Use of a Compliance Index for Community Fluoridation

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Synopsis ....

Fluoridation of public water supplies is the best method of preventing dental caries. Yet, many water systems do not maintain the optimal concentration of fluoride. The Community Fluoridation Compliance Index was developed to provide retrospective and prospective information on water systems in complying with local and State standards. This index permits flexibility in the amounts of optimal fluoride concentration and the frequency of fluoride sample testing. In addition, the index can be modified to address the size of the population served by the water system.

The index's components are reviewed, and its use is demonstrated on 50 water systems from Illinois and 50 from Ohio. Annual data from these two States show how this information can be used for targeting corrective action so that the population receives the greatest benefit from fluoridation.

These findings suggest that the Community Fluoridation Compliance Index can be a useful administrative instrument for comparing relative compliance results. Further studies to determine its acceptance at the State and local levels are warranted.

THE PURPOSE OF COMMUNITY WATER fluoridation is to provide a safe, effective method for the prevention of dental caries. Fluoridation is considered one of the most cost-effective public health measures of this century, with most studies showing a reduction in caries of 50–65 percent when fluoridated water is consumed from birth (*1,2*). Table 1 shows the number of persons served by water systems that provide fluoridated water in the United States in 1975, 1980, and 1984 (*3,4*). Approximately 54 percent of Americans have access to water that is fluoridated either naturally or through adjustment of natural levels (*4*).

Unfortunately, the maintenance of optimal levels of fluoride by many water suppliers has been disappointing. Even with a liberal range for compliance, the voluntary, quarterly fluoridation reports of the Association of State and Territorial Dental Directors (in cooperation with the Centers for Disease Control) show only a 50–70 percent level of compliance by water systems (*5*). (Thirty-two States currently participate in this program.) Other investigators have found similar results (*6–13*), with the noncompliant water systems almost exclusively maintaining suboptimal concentrations.

Population, certification level of the water plant operator, and operator turnover have been named as factors that may influence compliance by water system operators (*9*). Another complicating factor is the differing levels of optimal fluoride concentration recommended for different geographic locations of the United States. Optimal amounts of fluoride range from 0.7 mg per liter in the southernmost part of the United States to 1.2 mg per liter in the extreme north, based on the mean maximum daily air temperature (*14*). More than two-thirds of the contiguous States have multiple optimal fluoride temperature zones crossing their borders (*15*), but many States either choose to observe one uniform concentration or use a range mandated by statute.

Individual States also have variable monitoring and water sample testing requirements. Most States require that a monthly "split sample" be sent to a central laboratory for analysis. (In a split sample, the water plant operator analyzes a portion of the distribution sample and records the results on the monthly operating report to the State. The operator then forwards the remainder of the sample to the State or an approved laboratory for analysis.) However, the range of testing may be as often as

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Table 1. Community water fluoridation in the United States: number of water systems and population served

Characteristics of national fluoridation surveys	1975[1]	1980[2]	1984[3]
Systems adjusting fluoride	6,795	4,846	5,565
Systems with natural fluoride (> 0.7 ppm)	2,630	3,010	3,010
Total systems	9,425	7,856	8,575
Population served	105,388,343	115,948,946	129,000,000

[1] Reference 3. [2] Reference 4. [3] Estimated.

weekly or as infrequent as quarterly. The uneven collection and testing requirements of States have made national fluoridation data difficult to interpret.

The purpose of our study was to assess the usefulness of the Community Fluoridation Compliance Index (CFCI) in performing fluoridation surveillance at the State and local levels. In addition, we sought to determine the degree to which monthly fluoride concentrations vary throughout the year.

Methods

The States of Illinois and Ohio were chosen because both have fluoridation statutes, legal ranges for compliance, and readily available information. Both States require daily fluoride monitoring plus a monthly split sample analysis validated by a central State laboratory.

Fifty water systems were randomly selected from all fluoridated systems in Ohio. Because of the large number of water systems that fluoridate in Illinois, a sample of 50 systems was picked randomly from the northeastern quadrant of the State (two regional territories of the State health department), where water information on each supply is located in one office. Because both States have a monthly requirement for centralized analysis, data were collected for 1984 (12 possible monthly samples). The population served and the water plant operator's certification level were noted also. Natural levels of fluoride (prior to adjustment) were not recorded because many systems had multiple water sources and consequently varying natural fluoride levels.

