Cost of Fluoridation: 44 Florida Communities

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Abstract

Previous data relating to the cost of fluoridation often do not include annualized costs or costs for labor and maintenance. The purpose of this study was to estimate accurately current costs for initiating and maintaining fluoridation and to develop a methodology that can be used to provide the cost basis for further cost-effectiveness studies. The data were collected from 44 Florida communities that had initiated community water fluoridation between 1981 and 1989. Equipment, installation, and engineering costs were derived from copies of actual invoices for equipment and services and then adjusted to 1988 dollars. The chemical costs were calculated from operational reports listing flow rate and pounds used. The cost was then adjusted according to whether the hydrofluosilicic acid was supplied as 15-gallon carboys, 55-gallon drums, in bulk, or as sodium silicofluoride or sodium fluoride. The initial cost was annualized at 2 percent and 4 percent over 15 years. Calculated operational costs included chemical costs, labor costs, and maintenance and repair costs. The operational costs were then added to the annualized depreciation costs and opportunity costs for the initial investment, to produce an estimated cost per person served. The total mean cost per person for all installations was $1.14 per year at 2 percent and $1.25 per year at 4 percent. The mean cost at 4 percent for communities of fewer than 10,000 was $2.12; for communities between 10,000 and 50,000 it was $0.68; and for communities over 50,000 it was $0.31. The total mean cost per person across all installations was $0.41 at 2 percent and 0.45 at 4 percent. The average yearly cost was related to the size of the community, the number of injection points, and the method of chemical purchase and delivery.

Key Words: fluoridation, cost analysis.

Interest in determining the cost, cost benefit, and cost effectiveness of caries preventive measures began in the 1970s in a series by Davies (1). Other work on this issue was published by Dowell (2), Kunzel (3), and Nelson and Swint (4), who did a prospective cost-benefit analysis of fluoridation in Houston, Texas. A summary of studies was provided by Newbrun (5) in a paper presented at the University of Michigan workshop on the relative efficiency of methods of caries prevention in 1978. Subsequently, Burt (6) presented a treatise on some areas in the prevention of dental caries that require economic analysis. More recently, a follow-up workshop was again held at the University of Michigan in the spring of 1989. A paper by Garcia (7) was used as the cost basis for community water fluoridation. Garcia's data were derived from 16 communities in 16 different states through information supplied by state dental directors, utility directors, and others.

An opportunity existed to use data collected by the state of Florida public health dental program on 44 Florida communities that authorized and implemented community water fluoridation in the 1980s. The purpose of this study was to estimate accurately current costs for initiating and monitoring fluoridation and to develop a methodology that could be used to provide the cost basis for further cost-effectiveness studies.

Methods

Allowable initial one-time costs included equipment, installation, testing equipment, safety equipment, and

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consultant engineering fees up to 15 percent of the other direct costs. Not included were the costs for new buildings or construction. It is not appropriate to include buildings or water system capital costs since this capital already exists and would not have been an incurred cost for the community whether or not the system was fluoridated. Costs were documented by copies of actual invoices for equipment and services. Types of equipment varied by size of system from simple solution feeders with carboy day tanks to variable rate flow meters, in-line continual monitoring devices, and telemetry.

The opportunity cost of the capital investment (the cost of the next best alternative for that amount of money) was included as part of the total cost of fluoridation. These costs were separate and in addition to the annualized depreciation cost. The initial capital cost was annualized at 2 percent and 4 percent over 15 years. The adjusted total and per capita costs included the interest costs on the installation capital. The constant costs equations are as follows:

1. Total per capita costs = total costs/population.
2. Total costs = operating costs + opportunity costs of capital + capital depreciation.
3. Operating costs = chemical costs + labor costs + maintenance costs.
4. Opportunity costs of capital (interest on fixed initial investment) = (initial costs of equipment + installation costs) × (interest rate @ 4% or 2%).
5. Capital depreciation was calculated assuming a 15-year equipment turnover and no salvage value. A sinking-fund approach to depreciation was used with interest rates of 2 percent and 4 percent.

The initial costs were adjusted to 1988 dollars and also adjusted to remove differences in costs among counties in the state of Florida. The unpublished investment component of the GNP implicit price deflator (IPD), developed by the US Department of Commerce, was used to adjust the installation costs to 1988 dollars. The housing component of the Florida price level index (FPLI) was used to adjust for regional cost differences (8). The FPLI was established by the Florida legislature as the basis for the district cost differential in the formula for the distribution of state funds to local school districts.

