactive uranium and plutonium to determine the maximal tolerated dose. Motivation aside, it is clear that at least one of the major personalities driving the adoption of water fluoridation had zero problem violating ethical boundaries that the vast majority of the community takes for granted and considers sacrosanct.

Moving Forward

- Public sentiment on blood letting changed, public sentiment on handwashing before child delivery changed, public sentiment on smoking changed.
- Once a critical mass of sufficient evidence on a topic occurs, it is generally only a matter of time before political and public will attunes itself to the data.
- The critical mass of evidence for the harm from water fluoridation has been achieved. It is a far more prudent position to adopt one's business and behavior to the science than to be the last one holding out that smoking doesn't cause lung cancer.

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International Academy of Oral Medicine and Toxicology (IAOMT) Position Paper against Fluoride Use in Water, Dental Materials, and Other Products for Dental and Medical Practitioners, Dental and Medical Students, Consumers, and Policy Makers

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International Academy of
IAOMT
Oral Medicine & Toxicology

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Section 1: Summary of the IAOMT's Position against Fluoride Use in Water, Dental Materials, and Other Products

Other than its natural existence in minerals, as well as in soil, water, and air, fluoride is also chemically synthesized for use in community water fluoridation, dental products, fertilizers, pesticides, and an array of other consumer items. For example, hydrogen fluoride is used to make aluminum, electrical components, fluorescent light bulbs, herbicides, high-octane gasoline, plastics, refrigerants, and etched metal and glass (such as that used in some electronic devices). Additionally, fluorinated compounds are present in a significant quantity of pharmaceutical drugs, and perfluorinated chemicals are used in carpets, cleaners, clothing, cookware, food packaging, paints, paper, and other products.

Unfortunately, all of these applications were introduced before the health risks of fluoride, safety levels for its use, and appropriate restrictions were adequately researched and established. Compounding this dangerous status quo is the fact that the National Research Council concluded the maximum contaminant level goals for fluoridated drinking water should be lowered in 2006, but the Environmental Protection Agency has yet to lower the level.

Fluoride is not a nutrient and has no biological function in the body. Furthermore, hundreds of research articles published over the past several decades have demonstrated potential harm to humans from fluoride at various levels of exposure, including levels currently deemed as safe. Scientific research has examined fluoride's effect on the skeletal system in detail and has indicated a definitive link between fluoride exposure and skeletal fluorosis, as well as dental fluorosis (which is permanent damage to the developing tooth, is the first visible sign of fluoride toxicity, and is currently on the rise in the United States). Fluoride is also known to impact the cardiovascular, central nervous, digestive, endocrine, immune, integumentary, renal, and respiratory systems, and exposure to fluoride has been linked to Alzheimer's disease, cancer, diabetes, heart disease, infertility, and many other adverse health outcomes.

The need to update previously established fluoride guidelines is extremely urgent, as fluoride exposures have dramatically increased for all Americans since the 1940's, when community water fluoridation was first introduced. In the subsequent decades, fluoride was also introduced for use in dental products applied in the office and at home, such as toothpaste and mouth rinse, and during this time frame, it was also added to other consumer products. Understanding fluoride exposure levels from all sources is crucial because recommended intake levels for fluoride in water and food should now be based upon these common multiple exposures.

However, accurate data currently does not exist for either collective sources or singular sources of fluoride exposure. Another concern is that fluoride has a synergistic interaction with other elements. Fluoride is also known to impact each individual differently based on allergies to fluoride, nutrient deficiencies, genetic factors, and other variables. Additionally, susceptible populations with low body weights, such as infants and children, and individuals who consume increased amounts of water, such as athletes, military personnel, outdoor laborers, and those with diabetes or kidney dysfunction, can be more intensely effected by fluoride. Therefore, recommending an optimal level of fluoride or "one dose fits all" level is unacceptable.

It is obvious that risk assessments must consider the total fluoride exposure from all sources, as well as individual susceptibility. Furthermore, there is a significant gap, if not a major void, in scientific literature that includes fluoride releases from products administered at the dental office, such as dental filling materials and varnishes, as part of overall fluoride intake. Part of this is likely due to the fact that the research attempting to evaluate singular exposures from these dental products has demonstrated that determining any type of "average" release rate is virtually impossible.

Moreover, there is even doubt about fluoride's efficacy in preventing tooth decay. For example, research has indicated that fluoride does not aid in preventing pit and fissure decay (which is the most prevalent form of tooth decay in the U.S.) or in preventing baby bottle tooth decay (which is prevalent in poor communities). Also, research has suggested that in malnourished children and individuals of lower socio-economic status, fluoride can actually increase the risk of dental caries due to calcium depletion and other circumstances.

An important consideration is that the trend of decreased decayed, missing, and filled teeth over the past several decades has occurred both in countries with and without the systemic application of fluoridated water. This suggests that increased access to preventative hygiene services and more awareness of the detrimental effects of sugar are responsible for these improvements in dental health. Research has also documented decreases of tooth decay in communities that have discontinued water fluoridation.

Additionally, ethical questions have been raised in regard to the use of fluoride, especially because of fluoride's ties to the phosphate fertilizer and dental industries. Researchers have reported difficulties with getting articles published that are critical of fluoride, and an urgent need for an appropriate application of the precautionary principle (i.e. first, do no harm) related to fluoride usage has emerged.

The issue of consumer choice is vital to fluoride usage for a variety of reasons. First, consumers have choices when it comes to utilizing fluoride-containing products; however, many over-the-counter products do not offer appropriate labeling. Second, materials used at the dental office provide virtually no consumer informed consent because the presence of fluoride (and its risks) in these dental materials is, in many cases, never mentioned to the patient. Third, the only choice consumers have when fluoride is added to their municipal water is to buy bottled water or costly filters. Concerns have been raised that fluoride is added only for allegedly preventing tooth decay, while other chemicals added to water serve a purpose of decontamination and elimination of pathogens.

Educating medical and dental practitioners, students, consumers, and policy makers about fluoride exposures and the associated potential health risks is essential to improving the dental and overall health of the public. Since a scientific understanding of the health effects of fluoride has been limited to promoting its benefits, the reality of its overexposure and potential harms must now be conveyed to healthcare workers and students, such as those in the medical, dental, and public health fields.

Although informed consumer consent and more informative product labels would contribute to increasing public awareness about fluoride intake, consumers also need to take a more active role in preventing caries. In particular, a better diet (with less sugar), improved oral health practices, and other measures would assist in reducing tooth decay.

Finally, policy makers are tasked with the obligation of evaluating the benefits and risks of fluoride. These officials have a responsibility to acknowledge the dated claims of fluoride's alleged purposes, many of which are based on limited evidence of safety and improperly formulated intake levels that fail to account for multiple exposures, fluoride's interaction with other chemicals, individual variances, and independent (non-industry sponsored) science.

In summary, given the elevated number of fluoride sources and the increased rates of fluoride intake in the American population, which have risen substantially since water fluoridation began in the 1940's, it has become a necessity to reduce and work toward eliminating avoidable sources of fluoride exposure, including water fluoridation, fluoride-containing dental materials, and other fluoridated products.

Section 2: Chemical Profile

Fluorine (F) is the ninth element on the periodic table and is a member of the halogen family. It has an atomic weight of 18.9984, is the most reactive of all of the elements, and forms strong electronegative bonds. It is particularly attracted to the divalent cations of calcium and magnesium. In its free state, fluorine is a highly toxic, pale yellow diatomic gas. However, fluorine is rarely found in its free state in nature because it almost always combines with other elements as a result of its high level of reactivity. Fluorine commonly occurs as the minerals fluorspar (CaF_2), cryolite (Na_3AlF_6), and fluorapatite ($3Ca_3(PO_4)_2\ Ca(F,Cl)_2$), and it is the 13th most abundant element on earth.

Fluoride (F^-) is a chemical ion of fluorine that contains an extra electron, thereby giving it a negative charge. Other than its natural existence in minerals, as well as in soil, water, and air, fluoride is also chemically synthesized for use in community water fluoridation, dental products, and other manufactured items. Fluoride is not essential for human growth and development.[1] In fact, it is not required for any physiological process in the human body; consequently, no one will suffer from a lack fluoride. In 2014, Dr. Philippe Grandjean of the Harvard School of Public Health and Dr. Philip J. Landrigan of Icahn School of Medicine at Mount Sinai identified fluoride as one of 12 industrial chemicals known to cause developmental neurotoxicity in humans.[2]

Section 3: Sources of Fluoride

Fluoride exposures in humans occur from both natural and anthropogenic sources. Table 1 is a listing of the most prevalent *natural* sources of fluoride exposure, while Table 2 is a listing of the most prevalent *chemically synthesized* sources of fluoride exposure.

Table 1: Natural sources of fluoride[3]

NATURAL SOURCE	ADDITIONAL INFORMATION
Volcanic activity	This often occurs in the form of hydrogen fluoride.
Water (including groundwater, streams, rivers, lakes, and some well and drinking water) *The naturally occurring form of fluoride in water, which varies by geographic location, is different than community water fluoridation, which is done using a chemically synthesized form of fluoride.*	Naturally, this occurs when water run-off is exposed to fluoride containing rock. However, fluoride in water can also occur due to human activity through industrial emissions, such as releases from coal-fired power plants, and community water fluoridation.
Food	While negligible levels of fluoride in food can occur naturally, significant levels of fluoride in food occur due to human activity, especially through the use of pesticides.
Soil	While fluoride in soil can occur naturally, increased levels of fluoride in soil can occur due to human activity through the use of fertilizers, pesticides and/or industrial emissions.

Table 2: Chemically synthesized sources of fluoride

CHEMICALLY SYNTHESIZED SOURCE	ADDITIONAL INFORMATION
Water: fluoridated municipal drinking water[4]	Most of the fluoride added to drinking water is in the form of fluorosilicates, also known as fluosilicic acid (fluorosilicic acid, H_2SiF_6) and sodium salt (sodium fluorosilicate, Na_2SiF_6).[5]
Water: bottled water[6]	The levels of fluoride in bottled water vary depending on manufacturer and the source of the water.[7]
Water: perfluorinated compounds[8]	Concerns about health risks have led over 200 scientists from 38 countries to sign the Madrid Statement calling for government and manufacturer action on poly- and perfluoroalkyl substances (PFASs), which can be found in drinking water due to contamination in ground and surface water.[9]

Beverages: made with fluoridated water and/or made with water/ingredients exposed to fluoride-containing pesticide[10]	Significant levels of fluoride have been recorded in infant formula, tea, and commercial beverages, such as juice and soft drinks.[11] Significant levels of fluoride have also been recorded in alcoholic beverages, especially wine and beer.[12] [13]
Food: general[14]	Fluoride exposure can occur in food prepared with fluoridated water and/or food exposed to fluoride-containing pesticide/fertilizer.[15] Significant fluoride levels have been recorded in grapes and grape products.[16] Fluoride levels have also been reported in cow's milk due to livestock raised on fluoride-containing water, feed, and soil,[17] [18] as well as processed chicken[19] (likely due to mechanical deboning, which leaves skin and bone particles in the meat).[20]
Food: perfluorinated compounds[21]	Food can also be contaminated by perfluorinated compounds during preparation in certain types of cookware (i.e. non-stick coating)[22] and/or by exposure to grease/oil/water resistant packaging (i.e. fast food wrappers, pizza boxes, and popcorn bags).[23]
Pesticides[24]	Cryolite (insecticide) and sulfuryl fluoride (fumigant) have been regulated due to the inorganic fluoride levels they add to food.[25]
Soil: phosphate fertilizers and/or airborne emissions from industrial activities[26]	Releases from industrial activities can impact the levels of fluoride in food grown in the polluted soil. Soil contamination by fluoride is also relevant to children with pica (a condition characterized by an appetite for non-food items such as dirt).[27]
Air: fluoride releases from industry[28]	Anthropogenic sources of atmospheric fluoride can result from coal combustion by electrical utilities and other industries.[29] Releases can also occur from refineries and metal ore smelters,[30] aluminum production plants, phosphate fertilizer plants, chemical production facilities, steel mills, magnesium plants, and brick and structural clay manufacturers,[31] as well as copper and nickel producers, phosphate ore processors, glass manufacturers, and ceramic manufacturers.[32]

Dental product: toothpaste[33]	Fluoride added to toothpaste can be in the form of sodium fluoride (NaF), sodium monofluorophosphate (Na_2FPO_3), stannous fluoride (tin fluoride, SnF_2) or a variety of amines.[34] Concerns have been raised about children's use of fluoridated toothpaste.[35 36]
Dental product: prophy paste[37]	This paste, used during teeth cleanings (prophylaxis) at the dental office, can contain over 20 times more fluoride than toothpaste sold directly to consumers.[38]
Dental product: mouthwash/rinse[39]	Mouthwashes (mouth rinses) can contain sodium fluoride (NaF) or acidulated phosphate fluoride (APF).[40]
Dental product: dental floss[41 42]	Researchers have demonstrated that fluoride releases from dental floss are higher than those from fluoridated mouth rinses.[43] Fluoridated dental floss is often associated with stannous fluoride (tin fluoride, SnF_2),[44] but flosses can also contain perfluorinated compounds.[45]
Dental product: fluoridated toothpicks and interdental brushes[46]	The amount of fluoride released from these products can be influenced by the saliva of the individual using the product.[47]
Dental product: topical fluoride gel and foam[48]	Used in a dental office or at home, these dental products are applied directly on the teeth and can contain acidulated phosphate fluoride (APF), sodium fluoride (NaF), or stannous fluoride (tin fluoride, SnF2).[49]
Dental product: fluoride varnish[50]	High-concentration fluoride varnish that is applied directly on the teeth by dental or healthcare professionals contains sodium fluoride (NaF) or difluorsilane.[51]
Dental material for fillings: glass ionomer cements[52]	These materials, used for dental fillings, are made of fluoride-containing silicate glass and polyalkenoic acids that release an initial burst of fluoride and then a long-term lower release.[53]

Dental material for fillings: resin-modified glass ionomer cements[54]	These materials, used for dental fillings, are created with methacrylate components and release an initial burst of fluoride and then a long-term lower release.[55]
Dental material for fillings: giomers[56]	These newer hybrid materials, used for dental fillings, include pre-reacted glass ionomers and usually have lower amounts of fluoride released than glass ionomers but higher amounts than compomers and composites.[57]
Dental material for fillings: polyacid-modified composites (compomers)[58]	The fluoride in these materials, used for dental fillings, is in the filler particles, and while there is no initial burst of fluoride, fluoride is released continually over time.[59]
Dental material for fillings: composites[60]	Not all, but some of these materials, used for dental fillings, can contain different types of fluoride such as inorganic salts, leachable glasses, or organic fluoride.[61] The fluoride released is generally considered to be lower than that from glass ionomers and compomers, although releases vary depending on the commercial brand of the composites.[62]
Dental material for fillings: dental mercury amalgams[63]	Low levels of fluoride have been recorded in the types of dental mercury amalgam fillings that are lined with glass ionomer cement and other materials.[64] [65] [66]
Dental material for orthodontics: glass ionomer cement, resin-modified glass ionomer cement, and polyacid-modified composite resin (compomer) cement[67]	These materials, used for orthodontic band cements, can all release fluoride at varying levels.[68]
Dental material for pit and fissure sealants: resin-based, glass-ionomer, and giomers[69]	Commercially available fluoride-releasing sealants can contain sodium fluoride (NaF), fluoride-releasing glass material, or both.[70]
Dental material for tooth sensitivity/caries treatment: silver diamine fluoride[71]	This material, recently introduced to the U.S. market, contains silver and fluoride and is being used as an alternative to conventional cavity treatment with dental fillings.[72]

Pharmaceutical/prescription drugs: fluoride tablets, drops, lozenges, and rinses[73]	These drugs, usually prescribed to children, contain varying levels of sodium fluoride (NaF).[74] These drugs are not approved by the FDA because there is no substantial evidence of drug effectiveness.[75] [76]
Pharmaceutical/prescription drugs: fluorinated chemicals[77]	20-30% of pharmaceutical compounds have been estimated to contain fluorine.[78] Some of the most popular drugs include Prozac, Lipitor, and Ciprobay (ciprofloxacin),[79] as well as the rest of fluoroquinolone family (gemifloxacin [marketed as Factive], levofloxacin [marketed as Levaquin], moxifloxacin [marketed as Avelox], norfloxacin [marketed as Noroxin], and ofloxacin [marketed as Floxin and generic ofloxacin]).[80] The fluorinated compound fenfluramine (fen-phen) was also used for many years as an anti-obesity drug,[81] but it was removed from the market in 1997 due to its link with heart valve problems.[82]
Consumer products made with perfluorinated compounds such as Teflon[83]	Products made with perfluorinated compounds include protective coatings for carpets and clothing (such as stain-resistant or water-proof fabric), paints, cosmetics, non-stick coatings for cookware, and paper coatings for oil and moisture resistance,[84] as well as leather, paper, and cardboard.[85]
Household dust: perfluorinated compounds[86] [87]	Poly- and perfluoroalkyl substances (PFASs) can be found in household dust due to contamination from consumer products,[88] especially textiles and electronics.
Occupational[89]	Occupational exposure can occur for workers at industries with fluoride emissions. This includes work that involves welding, aluminum, and water treatment,[90] as well as work that involves electronics and fertilizers.[91] Additionally, fire-fighters are exposed to perfluorinated chemicals in foams applied to fires.[92] Warnings have been made that workers can carry fluorides home on clothing, skin, hair, tools, or other items and that this can contaminate cars, homes, and other locations.[93]

Cigarette smoke[94]	Significant levels of fluoride have been associated with heavy smokers.[95]
Fluoridated salt and/or milk[96 97]	Some countries have opted to use fluoridated salt and milk (instead of water) as a means to offer consumers the choice of whether they would like to consume fluoride or not. Fluoridated salt is sold in Austria, the Czech Republic, France, Germany, Slovakia, Spain, and Switzerland,[98] as well as Colombia, Costa Rica, and Jamaica.[99] Fluoridated milk has been used in programs in Chile, Hungary, Scotland, and Switzerland.[100]
Aluminofluoride exposure from ingesting a fluoride source *with* an aluminum source[101]	This synergistic exposure to fluoride and aluminum can occur through water, tea, food residue, infant formulas, aluminum-containing antacids or medications, deodorants, cosmetics, and glassware.[102]
Nuclear reactors and nuclear weapons[103]	Fluorine gas is used to make uranium hexafluoride, which separates isotopes of uranium in nuclear reactors and weapons.[104]

Section 4: Brief History of Fluoride

Human knowledge of the mineral fluorspar dates back centuries.[105] However, the discovery of how to isolate fluorine from its compounds is an essential date in the history of humankind's use of fluoride: Several scientists were killed in early experiments involving attempts to generate elemental fluorine, but in 1886, Henri Moissan reported the isolation of elemental fluorine, which earned him the Nobel Prize in chemistry in 1906.[106 107]

This discovery paved the way for human experimentation to begin with chemically synthesized fluorine compounds, which were eventually utilized in a number of industrial activities. Notably, uranium fluoride and thorium fluoride were used during the years of 1942-1945 as part of the Manhattan Project[108] to produce the first atomic bomb. Data from reports about the Manhattan Project, some of which were initially classified and unpublished, include mention of fluoride poisoning and its role in the hazards of the uranium industry.[109] As industry expanded during the 20th century, so did the use of fluoride for industrial processes, and cases of fluoride poisoning likewise increased.[110]

Fluoride was not widely used for any dental purposes prior to the mid-1940's,[111] although it was studied for dental effects caused by its natural presence in community water supplies at varying levels. Early research in the 1930's by Frederick S. McKay, DDS, correlated high levels of fluoride with increased cases of dental fluorosis (a permanent damage to the enamel of the teeth that can occur in children from overexposure to fluoride) and demonstrated that reducing levels of fluoride resulted in lower rates of dental fluorosis.[112] [113] This work led H. Trendley Dean, DDS, to research fluoride's minimal threshold of toxicity in the water supply.[114] In work published in 1942, Dean suggested that lower levels of fluoride might result in lower rates of dental caries.[115]

While Dean worked to convince others to test his hypothesis about adding fluoride to community water supplies as a means of reducing caries, not everyone supported the idea. In fact, an editorial published in the *Journal of the American Dental Association* (JADA) in 1944 denounced purposeful water fluoridation and warned of its dangers:

> We do know the use of drinking water containing as little as 1.2 to 3.0 parts per million of fluorine will cause such developmental disturbances in bones as osteosclerosis, spondylosis, and osteopetrosis, as well as goiter, and we cannot afford to run the risk of producing such serious systemic disturbances in applying what is at present a doubtful procedure intended to prevent development of dental disfigurements among children.
>
> [...] Because of our anxiety to find some therapeutic procedure that will promote mass prevention of caries, the seeming potentialities of fluorine appear speculatively attractive, but, in the light of our present knowledge or lack of knowledge of the chemistry of the subject, the potentialities for harm far outweigh those for good.[116]

A few months after this warning was issued, Grand Rapids, Michigan, became the first city to be artificially fluoridated on January 25, 1945. Dean had succeeded in his efforts to test his hypothesis, and in a landmark study, Grand Rapids was to serve as a test city, and its decay rates were to be compared with those of non-fluoridated Muskegon, Michigan. After only slightly more than five years, Muskegon was dropped as a control city, and the results published about the experiment only reported the decrease in caries in Grand Rapids.[117] Because the results did not include the control variable from the incomplete Muskegon data, many have stated that the initial studies presented in favor of water fluoridation were not even valid.