The CFCI was patterned after the Community Fluoridation Effectiveness Index, which was originally developed for use by the Indian Health Service of the Public Health Service. That index was developed because of the multiple optimal fluoride levels of water supplies on Indian reservations and the desire to have one overall indicator of performance that would assess current effectiveness, provide a basis for comparison within and between systems and program components, and promote improved compliance (*16*). The CFCI reflects a score based on the frequency of sampling per unit of time and degree of achievement of optimal concentration for that water system.

For each water system, the CFCI was calculated two different ways. In the first way, each system's score was determined using an unweighted mean (CFCI 1), where

a = sample fluoride concentration for the period studied,
b = optimal fluoride concentration for that period,
c = number of samples submitted for the time studied, and
d = number of samples that should have been submitted.

For each sample period (month), $a \div b$ is calculated with $0 \leq a \div b \leq 1$. If a is greater than b for that particular sample, the formula is calculated as $b \div a$, with $0 \leq b \div a \leq 1$. For each month ($_i$), let $(a \div b)_i$ be that value. When calculating the average performance score, the formula reads

$$\frac{\Sigma\ (a \div b)_i}{c}$$

where $(a \div b)_i$ is averaged over the number of samples actually reported c. This figure is multiplied by the number of samples reported c and divided by the number of samples that should have been submitted for this timeframe d. Also note that c is less than or equal to d. Thus, the formula would be expressed as

$$\text{CFCI 1} = \frac{\Sigma (a \div b)_i}{c} \times \frac{c}{d} = \frac{\Sigma (a \div b)_i}{d}$$

With this methodology, nonsubmission of samples will result in a zero score for both a and c for the individual time period because of the fixed interval sampling. The resulting score ranges from 0.0 (lowest) to 1.0 (optimum).

In the second formula for the index (CFCI 2), a weighted mean score was used where, in the absence of a monthly sample, the previous month's result was continued (variable interval sampling). Here $a \div b$ is a hypothesized average performance score, with $0 \leq a \div b \leq 1$. This score is divided by a hypothesized number of samples submitted (c_h). Because this is a hypothesized value of c and, therefore, should be equivalent to the amount of samples that could have been submitted, then $c_h = d$. Thus, the resultant formula is

$$\text{CFCI 2} = \frac{\Sigma (a \div b)_i}{d} \times \frac{c}{d} = \frac{c\,\Sigma (a \div b)_i}{d^2}$$

With this formula, only a missed component of c would be affected by a zero score for a sample that was not submitted.

The following example shows how each method was implemented, using monthly samples for 1 year. In this instance, 1.0 part per million (ppm) of fluoride will be considered the optimal level of fluoride, and the total number of samples that should be submitted equals 12 (once monthly).

Month	*Fluoride level (ppm)*	*Month*	*Fluoride level (ppm)*
1	0.99	7	. . .
2	0.75	8	0.94
3	. . .	9	0.23
4	0.91	10	. . .
5	0.98	11	0.92
6	0.84	12	1.00

$$\text{CFCI 1} = \frac{\dfrac{(.99 + .75 + 0 + .91 + .98 + .84 + 0 + .94 + .23 + 0 + .92 + 1.00)}{1.00}}{12} = 0.63$$

$$\text{CFCI 2} = \frac{\dfrac{9\,(.99 + .75 + .75 + .91 + .98 + .84 + .84 + .94 + .23 + .23 + .92 + 1.00)}{1.00}}{144} = 0.59$$

Once the resulting scores were established, we developed a method for rating performance of each water system and setting priorities for administrative action. This empirical rating scale uses the population served to determine some criterion for administrative intervention:

Population served	*Minimal acceptable CFCI scores*
50,001 or more persons	0.85
20,001-50,000 persons	0.80
5,001-20,000 persons	0.75
1,001-5,000 persons	0.70
501-1,000 persons	0.65
500 or fewer persons	0.60

This mechanism was designed so that priorities for corrective or regulatory actions could be based on the population served as well as on straight CFCI scores. For instance, if the scores calculated in the previous example applied to a water system that served 15,000 persons, either score (0.63 or 0.59) would be unacceptable for that size system, and immediate followup would be indicated. This rudimentary "triage" system could be applied routinely or in periods of manpower constraints, depending on the ability and sophistication of the regulatory agency.