The chemical costs were derived from daily operational reports, which provided data on actual pounds or gallons of chemical used. Data from 1988 were used, although that was not the first year of operation for most of the systems. The cost in 1988 dollars was then computed. If the chemical was hydrofluosilicic acid, different costs per pound were used depending on whether the plant in question used 15-gallon carboys, ($0.25) 55-gallon drums, ($0.18) or bulk storage ($0.11). Sodium silicofluoride was estimated at $0.47/lb and sodium fluoride at $0.89/lb. All but two of the systems used acid, with one system (Hawthorne) using sodium fluoride and one system (New Smyrna Beach) using sodium silicofluoride.

Chemical costs may vary from time to time contingent on availability. This variability in cost is reflected on a relative level nationally. Our recent survey of costs for hydrofluosilicic acid indicated a 27 percent variability nationally. This variability was due to distributor and freight differences. Costs were similar in Florida, Cincinnati, St. Louis, and Seattle, but somewhat higher in Texas. The optimal fluoride level in Florida has been set at 0.8 ppm for the entire state by rule as set forth in Florida Administrative Code 17-555. Fluoride chemical cost will vary somewhat for similar-sized systems based on the ambient level of natural fluoride. Natural fluoride levels for these 44 systems vary from 0 to 0.3 ppm. A monitoring/surveillance system has been installed that ensures approximately 90 percent compliance with optimal levels. The acceptable range for optimal levels is from 0.7 to 1.2 ppm as established by the Centers for Disease Control Dental Disease Prevention Activity.

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Operational costs were calculated to include the actual chemical costs, maintenance and repair costs (calculated at 2.4% of initial costs), and labor costs. Labor costs were based on one hour per day for 365 days at $7.00 per hour for the small systems (<10,000) and $9.00 per hour for the medium and large systems (personal communication from Thomas G. Reeves, national fluoridation engineer, Centers for Disease Control). The 2.4 percent of initial cost for maintenance and repairs was derived from system upgrade data.

Results

There were 44 communities with complete data that implemented water fluoridation between May 1980 and June 1988. The populations of the communities varied from 1,500 to 430,000 (Table 1). One of the communities (New Smyrna Beach) used sodium silicofluoride and one (Hawthorne) a saturator with sodium fluoride. The rest used hydrofluosilic acid. Initial costs varied from $7,376 for a one-injection-point system to $190,890 for a 25-injection-point acid system. Costs per injection site varied from $7,376 to $92,061 for one site; from $6,416 to $59,009 for two or three sites; and from $6,974 to $17,486 for four or more sites. The average cost of chemicals was $0.19 per person for the year 1988. Total operating cost averaged $0.30 per person. After adjustment to 1988 dollars, the total installation cost was $1.10 per person (Table 1). The annualized depreciation cost over 15 years at 1988 dollars was $0.09 at 2 percent and $0.40 at 4 percent (Table 2).

TABLE 1
Costs of Water Fluoridation Deflated to 1988 Dollars Using the General Equipment Component of the GNP Price Deflator and the Florida County Price Index