Concerns were made to the United States Congress in 1952 about potential dangers of water fluoridation, the lack of evidence as to its alleged usefulness in controlling dental caries, and the need for more research to be conducted.[118] Yet, in spite of these concerns and many others, experiments with fluoridated drinking water continued. By 1960, fluoridation of drinking water for alleged dental benefits had spread to over 50 million people in communities throughout the United States.[119]

The use of fluoride in pharmaceutical drugs appears to have begun at about the same time as water fluoridation. Prior to the 1940's, the use of fluoride in American medicine was virtually unknown, with the exception of its rare use as an externally applied antiseptic and antiperiodic.[120] There is a consensus among authors of scientific reviews about fluoride's addition to "supplements" that this pharmaceutical use was introduced no earlier than the mid-1940s and was not widely used until the late 1950s or early 1960s.[121] Quinolones for clinical use were first discovered in 1962, and fluoroquinolones were created in the 1980's.[122] [123]

The production of perfluorinated carboxylates (PFCAs) and perfluorinated sulfontates (PFSAs) for process aids and surface protection in products also began over sixty years ago.[124] Perfluorinated compounds (PFCs) are now used in a wide range of items including cookware, extreme weather military uniforms, ink, motor oil, paint, products with water repellant, and sports clothing.[125] Fluorotelomers, which consist of fluoride carbon foundations, are considered the most commonly used perfluorinated substances in consumer products.[126]

Meanwhile, fluoridated toothpastes were introduced and their increase in the market occurred in the late 1960s and early 1970s.[127] By the 1980s, the vast majority of commercially available toothpastes in industrialized countries contained fluoride.[128]

Other fluoridated materials for dental purposes were likewise promoted for more common commercial use in recent decades. Glass ionomer cement materials, used for dental fillings, were invented in 1969,[129] and fluoride-releasing sealants were introduced in the 1970s.[130] Studies on the use of salt fluoridation for reduction of caries took place from 1965-1985 in Colombia, Hungary, and Switzerland.[131] Similarly, the use of fluoride in milk for caries management first began in Switzerland in 1962.[132]

By reviewing the development of fluoride regulations provided in Section 5, it is apparent that these applications of fluoride were introduced before the health risks of fluoride, safety levels for its use, and appropriate restrictions were adequately researched and established.

Section 5: Overview of U.S. Fluoride Regulations

Section 5.1: Community Water Fluoridation

In western Europe, some governments have openly recognized hazards of fluoride, and only 3% of the western European population drinks fluoridated water.[133] In the United States, over 66% of Americans are drinking fluoridated water.[134] Neither the Environmental Protection Agency (EPA) nor the federal government mandate water fluoridation in America, and the decision to fluoridate community water is made by the state or local municipality.[135] [136] However, the U.S. Public Health Service (PHS) establishes recommended fluoride concentrations in community drinking water for those who choose to fluoridate, and the Environmental Protection Agency (EPA) sets contaminant levels for public drinking water.

After water fluoridation in Grand Rapids, Michigan, began in 1945, the practice spread to locales across the country in the decades that followed. These efforts were encouraged by the Public Health Service (PHS) in the 1950s,[137] and in 1962, the PHS issued standards for fluoride in drinking water that would stand for 50 years. They stated that fluoride would prevent dental caries[138] and that optimal levels of fluoride added to drinking water should range between 0.7 to 1.2 milligrams per liter.[139] However, the PHS lowered this recommendation to the single level of 0.7 milligrams per liter in 2015 due to an increase in dental fluorosis (permanent damage to the teeth that can occur in children from overexposure to fluoride) and to the increase in sources of fluoride exposure to Americans.[140]

Meanwhile, the Safe Drinking Water Act was established in 1974 to protect the quality of American drinking water, and it authorized the EPA to regulate public drinking water. Because of this legislation, the EPA can set *enforceable* maximum contaminant levels (MCLs) for drinking water, as well as *non-enforceable* maximum contaminant level goals (MCLGs) and *non-enforceable* drinking water standards of secondary maximum contaminant levels (SMCLs).[141] The EPA specifies that the MCLG is "the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health of persons would occur, allowing an adequate margin of safety."[142] Additionally, the EPA qualifies that community water systems exceeding the MCL for fluoride "must notify persons served by that system as soon as practical, but no later than 30 days after the system learns of the violation."[143]

In 1975, the EPA set a maximum contaminant level (MCL) for fluoride in drinking water at 1.4 to 2.4 milligrams per liter.[144] They established this limit to prevent cases of dental fluorosis. In 1981, South Carolina argued that dental fluorosis is merely cosmetic, and the state petitioned the EPA to eliminate the MCL for fluoride.[145] As a result, in 1985, the EPA established a maximum contaminant level goal (MCLG) for fluoride at 4 milligrams per liter.[146] Rather than dental fluorosis serving as the protective endpoint (which would have required lower safety levels), this higher level was established as a means to protect against skeletal fluorosis, a bone disease caused by excess fluoride. Using skeletal fluorosis as the endpoint likewise resulted in a change for the MCL for fluoride, which was raised to 4 milligrams per liter in 1986.[147] Yet, dental fluorosis was applied as the endpoint for the SMCL for fluoride of 2 milligrams per liter, which was also set in 1986.[148]

Controversy ensued over these new regulations and even resulted in legal actions against the EPA. South Carolina argued that there was no need for any MCLG (maximum contaminant level goal) for fluoride, while the Natural Resources Defense Council argued that the MCLG should be lowered based on dental fluorosis.[149] A court ruled in the EPA's favor, but in a review of fluoride standards, the EPA enlisted the National Research Council (NRC) of the National Academy of Sciences to re-evaluate the health risks of fluoride.[150] [151]

The report from the National Research Council, released in 2006, concluded that the EPA's MCLG (maximum contaminant level goal) for fluoride should be lowered.[152] In addition to recognizing the potential for risk of fluoride and osteosarcoma (a bone cancer), the 2006 National Research Council report cited concerns about musculoskeletal effects, reproductive and developmental effects, neurotoxicity and neurobehavioral effects, genotoxicity and carcinogenicity, and effects on other organ systems.[153]

The NRC concluded that the MCLG for fluoride should be lowered in 2006, but the EPA has yet to lower the level.[154] In 2016, the Fluoride Action Network, the IAOMT, and a number of other groups and individuals petitioned the EPA to protect the public, especially susceptible subpopulations, from the neurotoxic risks of fluoride by banning the purposeful addition of fluoride to drinking water.[155] The petition was denied by the EPA in February 2017.[156]

Section 5.2: Bottled Water

The United States Food and Drug Administration (FDA) is responsible for making sure that standards for bottled water are consistent with standards for tap water set by the EPA[157] and the recommended levels set by the U.S. Public Health Service (PHS).[158] The FDA permits bottled water that meets its standards[159] to include language claiming that drinking fluoridated water may reduce the risk of tooth decay.[160]

Section 5.3: Food

The FDA ruled to limit the addition of fluorine compounds to food in the interest of public health in 1977.[161] However, fluoride is still present in food as a result of preparation in fluoridated water, exposure to pesticides and fertilizers, and other factors. In 2004, the United States Department of Agriculture (USDA) launched a database of fluoride levels in beverages and food, and a report with detailed documentation was published in 2005.[162] While this report is still significant, the levels of fluoride in food and beverages have likely increased over the past decade due to the use of fluoride in more recently approved pesticides.[163] Some indirect food additives currently used also contain fluoride.[164]

Additionally, in 2006, the National Research Council recommended that to "assist in estimating individual fluoride exposure from ingestion, manufacturers and producers should provide information on the fluoride content of commercial foods and beverages."[165] However, this will not be happening anytime in the near future. In 2016, the FDA revised its food labeling requirement for Nutrition and Supplement Facts labels and ruled that declarations of fluoride levels are voluntary both for products with intentionally added fluoride and products with naturally occurring fluoride.[166] At that time, the FDA also did not establish a Daily Reference Value (DRV) for fluoride.[167]

On the contrary, in 2016, the FDA prohibited perfluoroalkyl ethyl containing food-contact substances (PFCSs), which are used as oil and water repellants for paper and paperboard.[168] This action was taken as a result of toxicological data and a petition filed by the Natural Resources Defense Council and other groups.

Other than these considerations for fluoride in food, establishing safe levels of fluoride in food due to pesticides is shared by FDA, EPA, and the Food Safety and Inspection Service of the U.S. Department of Agriculture.[169]

Section 5.4: Pesticides

Pesticides sold or distributed in the U.S. must be registered with the EPA, and the EPA can establish tolerances for pesticide residue if exposures from food are deemed to be "safe."[170] In this regard, two fluoride-containing pesticides have been the subject of dispute:

1) Sulfuryl fluoride was first registered in 1959 for termite control in wood structures[171] and in 2004/2005 for control of insects in processed foods, such as cereal grains, dried fruits, tree nuts, cocoa beans, coffee beans, as well as in food handling and food processing facilities.[172] Cases of

human poisoning and even death, while rare, have been associated with sulfuryl fluoride exposure related to homes treated with the pesticide.[173] In 2011, due to updated research and concerns raised by the Fluoride Action Network (FAN), the EPA proposed that sulfuryl fluoride no longer meets safety standards and that the tolerances for this pesticide should be withdrawn.[174] In 2013, the pesticide industry mounted a massive lobbying effort to overturn EPA's proposal to phase-out sulfuryl fluoride, and the EPA proposal was reversed by a provision included in the 2014 Farm Bill.[175]

2) Cryolite, which contains sodium aluminum fluoride, is an insecticide that was first registered with the EPA in 1957.[176] Cryolite is the major fluoride pesticide used in growing food in the U.S. (whereas sulfuryl fluoride is used as a fumigant on post-harvest food). Cryolite is used on citrus and stone fruits, vegetables, berries, and grapes,[177] and people can be exposed to it through their diet, as cryolite can leave fluoride residues on food to which it has been applied.[178] In its 2011 proposed order on sulfuryl fluoride, the EPA also proposed to withdraw all fluoride tolerances in pesticides.[179] This would therefore have included cryolite; however, as noted above, this proposal was overturned.

Section 5.5: Dental Products for Use at Home

The FDA requires labeling for "anticaries drug products" sold over-the-counter, such as toothpaste and mouthwash. Specific wording for the labeling is designated by the form of the product (i.e. gel or paste and rinse), as well as by the fluoride concentration (i.e. 850-1,150 ppm, 0.02% sodium fluoride, etc.).[180] Warnings also are divided by age groups (i.e. two years and older, under six, 12 years and older, etc.). Some warnings apply to all products, such as the following:

> (1) For all fluoride dentifrice (gel, paste, and powder) products. "Keep out of reach of children under 6 years of age. [highlighted in bold type] If more than used for brushing is accidentally swallowed, get medical help or contact a Poison Control Center right away."[181]
>
> (2) For all fluoride rinse and preventive treatment gel products. "Keep out of reach of children. [highlighted in bold type] If more than used for" (select appropriate word: "brushing" or "rinsing") "is accidentally swallowed, get medical help or contact a Poison Control Center right away."[182]

A research article published in 2014 raised significant concerns about this labeling. Specifically, the authors established that over 90% of the products they evaluated listed the FDA warning for use only by children over the age of two on the back of the tube of toothpaste and in small font.[183] Similar circumstances were reported about warnings from the American Dental Association (ADA), which is a trade group and not a government entity. The researchers documented that all of the toothpastes with approval or acceptance by the ADA placed the ADA warning (that children should use a pea-sized amount of toothpaste and be supervised by an adult to minimize swallowing) on the back of the tube in small font.[184] Marketing strategies were further identified as promoting toothpaste as if it were a food product, which the researchers acknowledged was a tactic that could dangerously result in children swallowing the product.[185]

Although dental floss is categorized by the FDA as a Class I device,[186] dental floss containing fluoride (usually stannous fluoride) is considered a combination product[187] and requires premarket applications.[188] Dental floss can also contain fluoride in the form of perfluorinated compounds;[189] however, no regulatory information about this type of fluoride in dental floss could be located by the authors of this position paper.

Section 5.6: Dental Products for Use at the Dental Office

A vast majority of the materials used in the dental office that can release fluoride are regulated as medical/dental devices, such as some resin filling materials,[190] [191] some dental cements,[192] and some composite resin materials.[193] More specifically, most of these dental materials are classified by the FDA as Class II Medical Devices,[194] meaning that the FDA provides "reasonable assurance of the device's safety and effectiveness" without subjecting the product to the highest level of regulatory control.[195] Importantly, as part of the FDA's classification procedure, dental devices with fluoride are considered combination products,[196] and fluoride release rate profiles are expected to be provided as part of the pre-market notification for the product.[197] The FDA further states: "Claims of cavity prevention or other therapeutic benefits are permitted if supported by clinical data developed by an IDE [Investigational Device Exemption] investigation."[198] Moreover, while the FDA publicly mentions the fluoride-releasing mechanism of some dental restorative devices, the FDA does not publicly promote them on their website for use in caries prevention.[199]

Similarly, while fluoride varnishes are approved as Class II Medical Devices for use as a cavity liner and/or tooth desensitizer, they are not approved for use in caries prevention.[200] Therefore, when claims of caries prevention are made about a product that has been adulterated with added fluoride, this is considered by the FDA to be an unapproved, adulterated drug. In addition, FDA regulations make the physician/dentist personally liable for off-label use of approved drugs.[201]

Additionally, in 2014, the FDA permitted the use of silver diamine fluoride for reducing tooth sensitivity.[202] In an article published in 2016, a committee at the University of California, San Francisco, School of Dentistry, recognized that, while the off-label use of silver diamine fluoride (such as in caries management) is now permissible by law, there is a need for a standardized guideline, protocol, and consent.[203]

Also essential to note is that fluoride-containing paste used during dental prophylaxis (cleaning) contains much higher levels of fluoride than commercially sold toothpaste (i.e. 850-1,500 ppm in standard toothpaste[204] versus 4,000-20,000 ppm fluoride in prophy paste[205]). Fluoride paste is not accepted by the FDA or the ADA as an efficient way to prevent dental caries.[206]

Section 5.7: Pharmaceutical Drugs (Including Supplements)

Fluoride is intentionally added to pharmaceutical drugs (drops, tablets, and lozenges often called "supplements" or "vitamins") that are routinely prescribed to children, allegedly to prevent cavities. In 1975, the FDA addressed the use of fluoride supplements by withdrawing the new drug application for Ernziflur fluoride. After the FDA's actions on Ernziflur lozenges were published in the *Federal Register*, an article appeared in *Drug Therapy* stating that the FDA approval was withdrawn "because there is no substantial evidence of drug effectiveness as prescribed, recommended, or suggested in its labeling."[207][208] The article also stated: "The FDA has therefore advised manufacturers of combination fluoride and vitamin preparations that their continued marketing is in violation of the new drug provisions of the Federal Food, Drug, and Cosmetic Act; they have, therefore, requested that marketing of these products be discontinued." [209][210]

In 2016, the FDA sent yet another warning letter out about the same issue of unapproved new drugs in many forms including the fluoride supplements addressed in 1975. A letter, dated January 13, 2016, was sent to Kirkman Laboratories in regard to four different types of pediatric fluoride concoctions labeled as aids in the prevention of dental caries.[211] The FDA warning letter offered the company 15 days to become compliant with law[212] and serves as a yet another example of children hazardously receiving unapproved fluoride preparations, which has now been an issue in the U.S. for over 40 years.

Meanwhile, fluorine is also *permissibly* added to other pharmaceutical drugs. Some reasons that have been identified for its addition to drugs include claims that it can "increase the drug's selectivity, enable it to dissolve in fats, and decrease the speed at which the drug is metabolized, thus allowing it more time to work."[213] 20-30% of pharmaceutical compounds have been estimated to contain fluorine.[214] Some of the most popular drugs include Prozac, Lipitor, and Ciprobay (ciprofloxacin),[215] as well as the rest of fluoroquinolone family (gemifloxacin [marketed as Factive], levofloxacin [marketed as Levaquin], moxifloxacin [marketed as Avelox], norfloxacin [marketed as Noroxin], and ofloxacin [marketed as Floxin and generic ofloxacin]).[216]

In regard to fluoroquinolones, the FDA issued a new warning about disabling side effects in 2016, years after these drugs were first introduced to the market. In their July 2016 announcement, the FDA stated:

> These medicines are associated with disabling and potentially permanent side effects of the tendons, muscles, joints, nerves, and central nervous system that can occur together in the same patient. As a result, we revised the Boxed Warning, FDA's strongest warning, to address these serious safety issues. We also added a new warning and updated other parts of the drug label, including the patient Medication Guide.[217]

Because of these debilitating side effects, the FDA advised that these drugs should only be used when there is no other treatment option available for patients because the risks outweigh the benefits.[218] At the time of this 2016 FDA announcement, it was estimated that over 26 million Americans were taking these drugs annually.[219]

Section 5.8: Perfluorinated Compounds

Per- and polyfluoroalkyl substances (PFASs), also referred to as perfluorinated compounds or perfluorinated chemicals (PFCs), are substances used in carpets, cleaners, clothing, cookware, food packaging, paints, paper, and other products because they provide fire resistance and oil, stain, grease, and water repellency.[220][221] For example, perfluorooctanoic acid (PFOA) is used to make polytetrafluoroethylene (PTFE), which is used in Teflon, Gore-tex, Scotchguard, and Stainmaster.[222]

However, when over 200 scientists from 38 countries signed on to the "Madrid Statement" in 2015,[223] concerns about such substances and their possible link to ill-health were publicized.[224] Additionally, in 2016, the EPA stated of PFSAs:

> Studies indicate that exposure to PFOA and PFOS over certain levels may result in adverse health effects, including developmental effects to fetuses during pregnancy or to breast-fed infants (e.g., low birth weight, accelerated puberty, skeletal variations), cancer (e.g., testicular, kidney), liver effects (e.g., tissue damage), immune effects (e.g., antibody production and immunity), and other effects (e.g., cholesterol changes).[225]

Thus, in the U.S., efforts have only recently begun to decrease the use of these chemicals. For example, in 2016, the EPA issued health advisories for PFOA and PFOS in drinking water, identifying the level at or below which adverse health effects are not anticipated to occur over a lifetime of exposure as 0.07 parts per billion (70 parts per trillion) for PFOA and PFOS.[226] As another example, in 2006, the EPA joined forces with eight companies through a stewardship program for these eight companies to reduce and eliminate PFOA by 2015.[227] Yet, the EPA has also written that they "remain concerned" about the companies producing these products that did not participate in this program.[228]

Section 5.9: Occupational

Exposure to fluorides (fluoride, perfluoride) in the workplace is regulated by the Occupational Safety & Health Administration (OSHA). The health factor most taken into consideration for these standards is skeletal fluorosis, and the limit values for occupational exposure to fluorides are consistently listed as 2.5 mg/m^3. [229]

In a 2005 article published in the *International Journal of Occupational and Environmental Health* and presented in part at the American College of Toxicology Symposium, author Phyllis J. Mullenix, PhD, identified the need for better workplace protection from fluorides.[230] Specifically, Dr. Mullenix wrote that while fluoride standards have remained consistent:

> Only recently have data become available suggesting not only that these standards have provided inadequate protection to workers exposed to fluorine and fluorides, but that for decades industry has possessed the information necessary to identify the standards' inadequacy and to set more protective threshold levels of exposure.[231]

Section 6: Health Effects of Fluoride

In a 2006 report by the National Research Council (NRC) of the National Academy of Sciences in which the health risks of fluoride were evaluated, concerns were raised about potential associations between fluoride and osteosarcoma (a bone cancer), bone fractures, musculoskeletal effects, reproductive and developmental effects, neurotoxicity and neurobehavioral effects, genotoxicity and carcinogenicity, and effects on other organ systems.[232]

Since the NRC report was released in 2006, a number of other relevant research studies have been published. In fact, in a 2016 citizen petition to the EPA from the Fluoride Action Network (FAN), the IAOMT, and other groups, Michael Connett, Esq., Legal Director of FAN, provided a list of the newer research demonstrating harm from fluoride, which is highly relevant, especially due to the number of additional human studies:[233]

> In total, Petitioners have identified and attached 196 published studies that have addressed the neurotoxic effects of fluoride exposure subsequent to the NRC's review, including 61 human studies, 115 animal studies, 17 cell studies, and 3 systematic reviews.
>
> The post-NRC human studies include:
> - 54 studies investigating fluoride's effect on cognitive performance, including but not limited to IQ, with all but 8 of these studies finding statistically significant associations between fluoride exposure and cognitive deficits.[234]
> - 3 studies investigating fluoride's effect on fetal brain, with each of the 3 studies reporting deleterious effects.[235]
> - 4 studies investigating fluoride's association with other forms of neurotoxic harm, including ADHD, altered neonatal behavior, and various neurological symptoms.[236]
>
> The post-NRC animal studies include:
> - 105 studies investigating fluoride's ability to produce neuroanatomical and neurochemical changes, with all but 2 of the studies finding at least one detrimental effect in at least one of the tested dosage levels.[237]
> - 31 studies investigating fluoride's effect on learning and memory, with all but one of the studies finding at least one deleterious effect in the fluoride-treated groups.[238]
> - 18 studies investigating fluoride's impact on other parameters of neurobehavior besides learning and memory, with all but one of the studies finding effects.[239]
>
> The post-NRC cell studies include:
> - 17 studies, including 2 studies that investigated and found effects at fluoride levels that chronically occur in the blood of Americans living in fluoridated communities.[240]
>
> In addition to the above studies, Petitioners are submitting three post-NRC systematic reviews of the literature, including two that address the human/IQ literature, and one that addresses the animal/cognition literature.[241]

It is clear that numerous research articles have already identified potential harm to humans from fluoride at various levels of exposure, including levels currently deemed as safe. Although each of these articles merit attention and discussion, an abbreviated list is included below in the form of a general description of health effects related to fluoride exposure, which features highlights of pertinent reports and studies.

Section 6.1: Skeletal System

Fluoride taken into the human body enters the bloodstream through the digestive tract.[242] Most of the fluoride that is not released through urine is stored in the body. It is generally stated that 99% of this fluoride resides in the bone,[243] where it is incorporated into the crystalline structure and accumulates over time.[244] Thus, it is indisputable that the teeth and bones are tissues of the body that concentrate the fluoride to which we are exposed.