For this study the following definitions were used for optimal fluoride levels. In Illinois, water system operators are required to maintain the fluoride concentration between 0.9 and 1.2 ppm. This range is the legal constraint established with passage of the Illinois fluoridation statute in 1967 (*17*). For a monthly sample, any amount within this range was deemed to indicate that a water system was in compliance with the fluoride standard. Although the Ohio fluoridation statute allows more flexibility in its range (0.8–1.3 ppm), the Ohio Department of Health has strongly encouraged water systems to maintain 1.0 ppm as the optimal fluoride concentration (*18*). Therefore, 1.0 ppm was selected as the Ohio standard in calculating the CFCI.

Results

Table 2 shows the CFCI scores from 12 monthly water samples of systems in Illinois and Ohio for both the unweighted (CFCI 1) and weighted (CFCI 2) methods of calculating the index. One Illinois facility failed to report any samples during the sampling year; the last available sample value from a previous year was used in calculating its CFCI 2. As confirmed by a paired t test, there is no statistically significant difference ($P < 0.27$) between the two methods employed in this study:

Table 2. CFCI[1] scores for random sample of water systems in Illinois and Ohio (50 systems each)

State and index method	Mean	SD	Median	Range
Illinois:				
CFCI 1	0.76	0.25	0.84	0.00–0.98
CFCI 2	0.76	0.25	0.84	0.00–0.98
Ohio:				
CFCI 1	0.86	0.12	0.90	0.43–0.96
CFCI 2	0.86	0.12	0.90	0.40–0.96

[1] CFCI = Community Fluoridation Compliance Index.

Regulatory agencies can use the index quickly to correct systems that stray from acceptable levels. This type of index also may be desirable for administrative planning as well as for clinical epidemiologists interested in a community's history of fluoride exposure.

State	Number of systems	Mean difference (CFCI 1 − CFCI 2)	SD	t value
Illinois....	50	−0.0016	0.010	−1.10
Ohio	50	−0.0004	0.005	−0.60

Only five pairs of CFCI scores differed by more than 0.01 in the sample population, with the greatest difference being 0.03.

Table 2 also shows that Ohio scores are higher than those in Illinois. Since the Illinois fluoridation law requires all public water supplies to comply with the statute regardless of their size, the Illinois sample has a disproportionate number of smaller water systems (table 3). The minimally acceptable CFCI score and number of water systems failing to meet this score also are reflected in this table. A total of 15 water systems failed to meet the acceptable CFCI score.

Each mean monthly CFCI score for Illinois and Ohio water systems is shown in table 4. All CFCI scores for each State were within one standard deviation of the minimum and maximum score.

Discussion

The CFCI is an administrative ledger for adherence to State fluoridation requirements. It is not intended as a replacement for more frequent monitoring, but as an indicator of compliance trends by fluoridated water systems. This information may provide local, State, or national data either retrospectively or prospectively for any timeframe desired. Further, regulatory agencies can use it quickly to correct systems that stray from acceptable levels. This type of index also may be desirable for administrative planning as well as for clinical epidemiologists interested in a community's history of fluoride exposure.

One advantage of the CFCI is that Federal, State, or local agencies can set the appropriate parameters for two of the four variables: optimal concentration and number of samples that should have been submitted. For instance, some people believe that fluoridation statutes implemented in the 1960s were made intentionally liberal because of the limited technical capabilities available to communities then. Now more precise technology exists, and narrower optimal ranges can be used in the implementation and surveillance of a State's fluoridation program.

The minimal differences noted between the weighted and unweighted CFCI scores indicate that either score could be successfully used. Because of the number of facilities participating in this study, any perceptible difference between the two methods would only be noticed when one looks at the third and fourth decimal place in the mean difference, as seen in the paired t tests. For bookkeeping, it may be easier to record the zero when a water system has neglected to submit a sample.