City	Population	Year Funded	Injection Points	Chemical Cost/ Person ($)	Total Labor Costs ($)	Total Operating Costs ($)	Total Installation Costs ($)
Tampa	430,000	88	2	0.11	4,573	53,395	53,403
Ft. Lauderdale	237,350	81	2	0.24	5,731	62,089	118,017
Lakeland	118,350	82	1	0.23	4,926	32,413	92,061
Tallahassee	116,239	88	25	0.23	7,438	34,459	190,890
Sunrise	90,000	83	1	0.16	4,571	19,025	56,324
Tamarac	59,000	86	1	0.08	4,171	9,042	35,659
Titusville	47,500	83	1	0.14	3,852	10,274	29,374
Pembroke	46,221	88	1	0.16	3,969	11,516	25,399
Coral Springs	46,000	88	1	0.10	3,865	8,356	21,519
Port Orange	44,240	82	1	0.11	3,753	8,716	24,814
New Smyrna Beach	32,000	83	1	0.18	4,923	10,544	85,073
Seminole	31,635	86	8	0.20	6,155	12,347	137,065
Kissimmee	29,200	81	2	0.18	3,509	8,635	12,831
Homestead	27,500	85	2	0.30	4,843	13,080	66,193
Vero Beach	27,000	84	1	0.30	4,327	12,518	52,096
Lake City	21,000	82	1	0.16	3,935	7,231	38,977
Okeechobee	20,451	82	1	0.09	3,571	5,403	16,171
Eustis	17,301	84	3	0.29	3,834	8,860	29,496
Auburndale	16,788	85	2	0.15	3,829	6,290	29,018
Haines City	14,910	86	2	0.26	4,232	8,152	47,767
Longwood	14,877	82	2	0.25	4,041	7,693	39,078
Avon Park	13,800	81	1	0.27	3,537	7,325	15,341
Niceville	13,090	81	6	0.41	3,942	9,294	41,841
Milton	12,890	85	4	0.44	4,508	10,202	69,944
Ocoee	12,500	86	3	0.42	3,816	9,061	24,669
Crestview	9,640	83	5	0.46	4,402	8,818	64,556
Inverness	8,640	86	2	0.34	3,914	6,871	32,469
Quincy	8,611	87	1	0.39	3,640	6,982	18,183
Marianna	7,600	87	3	0.46	3,880	7,398	32,392
Live Oak	7,263	82	1	0.40	3,512	6,432	14,187
Madison	6,160	85	1	0.41	3,453	5,978	10,027
Brooksville	6,000	85	3	0.54	3,969	7,204	36,612
Lake Mary	5,900	85	1	0.32	3,494	5,390	10,534
Tavares	5,230	83	2	0.46	3,556	5,968	14,671
Chipley	4,760	87	1	0.37	4,185	5,926	49,363
Green Cove Springs	4,486	82	1	0.28	3,484	4,729	10,848
Belleair	3,950	86	1	0.30	3,743	4,912	19,497
Lake Alfred	3,900	82	1	0.29	3,755	4,869	26,351
Monticello	3,500	87	2	0.55	3,908	5,817	33,686
Hillsboro Beach	3,000	82	1	0.41	3,555	4,781	14,313
Umatilla	2,700	84	1	0.42	3,422	4,560	7,376
Century	2,300	86	1	0.36	3,633	4,450	18,309
Hawthorne	1,610	81	1	0.87	3,417	4,820	7,923
Gretna	1,500	86	2	0.39	3,921	4,507	33,786
Grand totals	1,636,601		106	315,638	180,694	496,332	1,808,103
Mean cost/person				0.19	0.11	0.30	1.10
Mean cost/system				7,174	4,107	11,280	41,093
SD/system				11,350	770	11,831	36,190

TABLE 2
1988 Annualized Depreciation Costs, Opportunity Costs, and Total 1988 Costs per Person