In fact, in its 2006 report, the National Research Council (NRC)'s discussion on the danger of bone fractures from excessive fluoride was substantiated with significant research. Specifically, the report stated: "Overall, there was consensus among the committee that there is scientific evidence that under certain conditions fluoride can weaken bone and increase the risk of fractures."[245]

Section 6.1.1: Dental Fluorosis

Exposure to excess fluoride in children is known to result in dental fluorosis, a condition in which the teeth enamel becomes irreversibly damaged and the teeth become permanently discolored, displaying a white or brown mottling pattern and forming brittle teeth that break and stain easily.[246] It has been scientifically recognized since the 1940's that overexposure to fluoride causes this condition, which can range from very mild to severe. According to data from the Centers for Disease Control and Prevention (CDC) released in 2010, 23% of Americans aged 6-49 and 41% of children aged 12-15 exhibit fluorosis to some degree.[247] These drastic increases in rates of dental fluorosis were a crucial factor in the Public Health Service's decision to lower its water fluoridation level recommendations in 2015.[248]

Figure 1: Dental Fluorosis Ranging from Very Mild to Severe
(Photos from Dr. David Kennedy and are used with permission from victims of dental fluorosis.)

Section 6.1.2: Skeletal Fluorosis and Arthritis

Like dental fluorosis, skeletal fluorosis is an undeniable effect of overexposure to fluoride. Skeletal fluorosis causes denser bones, joint pain, a limited range of joint movement, and in severe cases, a completely rigid spine.[249] Although considered rare in the U.S., the condition does occur,[250] and it has been recently suggested that skeletal fluorosis could be more of a public health issue than previously recognized.[251]

As research published in 2016 noted, there is not yet a scientific consensus as to how much fluoride and/or how long levels of fluoride need to be taken in before skeletal fluorosis occurs.[252] While some authorities have suggested skeletal fluorosis only occurs after 10 years or more of exposure, research has shown that children can develop the disease in as little as six months,[253] and some adults have developed it in as little as two to seven years.[254] Similarly, while some authorities have suggested that 10 mg/day of fluoride is necessary to develop skeletal fluorosis, research has reported that much lower levels of exposure to fluoride (in some cases less than 2ppm) can also cause the disease.[255] Furthermore, research published in 2010 confirmed that skeletal tissue response to fluoride varies by individual.[256]

In patients with skeletal fluorosis, fluoride has also been suspected of causing secondary hyperparathyroidism and/or causing bone damage resembling secondary hyperparathyroidism. The condition, which commonly results from kidney disease, is triggered when the levels of calcium and phosphorous in the blood are too low.[257] A number of studies that have been collected by the Fluoride Action Network (FAN) examine the possibility that fluoride is one contributor to this health effect.[258]

Because arthritic symptoms are associated with skeletal fluorosis, arthritis is another area of concern in relation to fluoride exposures. Notably in this regard, research has linked fluoride to osteoarthritis, both with or without skeletal fluorosis.[259] Additionally, temporomandibular joint disorder (TMJ) has been associated with dental and skeletal fluorosis.[260]

Section 6.1.3: Cancer of the Bone, Osteosarcoma

In 2006, the NRC discussed a potential link between fluoride exposure and osteosarcoma. This type of bone cancer has been recognized as "the sixth most common group of malignant tumors in children and the third most common malignant tumor for adolescents."[261] The NRC stated that while evidence was tentative, fluoride appeared to have the potential to promote cancers.[262] They elucidated that osteosarcoma was of significant concern, especially because of fluoride deposition in bone and the mitogenic effect of fluoride on bone cells.[263]

While some studies have failed to find an association between fluoride and osteosarcoma, according to the research completed by Dr. Elise Bassin while at Harvard School of Dental Medicine, exposure to fluoride at recommended levels correlated with a seven-fold increase in osteosarcoma when boys were exposed between the ages of five and seven.[264] Bassin's research, published in 2006, is the only study about osteosarcoma that has taken age-specific risks into account.[265]

Section 6.2: Central Nervous System

The potential for fluorides to impact the brain have been well-established. In their 2006 report, the NRC explained: "On the basis of information largely derived from histological, chemical, and molecular studies, it is apparent that fluorides have the ability to interfere with the functions of the brain and the body by direct and indirect means."[266] Both dementia and Alzheimer's disease are also mentioned in the NRC report for consideration as being potentially linked to fluoride.[267]

These concerns have been substantiated. Studies about water fluoridation and IQ effects were closely examined in research published in October of 2012 in *Environmental Health Perspectives*.[268] In this meta-review, 12 studies demonstrated that communities with fluoridated water levels below 4 mg/L (average of 2.4 mg/L) had lower IQs than the control groups.[269] Since the publication of the 2012 review, a number of additional studies finding reduced IQs in communities with less than 4 mg/L of fluoride in the water have become available.[270] To be more precise, in a citizen petition to the EPA in 2016, Michael Connett, Esq., Legal Director of FAN, identified 23 studies reporting reduced IQ in areas with fluoride levels currently accepted as safe by the EPA.[271]

Moreover, in 2014, a review was published in *The Lancet* entitled "Neurobehavioral effects of developmental toxicity." In this review, fluoride was listed as one of 12 industrial chemicals known to cause developmental neurotoxicity in human beings.[272] The researchers warned: "Neurodevelopmental disabilities, including autism, attention-deficit hyperactivity disorder, dyslexia, and other cognitive impairments, affect millions of children worldwide, and some diagnoses seem to be increasing in frequency. Industrial chemicals that injure the developing brain are among the known causes for this rise in prevalence."[273]

Section 6.3: Cardiovascular System

According to statistics published in 2016, heart disease is the leading cause of death for both men and women in the U.S., and it costs the country $207 billion annually.[274] Thus, recognizing the potential relationship between fluoride and cardiovascular problems is essential not only for safe measures to be established for fluoride but also for preventative measures to be established for heart disease.

An association between fluoride and cardiovascular problems has been suspected for decades. The 2006 NRC report described a study from 1981 by Hanhijärvi and Penttilä that reported elevated serum fluoride in patients with cardiac failure.[275] Fluoride has also been related to arterial calcification,[276] arteriosclerosis,[277] cardiac insufficiency,[278] electrocardiogram abnormalities,[279] hypertension,[280] and myocardial damage.[281] Additionally, researchers of a study from China published in 2015 concluded: "The results showed that, NaF [sodium fluoride], in a concentration dependent-manner and even at the low concentration of 2 mg/L, changed the morphology of the cardiomyocytes, reduced cell viability, increased the cardiac arrest rate, and enhanced the levels of apoptosis."[282]

Section 6.4: Endocrine System

Fluoride's effects on the endocrine system, which consists of glands that regulate hormones, have also been studied. In the 2006 NRC report, it was stated: "In summary, evidence of several types indicates that fluoride affects normal endocrine function or response; the effects of the fluoride-induced changes vary in degree and kind in different individuals."[283] The 2006 NRC report further included a table demonstrating how extremely low doses of fluoride have been found to disrupt thyroid function, especially when there was a deficiency in iodine present.[284] In more recent years, the impact of fluoride on the endocrine system has been re-emphasized. A study published in 2012 included sodium fluoride on a list of endocrine disrupting chemicals (EDCs) with low-dose effects,[285] and the study was cited in a 2013 report from the United Nations Environment Programme and the World Health Organization.[286]

Meanwhile, increased rates of thyroid dysfunction have been associated with fluoride.[287] Research published in 2015 by researchers at the University of Kent in Canterbury, England, noted that higher levels of fluoride in drinking water could predict higher levels of hypothyroidism.[288] They further explained: "In many areas of the world, hypothyroidism is a major health concern and in addition to other factors—such as iodine deficiency— fluoride exposure should be considered as a contributing factor. The findings of the study raise particular concerns about the validity of community fluoridation as a safe public health measure."[289] Other studies have supported the association between fluoride and hypothyroidism,[290] an increase in thyroid stimulating hormone (THS),[291] and iodine deficiency.[292]

According to statistics released by the Centers for Disease Control and Prevention (CDC) in 2014, 29.1 million people or 9.3% of the population have diabetes.[293] Again, the potential role of fluoride in this condition is essential to consider. The 2006 NRC report warned:

> The conclusion from the available studies is that sufficient fluoride exposure appears to bring about increases in blood glucose or impaired glucose tolerance in some individuals and to increase the severity of some types of diabetes. In general, impaired glucose metabolism appears to be associated with serum or plasma fluoride concentrations of about 0.1 mg/L or greater in both animals and humans (Rigalli et al. 1990, 1995; Trivedi et al. 1993; de al Sota et al. 1997).[294]

Research has also associated diabetes with a reduced capacity to clear fluoride from the body,[295] as well as a syndrome (polydispsia-polyurea) that results in increased intake of fluoride,[296] and research has also linked insulin inhibition and resistance to fluoride.[297]

Also of concern is that fluoride appears to interfere with functions of the pineal gland, which helps control circadian rhythms and hormones, including the regulation of melatonin and reproductive hormones. Jennifer Luke of the Royal Hospital of London has identified high levels of fluoride accumulated in the pineal gland[298] and further demonstrated that these levels could reach up to 21,000 ppm, rendering them higher than the fluoride levels in the bone or teeth.[299] Other studies have linked fluoride to melatonin levels,[300] insomnia,[301] and early puberty in girls,[302] as well as lower fertility rates (including men) and reduced testosterone levels.[303]

Section 6.5: Renal System

Urine is a major route of excretion for fluoride taken into the body, and the renal system is essential for the regulation of fluoride levels in the body.[304 305] Urinary excretion of fluoride is influenced by urine pH, diet, presence of drugs, and other factors.[306] Researchers of a 2015 article published by the Royal Society of Chemistry explained: "Thus, plasma and the kidney excretion rate constitutes the physiologic balance determined by fluoride intake, uptake to and removal from bone and the capacity of fluoride clearance by the kidney."[307]

The 2006 NRC report likewise recognized the role of the kidney in fluoride exposures. They noted that it is not surprising for patients with kidney disease to have increased plasma and bone fluoride concentrations.[308] They further stated that human kidneys "have to concentrate fluoride as much as 50-fold from plasma to urine. Portions of the renal system may therefore be at higher risk of fluoride toxicity than most soft tissues."[309]

In light of this information, it makes sense that researchers have indeed linked fluoride exposures to problems with the renal system. More specifically, researchers from Toronto, Canada, demonstrated that dialysis patients with renal osteodystrophy had high levels of fluoride in the bone and concluded that "bone fluoride may diminish bone microhardness by interfering with mineralization."[310] Additionally, a study on workers exposed to cryolite by Philippe Grandjean and Jørgen H. Olsen published in 2004 suggested that fluoride be considered as a possible cause of bladder cancer and a contributory cause in lung cancer.[311]

Section 6.6: Respiratory System

The effects of fluoride on the respiratory system are most clearly documented in literature about occupational exposures. Obviously, workers in industries involving fluoride are at a much higher risk of inhaling fluoride than those who do not work in the industry; however industrial usage can also impact the respiratory systems of average citizens through a variety of exposure routes.

Inhalation of hydrogen fluoride serves as a prime example of the dually evidenced occupational and non-occupational health risk. Hydrogen fluoride is used to make refrigerants, herbicides, pharmaceuticals, high-octane gasoline, aluminum, plastics, electrical components, fluorescent light bulbs, and etched metal and glass (such as that used in some electronic devices),[312] as well as uranium chemicals production and quartz purification.[313] The Centers for Disease Control and Prevention (CDC) has explained that in addition to exposures at the workplace, non-occupational exposures to hydrogen fluoride can also occur at retail locations and through hobbies involving items made with the substance, as well as the rare event of exposure to a chemical terrorism agent.[314]

Health effects from hydrogen fluoride can damage multiple different organs, including those involved with the respiratory system. Breathing the chemical can harm lung tissue and cause swelling and fluid accumulation in the lungs (pulmonary edema).[315] High levels of exposure to hydrogen fluoride can cause death from the buildup in the lungs,[316] while chronic, low level inhalation can cause irritation and congestion of the nose, throat, and lungs.[317]

Strictly from an occupational standpoint, the aluminum industry has been the subject of an array of investigations into fluoride's impact on the respiratory systems of workers. Evidence from a series of studies indicates a correlation between workers at aluminum plants, exposures to fluoride, and respiratory effects, such as emphysema, bronchitis, and diminished lung function.[318]

Section 6.7: Digestive System

Upon ingestion, including through fluoridated water, fluoride is absorbed by the gastrointestinal system where it has a half-life of 30 minutes.[319] The amount of fluoride absorbed is dependent upon calcium levels, with higher concentrations of calcium lowering gastrointestinal absorption.[320] [321] Also, according to research published in 2015 by the American Institute of Chemical Engineers, fluoride's interaction in the gastrointestinal system "results in formation of hydrofluoric [HF] acid by reacting with hydrochloric [HCL] acid present in the stomach. Being highly corrosive, the HF acid so formed will destroy the stomach and intestinal lining with the loss of microvilli."[322]

Another area of research related to fluoride's impact on the gastrointestinal tract is the accidental ingestion of toothpaste. In 2011, the Poison Control Center received 21,513 calls related to overconsumption of fluoridated toothpaste.[323] The numbers of impacted individuals are likely to be much higher, however. Concerns have been raised that some gastrointestinal symptoms might not be readily considered as related to fluoride ingestion, as researchers explained in 1997:

> Parents or caregivers may not notice the symptoms associated with mild fluoride toxicity or may attribute them to colic or gastroenteritis, particularly if they did not see the child ingest fluoride. Similarly, because of the nonspecific nature of mild to moderate symptoms, a physician's differential diagnosis is unlikely to include fluoride toxicity without a history of fluoride ingestion.[324]

Other areas of the digestive system are also known to be impacted by fluoride. For example, the 2006 NRC report called for more information about fluoride's effect on the liver: "It is possible that a lifetime ingestion of 5-10 mg/day from drinking water containing fluoride at 4 mg/L might turn out to have long-term effects on the liver, and this should be investigated in future epidemiologic studies."[325] As another example, fluoride toothpaste may cause stomatitis, such as mouth and canker sores in some individuals.[326]

Section 6.8: Immune System

The immune system is yet another part of the body that can be impacted by fluoride. An essential consideration is that immune cells develop in the bone marrow, so the effect of fluoride on the immune system could be related to fluoride's prevalence in the skeletal system. The 2006 NRC report elaborated on this scenario:

Nevertheless, patients who live in either an artificially fluoridated community or a community where the drinking water naturally contains fluoride at 4 mg/L have all accumulated fluoride in their skeletal systems and potentially have very high fluoride concentrations in their bones. The bone marrow is where immune cells develop and that could affect humoral immunity and the production of antibodies to foreign chemicals.[327]

Allergies and hypersensitivities to fluoride are another risk component related to the immune system. Research published in 1950's, 1960's, and 1970's showed that some people are hypersensitive to fluoride.[328] Interestingly, authors of research published in 1967 pointed out that while some still questioned the fact that fluoride in toothpaste and "vitamins" could cause sensitivities, the case reports presented in their publication established that allergic reactions to fluoride do exist.[329] More recent studies have confirmed this reality.[330]

Section 6.9: Integumentary System

Fluoride can also impact the integumentary system, which consists of the skin, exocrine glands, hair, and nails. In particular, reactions to fluoride, including fluoride used in toothpaste, have been linked to acne and other dermatological conditions.[331] [332] [333] Moreover, a potentially life-threatening condition known as fluoroderma is caused by a hypersensitive reaction to fluorine,[334] and this type of skin eruption (a halogenoderma) has been associated with patients using fluoridated dental products.[335] Additionally, hair and nails have been studied as biomarkers of fluoride exposure.[336] Nail clippings are capable of demonstrating chronic fluoride exposures[337] and exposures from toothpaste,[338] and using fluoride concentrations in nails to identify children at risk for dental fluorosis has been examined.[339]

Section 6.10: Fluoride Toxicity

The first large scale case of alleged industrial poisoning from fluorine involved a disaster at Meuse Valley in Belgium in the 1930s. Fog and other conditions in this industrialized area were associated with 60 deaths and several thousand people becoming ill. Evidence has since related these casualties to fluorine releases from the nearby factories.[340]

Another case of industrial poisoning occurred in 1948 in Donora, Pennsylvania, due to fog and temperature inversion. In this instance, gaseous releases from zinc, steel, wire, and nail galvanizing industries have been suspected of causing 20 deaths and six thousand people to become ill as a result of fluoride poisoning.[341]

Fluoride toxicity from a dental product in the United States occurred in 1974 when a three-year old Brooklyn boy died due to a fluoride overdose from dental gel. A reporter for the *New York Times* wrote of the incident: "According to a Nassau County toxicologist, Dr. Jesse Bidanset, William ingested 45 cubic centimeters of 2 percent stannous fluoride solution, triple an amount sufficient to have been fatal."[342]

Several major cases of fluoride poisoning in the United States have achieved attention in recent decades, such as the 1992 outbreak in Hooper Bay, Alaska, as a result of high levels of fluoride in the water supply[343] and the 2015 poisoning of a family in Florida as a result of sulfuryl fluoride used in a termite treatment on their home.[344]

While the examples provided above are cases of acute (high dose, short-term) poisoning, chronic (low dose, long-term) poisoning must also be considered. At least information about fluoride poisoning is becoming available to help form a better understanding of the issue. In work published in 2015, researchers reviewed the facts that the first sign of fluoride toxicity is dental fluorosis and that fluoride is a known enzyme disruptor.[345] Additionally, a review published in 2012 provided a detailed account of the hazards of fluoride toxicity's effect on cells: "It activates virtually all known intracellular signaling pathways including G protein-dependent pathways, caspases, and mitochondria- and death receptors-linked mechanisms, as well as triggers a range of metabolic and transcription alterations, including the expression of several apoptosis-related genes, ultimately leading to cell death."[346]

The urgency for fluoride toxicity to be more widely recognized was explored in a 2005 publication entitled "Fluoride poisoning: a puzzle with hidden pieces." Author Phyllis J. Mullenix, PhD, began the article, which was presented in part at the American College of Toxicology Symposium, by warning: "A history of enigmatic descriptions of fluoride poisoning in the medical literature has allowed it to become one of the most misunderstood, misdiagnosed, and misrepresented health problems in the United States today."[347]

Section 7: Exposure Levels

Due to increased rates of dental fluorosis and increased sources of exposure to fluoride, the Public Health Service (PHS) lowered its recommended levels of fluoride set at 0.7 to 1.2 milligrams per liter in 1962[348] to 0.7 milligrams per liter in 2015.[349] The need to update previously established fluoride levels is extremely urgent, as fluoride exposures have obviously surged for Americans since the 1940's, when community water fluoridation was first introduced.

Table 2, provided in Section 3 of this document, helps identify just how many sources of fluoride exposure are relevant to modern-day consumers. Similarly, a history of fluoride, as provided in Section 4 of this document, helps firmly demonstrate the number of fluoride-containing products developed over the past 75 years. Furthermore, the health effects of fluoride, as provided in Section 6 of this document, offer details about the damages of fluoride exposures inflicted upon all systems of the human body. When viewed in context with the history, sources, and health effects of fluoride, the uncertainty of exposure levels described in this section provides overwhelming evidence of potential harm to human health.

Section 7.1: Fluoride Exposure Limits and Recommendations

Generally, the optimal exposure for fluoride has been defined as between 0.05 and 0.07 mg of fluoride per kilogram of body weight.[350] However, this level has been criticized for failing to directly assess how intake of fluoride is related to the occurrence or severity of dental caries and/or dental fluorosis.[351] To elaborate, in a 2009 longitudinal study, researchers at the University of Iowa noted the lack of scientific evidence for this intake level and concluded: "Given the overlap among caries/fluorosis groups in mean fluoride intake and extreme variability in individual fluoride intakes, firmly recommending an 'optimal' fluoride intake is problematic."[352]

In light of this disparity, as well as the fact that the established levels directly influence the amounts of fluoride to which consumers are exposed, it is essential to evaluate some of the established limits and recommendations for fluoride exposures. While a detailed description of fluoride regulations is provided in Section 5 of this document, recommendations issued by other government groups are also important to consider. Comparing regulations and recommendations helps to exemplify the complexity of establishing levels, of enforcing levels, of utilizing them to protect *all* individuals, and of applying them to everyday life. To illustrate this point, Table 3 provides a comparison of recommendations from the Public Health Service (PHS), recommendations from the Institute of Medicine (IOM), and regulations from the Environmental Protection Agency (EPA).

Table 3: Comparison of PHS Recommendations, IOM Recommendations, and EPA Regulations for Fluoride Intake

TYPE OF FLUORIDE LEVEL	SPECIFIC FLUORIDE RECOMMENDATION/ REGULATION	SOURCE OF INFORMATION AND *NOTES*
Recommendation for Fluoride Concentration in Drinking Water for the Prevention of Dental Caries	0.7 mg per liter	U.S. Public Health Service (PHS)[353] *This is a non-enforceable recommendation.*
Dietary Reference Intake: Tolerable Upper Intake Level of Fluoride	Infants 0-6 mo. .... 0.7 mg/d Infants 6-12 mo. .... 0.9 mg/d Children 1-3 y .... 1.3 mg/d Children 4-8 y .... 2.2 mg/d Males 9->70 y .... 10 mg/d Females 9->70 y* 10 mg/d (*includes pregnancy and lactation)	Food and Nutrition Board, Institute of Medicine (IOM), National Academies[354] *This is a non-enforceable recommendation.*
Dietary Reference Intake: Recommended Dietary Allowances and Adequate Intakes	Infants 0-6 mo. .... 0.01 mg/d Infants 6-12 mo. .... 0.5 mg/d Children 1-3 y .... 0.7 mg/d Children 4-8 y .... 1.0 mg/d Males 9-13 y .... 2.0 mg/d Males 14-18 y .... 3.0 mg/d Males 19->70 y .... 4.0 mg/d Females 9-13 y .... 2.0 mg/d Females 14->70 y* 3.0 mg/d (*includes pregnancy and lactation)	Food and Nutrition Board, Institute of Medicine (IOM), National Academies[355] *This is a non-enforceable recommendation.*
Maximum Contaminant Level (MCL) of Fluoride from Public Water Systems	4.0 mg per liter	U.S. Environmental Protection Agency (EPA)[356] *This is an **enforceable** regulation.*

Maximum Contaminant Level Goal (MCLG) of Fluoride from Public Water Systems	4.0 mg per liter	U.S. Environmental Protection Agency (EPA)[357] *This is a non-enforceable regulation.*
Secondary Standard of Maximum Contaminant Levels (SMCL) of Fluoride from Public Water Systems	2.0 mg per liter	U.S. Environmental Protection Agency (EPA)[358] *This is a non-enforceable regulation.*

By interpreting the selected examples above, it is obvious that the limits and recommendations for fluoride in food and water vary tremendously and, in their current state, would be nearly impossible for consumers to incorporate into daily life. It is also obvious that these levels do not consider a multitude of other fluoride exposures. This means that consumers are reliant upon policy makers to protect them by enacting *enforceable regulations* based upon accurate data. One issue is that accurate data does not exist for either collective sources or singular sources of fluoride exposure. Another issue is that fluoride is known to impact each individual differently.

