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Effect of CDC adjustment of state-reported data on community water fluoridation statistics

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Abstract

Objectives: Advancing community water fluoridation (CWF) coverage is a national health objective. The Centers for Disease Control and Prevention began adjusting state-reported data to calculate CWF coverage in 2012, and then modified methods in 2016. We evaluate improvements attributable to data adjustment and implications for interpreting trends.

Methods: To assess adjustment, we compared the percentage deviation of state-reported data and data adjusted by both methods to the standard estimated by the U.S. Geological Survey. To assess effects on estimated CWF trends, we compared statistics calculated with data adjusted by each method.

Results: The 2016 method outperformed on all points of evaluation. The CWF national objective measure (percentage of community water system population receiving fluoridated water) was negligibly affected by method. Percentage of US population receiving fluoridated water was lower with the 2016 method versus the 2012.

Conclusions: Adjustment of state-reported data improved overall quality of CWF coverage measures and had minimal impact on key measures.

Keywords

dental caries; dental caries susceptibility; public health dentistry; water fluoridation; water fluoridation statistics

INTRODUCTION

Untreated tooth decay, the most prevalent disease in the world [1], can lead to problems in eating, learning, and socializing [2]. Community water fluoridation (CWF; controlled adjustment of fluoride in a public water supply) helps prevent tooth decay [3] and was recognized as one of 10 great public health achievements of the 20th century [4].

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

The percentage of the population on community water systems (CWS) receiving fluoridated water has been used to set national health goals since 1990 [5] and is tracked by the National Oral Health Surveillance System [6]. During 1999–2000 Centers for Disease Control (CDC) introduced the Water Fluoridation Reporting System (WFRS), the principal tool now used to help states track fluoridation and provide data for surveillance [7]. Each year, state drinking water programs input data for each CWS regarding the population served and water fluoride content. CDC uses this information to generate biennial reports of national CWF coverage [8].

The state-reported number of people served by a CWS is typically estimated based on an assumed number of people served per connection and is subject to under- or overestimation. In 2012, CDC began adjusting the reported CWS populations downward if the sum of the state's total CWS population exceeded the total state population estimated by the U.S. Census Bureau (USCB). This approach was limited in that it (1) assumed that all reporting errors were overestimates, and (2) adjusted the overestimates down to the full state population, only lessening the overestimation. With the 2016 data release, CDC began additionally incorporating the U.S. Geological Survey's (USGS) most recent estimated percentage of the state population on CWS to enable both upward and downward adjustment of reported CWS populations. The USGS estimates are released every 5 years and are thought to be more accurate than the state-reported values as they are derived with data from multiple sources, including state reports, the US Environmental Protection Agency's Safe Drinking Water Information System database, USCB, and public water suppliers on service connections [9].

This report (1) briefly describes the methods used to adjust state reported CWS populations beginning in 2012 and how they changed in 2016, (2) assesses how reported CWS populations adjusted by each methodology deviate from USGS estimates, and (3) examines how reported fluoridation statistics vary between the two adjustment methods, which has implications for the comparability of statistics reported between 2012 and 2015 and those reported from 2016 and beyond.

METHODS

The first adjustment method introduced with the release of 2012 fluoridation statistics used data from the USCB, published annually [10]. If a state's total reported CWS population exceeded the USCB state population estimate, it was replaced with this lower number (i.e., adjusted downward); otherwise, it was not adjusted. The individual reported CWS populations within the state were then proportionately reduced using a multiplier. Finally, the adjusted populations for each fluoridated CWS were summed to obtain the state CWF population.

The new method, introduced with the release of 2016 fluoridation statistics, adjusts reported CWS populations using data from both USCB and USGS [9]. Each state's total adjusted CWS population is calculated by multiplying the USCB state population estimate by USGS's most recent estimated percentage of the state population on CWS. Each individual reported CWS population within the state is then proportionately adjusted using a multiplier.