City	Pop.	1988 Annualized Depreciation Cost ($)		All 1988 Costs Less Interest ($)		1988 Annual Interest Inst. Cost ($)		1988 Total Cost ($)		1988 Total Costs/ Person ($)	
		2%	4%	2%	4%	2%	4%	2%	4%	2%	4%
Tampa	430,000	4,156	4,803	57,551	58,198	1,068	2,136	58,619	60,334	0.14	0.14
Ft. Lauderdale	237,350	9,185	10,615	71,274	72,704	2,360	4,721	73,634	77,424	0.31	0.33
Lakeland	118,350	7,165	8,280	39,578	40,693	1,841	3,682	41,419	44,375	0.35	0.37
Tallahassee	116,239	14,856	17,169	49,315	51,628	3,818	7,636	53,133	59,264	0.46	0.51
Sunrise	90,000	4,383	5,066	23,408	24,091	1,126	2,253	24,535	26,344	0.27	0.29
Tamarac	59,000	2,775	3,207	11,817	12,249	713	1,426	12,530	13,676	0.21	0.23
Titusville	47,500	2,286	2,642	12,560	12,916	587	1,175	13,148	14,091	0.28	0.30
Pembroke	46,221	1,977	2,284	13,493	13,800	508	1,016	14,001	14,816	0.30	0.32
Coral Springs	46,000	1,675	1,935	10,031	10,291	430	861	10,461	11,152	0.23	0.24
Port Orange	44,240	1,931	2,232	10,647	10,948	496	993	11,143	11,940	0.25	0.27
New Smyrna Beach	32,000	6,621	7,652	17,165	18,196	1,701	3,403	18,866	21,598	0.59	0.67
Seminole	31,635	10,667	12,328	23,014	24,675	2,741	5,483	25,755	30,157	0.81	0.95
Kissimmee	29,200	999	1,154	9,634	9,789	257	513	9,890	10,302	0.34	0.35
Homestead	27,500	5,152	5,954	18,232	19,034	1,324	2,648	19,555	21,681	0.71	0.79
Vero Beach	27,000	4,054	4,686	16,572	17,204	1,042	2,084	17,614	19,287	0.65	0.71
Lake City	21,000	3,033	3,506	10,264	10,737	780	1,559	11,044	12,296	0.53	0.59
Okeechobee	20,451	1,259	1,454	6,662	6,857	323	647	6,985	7,504	0.34	0.37
Eustis	17,301	2,296	2,653	11,156	11,513	590	1,180	11,745	12,693	0.68	0.73
Auburndale	16,788	2,258	2,610	8,548	8,900	580	1,161	9,129	10,061	0.54	0.60
Haines City	14,910	3,717	4,296	11,869	12,448	955	1,911	12,825	14,359	0.86	0.96
Longwood	14,877	3,041	3,515	10,734	11,208	782	1,563	11,516	12,771	0.77	0.86
Avon Park	13,800	1,194	1,380	8,519	8,705	307	614	8,826	9,318	0.64	0.68
Niceville	13,090	3,256	3,763	12,550	13,057	837	1,674	13,387	14,731	1.02	1.13
Milton	12,890	5,443	6,291	15,645	16,493	1,399	2,798	17,044	19,291	1.32	1.50
Ocoee	12,500	1,920	2,219	10,981	11,280	493	987	11,474	12,267	0.92	0.98
Crestview	9,640	5,024	5,806	13,842	14,624	1,291	2,582	15,133	17,206	1.57	1.78
Inverness	8,640	2,527	2,920	9,398	9,791	649	1,299	10,047	11,090	1.16	1.28
Quincy	8,611	1,415	1,635	8,397	8,617	364	727	8,761	9,345	1.02	1.09
Marianna	7,600	2,251	2,913	9,919	10,311	648	1,296	10,567	11,607	1.39	1.53
Live Oak	7,263	1,104	1,276	7,536	7,709	284	567	7,820	8,276	1.08	1.14
Madison	6,160	780	902	6,758	6,880	201	401	6,959	7,281	1.13	1.18
Brooksville	6,000	2,849	3,293	10,053	10,497	732	1,464	10,786	11,961	1.80	1.99
Lake Mary	5,900	820	947	6,210	6,337	211	421	6,420	6,759	1.09	1.15
Tavares	5,239	1,142	1,320	7,110	7,288	293	587	7,403	7,874	1.41	1.50
Chipley	4,760	3,842	4,440	9,768	10,366	987	1,975	10,755	12,340	2.26	2.59
Green Cove Springs	4,486	844	976	5,573	5,705	217	434	5,790	6,139	1.29	1.37
Belleair	3,950	1,517	1,754	6,429	6,666	390	780	6,819	7,445	1.73	1.88
Lake Alfred	3,900	2,051	2,370	6,920	7,239	527	1,054	7,447	8,293	1.91	2.13
Monticello	3,500	2,622	3,030	8,439	8,847	674	1,347	9,112	10,194	2.60	2.91
Hillsboro Beach	3,000	1,114	1,287	5,895	6,068	286	573	6,181	6,641	2.06	2.21
Umatilla	2,700	574	663	5,134	5,223	148	295	5,282	5,518	1.96	2.04
Century	2,300	1,425	1,647	5,875	6,097	366	732	6,241	6,829	2.71	2.97
Hawthorne	1,610	617	713	5,437	5,533	158	317	5,595	5,850	3.48	3.63
Gretna	1,500	2,629	3,039	7,136	7,546	676	1,351	7,812	8,897	5.21	5.93
Grand totals	1,636,601	140,716	162,623	637,048	658,955	36,162	72,324	637,211	731,279		
Mean cost/person		0.09	0.10	0.39	0.40	0.02	0.04	0.41	0.45	0.41	0.45
Mean cost/system		3,198	3,696	14,478	14,976	822	1,644	15,300	16,620	1.14	1.25
SD/system		2,817	3,255	13,764	14,092	724	1,448	14,308	15,214	0.98	1.09

When 2 percent and 4 percent interest on the initial costs were added as the opportunity cost of the investment, the final adjusted total cost per year was $0.41 per person at 2 percent and $0.45 per person at 4 percent. This was calculated by taking the total adjusted cost and dividing by the total population served. The average adjusted total cost per person by system was $1.14 at 2 percent and $1.25 at 4 percent. This is the mean of the total cost per person for the 44 communities. The total cost per person by system ranged from $0.14 to $5.21 at 2 percent and from $0.14 to $5.93 at 4 percent (Table 2).