Section 7.2: Multiple Sources of Exposure

Understanding fluoride exposure levels from *all sources* is crucial because recommended intake levels for fluoride in water and food should be based upon these common multiple exposures. However, it is clear that these levels are *not* based on collective exposures because the authors of this document could not locate a single study or research article that included estimates of combined exposure levels from all of the sources identified in Table 2 in Section 3 of this position paper.

The concept of evaluating fluoride exposure levels from multiple sources was addressed in the 2006 National Research Council (NRC) report, which acknowledged the difficulties with accounting for all sources and individual variances.[359] Yet, the NRC authors attempted to calculate combined exposures from pesticides/air, food, toothpaste, and drinking water.[360] While these calculations did not include exposures from other dental materials, pharmaceutical drugs, and other consumer products, the NRC still recommended to lower the MCLG for fluoride,[361] which has not yet been accomplished.

The American Dental Association (ADA), which is a trade group and not a government entity, has recommended that collective sources of exposure should be taken into account. In particular, they have recommended that research should "estimate the total fluoride intake from all sources individually and in combination."[362] Furthermore, in an article about the use of fluoride "supplements" (prescription drugs given to patients, usually children, that contain additional fluoride), the ADA mentioned that all sources of fluoride should be evaluated and that "patient exposure to multiple water sources can make proper prescribing complex."[363]

Several studies conducted in the U.S. have offered data about multiple exposures to fluoride, as well as warnings about this current situation. A study published in 2005 by researchers at the University of Illinois at Chicago evaluated fluoride exposures in children from drinking water, beverages, cow's milk, foods, fluoride "supplements," toothpaste swallowing, and soil ingestion.[364] They found that the reasonable maximum exposure estimates exceeded the upper tolerable intake and concluded that "some children may be at risk for fluorosis."[365]

Additionally, a study published in 2015 by researchers at the University of Iowa considered exposures from water, toothpaste, fluoride "supplements," and foods.[366] They found considerable individual variation and offered data showing that some children exceeded the optimal range. They specifically stated: "Thus, it's doubtful that parents or clinicians could adequately track children's fluoride intake and compare it [to] the recommended level, rendering the concept of an 'optimal' or target intake relatively moot."[367]

Section 7.3: Individualized Responses and Susceptible Subgroups

Setting one universal level of fluoride as a recommended limit is also problematic because it does not take individualized responses into account. While age, weight, and gender are *sometimes* considered in recommendations, the current EPA regulations for water prescribe one level that applies to everyone, regardless of infants and children and their known susceptibilities to fluoride exposures. Such a "one dose fits all" level also fails to address allergies to fluoride,[368] genetic factors,[369] [370] [371] nutrient deficiencies,[372] and other personalized factors known to be pertinent to fluoride exposures.

The NRC recognized such individualized responses to fluoride numerous times in their 2006 publication,[373] and other research has affirmed this reality. For example, urine pH, diet, presence of drugs, and other factors have been identified as relative to the amount of fluoride excreted in the urine.[374] As another example, fluoride exposures of non-nursing infants were estimated to be 2.8-3.4 times that of adults.[375] The NRC further established that certain subgroups have water intakes that greatly vary from any type of assumed average levels:

> These subgroups include people with high activity levels (e.g., athletes, workers with physically demanding duties, military personnel); people living in very hot or dry climates, especially outdoor workers; pregnant or lactating women; and people with health conditions that affect water intake. Such health conditions include diabetes mellitus, especially if untreated or poorly controlled; disorders of water and sodium metabolism, such as diabetes insipidus; renal problems resulting in reduced clearance of fluoride; and short-term conditions requiring rapid rehydration, such as gastrointestinal upsets or food poisoning.[376]

Considering that the rate of diabetes is on the rise in the U.S., with over 9% (29 million) Americans impacted,[377] this particular subgroup is especially essential to factor into account. Furthermore, when added to the other subgroups mentioned in the NRC report above (including infants and children), it is apparent that hundreds of millions of Americans are at risk from the current levels of fluoride added to community drinking water.

The American Dental Association (ADA), a trade-based group that promotes water fluoridation,[378] has also recognized the issue of individual variance in fluoride intake. They have recommended for research to be conducted to "[i]dentify biomarkers (that is, distinct biological indicators) as an alternative to direct fluoride intake measurement to allow the clinician to estimate a person's fluoride intake and the amount of fluoride in the body."[379]

Additional comments from the ADA provide even more insight into individualized responses related to fluoride intake. The ADA has recommended to "[c]onduct metabolic studies of fluoride to determine the influence of environmental, physiological and pathological conditions on the pharmacokinetics, balance and effects of fluoride."[380] Perhaps most notably, the ADA has also acknowledged the susceptible subgroup of infants. In regard to infant exposure from fluoridated water used in baby formula, the ADA recommends following the American Academy of Pediatrics guideline that breastfeeding should be exclusively practiced until the child is six months old and continued until 12 months, unless contraindicated.[381]

While suggesting to exclusively breastfeed infants is certainly protective of their fluoride exposures, it is simply not practical for many American women today. The authors of a study published in 2008 in *Pediatrics* reported that only 50% of women continued to breast feed at six months and only 24% of women continued to breast feed at 12 months.[382]

What these statistics mean is that, due to infant formula mixed with fluoridated water, millions of infants most certainly exceed the optimal intake levels of fluoride based on their low weight, small size, and developing body. Hardy Limeback, PhD, DDS, a member of a 2006 National Research Council (NRC) panel on fluoride toxicity, and former President of the Canadian Association of Dental Research, has elaborated: "Newborn babies have undeveloped brains, and exposure to fluoride, a suspected neurotoxin, should be avoided."[383]

Section 7.4: Water and Food

Fluoridated water, including its direct consumption and its use in other beverages and food preparation, is generally considered the main source of fluoride exposure for Americans. The U.S. Public Health Service (PHS) has estimated that the average dietary intake (including water) of fluoride for adults living in areas with 1.0 mg/L fluoride in the water as between 1.4 to 3.4 mg/day (0.02-0.048 mg/kg/day) and for children in fluoridated areas as between 0.03 to 0.06 mg/kg/day.[384] Additionally, the Centers for Disease Control and Prevention (CDC) has reported that water and processed beverages can comprise 75% of a person's fluoride intake.[385]

The 2006 NRC report came to similar conclusions. The authors estimated just how much of overall fluoride exposures are attributable to water when compared to pesticides/air, background food, and toothpaste, and they wrote: "Assuming that all drinking-water sources (tap and non-tap) contain the same fluoride concentration and using the EPA default drinking-water intake rates, the drinking-water contribution is 67-92% at 1 mg/L, 80-96% at 2 mg/L, and 89-98% at 4 mg/L."[386] Yet, the levels of NRC's estimated fluoridated water intake rates were higher for athletes, workers, and individuals with diabetes.[387]

It is important to reiterate, however, that the fluoride added to water is not only taken in through drinking tap water. The water is also used for growing crops, tending to livestock (and domestic pets), food preparation, and bathing. It is also used to create other beverages, and for this reason, significant levels of fluoride have been recorded in infant formula and commercial beverages, such as juice and soft drinks.[388] Significant levels of fluoride have also been recorded in alcoholic beverages, especially wine and beer.[389 390]

In the exposure estimates provided in the 2006 NRC report, fluoride in food consistently ranked as the second largest source behind water.[391] Increased levels of fluoride in food can occur due to human activity, especially through food preparation and the use of pesticides and fertilizers.[392] Significant fluoride levels have been recorded in grapes and grape products.[393] Fluoride levels have also been reported in cow's milk due to livestock raised on fluoride-containing water, feed, and soil,[394] as well as processed chicken[395] (likely due to mechanical deboning, which leaves skin and bone particles in the meat.)[396]

An essential question about these levels of fluoride intake is just how much is harmful. A study about water fluoridation published in 2016 by Kyle Fluegge, PhD, of Case Western University, was conducted at the county level in 22 states from 2005-2010. Dr. Fluegge reported that his findings suggested that "a 1 mg increase in the county mean added fluoride significantly positively predicts a 0.23 per 1,000 person increase in age-adjusted diabetes incidence ($P < 0.001$) and a 0.17% increase in age-adjusted diabetes prevalence percent ($P < 0.001$)."[397] This led him to reasonably conclude that community water fluoridation is associated with epidemiological outcomes for diabetes.

Other studies have produced equally concerning results. A study published in 2011 found that children with 0.05 to 0.08 mg/L of fluoride in their serum had a 4.2 drop in IQ when compared to other children.[398] Meanwhile, a study published in 2015 found that IQ points dropped at urinary fluoride levels between 0.7 and 1.5 mg/L,[399] and another study published in 2015 linked fluoride at levels >0.7 mg/L with hyperthyroidism.[400] Additional research has established the threat of health effects of fluoride in the water at levels currently considered as safe.[401]

Section 7.5: Fertilizers, Pesticides, and Other Industrial Releases

Exposures to fertilizers and pesticides have been associated with serious health effects. For example, the Toxics Action Center has explained: "Pesticides have been linked to a wide range of human health hazards, ranging from short-term impacts, such as headaches and nausea, to chronic impacts like cancer, reproductive harm, and endocrine disruption."[402] Scientific studies have also associated exposure to pesticides with antibiotic resistance[403] and loss of IQ.[404]

Fluoride is an ingredient in phosphate fertilizers and certain types of pesticides. The use of these fluoride-containing products, in addition to irrigating with fluoridated water and industrial fluoride emissions, can raise the level of fluoride in topsoil.[405] What this means is that humans can be exposed to fluoride from fertilizers and pesticides both primarily and secondarily: a primary exposure can occur from the initial pollution emitted in a specific geographic area where the product was applied, and secondary exposures can occur from contamination brought to livestock who feed in the area, as well as water in the area that takes on the contamination from the soil.

It is therefore apparent that pesticides and fertilizers can constitute a significant portion of overall fluoride exposures. The levels vary based upon the exact product and the individual exposure, but in the 2006 NRC report, an examination of *only* dietary fluoride exposure levels from two pesticides found: "Under the assumptions for estimating the exposure, the contribution from pesticides plus fluoride in the air is within 4% to 10% for all population subgroups at 1 mg/L in tap water, 3-7% at 2 mg/L in tap water, and 1-5% at 4 mg/L in tap water."[406] Furthermore, as a result of concerns raised about the dangers of these exposures, the EPA proposed to withdraw all fluoride tolerances in pesticides in 2011,[407] although this proposal was later overturned.[408]

Meanwhile, the environment is contaminated by fluoride releases from additional sources, and these releases likewise impact water, soil, air, food, and human beings in the vicinity. Industrial releases of fluoride can result from coal combustion by electrical utilities and other industries.[409] Releases can also occur from refineries and metal ore smelters,[410] aluminum production plants, phosphate fertilizer plants, chemical production facilities, steel mills, magnesium plants, and brick and structural clay manufacturers,[411] as well as copper and nickel producers, phosphate ore processors, glass manufacturers, and ceramic manufacturers.[412] Concerns about the fluoride exposures generated from these industrial activities, especially when combined with other exposures, led researchers to state in 2014 that "industrial safety measures need to be tightened in order to reduce unethical discharge of fluoride compounds into the environment."[413]

Section 7.6: Dental Products for Use at Home

Fluoride from dental products used at home likewise contribute to overall exposure levels. These levels are highly significant and occur at rates which vary by person due to the frequency and amount of use, as well as individual response. However, they also vary not only by the type product used, but also by the specific brand of the product used. To add to the complexity, these products contain different types of fluoride, and the average consumer is unaware of what the concentrations listed on the labels actually mean. Additionally, most of the studies that have been done on these products involve children, and even the Centers for Disease Control and Prevention (CDC) has explained that research involving adult exposures to toothpaste, mouth rinse, and other products is lacking.[414]

Fluoride added to toothpaste can be in the form of sodium fluoride (NaF), sodium monofluorophosphate (Na_2FPO_3), stannous fluoride (tin fluoride, SnF_2) or a variety of amines.[415] Toothpaste used at home generally contains between 850 to 1,500 ppm fluoride,[416] while prophy paste used in the office during a dental cleaning generally contains 4,000 to 20,000 ppm fluoride.[417] Brushing with fluoridated toothpaste is known to raise fluoride concentration in saliva by 100 to 1,000 times, with effects lasting one to two hours.[418] The U.S. FDA requires specific wording for the labeling of toothpaste, including strict warnings for children.[419]

Yet, in spite of these labels and directions for use, research suggests that toothpaste significantly contributes to daily fluoride intake in children.[420] Part of this is due to swallowing toothpaste, and a study published in 2014 established that small fonts used for the required labeling (often placed on the back of the tube), intentional food-like flavoring, and the way in which children's toothpastes are marketed intensify this hazard.[421] While the CDC has acknowledged that overconsumption of toothpaste is associated with health risks to children, researchers from William Paterson University in New Jersey have noted that no clear definition of "overconsumption" exists.[422]

Some research has even suggested that, due to swallowing, toothpaste can account for greater amounts of fluoride intake in children than water.[423] In light of the significant fluoride exposures in children from toothpaste and other sources, researchers at the University of Illinois at Chicago concluded that their findings raised "questions about the continued need for fluoridation in the U.S. municipal water supply."[424]

Mouth rinses (and mouthwash) also contribute to overall fluoride exposures. Mouth rinses can contain sodium fluoride (NaF) or acidulated phosphate fluoride (APF),[425] and a 0.05% sodium fluoride solution of mouth rinse contains 225 ppm of fluoride. Like toothpaste, accidental swallowing of this dental product can raise fluoride intake levels even higher.

Fluoridated dental floss is yet another product that contributes to overall fluoride exposures. Flosses that have added fluoride, most often reported as 0.15mgF/m,[426] release fluoride into the tooth enamel[427] at levels greater than mouth rinse.[428] Elevated fluoride in saliva has been documented for at least 30 minutes after flossing,[429] but like other over-the-counter dental products, a variety of factors influence the fluoride release. Research from the University of Gothenburg in Sweden published in 2008 noted that saliva (flow rate and volume), intra- and inter-individual circumstances, and variation between products impact fluoride releases from dental floss, fluoridated toothpicks, and interdental brushes.[430] Additionally, dental floss can contain fluoride in the form of perfluorinated compounds, and a 2012 Springer publication identified 5.81 ng/g liquid as the maximum concentration of perfluorinated carboxylic acid (PFCA) in dental floss and plaque removers.[431]

Many consumers utilize toothpaste, mouthwash, and floss in combination on a daily basis, and thus, these multiple routes of fluoride exposure are even more relevant when estimating overall intakes. In addition to these over-the-counter dental products, some of the materials used at the dental office can result in even higher fluoride exposure levels for millions of Americans.

Section 7.7: Dental Products for Use at the Dental Office

There is a significant gap, if not a major void, in scientific literature that includes fluoride releases from procedures and products administered at the dental office as part of overall fluoride intake. Part of this is likely due to the fact that the research attempting to evaluate singular exposures from these products has demonstrated that establishing any type of average release rate is virtually impossible.

A prime example of this scenario is the use of dental "restorative" materials, which are used to fill cavities. Because 92% of adults aged 20 to 64 have had dental caries in their permanent teeth,[432] and these products are also used on children, consideration of the fluoridated materials used to fill cavities is crucial to hundreds of millions of Americans. Many of the options for filling materials contain fluoride, including *all* glass ionomer cements,[433] *all* resin-modified glass ionomer cements,[434] *all* giomers,[435] *all* polyacid-modified composites (compomers),[436] *certain types of* composites,[437] and *certain types of* dental mercury amalgams.[438] Fluoride-containing glass ionomer cements, resin-modified glass ionomer cements, and polyacid-modified composite resin (compomer) cements are also used in orthodontic band cements.[439]

Generally speaking, composite and amalgam filling materials release much lower levels of fluoride than the glass ionomer-based materials.[440] Glass ionomers and resin-modified glass ionomers release an "initial burst" of fluoride and then give off lower levels of fluoride long-term.[441] The long-term cumulative emission also occurs with giomers and compomers, as well as fluoride-containing composites and amalgams.[442] To put these releases in perspective, a Swedish study demonstrated that the fluoride concentration in glass ionomer cements was approximately 2-3 ppm after 15 minutes, 3-5 ppm after 45 minutes, 15-21 ppm within twenty-four hours, and 2-12 mg of fluoride per ml of glass cement during the first 100 days.[443]

As with other fluoride products, however, the rate of fluoride release is impacted by a wide range of factors. Some of these variables include the media used for storage, the change rate for the storage solution, and the composition and pH-value of saliva, plaque, and pellicle formation.[444] Other factors that can influence the release rate of fluoride from filling materials are the cement matrix, porosity, and composition of the filling material, such as the type, amount, particle size, and silane treatment.[445]

To complicate matters, these dental materials are designed to "recharge" their fluoride releasing capacity, thereby boosting the amounts of fluoride released. This increase in fluoride release is initiated because the materials are constructed to serve as a fluoride reservoir that can be refilled. Thus, by utilizing another fluoride-containing product, such as a gel, varnish, or mouthwash, more fluoride can be retained by the material and thereafter released over time. Glass ionomers and compomers are most recognized for their recharging effects, but a number of variables influence this mechanism, such as the composition of the material and the age of the material,[446] in addition to the frequency of recharging and the type of agent used for recharging.[447]

In spite of the many factors that influence fluoride release rates in dental devices, attempts have been made to establish fluoride release profiles for these products. The result is that researchers have produced a vast array of measurements and estimations. Researchers from Belgium wrote in 2001: "However, it was impossible to correlate the fluoride release of materials by their type (conventional or resin-modified glass-ionomers, polyacid-modified resin composite and resin composite) except if we compared the products from the same manufacturer."[448]

Other materials used at the dental office likewise fluctuate in fluoride concentration and release levels. Currently, there are over 30 products on the market for fluoride varnish, which, when used, is usually applied to the teeth during two dental visits per year. These products have different compositions and delivery systems[449] that vary by brand.[450] Typically, varnishes contain either 2.26% (22,600 ppm) sodium fluoride or 0.1% (1,000 ppm) difluorsilane.[451]

Gels and foams can also be used at the dentist office, and sometimes even at home. The ones used at the dentist office are usually very acidic and can contain 1.23% (12,300 ppm) acidulated phosphate fluoride or 0.9% (9,040 ppm) sodium fluoride.[452] Gels and foams used at home can contain 0.5% (5,000 ppm) sodium fluoride or 0.15% (1,000 ppm) stannous fluoride.[453] Brushing and flossing before applying gel can result in higher levels of fluoride retained in the enamel.[454]

Silver diamine fluoride is now also used in dental procedures, and the brand used in the U.S. contains 5.0-5.9% fluoride.[455] This is a relatively new procedure that was FDA approved in 2014 for treating tooth sensitivity but not dental caries.[456] Concerns have been raised about risks of silver diamine fluoride, which can permanently stain teeth black.[457 458] Additionally, in a randomized control trial published in 2015, the researchers concluded: "There are some lingering concerns as the authors do not suggest adequate safety information regarding this preparation or the potential toxicity levels for children, but it provides a basis for future research."[459]

Section 7.8: Pharmaceutical Drugs (Including Supplements)

20-30% of pharmaceutical compounds have been estimated to contain fluorine.[460] Fluorine is used in drugs as anesthetics, antibiotics, anti-cancer and anti-inflammatory agents, psychopharmaceuticals,[461] and in many other applications. Some of the most popular fluorine-containing drugs include Prozac and Lipitor, as well as the fluoroquinolone family (ciprofloxacin [marketed as Ciprobay],[462] gemifloxacin [marketed as Factive], levofloxacin [marketed as Levaquin], moxifloxacin [marketed as Avelox], norfloxacin [marketed as Noroxin], and ofloxacin [marketed as Floxin and generic ofloxacin]).[463] The fluorinated compound fenfluramine (fen-phen) was also used for many years as an anti-obesity drug,[464] but it was removed from the market in 1997 due to its link with heart valve problems.[465]

Fluoride accumulation in tissue as a result of exposure to these pharmaceuticals is one potential culprit in quinolone chondrotoxicity,[466] and fluoroquinolones have received media attention as a result of their serious health risks. Reported side effects from fluoroquinolones include retinal detachment, kidney failure, depression, psychotic reactions, and tendinitis.[467] In a *New York Times* article published in 2012 about the controversial family of drugs, writer Jane E. Brody revealed that more than 2,000 lawsuits have been filed over the fluoroquinolone Levaquin.[468] In 2016, the FDA acknowledged "disabling and potentially permanent side effects" caused by fluoroquinolones and advised that these drugs only be used when there is no other treatment option available for patients because the risks outweigh the benefits.[469]

Defluorination of any type of fluorinated drug can occur, and this, among other risks, led researchers to conclude in a 2004 review: "No one can responsibly predict what happens in a human body after administration of fluorinated compounds. Large groups of people, including neonates, infants, children, and ill patients serve thus as the subjects of pharmacological and clinical research."[470]

One other major type of prescription drug is essential to consider in regard to overall fluoride exposure levels. Many dentists prescribe fluoride tablets, drops, lozenges, and rinses, which are often referred to as fluoride "supplements" or "vitamins." These products contain 0.25, 0.5, or 1.0 mg fluoride,[471] and they are **not approved** as safe and effective for caries prevention by the FDA.[472]

The dangers of these fluoride "supplements" have been made clear. The author of a 1999 publication warned: "Fluoride supplements, when ingested for a pre-eruptive effect by infants and young children in the United States, therefore, now carry more risk than benefit."[473] Similarly, the 2006 NRC report established that age, risk factors, ingestion of fluoride from other sources, inappropriate use, and other considerations should be taken into account for these products.[474] The NRC report further included statistics that "all children through age 12 who take fluoride supplements (assuming low water fluoride) will reach or exceed 0.05-0.07 mg/kg/day."[475]

Yet, these products continue to be prescribed by dentists and regularly used by consumers, especially children,[476] even as concerns about fluoride "supplements" continue to be repeated. For example, researchers of a Cochrane Collaboration review published in 2011 advised: "No data were available concerning adverse effects related to fluoride supplementation in children aged less than 6 years. The ratio benefit/risk of fluoride supplementation was thus unknown for young children."[477] Moreover, in 2015, scientists conducting an analysis of fluoride in toothpaste and fluoride supplements wrote: "Taking into consideration the toxicity of fluorides, more strict control of fluoride content in pharmaceutical product[s] for oral hygiene is proposed."[478]

Section 7.9: Perfluorinated Compounds

In 2015, over 200 scientists from 38 countries signed on to the "Madrid Statement,"[479] a research-based call for action by governments, scientists, and manufacturers to address the signatories' concerns about "production and release into the environment of an increasing number of poly- and perfluoroalkyl substances (PFASs)."[480] Products made with perfluorinated compounds (PFCs) include protective coatings for carpets and clothing (such as stain-resistant or water-proof fabric), paints, cosmetics, insecticides, non-stick coatings for cookware, and paper coatings for oil and moisture resistance,[481] as well as leather, paper, and cardboard,[482] deck stains,[483] and a wide variety of other consumer items.