Finally, the adjusted populations for each fluoridated CWS are summed to obtain the state CWF population. Details on each method are published on CDC's Estimating Community Water System Populations webpage [8].

Comparing methodologies

Performance—We used WFRS reported CWS population data from 2015, for all 50 states and Washington, D.C., and adjusted by each methodology. We evaluated 3 estimates of 2015 CWS populations: (1) WFRS state-reported populations, (2) adjusted populations using the 2012 method, and (3) adjusted populations using the 2016 method. We calculated percentage deviations from the later published USGS 2015 CWS population estimates as the benchmark. To evaluate how closely each estimate aligns with the benchmark, we compared (1) the range of percentage deviations, (2) the mean and median of the absolute percentage deviations, and (3) the number of estimates that fall within 1%, 5%, and 10%.

Differences in CWF coverage attributable to methodology—We used WFRS reported CWS population data from 2012 and 2014 as these were the two reports that utilized the 2012 methodology. We used the 2016 methodology to calculate all CWF coverage measures included in biennially released reports. We then compared the percentage change in measures between the 2012 and the 2016 methodologies.

RESULTS

Performance

Table 1 provides the three sets of numbers evaluated and the USGS 2015 estimates as benchmark. The 2016 method produced the narrowest deviation range from benchmark estimates (−15.0%, 16.2%), followed by the 2012 method (−17.3%, 23.9%). State-reported populations had the widest range in percentage deviation (−17.3%, 31.0%). All other indicators resulted in the same order of performance (2016 method, 2012 method, State-reported). The 2016 method performed best; with a 2.8% mean absolute deviation and a 1.0% median absolute deviation from benchmark estimates. Twenty-six out of 51 adjusted estimates fell within 1% of benchmark. Forty-two of 51 fell within 5%, and 46 of 51 fell within 10% of benchmark.

Differences in CWF coverage

Table 2 provides all measures of CWF coverage included in biennially released reports in 2012 and 2014, calculated using CWS population data adjusted by both methodologies. The most notable difference is that the estimated CWS population is now lower, where previously this number was overestimated. By extension, the estimated U.S. population and percentage of U.S. population on fluoridated water are now lower.

The percentage of the total CWS population that is receiving fluoridated water, however, is only negligibly affected. This is because both the numerator, number of people served by fluoridated CWS, and the denominator, total number of people on CWS, are multiplied by the same unique multiplier. By extension, estimated percentage of CWS population receiving fluoridated water should be quite similar for all years of reporting. However, there

still will be some minimal deviation since unique adjustment is applied at the state level and aggregated to reach the national estimate. For example, the percentage difference in this measure between the 2012 and 2016 adjustment methods was -0.1% for 2012 data and -0.03% for 2014 data. Numbers of systems and system types are not affected.

State level comparisons are similar. The estimated number of people on CWS changes. By extension, the estimated number of people on fluoridated CWS changes. But the percentage of the state CWS population receiving fluoridated water is not affected.

DISCUSSION

The newer CWS population adjustment method introduced in 2016 adjusts each state's reported CWS population to be more in line with other published, quality estimations. It outperforms both directly reported CWS populations and the previous 2012 adjustment method when benchmarked against later USGS published CWS population estimates.

This study sheds light on changes in CWF coverage measures resulting from changes in population adjustment methodologies, rather than actual changes in coverage. The estimated U.S. populations both on CWS and on fluoridated CWS are lower under the new methodology, in turn lowering the estimated percentages of the overall population receiving fluoridated water. However, analysis here shows these updated methods likely more accurately reflect true population proportions and that the historic numbers were likely overestimates. Most notably, the percentage of the US CWS population receiving fluoridated water (a Healthy People 2020 national health objective) is only negligibly affected by adjustment methodologies and thus it is reasonable to compare these values from 1990 to present. Similarly, at the state level, this key CWF measure is not affected.