Discussion

The chemical costs are based on actual gallons or pounds of chemical pumped per day. Chemical costs were higher in Hawthorne than Gretna because sodium fluoride was used in Hawthorne. Natural fluoride levels among the communities studied varied from 0.0 to 0.3 ppm. Fluoride chemical costs varied somewhat for similar-sized systems based on the ambient level of natural fluoride. In Florida, there are no large industrial users of community water supplies that could affect the chemical cost per person. The orange juice concentrate companies and the sugar mills have their own water systems.

"Previous studies that have not included opportunity costs have shown lower costs per person than this study."

Labor costs varied among systems. The amount of repair needed is contingent on how well and often the equipment is serviced. Sodium silicofluoride systems require more attention and servicing than do closed acid systems. Some types of system designs are more operator dependent than others. In general, the smaller manual systems require more operator time than the larger closed systems with multiple electronic monitoring devices.

There was a large difference in the total installation cost between Tavares and Chipley, which had similar sized populations. There were two additional backup auxiliary wells in Chipley that were both fully equipped, even though only one injection point was used. In addition, Chipley used a contractor for installation, which inflates installation costs; subsequently, the consultant engineer's fee was higher. Tavares bought only solution feeders and platform scales and the equipment was installed by the water operators. In some instances, the consultant engineers recommended loss-of-weight recorders, telemetry equipment, variable flow rate meters, and in-line monitoring devices, all of which affect the cost estimates among communities.

White et al. (9) have suggested ten types of cost information to be included in a complete description of a community water fluoridation program; eight of the ten have been met by these data to varying degrees of completeness. Only two of the communities (Pembroke Pines and Coral Springs) went to referendum; all others were authorized by council action as a part of their usual business. Thus, political costs were not a relevant issue. Overhead costs such as electricity, rent, shared space costs, etc., were not possible to estimate and would have represented only a very small portion of the operational costs.

The cost per person is highly dependent on the population of the community with an economy of size going to the larger communities. The total mean cost per person per installation was $1.14 per year at 2 percent and $1.25 per year at 4 percent. The mean cost at 4 percent for communities of fewer than 10,000 was $2.12; for communities between 10,000 and 50,000 it was $0.68; and for communities over 50,000 it was $0.31. The total mean cost per person across all installations was $0.41 at 2 percent and $0.45 at 4 percent.

Previous studies that have not included opportunity costs have shown lower costs per person than this study. The annual cost per capita from Newbrun's (5) work in 1974, in 1974 dollars, was from $0.13 to $0.18 per person for California communities of 85,000 to 500,000. The Florida data show an average cost per person of $0.31 from the five communities of 90,000 or more. Newbrun's data was depreciated over varying amounts of time (from ten to 50 years) and was not adjusted for opportunity costs, which, along with inflation, may explain most of the difference.

The data compiled and published by Garcia (8) show a mean cost per person by system of $0.46 at 2 percent and $0.49 at 4 percent, compared to $1.14 at 2 percent and $1.25 at 4 percent from this study. Thus, the total cost per person by system in this study were approximately two-and-one-half times higher than the cost per person published by Garcia. There are differences in costs between the two studies. This study included bulk storage and containment as part of the equipment costs. It also included labor and the opportunity costs of capital investment, which the Garcia study did not. The major difference is in the population distribution of the water systems in the two studies. The average size of the population per water systems was 514,000 in the Garcia study and 37,000 in this study. In the Garcia study, six of 16 systems served over 100,000 people and included populations of 1.1 and 4.9 million, whereas in this study only four of 44 served over 100,000. Since the cost of water fluoridation varies greatly with the size of the population served, comparison between studies of different sized systems is difficult.

This study provides a basis for estimating the cost of fluoridation for communities that are considering water fluoridation. It should be remembered, however, that costs can and do vary with system design, type of chem-

ical, equipment, natural fluoride level, and number of injection points. The one most important variable in estimating cost per person is the size of the population served. This does not mean that fluoridation is not justified for smaller systems. The benefits of fluoridation should be measured against the costs.

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