In research published in 2012, dietary intake was identified as the major source of exposure to perfluorinated compounds (PFCs),[484] and additional scientific investigation has supported this claim. In an article published in 2008, researchers stated that in North America and Europe, contaminated food (including drinking water) is the most essential exposure route of perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA).[485] The researchers also concluded that children have increased uptake doses due to their smaller body weight, and they provided the following statistics for average consumers: "We find that North American and European consumers are likely to experience ubiquitous and long-term uptake doses of PFOS and PFOA in the range of 3 to 220 ng per kg body weight per day (ng/kg(bw)/day) and 1 to 130 ng/kg(bw)/day, respectively."[486]

A chapter in *The Handbook of Environmental Chemistry* published in 2012 explored some of the other common exposures to PFCs. In particular, data was offered that commercial carpet-care liquids, household carpet and fabric-care liquids and foams, and treated floor waxes and stone/wood sealants had higher concentrations of PFCs when compared to other PFC-containing products.[487] The author also specified that the exact compositions of PFCs in consumer products are often kept confidential and that knowledge about these compositions is "very limited."[488]

Section 7.10: Interactions of Fluoride with Other Chemicals

The concept of multiple chemicals interacting within the human body to produce ill-health should now be an essential understanding required for practicing modern-day medicine. Researchers Jack Schubert, E. Joan Riley, and Sylvanus A. Tyler addressed this highly relevant aspect of toxic substances in a scientific article published in 1978. Considering the prevalence of chemical exposures, they noted: "Hence, it is necessary to know the possible adverse effects of two or more agents in order to evaluate potential occupational and environmental hazards and to set permissible levels."[489]

The need to study the health outcomes caused by exposures to a variety of chemicals has also been reported by researchers affiliated with a database which tracks associations between approximately 180 human diseases or conditions and chemical contaminants. Supported by the Collaborative on Health and the Environment, the researchers for this project, Sarah Janssen, MD, PhD, MPH, Gina Solomon, MD, MPH, and Ted Schettler, MD, MPH, clarified:

> More than 80,000 chemicals have been developed, distributed, and discarded into the environment over the past 50 years. The majority of them have not been tested for potential toxic effects in humans or animals. Some of these chemicals are commonly found in air, water, food, homes, work places, and communities. Whereas the toxicity of one chemical may be incompletely understood, an understanding of the effect from exposures to mixtures of chemicals is even less complete.[490]

Clearly, the interaction of fluoride with other chemicals is crucial to understanding exposure levels and their impacts. While countless interactions have yet to be examined, several hazardous combinations have been established.

Aluminofluoride exposure occurs from ingesting a fluoride source *with* an aluminum source.[491] This synergistic exposure to fluoride and aluminum can occur through water, tea, food residue, infant formulas, aluminum-containing antacids or medications, deodorants, cosmetics, and glassware.[492] Authors of a research report published in 1999 described the hazardous synergy between these two chemicals: "In view of the ubiquity of phosphate in cell metabolism and together with the dramatic increase in the amount of reactive aluminum now found in ecosystems, aluminofluoride complexes represent a strong potential danger for living organisms including humans."[493]

Examples of ingredients in dental products dangerously interacting with fluoride also exist in the scientific literature. Authors of a 1994 publication suggested avoiding oral treatment involving high fluoride ions concentration and dental mercury amalgam fillings due to increased corrosion.[494] Similarly, a publication from 2015 found that certain orthodontic wires and brackets had increased levels of corrosion due to fluoride mouthwash.[495] Essential to note is that galvanic corrosion of dental materials has been linked to other health effects such as oral lesions,[496] as well as metallic tastes in the mouth, irritation, and even allergies.[497]

Furthermore, fluoride, in its form of hydrofluosilicic acid (which is added to many water supplies to fluoridate the water), attracts manganese and lead (both of which can be present in certain types of plumbing pipes). Likely because of the affinity for lead, fluoride has been linked to higher blood lead levels in children,[498] especially in minority groups.[499] Lead is known to lower IQs in children,[500] and lead has even been linked to violent behavior.[501] [502] Other research supports the potential association of fluoride with violence.[503]

Section 8: Lack of Efficacy, Lack of Evidence, and Lack of Ethics

Upon reading the preceding Section 7 about exposures to fluoride, it becomes glaringly obvious just how much additional research is required before any "safe" level for fluoride exposures can be adequately established. This lack of evidence reaches far beyond what is currently *unknown*, however. The lack of evidence is also predominant in what is already known about humankind's use of fluoride, especially in regard to its alleged "benefit" of preventing caries.

Section 8.1: Lack of Efficacy

The fluoride in toothpastes and other consumer products is added because it allegedly reduces dental caries. The suggested benefits of this form of fluoride are related to its activity on teeth of inhibiting bacterial respiration of Streptococcus mutans, the bacterium that turns sugar and starches into a sticky acid that dissolves enamel.[504] In particular, the interaction of fluoride with the mineral component of teeth produces a fluorohydroxyapatite (FHAP or FAP), and the result of this action is said to be enhanced remineralization and reduced demineralization of the teeth. While there is scientific support for this mechanism of fluoride, it has also been established that fluoride primarily works to reduce tooth decay *topically* (i.e. scrubbing it directly onto to teeth with a toothbrush), as opposed to *systemically* (i.e. drinking or ingesting fluoride through water or other means).[505]

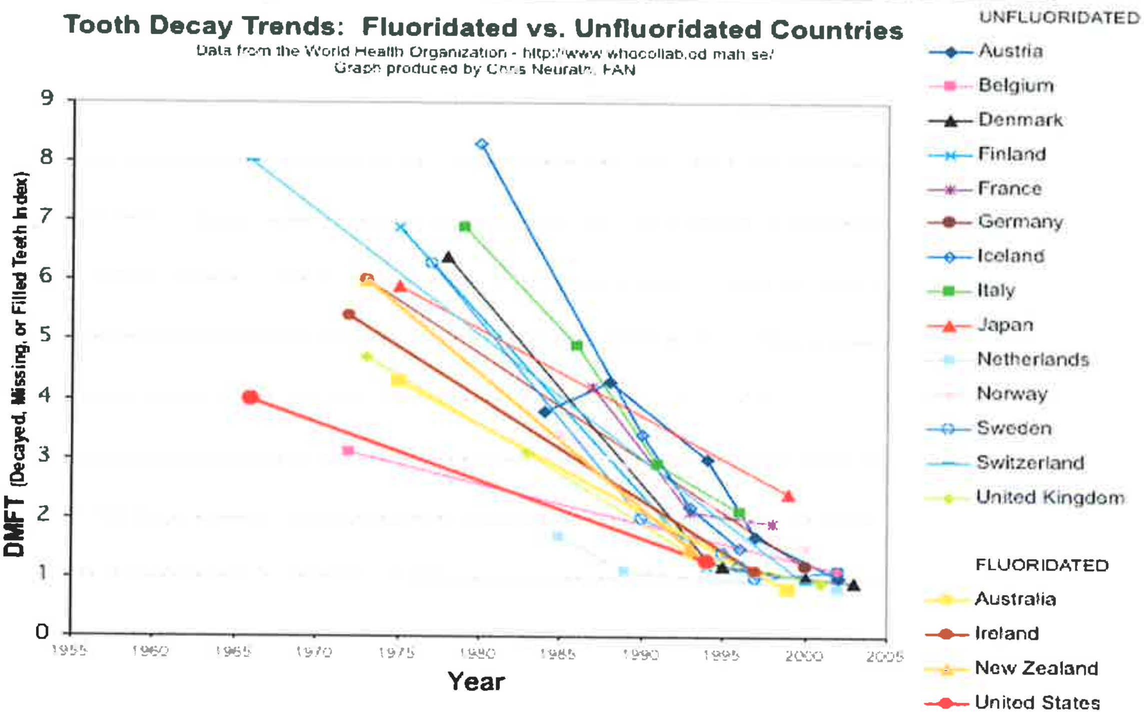
Although the *topical* benefits of fluoride have been distinctly expressed in scientific literature, research has likewise questioned these benefits. For example, researchers from the University of Massachusetts Lowell explained several controversies associated with topical uses of fluoride in an article published in the *Journal of Evidence-Based Dental Practice* in 2006. After citing a 1989 study from the National Institute of Dental Research that found minimal differences in children receiving fluoride and those not receiving fluoride, the authors referenced other studies demonstrating that cavity rates in industrialized countries have decreased without fluoride use.[506] The authors further referenced studies indicating that fluoride does not aid in preventing pit and fissure decay (which is the most prevalent form of tooth decay in the U.S.) or in preventing baby bottle tooth decay (which is prevalent in poor communities).[507]

As another example, early research used to support water fluoridation as a means of reducing dental caries was later re-examined, and the potential of misleading data was identified. Initially, the reduction of decayed and filled deciduous teeth (DFT) collected in research was interpreted as proof for the efficacy of water fluoridation. However, subsequent research by Dr. John A. Yiamouyiannis suggested that water fluoridation could have contributed to the delayed eruption of teeth.[508] Such delayed eruption would result in less teeth and therefore, the absence of decay, meaning that the lower rates of DFT were actually caused by the lack of teeth as opposed to the alleged effects of fluoride on dental caries.

Other examples in the scientific literature have questioned fluoride's use in preventing tooth decay. A 2014 review affirmed that fluoride's anti-caries effect is reliant upon calcium and magnesium in the tooth enamel but also that the remineralization process in tooth enamel is not dependent on fluoride.[509] Research published in 2010 identified that the concept of "fluoride strengthening teeth" could no longer be deemed as clinically significant to any decrease in caries linked to fluoride use.[510] Furthermore, research has suggested that *systemic* fluoride exposure has minimal (if any) effect on the teeth,[511] [512] and researchers have also offered data that dental fluorosis (the first sign of fluoride toxicity[513]) is higher in U.S. communities with fluoridated water as opposed to those without it.[514]

Still other reports show that as countries were developing, decay rates in the general population rose to a peak of four to eight decayed, missing, or filled teeth (in the 1960's) and then showed a dramatic decrease (today's levels), regardless of fluoride use. It has been hypothesized that increased oral hygiene, access to preventative services, and more awareness of the detrimental effects of sugar are responsible for the visible decrease of tooth decay. Whatever the reasons might be, it should be noted that this trend of decreased tooth decay occurred with <u>and without</u> the systemic application of fluoridated water,[515] so it would appear that factors other than fluoride caused this change. Figure 2 below exhibits the tooth decay trends by fluoridated and non-fluoridated countries from 1955-2005.

Figure 2: Tooth Decay Trends in Fluoridated and Unfluoridated Countries, 1955-2005



Several other considerations are relevant in any decision about using fluoride to prevent caries. First, it should also be noted that fluoride is not an essential component for human growth and development.[516] Second, fluoride has been recognized as one of 12 industrial chemicals "known to cause developmental neurotoxicity in human beings."[517] And finally, the American Dental Association (ADA) called for more research in 2013 in regard to the mechanism of fluoride action and effects:

> Research is needed regarding various topical fluorides to determine their mechanism of action and caries-preventive effects when in use at the current level of background fluoride exposure (that is, fluoridated water and fluoride toothpaste) in the United States. Studies regarding strategies for using fluoride to induce arrest or reversal of caries progression, as well as topical fluoride's specific effect on erupting teeth, also are needed.[518]

Section 8.2: Lack of Evidence

References to the unpredictability of levels at which fluoride's effects on the human system occur have been made throughout this position paper. However, it is important to reiterate the lack of evidence associated with fluoride usage, and thus, Table 4 provides an abbreviated list of stringent warnings from governmental, scientific, and other pertinent authorities about the dangers and uncertainties related to utilizing fluoridated products.

Table 4: Selected Quotes about Fluoride Warnings Categorized by Product/Process and Source

PRODUCT/ PROCESS REFERENCED	QUOTE/S	SOURCE OF INFORMATION
Fluoride for dental uses, including water fluoridation	"The prevalence of dental caries in a population is not inversely related to the concentration of fluoride in enamel, and a higher concentration of enamel fluoride is not necessarily more efficacious in preventing dental caries." "Few studies evaluating the effectiveness of fluoride toothpaste, gel, rinse, and varnish among adult populations are available."	Centers for Disease Control and Prevention (CDC). Kohn WG, Maas WR, Malvitz DM, Presson SM, Shaddik KK. Recommendations for using fluoride to prevent and control dental caries in the United States. *Morbidity and Mortality Weekly Report: Recommendations and Reports*. 2001 Aug 17:i-42.
Fluoride in drinking water	"Overall, there was consensus among the committee that there is scientific evidence that under certain conditions fluoride can weaken bone and increase the risk of fractures."	National Research Council. *Fluoride in Drinking Water: A Scientific Review of EPA's Standards.* The National Academies Press: Washington, D.C. 2006.

Fluoride in drinking water	"The recommended Maximum Contaminant Level Goal (MCLG) for fluoride in drinking water should be zero."	Carton RJ. Review of the 2006 United States National Research Council Report: Fluoride in Drinking Water. *Fluoride.* 2006 Jul 1;39(3):163-72.
Water fluoridation	"Fluoride exposure has a complex relationship in relation to dental caries and may increase dental caries risk in malnourished children due to calcium depletion and enamel hypoplasia..."	Peckham S, Awofeso N. Water fluoridation: a critical review of the physiological effects of ingested fluoride as a public health intervention. *The Scientific World Journal.* 2014 Feb 26; 2014.
Fluoride in dental products, food, and drinking water	"Because the use of fluoridated dental products and the consumption of food and beverages made with fluoridated water have increased since HHS recommended optimal levels for fluoridation, many people now may be exposed to more fluoride than had been anticipated."	Tiemann M. Fluoride in drinking water: a review of fluoridation and regulation issues. *BiblioGov.* 2013 Apr 5. Congressional Research Service Report for Congress.
Fluoride intake in children	"The 'optimal' intake of fluoride has been widely accepted for decades as between 0.05 and 0.07 mg fluoride per kilogram of body weight but is based on limited scientific evidence." "These findings suggest that achieving a caries-free status may have relatively little to do with fluoride intake, while fluorosis is clearly more dependent on fluoride intake."	Warren JJ, Levy SM, Broffitt B, Cavanaugh JE, Kanellis MJ, Weber-Gasparoni K. Considerations on optimal fluoride intake using dental fluorosis and dental caries outcomes–a longitudinal study. *Journal of Public Health Dentistry.* 2009 Mar 1;69(2):111-5.
Fluoride-releasing dental restorative materials (i.e. dental fillings)	"However, it is not proven by prospective clinical studies whether the incidence of secondary caries can be significantly reduced by the fluoride release of restorative materials."	Wiegand A, Buchalla W, Attin T. Review on fluoride-releasing restorative materials—fluoride release and uptake characteristics, antibacterial activity and influence on caries formation. *Dental Materials.* 2007 Mar 31;23(3):343-62.

Dental material: silver diamine fluoride	"Because silver diamine fluoride is new to American dentistry and dental education, there is a need for a standardized guideline, protocol, and consent." "It is unclear what will happen if treatment is stopped after 2-3 years and research is needed."	Horst JA, Ellenikiotis H, Milgrom PM, UCSF Silver Caries Arrest Committee. UCSF Protocol for Caries Arrest Using Silver Diamine Fluoride: Rationale, Indications, and Consent. *Journal of the California Dental Association.* 2016 Jan;44(1):16.
Topical fluoride for dental use	"The panel had a low level of certainty regarding the benefit of 0.5 percent fluoride paste or gel on the permanent teeth of children and on root caries because there were few data on the home use of these products." "Research is needed concerning the effectiveness and risks of specific products in the following areas: self-applied, prescription-strength, home-use fluoride gels, toothpastes or drops; 2 percent professionally applied sodium fluoride gel; alternative delivery systems, such as foam; optimal application frequencies for fluoride varnish and gels; one-minute applications of APF gel; and combinations of products (home-use and professionally applied)."	Weyant RJ, Tracy SL, Anselmo TT, Beltrán-Aguilar ED, Donly KJ, Frese WA, Hujoel PP, Iafolla T, Kohn W, Kumar J, Levy SM. Topical fluoride for caries prevention: Executive summary of the updated clinical recommendations and supporting systematic review. *Journal of the American Dental Association.* 2013;144(11):1279-1291.
Fluoride "supplements" (tablets)	"Evident disagreements among the results show that there's a limited effectiveness on fluoride tablets."	Tomasin L, Pusinanti L, Zerman N. The role of fluoride tablets in the prophylaxis of dental caries. A literature review. *Annali di Stomatologia.* 2015 Jan;6(1):1.
Pharmaceuticals, fluorine in medicine	"No one can responsibly predict what happens in a human body after administration of fluorinated compounds."	Strunecká A, Patočka J, Connett P. Fluorine in medicine. *Journal of Applied Biomedicine.* 2004; 2:141-50.

Drinking water with poly- and perfluoroalkyl substances (PFASs)	"Drinking water contamination with poly- and perfluoroalkyl substances (PFASs) poses risks to the developmental, immune, metabolic, and endocrine health of consumers." "…information about drinking water PFAS exposures is therefore lacking for almost one-third of the U.S. population."	Hu XC, Andrews DQ, Lindstrom AB, Bruton TA, Schaider LA, Grandjean P, Lohmann R, Carignan CC, Blum A, Balan SA, Higgins CP. Detection of Poly-and Perfluoroalkyl Substances (PFASs) in US Drinking Water Linked to Industrial Sites, Military Fire Training Areas, and Wastewater Treatment Plants. *Environmental Science & Technology Letters*. 2016 Oct 11.
Occupational exposures to fluoride and fluoride toxicity	"Review of unpublished information regarding the effects of chronic inhalation of fluoride and fluorine reveals that current occupational standards provide inadequate protection."	Mullenix PJ. Fluoride poisoning: a puzzle with hidden pieces. *International Journal of Occupational and Environmental Health.* 2005 Oct 1;11(4):404-14.
Review of safety standards for exposure to fluorine and fluorides	"If we were to consider only fluoride's affinity for calcium, we would understand fluoride's far-reaching ability to cause damage to cells, organs, glands, and tissues."	Prystupa J. Fluorine—a current literature review. An NRC and ATSDR based review of safety standards for exposure to fluorine and fluorides. *Toxicology Mechanisms and Methods.* 2011 Feb 1;21(2):103-70.

Section 8.3: Lack of Ethics

Another major concern about fluoride exposure from drinking water and food is related to the production of the fluorides used in community water supplies. According to the Centers for Disease Control and Prevention (CDC), three types of fluoride are generally used for community water fluoridation:

- Fluorosilicic acid: a water-based solution used by most water systems in the United States. Fluorosilicic acid is also referred to as hydrofluorosilicate, FSA, or HFS.
- Sodium fluorosilicate: a dry additive, dissolved into a solution before being added to water.
- Sodium fluoride: a dry additive, typically used in small water systems, dissolved into a solution before being added to water.[519]

Controversy has arisen over the industrial ties to these ingredients. The CDC has explained that phosphorite rock is heated with sulfuric acid to create 95% of the fluorosilicic acid used in water fluoridation.[520] The CDC has further explained: "Because the supply of fluoride products is related to phosphate fertilizer production, fluoride product production can also fluctuate depending on factors such as unfavorable foreign exchange rates and export sales of fertilizer."[521] A government document from Australia has more openly stated that hydrofluosilicic acid, sodium silicofluoride and sodium fluoride are *all* "commonly sourced from phosphate fertilizer manufacturers."[522] Safety advocates for fluoride exposures have questioned if such industrial ties are ethical and if the industrial connection with these chemicals might result in a cover-up of the health effects caused by fluoride exposure.