A limitation in this study is the use of USGS estimates of CWS populations as a benchmark. This is not an actual value, but a proxy that is derived using data from multiple trusted sources, and thus thought to be the most accurate available.

Adjustment of reported CWS populations is intended to overcome innate inaccuracies and improve the overall quality and accuracy of CWF coverage measures. A change in the adjustment method brings a trade-off in comparability of some CWF measures over time. But these changes are shown to improve accuracy of CWF measures, while the key measure used to set and track national health objectives is shown to be virtually unaffected by adjustment, thus remaining comparable over time.

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TABLE 1

Comparison of state-reported versus 2012 adjustment method versus 2016 adjustment method community water system (CWS) population estimates for 2015^a. Compared to U.S. Geological Survey (USGS) published 2015 estimates as the benchmark for performance.

State	2015 population (USCB)	2015 CWS population (USGS)	From WFRS			2012 adjustment method			2016 adjustment method		
			2015 reported CWS population	Deviation from USGS (%)	2015 adjusted CWS population ^b	Deviation from USGS (%)	2015 adjusted CWS population ^c	Deviation from USGS (%)			
USA	321,417,401	278,995,942	286,350,876	2.6%	284,218,160	1.9%	275,475,820	-1.3%			
AL	4,858,979	4,319,585	5,659,421	31.0%	4,858,979	12.5%	4,310,642	-0.2%			
AK	737,458	549,638	680,780	23.9%	680,780	23.9%	467,040	-15.0%			
AZ	6,828,065	6,609,895	5,536,324	-16.2%	5,536,324	-16.2%	6,595,023	-0.2%			
AR	2,978,204	2,833,760	2,811,665	-0.8%	2,811,665	-0.8%	2,830,685	-0.11%			
CA	39,144,818	37,709,308	35,912,482	-4.8%	35,912,482	-4.8%	36,543,097	-3.1%			
CO	5,456,574	5,170,100	5,390,219	4.3%	5,390,219	4.3%	5,118,474	-1.0%			
CT	3,590,886	2,729,414	2,690,930	-1.4%	2,690,930	-1.4%	2,715,420	-0.5%			
DE	945,934	764,294	818,110	7.0%	818,110	7.0%	750,763	-1.8%			
DC	672,228	672,228	595,000	-11.5%	595,000	-11.5%	672,228	0.0%			
FL	20,271,272	17,810,977	17,150,379	-3.7%	17,150,379	-3.7%	18,214,525	2.3%			
GA	10,214,860	8,700,463	10,276,824	18.1%	10,214,860	17.4%	8,601,465	-1.1%			
HI	1,431,603	1,375,307	1,491,714	8.5%	1,431,603	4.1%	1,373,000	-0.2%			
ID	1,654,930	1,258,715	1,218,565	-3.2%	1,218,565	-3.2%	1,198,916	-4.8%			
IL	12,859,995	11,708,882	13,458,992	14.9%	12,859,995	9.8%	11,702,009	-0.1%			
IN	6,619,680	4,942,341	4,582,496	-7.3%	4,582,496	-7.3%	4,926,235	-0.3%			
IA	3,123,899	2,629,877	2,783,201	5.8%	2,783,201	5.8%	2,517,442	-4.3%			
KS	2,911,641	2,762,359	2,693,180	-2.5%	2,693,180	-2.5%	2,757,663	-0.17%			
KY	4,425,092	3,984,429	4,357,666	9.4%	4,357,666	9.4%	3,748,348	-5.9%			
LA	4,670,724	4,179,142	4,835,945	15.7%	4,670,724	11.8%	4,065,419	-2.7%			
ME	1,329,328	668,831	661,140	-1.1%	661,140	-1.1%	768,119	14.8%			
MD	6,006,401	4,582,453	5,279,808	15.2%	5,279,808	15.2%	4,893,406	6.8%			
MA	6,794,422	6,178,474	6,962,282	12.7%	6,794,422	10.0%	6,240,481	1.0%			
MI	9,922,576	7,325,262	8,201,134	12.0%	8,201,134	12.0%	7,236,262	-1.2%			
MN	5,489,594	4,312,677	4,215,391	-2.3%	4,215,391	-2.3%	4,322,133	0.2%			
MS	2,992,333	2,557,567	3,270,454	27.9%	2,992,333	17.0%	2,542,440	-0.6%			