A specific ethical issue that arises with such industry involvement is that profit-driven groups seem to define the evolving requirements of what constitutes the "best" evidence-based research, and in the meantime, unbiased science becomes difficult to fund, produce, publish, and publicize. This is because funding a large-scale study can be very expensive, but industrial-based entities can easily afford to support their own researchers. They can also afford to spend time examining different ways of reporting the data (such as leaving out certain statistics to obtain a more favorable result), and they can further afford to publicize any aspect of the research that supports their activities. Unfortunately, history has shown that corporate entities can even afford to harass independent scientists as a means of ending their work if that work shows harm generated by industrial pollutants and contaminants.

Indeed, this scenario of unbalanced science has been recognized in fluoride research. Authors of a review published in *the Scientific World Journal* in 2014 elaborated: "Although artificial fluoridation of water supplies has been a controversial public health strategy since its introduction, researchers—whom include internationally respected scientists and academics—have consistently found it difficult to publish critical articles of community water fluoridation in scholarly dental and public health journals."[523]

Additionally, a conflict of interest can be directly related to studies about dietary exposures to perfluorinated compounds (PFCs). In an article published in 2012, research about food intake from PFCs was examined by country. The author revealed that data from the U.S. was very limited, consisting only of a 2010 publication by a number of American academic researchers, as well as a 3M sponsored survey that served as the primary research prior to the 2010 publication (and alleged that most samples of food had contaminant levels below detection.)[524] Yet, the academic researchers produced different findings than the 3M report and wrote in their 2010 publication: "Despite product bans, we found POPs [persistent organic pollutants] in U.S. food, and mixtures of these chemicals are consumed by the American public at varying levels. This suggests the need to expand testing of food for chemical contaminants."[525]

Conflicts of interest have also been known to infiltrate government agencies involved in toxic chemical regulation. A 2014 *Newsweek* article by Zoë Schlanger entitled "Does the EPA Favor Industry When Assessing Chemical Dangers?" included a quote from ecologist Michelle Boone that alleged "'all or most of the data used in risk assessments may come from industry-supplied research, despite clear [conflicts of interest].'"[526]

It is easily recognizable that the dental industry has a major conflict of interest with fluoride because profits are made by corporations that produce fluoride-containing dental products. Additionally, procedures involving fluoride administered by the dentist and dental staff can also earn profits for dental offices,[527] [528] and ethical questions have been raised about pushing these fluoride procedures on patients.[529]

In relation to the ethics of medical and dental practices, a cornerstone of public health policy known as the precautionary principle must be considered as well. The basic premise of this policy is built upon the centuries-old medical oath to "first, do no harm." Yet, the modern application of the precautionary principle is actually supported by an international agreement.

In January 1998, at an international conference involving scientists, lawyers, policy makers, and environmentalists from the U.S., Canada and Europe, a formalized statement was signed and became known as the "Wingspread Statement on the Precautionary Principle."[530] In it, the following advice is given: "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. In this context the proponent of an activity, rather than the public, should bear the burden of proof."[531]

Not surprisingly, the need for the appropriate application of the precautionary principle has been associated with fluoride usage. Authors of a 2006 article entitled "What Does the Precautionary Principle Mean for Evidence-Based Dentistry?" suggested the need to account for cumulative exposures from all fluoride sources and population variability, while also stating that consumers can reach "optimal" fluoridation levels without ever drinking fluoridated water.[532] Additionally, researchers of a review published in 2014 addressed the obligation for the precautionary principle to be applied to fluoride usage, and they took this concept one step further when they suggested that our modern-day understanding of dental caries "diminishes any major future role for fluoride in caries prevention."[533]

Section 9: Alternatives to Fluoride Use

Based upon the elevated number of fluoride sources and the increased rates of fluoride intake in the American population, which have risen substantially since water fluoridation began in the 1940's, lowering exposures to fluoride has become a necessary and viable alternative. For example, the author of a 2013 Congressional Report noted that significant levels of fluoride can be obtained from sources other than water.[534] As another example, researchers from the University of Kent in Canterbury, England, considered the quantity of fluoride sources and wrote in 2014 that "the prime public health priority in relation to fluoride is how to reduce ingestion from multiple sources, rather than adding this abundant and toxic chemical to water or food."[535]

Section 9.1: Caries Prevention

There are many ways to prevent caries without fluoride. The American Dental Association (ADA) Council on Scientific Affairs has stated that some strategies for caries prevention are "altering the bacteria flora in the mouth, modifying the diet, increasing the resistance of tooth enamel to acid attack or reversing the demineralization process."[536] Other strategies of preventing caries can be deduced by the factors that cause them, which include high levels of cariogenic bacteria and/or intake of fermentable carbohydrates; inadequate salivary flow, dental care, and/or oral hygiene; inappropriate methods of feeding of infants; and the presence of poverty and/or malnutrition.[537] (Interestingly, while some proponents of water fluoridation believe they are helping those of lower socio-economic status, as well as malnourished children, fluoride can actually increase the risk of dental caries in these populations due to calcium depletion and other circumstances.[538])

At any extent, it is essential to understand that tooth decay is a disease caused by specific bacteria called Streptococcus mutans. Many bacteria do not process their food into carbon dioxide and water, but, rather, they "ferment" their foods into other kinds of waste products, such as alcohols or acids. Streptococcus mutans lives in microscopic colonies on the surface of the teeth, and it has the distinction of being able to produce concentrated acid waste that can dissolve the tooth enamel on which it resides. In other words, these germs can create holes in teeth, and all they require to do so is a fuel such as sugar, processed foods, and/or other carbohydrates.

Thus, utilizing the knowledge of what causes tooth decay is instrumental in developing ways to prevent it without fluoride. Some simple methods to prevent caries include eating less sugar-containing foods, drinking less sugar-containing beverages such as soft drinks, improving oral hygiene, and establishing a nutritious diet and lifestyle that strengthens the teeth and bones.

In support of such strategies to prevent dental caries without fluoride, the trend of decreased decayed, missing, and filled teeth over the past few decades has occurred both in countries *with and without* the systemic application of fluoridated water.[539] This suggests that increased access to preventative services and more awareness of the detrimental effects of sugar are responsible for these improvements in dental health.[540] Furthermore, research has documented decreases of tooth decay in communities that have discontinued water fluoridation.[541]

Section 9.2: Consumer Choice and Consent

The issue of consumer choice is essential in relation to fluoride for a variety of reasons. First, consumers have many choices when it comes to utilizing fluoride-containing products; however, many of these products do not require informed consumer consent or labeling that provides the levels of fluoride in the item. Second, the only choice consumers have when fluoride is added to their municipal water is to buy bottled water or costly filters. In regard to water fluoridation, concerns have been raised that fluoride is added allegedly for the prevention tooth decay, while other chemicals added to water serve a purpose of decontamination and elimination of pathogens. Researchers wrote in 2014: "In addition, community water fluoridation provides policy makers with important questions about medication without consent, the removal of individual choice and whether public water supplies are an appropriate delivery mechanism."[542]

Furthermore, in a 2013 Congressional Report, it was established that the practice of adding fluoride to water for dental reasons should not be imposed by the government, especially because it means that consumers are not able to exercise choice without buying bottled water or treating their tap water.[543] Filtration systems are available to consumers for purchase to take the fluoride out of their water, but these filters are expensive, and some of the consumers who could benefit from them (i.e. individuals with diabetes, renal problems, or infants) cannot afford them. The

EPA has acknowledged that charcoal-based water filtration systems do not remove fluoride and that distillation and reverse osmosis systems, which can remove fluoride, are costly.[544]

97% of western Europe does not use water fluoridation, and governments from this region of the world have identified consumer consent as one reason for not adding fluoride to community drinking water. The following are just a few statements from these countries:

- "Fluoride has never been added to the public water supplies in Luxembourg. In our views, the drinking water isn't the suitable way for medicinal treatment and that people needing an addition of fluoride can decide by their own to use the most appropriate way, like the intake of fluoride tablets, to cover their [daily] needs."[545]
- "This water treatment has never been of use in Belgium and will never be (we hope so) into the future. The main reason for that is the fundamental position of the drinking water sector that it is not its task to deliver medicinal treatment to people."[546]
- "In Norway we had a rather intense discussion on this subject some 20 years ago, and the conclusion was that drinking water should not be fluoridated."[547]

Some of the countries that do not use fluoridated water have opted to use fluoridated salt and milk as a means to offer consumers the choice of whether they would like to consume fluoride or not. Fluoridated salt is sold in Austria, the Czech Republic, France, Germany, Slovakia, Spain, and Switzerland,[548] as well as Colombia, Costa Rica, and Jamaica.[549] Fluoridated milk has been used in programs in Chile, Hungary, Scotland, and Switzerland.[550]

On the contrary, a major issue in the U.S. is that consumers simply are not aware of the fluoride added to hundreds of products they routinely use. Some citizens do not even know that fluoride is added to their water, and because there are no food or bottled water labels, consumers are likewise not aware of those sources of fluoride. While toothpaste and other over-the-counter dental products include disclosure of fluoride contents and warning labels, the average person has no context for what these ingredients or contents mean (if they are fortunate enough to read the small font on the back of their product). Materials used at the dental office provide even less consumer awareness as informed consent is generally not practiced, and the presence and risks of fluoride in dental materials is, in many instances, never mentioned to the patient.[551] For example, in the case of silver diamine fluoride, the product was introduced to the U.S. market in 2014 without a standardized guideline, protocol, or consent.[552]

Section 9.3: Education for Medical/Dental Professionals, Student, Patients, and Policy Makers

Educating medical and dental practitioners, students of medicine and dentistry, patients, and policy makers about fluoride exposures and the associated potential health risks is essential to improving the dental and overall health of the public. Since a scientific understanding of the health effects of fluoride has been limited to promoting its benefits, the reality of its overexposure and potential harms must now be conveyed to healthcare workers and students, such as those in the medical, dental, and public health fields. This concept was supported in a 2005 publication in which the authors explained that their findings emphasized "the significance of educating parents and child-care specialists about fluorosis risk by public health practitioners, physicians, and dentists."[553]

Although informed consumer consent and more informative product labels would contribute to increasing patient awareness about fluoride intake, consumers also need to take a more active role in preventing caries. Better diet, improved oral health practices, and other measures would assist in reducing tooth decay, as well as many other ailments that not only drain the human body but also drain the financial resources of individuals and the government due to rising healthcare costs.

Finally, policymakers are tasked with the obligation of evaluating the benefits and risks of fluoride. These officials are often bombarded by dated claims of fluoride's alleged purposes, many of which are constructed upon limited evidence of safety and improperly formulated intake levels that fail to account for multiple exposures, individual variances, fluoride's interaction with other chemicals, and independent (non-industry sponsored) science. Authors of a 2011 publication linked parents and policymakers to the basics of fluoride's impact on the human system:

> Safe, responsible, and sustainable use of fluorides is dependent on decision makers (whether they be politicians or parents) having a firm grasp on three key principles: (i) fluorine is not so much 'essential' as it is 'everywhere,' (ii) recent human activities have significantly increased fluorine exposures to the biosphere, and (iii) fluorine has biogeochemical effects beyond bones and teeth.[554]

Section 10: Conclusion

The sources of human exposure to fluoride have drastically increased since community water fluoridation began in the U.S. in the 1940's. In addition to water, these sources now include food, air, soil, pesticides, fertilizers, dental products used at home and in the dental office (some of which are implanted in the human body), pharmaceutical drugs, cookware, clothing, carpeting, and an array of other consumer items used on a regular basis. Official regulations and recommendations on fluoride use, many of which are not enforced, have been based on limited research and have only been updated after evidence of harm has been produced and reported.

Exposure to fluoride is suspected of impacting nearly every part of the human body, including the cardiovascular, central nervous, digestive, endocrine, immune, integumentary, renal, respiratory, and skeletal systems. Susceptible subpopulations, such as infants, children, and individuals with diabetes or renal problems, are known to be more severely impacted by intake of fluoride. Accurate fluoride exposure levels to consumers are unavailable; however, estimated exposure levels suggest that millions of people are at risk of experiencing the harmful effects of fluoride and even toxicity, the first visible sign of which is dental fluorosis. A lack of efficacy, lack of evidence, and lack of ethics are apparent in the current status quo of fluoride usage.

Informed consumer consent is needed for all uses of fluoride, and this pertains to water fluoridation, as well as all dental-based products, whether administered at home or in the dental office. Providing education about fluoride risks and fluoride toxicity to medical and dental professionals, medical and dental students, consumers, and policy makers is crucial to improving the future of public health.

There are fluoride-free strategies in which to prevent dental caries. Given the current levels of exposure, policies should reduce and work toward eliminating avoidable sources of fluoride, including water fluoridation, fluoride-containing dental materials, and other fluoridated products, as means to promote dental and overall health.

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[The 23 studies include the 10 studies listed in Table 1, the 11 studies listed in the paragraph above, and the studies by Eswar et al. (2011) and Shivaprakash et al. (2011).]
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To view the brochures in Connecticut and Maine, see
State of Connecticut Department of Environmental Protection. Fillings: The Choices You Have. Hartford, CT; Revised May 2011. Online at http://www.csda.com/docs/default-source/regulations/amalgam. Accessed November 8, 2016.
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Carolina-Powell, Letitia

From: Cyndie Baughman <cynthia_baughman@comcast.net>
Sent: Wednesday, January 29, 2020 7:14 PM
To: BudgetGroup
Cc: Finlayson, Sheila
Subject: Meeting to Consider Smart Meters
Attachments: WSSC - Letter to Commissioners on Smart Meters.docx

EXTERNAL EMAIL!

WSSC Commissioners:

In advance of your February 4, 2020 budget meeting where you will be discussing budgets for smart meter roll-outs, I would like to re-submit my letter on this topic from February 2019. Again, I would like to strongly express my concerns over a roll-out of these meters including concerns over manufacturer unaccountability, health, cost efficiency, privacy, and others.

I also wish to note that Montgomery County has advocated for residents in its several actions in federal court against the FCC – arguing against its "small cell order" and arguing for it to update its radiofrequency RF safety levels which are over 25 years old and do not take into consideration negative non-thermal health effects. Smell cell towers and "smart meters" such as WSSC is considering both emit RF radiation. In its 2019 filing (cited below) the County cites to many health studies on adverse effects of RF radiation. See Section I.D. titled "Current Research on RF Health Effects – Raising Concerns About Non-Thermal Health Risks" beginning on page 11. Cell towers, smart meters and other RF emitting devices raise health issues. Specifically, the County notes that "these and other studies examine a number of RF-related risks, such as carcinogenicity, DNA damage, genotoxicity, reproductive impacts, neurological effects, behavioral effects in children, non-thermal effects such as stimulating cell proliferation, and altering cell membrane function."

Finally, Montgomery County expresses its concern about rolling out 5G small cell towers (that would emit RF radiation in smaller millimeter waves and be placed close to homes) without studying health effects.

> Montgomery County states, **"if the new 5G environment, in fact, poses health risks, any prior rollout of 5G will have potentially injured citizens of Montgomery County and other municipalities, including sensitive populations like children, that cannot be undone. Such a result would be unconscionable."**
>
> [SOURCE: June 10, 2019 filing - U.S. Court of Appeals for the Ninth Circuit. Case 19-70147. See Section I.D. (Current Research on RF Health Effects - Raising Concerns About Non-Thermal Health Risks) beginning on p. page 11 and see also page 55.] https://www.khlaw.com/Files/39783_Montgomery_County_Brief.pdf

I strongly urge you to consider the multiple health studies noted in the Montgomery County federal filing when WSSC considers any smart meter roll-out especially one that would NOT provide for any sort of opt-out to its customers that do not wish to have such a meter as PEPCO has done. If WSSC in its review of health studies determines that RF emitting smart meters are safe for the public, please provide the public with its guarantee of safety and its rationale.

Thank you,
Cyndie Baughman

February 17, 2019

To WSSC Commissioners:

T. Eloise Foster, Chair
Chris Lawson, Vice Chair
Fausto R. Bayonet
Omar M. Boulware
Howard A. Denis
Thomasina V. Rogers

RE: WSSC AMI Smart Water Meter Roll-Out

Dear Commissioners:

I understand you are having a meeting on Wednesday, February 20th at 10:00 a.m. to discuss the AMI smart water meter roll-out, among other items. I have decided to write to you to share those concerns and I hope that you genuinely listen to them and consider them. I hope that you consider providing an "opt out" feature to the smart meters to allow individuals who may not want them to not have such a meter forced upon them and consider appropriate "opt out" fees or no fee options as well.

Listed below are some of the major concerns with these meters. I have provided source documentation below each for your information:

(1) Accountability: Radio Frequency radiation (RF) emitted by the smart meters is the same as from a cell phone and tower which have been identified several years ago by the World Health Organization as a Class 2B "possible carcinogen" and on Sept. 6, 2018 a peer review suggested such RF be upgraded to a "known human carcinogen" Group 1. Providers of towers and cell phones and other RF emitting devices acknowledge, and have for years, that their products have been linked to health concerns including cancer. They also acknowledge they are unable to maintain adequate insurance coverage to cover losses associated with something like this.

The same goes for providers of smart meters. Below is an excerpt from the Annual Report to Shareholders of Itron, a large manufacturer of smart meters:

> The safety and security of the power grid and natural gas and water supply systems, the accuracy and protection of the data collected by meters and transmitted via the smart grid, concerns ***about the safety and perceived health risks of using radiofrequency communications,*** and privacy concerns of monitoring home appliance energy usage have been the focus of recent adverse publicity. Unfavorable publicity and consumer opposition may cause utilities or their regulators to delay or modify planned smart grid initiatives. Smart grid projects may be, or may be perceived as, unsuccessful [⋯..]
>
> ***We may be subject to claims that there are adverse health effects from the radio frequencies utilized in connection with our products. If these claims prevail, our customers could suspend implementation or purchase substitute products, which could cause a loss of sales***.
>
> Source: https://www.sec.gov/Archives/edgar/data/780571/000078057118000013/itri10k12312017.htm

Similar to the dialogue with cell tower providers, smart meter providers offer no real compliance or maintenance programs to regularly check to ensure the RF emitting from their towers/meters meets any sort of safety standards. The Federal Communication Commission ("FCC"), the regulator of RF emissions, states on its website it does not have capacity to determine if cell towers complying with RF emissions – certainly it would not be able to inspect these other devices.

(2) Privacy: cybersecurity concerns can increase in homes with wireless networks. Read recent articles showing concern over new technologies such as 5G which is relevant here. See below.

Source:

https://www.inverse.com/article/48293-5g-future-cybersecurity-risks

(3) Health: Smart meters emit RF and contribute to cancer and other health problems including raising blood sugar levels with people who are diabetics. Some people are electrically hypersensitive and develop symptoms, such as cognitive, neurological, and sleep problems from RF. But EVERYONE is affected by RF even if you can't feel it – see the study below on diabetes. People should be able to opt out at no cost to preserve their health. The health issues of smart meters and cell towers, both products emitting RF, has been getting national attention for years. Most recently, please see the letter that Senator Blumenthal (CT) sent to FCC Commissioner Carr on the health effects of 5G and RF generally asking that it study this area as people are being exposed to dramatically increased amounts of RF in their daily lives. The FCC last considered RF safety limits (and it considered them largely for workers as people were not exposed to the extent they are today) in 1996 and their standards were based on data from the 1980s. A link to this letter and a press release on it from the National Institute of Science, Law and Public Policy are below. Also below (smart grid awareness) is a letter by the Department of Interior stating the FCC's regulations are outdated.

Sources: https://www.businesswire.com/news/home/20181203006017/en/Blumenthal-Presses-FCC-Commissioner-Brendan-Carr-Disclose

http://electromagnetichealth.org/wp-content/uploads/2018/12/IMG_20181203_0002.pdf

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4661664/

https://smartgridawareness.org/2014/03/23/can-we-protect-birds-and-people/ (U.S. Department of Interior Declares FCC Standards "Out of Date" and Inapplicable)

(4) Litigation: If you are set on launching a program deploying smart meters, does it make sense to not have an "opt out" option which may result in public outcry and litigation. Several states have free opt outs for "smart" radiating meters, and when states do not, lawsuits have resulted in forcing an opt out as is exemplified recently in Iowa by a recent court decision that cites the fact that the companies are aware but not enforcing the RF safety instructions on their products and some meters do not even comply with the very outdated FCC safety requirements.

Sources:

https://ehtrust.org/wp-content/uploads/Final-ruling.pdf (Iowa case)

https://ehtrust.org/wp-content/uploads/Lipman-Matara-Post-Hearing-Brief-PUBLIC.pdf (RF safety instructions; non-compliance with FCC p.7)

(5) Trends Toward No-Fee Opt-Out: Many localities have no fees for opting out. For example, Indiana (Duke Energy) makes it free IF you sign up for the Read-Your-Own Meter Program. In California, opt out

fees are no longer collected after 3 years. They are "sunsetted." New Mexico, Oregon, Tennessee, Vermont, Los Angeles, California, New York/Central Hudson have no fee. North Carolina has no fee if for health reasons. Texas offers low-income fee option. Below is a chart of opt out states but does not readily distinguish between fee-based or no charge opt outs but ***the ability to "opt out" of having a smart meter is overwhelmingly the trend***.

Source: https://www.ehs.group/smart-meter-opt-out-chart.php

(6) Discriminatory Effects of Meter Placement: Localities, like the Montgomery County Council, have labored over the issue of safe distances from cell towers as the wireless industry pushes its "5G small cells" into residential areas as close as 30 feet from homes in public rights of way. Larger towers must be 300 feet from a home. Think then about smart meters – some homes have them 30-40 feet away from a living space while some homes have them 1-2 feet (opposite wall) of a living space and some apartment or townhome complexes may have "bank" of meters on a single wall in close proximity to one residence. How can you standardize this so that ALL individuals are allowed a safe distance from a meter. Would WSSC be amenable to re-locating water meters should a customer request so that customer would be allowed the maximum distance from their own water meter. Have those costs been considered and/or estimated by WSSC if it chooses not allow an individual to "opt out."

The smart meters themselves disclose that people should not be closer than 20 cm to them. Remember also that they are basing this on FCC data over 30 years old! Please see the Iowa Legal Brief section on "IPL has not met its burden to show that the transmitting module in the Sensus Stratus meter and other meters are FCC compliant." The legal brief details how providers of these meters are aware of the safety distance but do not tell customers.

Source: https://ehtrust.org/wp-content/uploads/Lipman-Matara-Post-Hearing-Brief-PUBLIC.pdf

(7) Cost Efficiency. The cost savings of smart meters is debatable. Evidence is showing that smart meter systems may not significantly curtain U.S. electricity use. One example, in 2011 a pilot program across the country showed little or no savings and the Connecticut Attorney General announced the pilot program results shows no beneficial impact on the state and the benefits of advanced meters would not merit the $500 million cost of implementation. Studies also suggest that smart meters themselves use more energy to perpetually signal the "mesh" system. Further, a Consumer Digest report states that "what is discouraging about the all-but-mandatory dynamics of the smart-meter transition is that it's appealing only if you are willing to pay a lot of money to save a little electricity … if the success of the smart meter transition is based on consumers saving money and energy in the long run, we can't help but imagine that it could take decades for that to happen – if it ever does."

Query if the removal of perfectly working analog meters contributes to environmental waste. If cost is a factor having drivers quarterly read out meters – and our driver is wonderfully nice – could he not have an electric car or hybrid to save money; wouldn't that reduce the carbon footprint at a much reduced cost while maintaining the contact with the end-user. Sometimes seeing a face to WSSC and seeing their car come in shows that you are in touch with the consumers you are serving and is not a bad thing. Further, wouldn't components of the current meters need to be replaced since RF would not penetrate iron? The AMI smart meters would also use batteries which would create waste and require disposal and, from what I understand, the meters themselves may have a shorter shelf life than their current forms.

Source: https://www.manchesterjournal.com/stories/smart-meter-interference,71235

"Why Smart Meters Might be a Dumb Idea" W. Kelly, *Consumer Digest*, January 2011

My neighborhood in Potomac, MD has 85 homes and there are several just on my street that “opt out” from PEPCO smart meters for a variety of reasons. This is something people want. We have had HOA meetings on the PEPCO opt out and on legislation that would have allowed small cell towers in residential communities so we are active on these issues and some of us have testified on them. Those who have opted out do so for a variety of reasons. My family – my husband and I don’t want the exposure to RF and choose not to use wi fi in our home and greatly limit our children’s use of cell phones; my neighbor is more concerned on technology and risk of “hacking” of his personal information and another neighbor has a young child who is in remission from leukemia and completely re-did her home to remove potential irritants like mold, among others, and takes seriously the data on RF health effects. **We are relying on WSSC to provide the ability for families and individuals that DO NOT want smart meters installed to be able to “opt out.”**

Thank you for your consideration,

Cyndie Baughman,

Resident of Potomac, MD, Montgomery County and a long-time WSSC customer.

Carolina-Powell, Letitia

From: john william hirzy <jwhirzy@gmail.com>
Sent: Tuesday, February 4, 2020 4:00 PM
To: BudgetGroup
Cc: Cynthia Erville
Subject: Re: Powerpoint presentation on recent research and federal level activity on fluoride and developmental neurotoxicity
Attachments: Neurath on Fluoride's Developmental Neurtoxicity.pptx

And Now for Chris's powerpoint!!

On Feb 4, 2020, at 3:58 PM, john william hirzy <jwhirzy@gmail.com> wrote:

Dear Members of the Budget Group:

I had intended to attend your meeting this evening, February 4, 2020, but I think I'm coming down with the flu - ugh!

I would have liked to show this edited version of a powerpoint created by Chris Neurath, Research Director of the Fluoride Action Network (FAN), but that is not to be.

If someone at tonight's meeting could do that - pointing out the comments Chris has written below each slide - that would be great. I would have done that job of pointing out Chris's clear and convincing analysis of each slide had I been able to be there tonite.

If it is not possible for a showing to happen this evening, I, as a retired senior scientist in the Office of Toxic Substances, USEPA and a board member of FAN, ask that this powerpoint be entered into the record of the meeting.

I would be happy to make an in person presentation along the lines of Chris's piece and include some economic analysis as well (Chris has some of that in his full powerpoint, but I edited it to permit - for this evening's meeting - a focus on the toxicity issue.

The $300,000 or more needed to purchase the fluoridating chemical (98% of which will go into water that flushes toilets, washes dished and clothes, puts out fires, etc.) could be better spent, in my view, toward improving children's health by devoting it to a program of education on the importance of faithful brushing of teeth and limiting consumption of sugar.

I can be reached at 202-285-0498 and jwhirzy@gmail.com

Thank you for your attention.

J. William Hirzy, Ph.D.

The Scientific Evidence for Fluoride's Developmental Neurotoxicity

January 27, 2020

Chris Neurath

Research Director

American Environmental Health Studies Project

FLUORIDEALERT.ORG
Fluoride Action Network

F neurotoxicity

Brain development is highly complex dynamic process

What is Developmental Neurotoxicity?

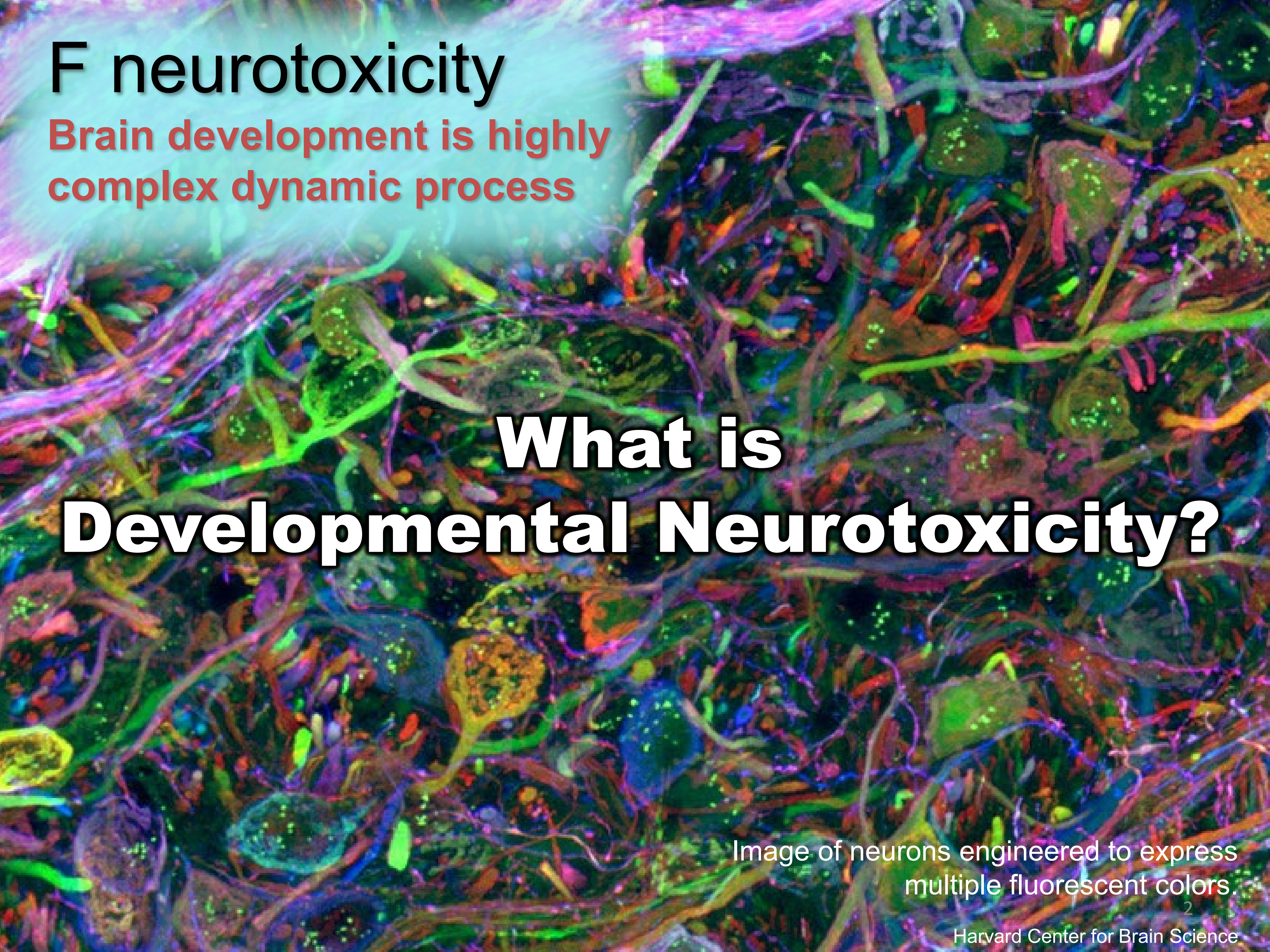
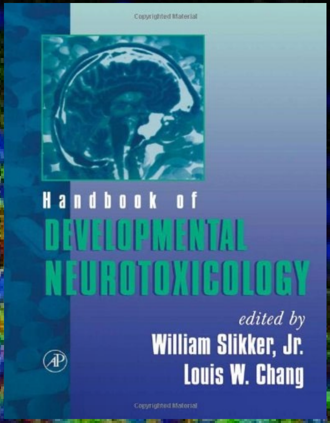


Image of neurons engineered to express multiple fluorescent colors.

Harvard Center for Brain Science

F neurotoxicity

Brain development is highly complex dynamic process



The fetal and infant brain is more susceptible than the adult to permanent harm from neurotoxic chemicals.

- The complex precisely timed neurodevelopment process offers many opportunities for disruption.
- The blood brain barrier is not well developed during the fetal period and the first 6 months of life.
- Disruption during even a short window of neurodevelopment can cause life-long permanent harm.

National Toxicology Program (NTP) systematic review and health assessment of the neurotoxicity of fluoride:

"**Conclusions:** NTP concludes that fluoride is presumed to be a cognitive neurodevelopmental hazard to humans. This conclusion is based on a consistent pattern of findings in human studies across several different populations showing that higher fluoride exposure is associated with decreased IQ or other cognitive impairments in children."

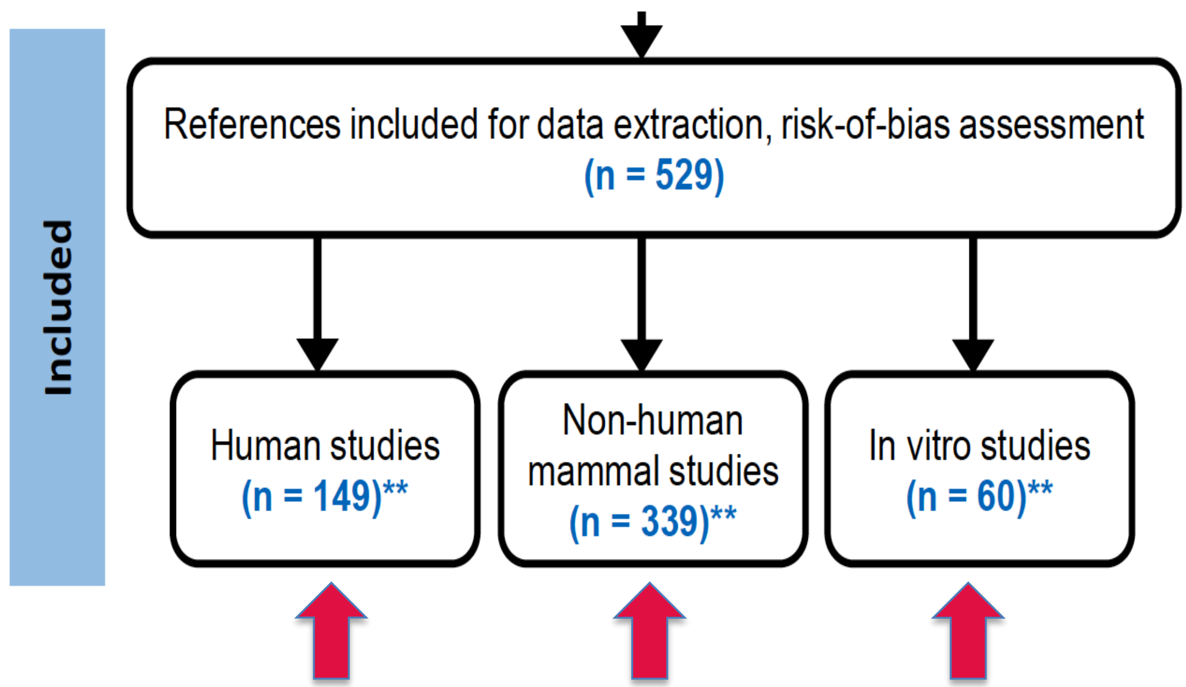
F neurotoxicity

Large number of studies

National Toxicology Program
U.S. Department of Health and Human Services

Systematic Review of Fluoride Exposure and Neurodevelopmental and Cognitive Health Effects

Figure 4. Study Selection Diagram



F neurotoxicity
Pre-conceptions


Research

JAMA Pediatrics | Original Investigation

Association Between Maternal Fluoride Exposure During Pregnancy and IQ Scores in Offspring in Canada

Rivka Green, MA; Bruce Lanphear, MD; Richard Hornung, PhD; David Flora, PhD; E. Angeles Martinez-Mier, DDS; Raichel Neufeld, BA; Pierre Ayotte, PhD; Gina Muckle, PhD; Christine Till, PhD

JAMA Editor's Podcast excerpts, on Green 2019:

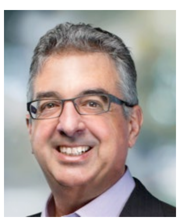
Pre-conceptions that people who claimed that fluoridation is harmful were "nuts".

Frederick P. Rivara, MD, MPH
Editor, *JAMA Networks Open*

Dimitri A. Christakis, MD, MPH
Editor, *JAMA Pediatrics*

F neurotoxicity
Pre-conceptions

Dr Rivara- "The paper is about fluoride, and maternal fluoride exposure during pregnancy, and its effects upon IQ scores of children at ages 3 and 4, which in itself is like a shocking title, because I had never known that there was even any concern that maternal fluoride use might affect children's IQ."



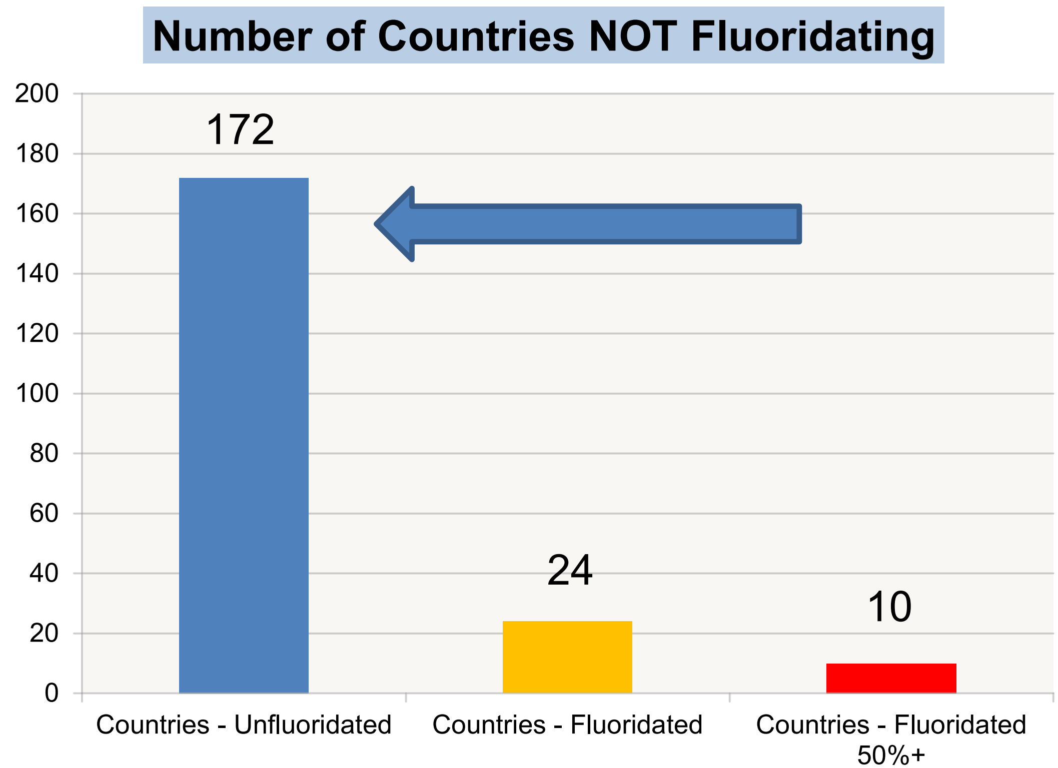
Dr Christakis- "… the traditional teaching when I was going through residency in my early professional career was that fluoride was completely safe, all these people that are trying to take it out of the water are nuts, its the best thing that's ever happened for children's dental health, and we just need to push back and get it into every water system."

"So when I first saw this title my initial inclination was 'What the hell?'"

F neurotoxicity

"in Europe only 3% of municipal water supplies are fluoridated"

Editors surprised by just how much of the world does *NOT* fluoridate.



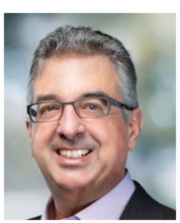
F neurotoxicity

“in Europe only 3% of municipal water supplies are fluoridated”

Editors surprised by just how much of the world does *NOT* fluoridate.

Dr Rivara- “… this was from Canada and they picked some large cities in Canada; these were Montreal, Vancouver, Kingston, Toronto, Hamilton and Halifax; so I’m a little surprised that those places did not [all] have fluoridated water supplies.”

Dr Rivara- “And the other interesting thing that came out, like in the editorial and in this paper, was that in Europe only 3% of municipal water supplies are fluoridated.”



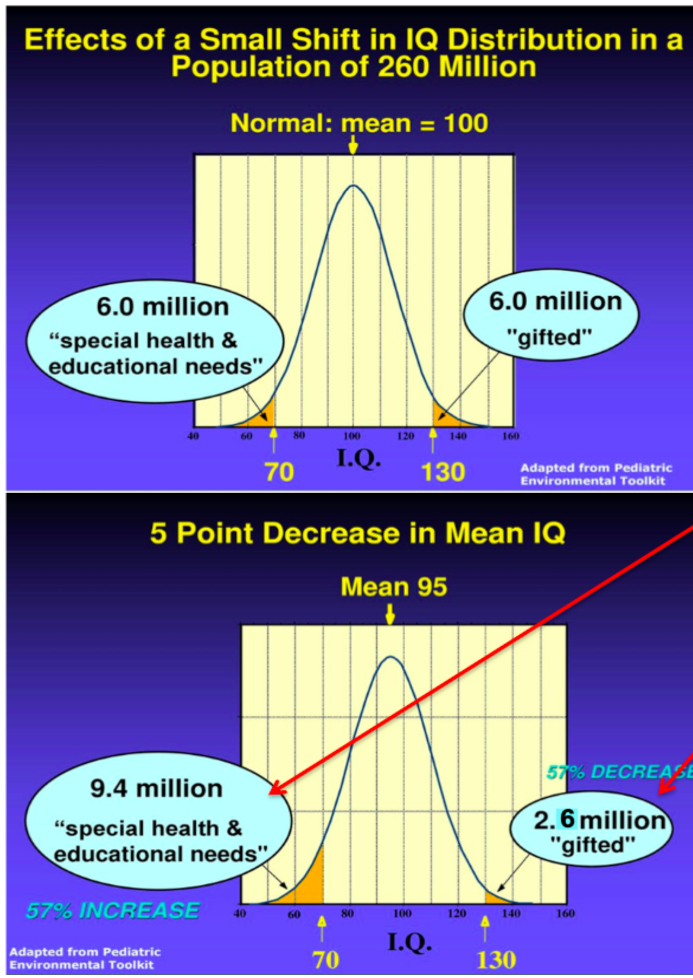
Dr Christakis- “Right, so again this was to me sort of eye-opening, that you known, I sort-of thought that ‘everyone did it’; certainly all developed countries, everyone that was at any level of sophistication was putting fluoride in the water.”

F neurotoxicity

A sizable effect "on par with lead" "that's a real concern"

Editors "really startled" at size of effect.

For an increase of 1 mg/L in maternal urine fluoride concentration, boys lost 5 IQ points.



Fluoridation in the USA is as bad as lead poisoning (75% fluoridated ≈ 260 million)

Green R. et al. JAMA Pediatr. 2019

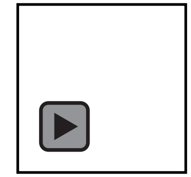
3.4 Million MORE special needs people

3.4 million FEWER gifted people (geniuses)

Steven Rosenberg, M.D., M.P.H.
Everything You Always Wanted to Know About Childhood Lead Poisoning (but Were Afraid to Ask)
SlideShare-June 21, 2007

F neurotoxicity

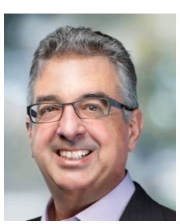
A sizable effect “on par with lead”
“that’s a real concern”



Dr Rivara- “… a 1 mg/L increase in the maternal urinary fluoride concentration was associated with a 5 point lower score on the boys’ IQ.”
Dr Christakis- “Right. An effect size which is sizable, on a par with lead”
Dr Rivara- “Right, it is.”

Dr Rivara- “The effect size is really quite large, because when you think about it really in terms of not the individual child so much as the shift in the curve … the shift in the curve, now, being shifted to the left, for boys, that’s a real concern ….”