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State	2015 population (USCB)	2015 CWS population (USGS)	From WFRS			2012 adjustment method			2016 adjustment method		
			2015 reported CWS population	Deviation from USGS (%)	2015 adjusted CWS population ^b	Deviation from USGS (%)	2015 adjusted CWS population ^c	Deviation from USGS (%)			
MO	6,083,672	5,262,329	5,226,030	-0.7%	5,226,030	-0.7%	5,186,438	-1.4%			
MT	1,032,949	728,319	788,805	8.3%	788,805	8.3%	735,260	1.0%			
NE	1,896,190	1,724,750	1,425,664	-17.3%	1,425,664	-17.3%	1,536,992	-10.9%			
NV	2,890,845	2,698,288	2,544,079	-5.7%	2,544,079	-5.7%	2,721,714	0.9%			
NH	1,330,608	833,428	870,564	4.5%	870,564	4.5%	880,283	5.6%			
NJ	8,958,013	7,991,989	8,288,715	3.7%	8,288,715	3.7%	7,975,690	-0.2%			
NM	2,085,109	1,792,944	1,571,600	-12.3%	1,571,600	-12.3%	1,778,153	-0.82%			
NY	19,795,791	17,296,356	18,147,111	4.9%	18,147,111	4.9%	17,705,650	2.4%			
NC	10,042,802	7,635,141	7,459,363	-2.3%	7,459,363	-2.3%	6,563,271	-14.0%			
ND	756,927	710,574	677,358	-4.7%	677,358	-4.7%	701,383	-1.3%			
OH	11,613,423	9,752,400	10,330,005	5.9%	10,330,005	5.9%	9,771,122	0.2%			
OK	3,911,338	3,554,478	3,531,832	-0.6%	3,531,832	-0.6%	3,582,204	0.8%			
OR	4,028,977	3,397,439	3,688,540	8.6%	3,688,540	8.6%	3,391,030	-0.2%			
PA	12,802,503	9,331,742	10,780,146	15.5%	10,780,146	15.5%	9,430,573	1.1%			
RI	1,056,298	943,445	997,824	5.8%	997,824	5.8%	942,957	-0.1%			
SC	4,896,146	3,713,425	3,728,367	0.4%	3,728,367	0.4%	3,676,582	-1.0%			
SD	858,024	752,046	690,759	-8.1%	690,759	-8.1%	778,369	3.5%			
TN	6,600,299	6,005,817	5,789,882	-3.6%	5,789,882	-3.6%	6,040,480	0.6%			
TX	27,469,114	26,154,041	26,731,689	2.2%	26,731,689	2.2%	24,803,008	-5.2%			
UT	2,995,919	2,934,541	2,868,759	-2.2%	2,868,759	-2.2%	2,941,164	0.2%			
VT	626,042	382,246	450,710	17.9%	450,710	17.9%	444,344	16.2%			
VA	8,382,993	6,824,878	6,688,079	-2.0%	6,688,079	-2.0%	6,654,777	-2.5%			
WA	7,170,351	6,146,498	5,525,840	-10.1%	5,525,840	-10.1%	6,100,964	-0.7%			
WV	1,844,128	1,452,537	1,489,745	2.6%	1,489,745	2.6%	1,452,678	0.0%			
WI	5,771,337	4,173,272	4,076,085	-2.3%	4,076,085	-2.3%	4,102,067	-1.7%			
WY	586,107	467,041	449,223	-3.8%	449,223	-3.8%	467,432	0.1%			
Deviation range (from USGS):				(-17.3%, 31.0%)		(-17.3%, 23.9%)	(-15.0%, 16.2%)				
Mean absolute dev. (from USGS):				8.2%		7.3%	2.8%				
Median absolute dev. (from USGS):				5.8%		5.7%	1.0%				