Dr Rivara- “the results are really startling”



Dr Christakis- “… there have been other observational studies that have shown this, and there have been animal models as well, that have shown this idea that fluoride could be a neurotoxin; which again was totally news to me because I thought it was junk science, anyone would ever say such a thing.”

F neurotoxicity

Editor's advice: Pregnant mothers should avoid fluoridated water

F neurotoxicity

Editor's advice: Pregnant mothers should avoid fluoridated water

Dr Rivara- "So, if mothers now come into their doctor's offices and ask the pediatrician what to do, what are you going to say?"

Dr Christakis- "I think I would advise them to drink bottled water, or filtered water, because its not a particularly odius thing to do, and potentially does reduce the risk."
Dr Rivara- "Yea, you know the other thing is that some people may not be able to afford bottled water, it could be a financial burden to some low-income families, and we need to think about that as well."

"Well, its going to get a lot of attention, and I'm very proud that you published it."

F neurotoxicity
Xiang 2003


84 Fluoride Vol. 36 No. 2 84-94 2003 Research Report

EFFECT OF FLUORIDE IN DRINKING WATER ON CHILDREN'S INTELLIGENCE

Q Xiang,[a] Y Liang,[a] L Chen,[b] C Wang,[b] B Chen,[a] X Chen,[b] M Zhou[c]
Shanghai, P.R. China

High quality study with individual level data; China.

F and IQ

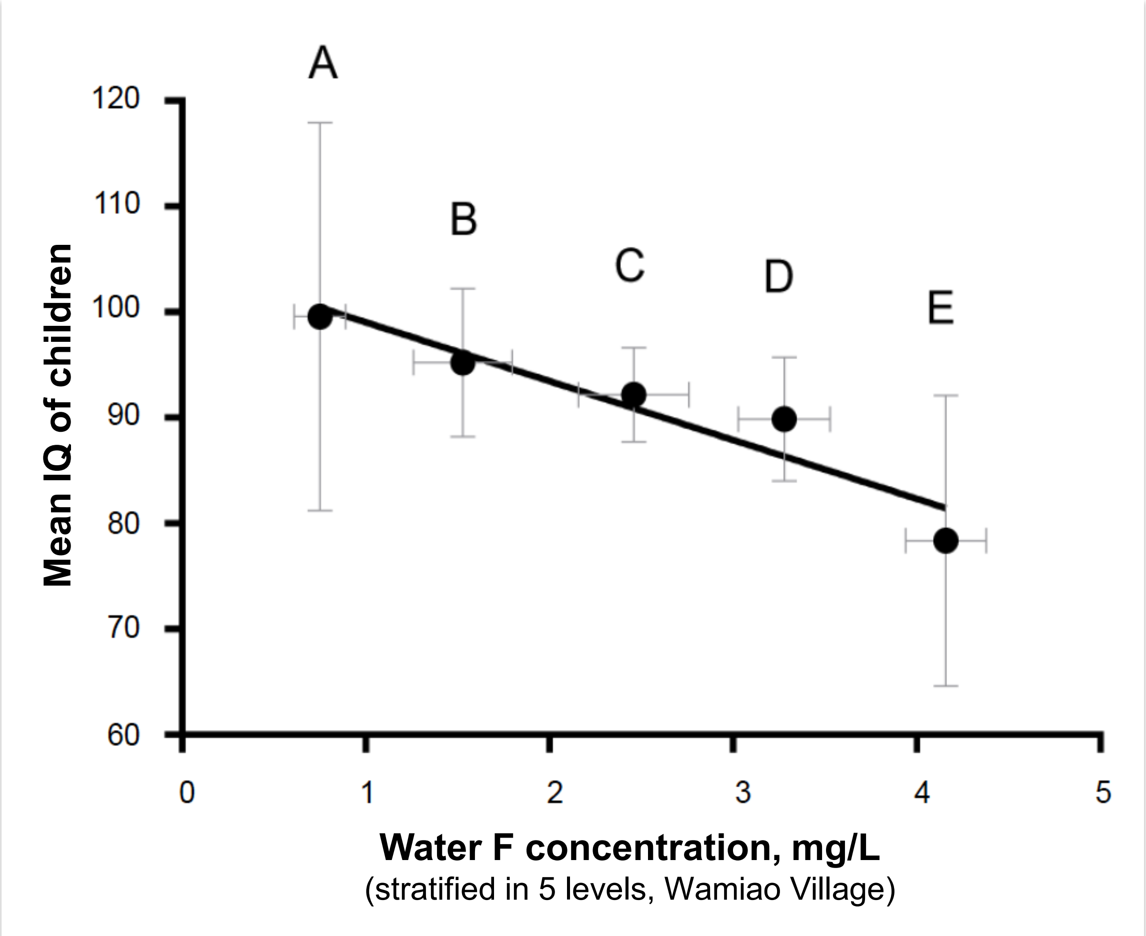
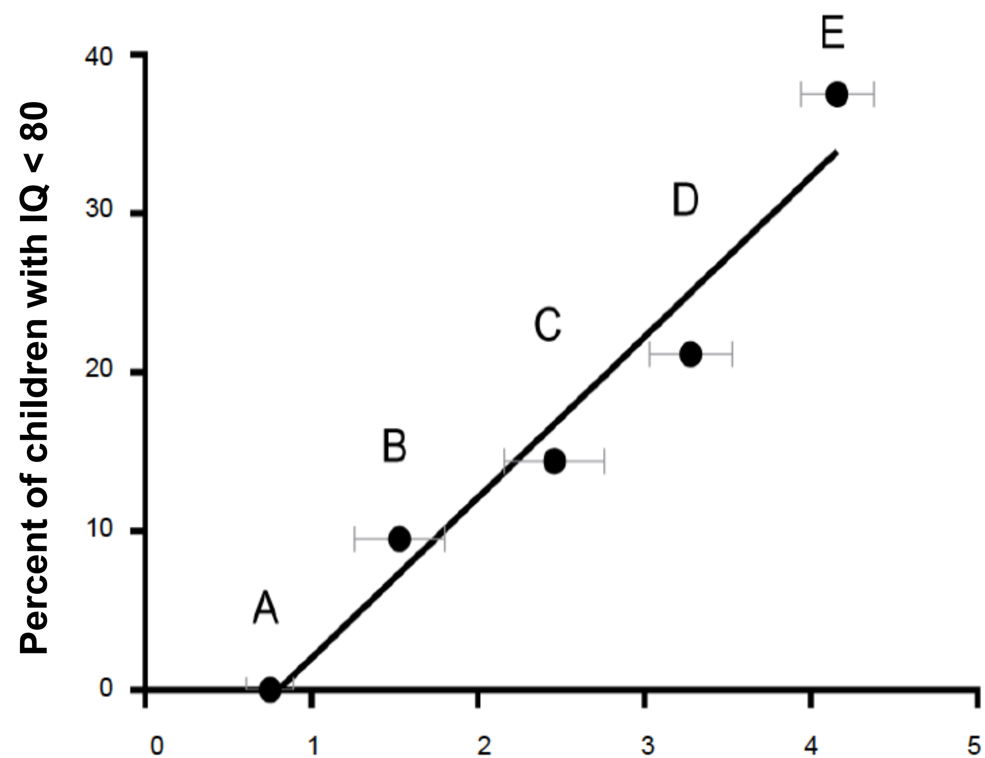


Figure adapted from Hirzy 2016 based on data reported in Xiang 2003.

F neurotoxicity
Xiang 2003

High quality study with individual level data; China.

F and % IQ below 80



Water F concentration, mg/L
(stratified in 5 levels, Wamiao Village)

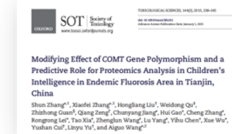
Figure adapted from Hirzy 2016 based on data reported in Xiang 2003.

F neurotoxicity

Zhang 2015

F and IQ

all genotypes combined


SOT Society of Toxicology
www.toxsci.oxfordjournals.org

Modifying Effect of COMT Gene Polymorphism and a Predictive Role for Proteomics Analysis in Children's Intelligence in Endemic Fluorosis Area in Tianjin, China

Shun Zhang, Xiaofei Zhang, Hongliang Liu, Weidong Qu, Zhizhong Guan, Qiang Zeng, Chunyang Jiang, Hui Gao, Cheng Zhang, Rongrong Lei, Tao Xia, Zhenglun Wang, Lu Yang, Yihu Chen, Xue Wu, Yushan Cui, Linyu Yu, and Aiguo Wang

High quality study; first with gene-F interaction; China.

Found 5x greater loss of IQ for those with specific genotype

Genotype	*N*	IQ points lost per 1 mg/L urine F	*p*-value
combined	108	–2.42	0.030
val/val	28	–9.67	0.003

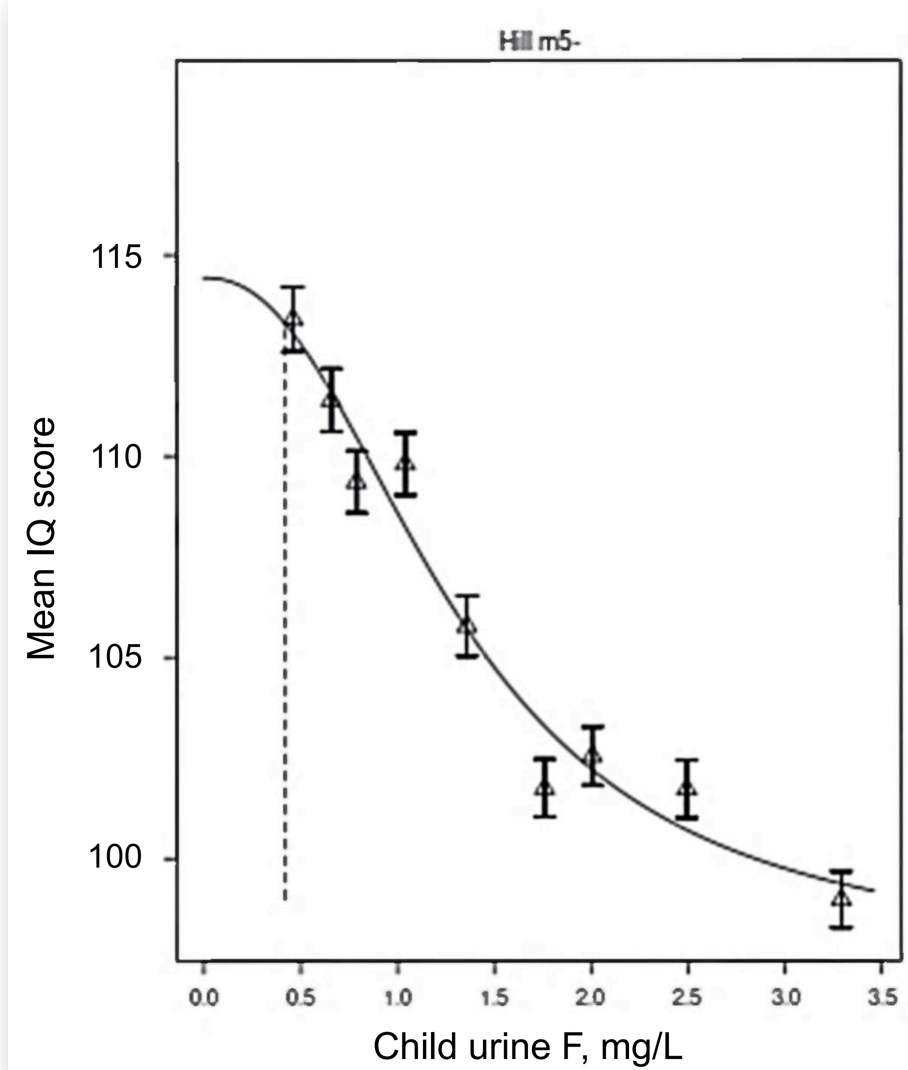
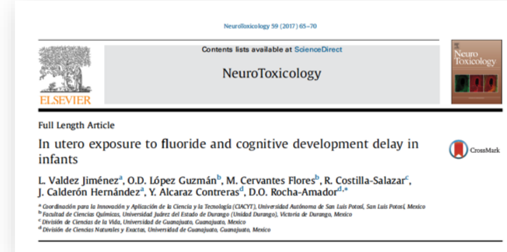


Figure based on Zhang 2015, Figure 1, with Benchmark Dose analysis using PROAST method.

F neurotoxicity

Valdez-Jimenez 2017


NeuroToxicology 59 (2017) 65–70

Contents lists available at ScienceDirect

NeuroToxicology

ELSEVIER

Full Length Article

In utero exposure to fluoride and cognitive development delay in infants

L. Valdez Jiménez[a], O.D. López Guzmán[b], M. Cervantes Flores[b], R. Costilla-Salazar[c], J. Calderón Hernández[a], Y. Alcaraz Contreras[d], D.O. Rocha-Amador[d,*]

[a] Coordinación para la Innovación y Aplicación de la Ciencia y la Tecnología (CIACYT), Universidad Autónoma de San Luis Potosí, San Luis Potosí, Mexico
[b] Facultad de Ciencias Químicas, Universidad Juárez del Estado de Durango (Unidad Durango), Victoria de Durango, Mexico
[c] División de Ciencias de la Vida, Universidad de Guanajuato, Guanajuato, Mexico
[d] División de Ciencias Naturales y Exactas, Universidad de Guanajuato, Guanajuato, Mexico

High quality study; first mother-offspring longitudinal cohort; Mexico.

F and IQ

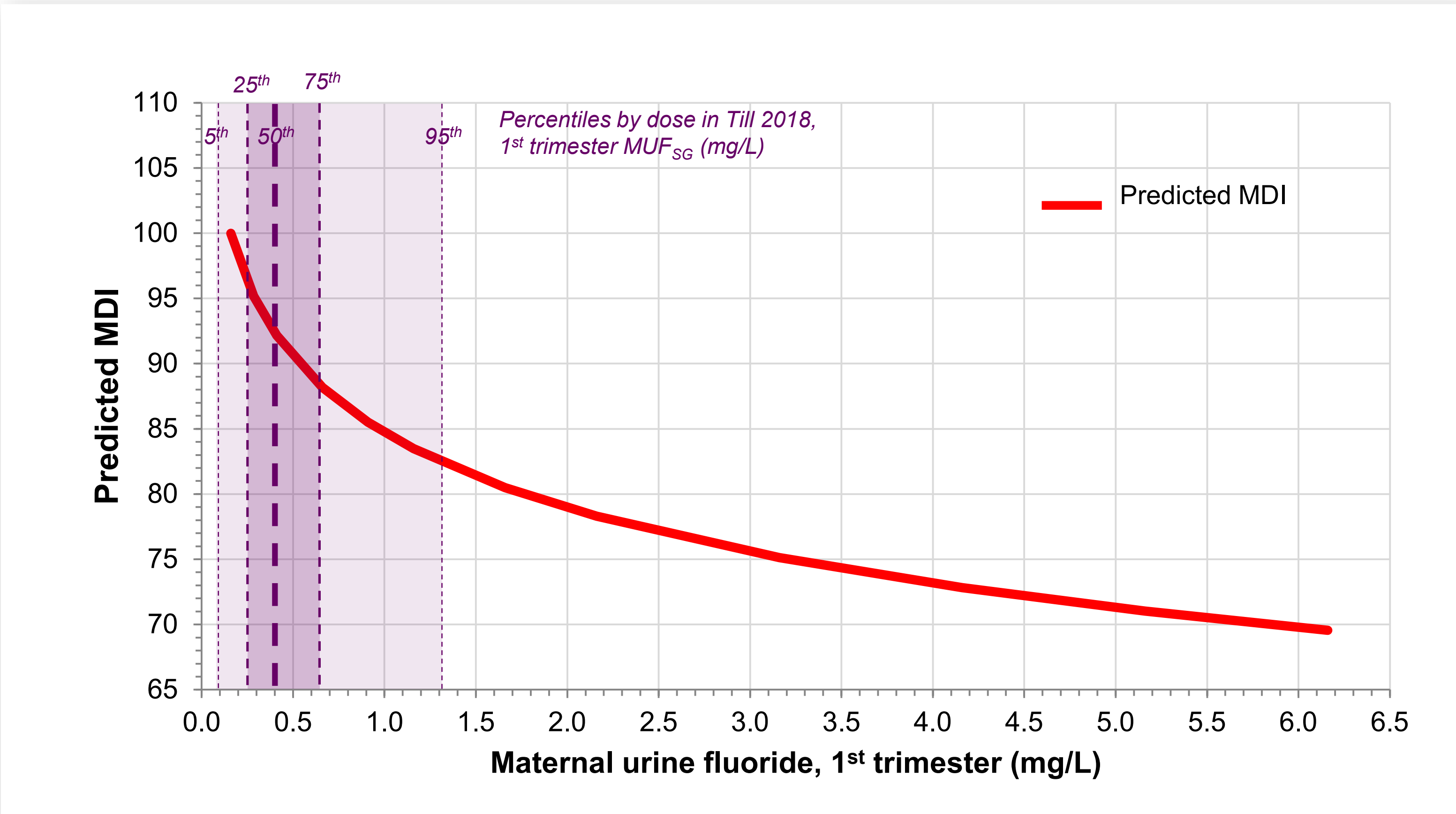


Figure based on Valdez-Jimenez 2017, Table 4, with overlay of Till 2018 exposure levels in Canada.

F neurotoxicity

Bashash 2017

ehp Environmental Health Perspectives
OPEN ACCESS
HOME CURRENT ISSUE ARCHIVES COLLECTIONS 中文翻译 AUTHORS ABOUT
Open Access
Vol. 125, No. 9 | Research

Prenatal Fluoride Exposure and Cognitive Outcomes in Children at 4 and 6–12 Years of Age in Mexico

is companion of

Morteza Bashash, Deena Thomas, Howard Hu, E. Angeles Martinez-Mier, Brisa N. Sanchez, Niladri Basu, Karen E. Peterson, Adrienne S. Ettinger, Robert Wright, Zhenzhen Zhang, Yun Liu, Lourdes Schnaas, Adriana Mercado-García, Martha María Téllez-Rojo, and Mauricio Hernández-Avila Show less Authors

Published: 19 September 2017 | CID: 097017 | https://doi.org/10.1289/EHP655 | Cited by: 15

High quality, mother-offspring longitudinal cohort study; Mexico City.

> **“Conclusion**
> In this study, higher levels of maternal urinary fluoride during pregnancy (a proxy for prenatal fluoride exposure) that are in the range of levels of exposure in other general population samples of pregnant women as well as nonpregnant adults were associated with lower scores on tests of cognitive function in the offspring at 4 and 6-12 y old.”

F neurotoxicity

Till 2020


Environment International 134 (2020) 105315

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

ELSEVIER

Fluoride exposure from infant formula and child IQ in a Canadian birth cohort

Christine Till[a,*], Rivka Green[a], David Flora[a], Richard Hornung[b], E. Angeles Martinez-Mier[c], Maddy Blazer[a], Linda Farmus[a], Pierre Ayotte[d,e], Gina Muckle[d,f], Bruce Lanphear[g,h]

High quality, mother-offspring longitudinal cohort study;
F in infant formula;
Canada.

Dramatic lowering of IQ

F neurotoxicity

Till 2020

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High quality, mother-offspring longitudinal cohort study;
F in infant formula;
Canada.

Children who were formula-fed and lived in fluoridated areas as babies have dramatically lower IQ compared to those who lived in non-fluoridated areas.

F neurotoxicity

Till 2020


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High quality, mother-offspring longitudinal cohort study;
F in infant formula;
Canada.

Recomendation: no fluoridated water for infants

"After adjusting for fetal exposure, we found that fluoride exposure during infancy predicts diminished non-verbal intelligence in children. In the absence of any [dental] benefit from fluoride consumption in the first six months, it is prudent to limit fluoride exposure by using non-fluoridated water or water with lower fluoride content as a formula diluent."

F neurotoxicity

Till 2020


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High quality, mother-offspring longitudinal cohort study;
F in infant formula;
Canada.

F and IQ

Very large loss of IQ with increasing tap water F for *formula-fed infants*:

-9 IQ points (Full Scale IQ) for each 1 mg/L increase in tap water F.

-19 IQ points (Performance Scale IQ) for each 1 mg/L increase in tap water F.

NOTE: Performance Scale IQ also know as non-verbal IQ

F neurotoxicity

Till 2020


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High quality, mother-offspring longitudinal cohort study;
F in infant formula;
Canada.

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F neurotoxicity

Riddell 2019

High quality study of F and ADHD; Canada.

Environment International 133 (2019) 105190

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

ELSEVIER

Full length article

Association of water fluoride and urinary fluoride concentrations with attention deficit hyperactivity disorder in Canadian youth

Julia K. Riddell[a,*], Ashley J. Malin[b], David Flora[a], Hugh McCague[c], Christine Till[a]

[a] Faculty of Health, York University, Ontario, Canada
[b] Department of Environmental Medicine and Public Health, Icahn School of Medicine at Mount Sinai, New York, NY, United States
[c] Institute for Social Research, York University, Ontario, Canada

F and ADHD

Found almost 300% higher risk of ADHD for those living in fluoridated areas in national sample of Canadian children.

Found 600% higher risk of ADHD for every 1 mg/L increase in tap water F.

> "In conclusion, we found that higher tap water fluoride levels and fluoridation of municipal water supplies were associated with a higher risk of an ADHD diagnosis as well as increased symptoms of hyperactivity and inattention, especially among adolescents."

The Scientific Evidence for Fluoride's Developmental Neurotoxicity . . .

is Overwhelming

National Toxicology Program (NTP) systematic review and health assessment of the neurotoxicity of fluoride:

"**Conclusions:** NTP concludes that fluoride is presumed to be a cognitive neurodevelopmental hazard to humans. This conclusion is based on a consistent pattern of findings in human studies across several different populations showing that higher fluoride exposure is associated with decreased IQ or other cognitive impairments in children."

F neurotoxicity
Should we care?

What are the implications of a few IQ points lost per person?

Should we care?