State	2015 population (USCB)	2015 CWS population (USGS)	From WFRS			2012 adjustment method			2016 adjustment method		
			2015 reported CWS population	Deviation from USGS (%)	2015 adjusted CWS population ^b	Deviation from USGS (%)	2015 adjusted CWS population ^c	Deviation from USGS (%)			
				4/51		4/51	4/51		26/51		26/51
				24/51		24/51	25/51		42/51		42/51
				35/51		35/51	37/51		46/51		46/51

Proportion within ± 1% of USGS:

Proportion within ± 5% of USGS:

Proportion within ± 10% of USGS:

Abbreviations: CWS, Community Water System; USCB, United States Census Bureau; USGS, United States Geological Survey; WFRS, Water Fluoridation Reporting System.

^aNumbers for 2015 are not published among official CDC national water fluoridation statistics. They are only calculated and reported here for illustration purposes.

^bAdjusted using Vintage 2015 U.S. Census Bureau estimated state populations.

^cAdjusted using Vintage 2015 U.S. Census Bureau estimated state populations and 2010 U.S. Geological Survey estimated percentages of state populations on community water systems.

TABLE 2

National water fluoridation statistics, differences in estimates attributable to changes in population adjustment methods.

Estimate	Difference attributable to adjustment method (yes/no)	2012 new method ^a		2014 new method ^a		% difference
		2012 old method	2012 new method ^a	2014 old method	2014 new method ^a	
Total U.S. population, persons	No	313,914,040	313,914,040	318,857,056	318,857,056	–
U.S. population on community water systems (CWS), persons	Yes ^b	282,534,910	268,790,428	284,099,832	273,221,981	–3.8%
U.S. population on fluoridated drinking water systems, persons	Yes ^b	210,655,401	200,171,061	211,393,167	203,230,762	–3.9%
Percentage of U.S. population receiving fluoridated water	Yes ^c	67.1%	63.8%	66.3%	63.7%	–3.9%
Percentage of U.S. population on CWS receiving fluoridated water	Yes, minimal ^d	74.6%	74.5%	74.4%	74.4%	–0.03%
Total number of CWS in United States	No	52,734	52,734	58,473	58,473	–
Number of CWS providing fluoridated water	No	18,502	18,502	18,186	18,186	–
Number of CWS adjusting fluoride	No	5999	5999	5919	5919	–
Number of CWS consecutive to systems with optimal fluoride levels	No	6342	6342	6015	6015	–
Number of CWS with naturally occurring fluoride at or above optimal levels	No	6151	6151	6205	6205	–
U.S. population served by CWS with naturally occurring fluoride at or above optimal levels	Yes ^b	11,116,202	10,727,755	11,883,007	11,748,184	–1.1%

^aNumbers for 2012 and 2014 using the new adjustment method are not published among official CDC national water fluoridation statistics. They are only calculated and reported here for illustration purposes.

^bThis is lower under the new method, since many reported state CWS populations are overestimated and now adjusted, while the old method only lowered those that exceeded the USCB state population estimate. Similarly, populations served by each CWS (and by extension, fluoridated CWS) are adjusted proportionately within each state.

^cThis is calculated from other estimates (U.S. population on fluoridated drinking water systems)/(Total U.S. population). Lower under the new method, since the numerator is now lower, but the denominator remains the same.

^dThis is calculated from other estimates (U.S. population on fluoridated drinking water systems)/(U.S. population on CWS). Both the numerator and the denominator are lower under the new method, adjusted in the same way, so the percentage should be comparable between the two methods. However, since CWS population adjustment methods are applied uniquely within each state and then aggregated to reach the national estimate, this number may not be identical between the two methods.