Three important considerations need to be addressed with the use of the CFCI. First, should an equal weight be given to both the appropriate frequency of submitting samples and achieving the optimal fluoride level? We agree that there may be instances when, through no fault of the water plant operator, samples may not reach the central laboratory on time. If this happens and no sample is received by the testing laboratory, the water system is given a zero. However, since regular sample submission is a key element in promoting the maintenance of a constant optimal level, we have given equal weight to both entities.

Second, the CFCI penalizes the water supply more for suboptimal levels than for exceeding optimum levels (that is, the mathematics results in a lower score when $a \div b$ is used rather than when $b \div a$ is indicated). Although we appreciate the undesirability of the cosmetic effects of consuming high levels of fluoride over long periods, the overriding concern is that most noncompliant water systems have suboptimal levels.

Finally, the southern climates may be more adversely affected if a nationwide sample is reviewed because of lower optimal fluoride concentrations (that is, the denominator would be a lower figure in southern areas; thus, any absolute difference from this number would constitute a lower score). Spears has written that variations from optimum in the South are far more significant than in cooler areas of the nation (*19*). Whether this holds true can only be determined by further testing of the index, coupled with epidemiologic studies.

The use of the population to set priorities for systems for administrative intervention is certainly an optional administrative decision. We have constructed this adjustment so that approximately 15 percent of the water systems should be followed for corrective action. A program management argument could be made that stricter monitoring of water systems serving larger populations should be accomplished before concentrating on smaller communities, given the overall potential yield in disease reduction.

The certification level of water plant operators was not factored into the index because the two States have noncomparable categories, making the comparison moot. But within a State such comparisons could provide officials with information on training requirements. Although other factors may also be associated with the proper maintenance of fluoride levels (*9*), they were not incorporated into the index.

Monthly variations in fluoride compliance have not been widely reported in the literature. Speculation exists that some of the following factors may adversely affect the maintenance of optimal fluoride levels: water demand during the summer (watering of lawns); vacations of water system operators (because they may not leave a reliable replacement), especially in the summer; operators assuming other seasonal responsibilities (especially true in smaller communities); turnover of personnel; faulty feed or testing equipment; and lack of information. This study demonstrated neither monthly nor seasonal differences (table 4).

Conclusion

The CFCI is a statistic that can assist local, State, and national personnel in evaluating and monitoring fluoridation performance in the maintenance of consistent optimal levels. Variables such as geographic differences that give rise to differing optimal fluoride levels and frequency of sample testing are included in a single statistic in order to characterize overall performance in a way that allows rank ordering of water systems for relative compliance. This allows a simple comparison of the index with values calculated from previous times and comparison with results from other systems. Populations served can also be incorporated in the index to help establish guidelines for corrective action.

The generic nature of this index allows a means for analysis of any particular time interval, but may also identify long-term trends. Further, the index may provide valuable background information in communities where clinical dental caries studies are performed.

Table 3. Sample distribution by population served and number of surveyed water systems below CFCI[1] limit

Population served	*Illinois*	*Ohio*	*Number below CFCI limit (Illinois and Ohio)*
50,001 or more persons	1	8	2
20,001–50,000 persons	4	9	1
5,001–20,000 persons	7	22	3
1,001–5,000 persons	16	10	2
501–1,000 persons	5	1	2
500 or fewer persons	17	0	5
Total	50	50	15

[1] CFCI = Community Fluoridation Compliance Index.

Table 4. 1984 mean monthly CFCI[1] for 50 water systems in Illinois and 50 in Ohio

	Illinois		*Ohio*	
Month	*Mean index*	*SD*	*Mean index*	*SD*
January	0.82	0.32	0.87	0.21
February	0.72	0.40	0.85	0.24
March	0.74	0.40	0.82	0.29
April	0.74	0.41	0.88	0.20
May	0.66	0.43	0.88	0.19
June	0.78	0.38	0.89	0.15
July	0.74	0.38	0.82	0.28
August	0.85	0.38	0.86	0.23
September	0.77	0.35	0.86	0.23
October	0.82	0.31	0.86	0.26
November	0.78	0.35	0.88	0.23
December	0.76	0.38	0.90	0.19

[1] CFCI = Community Fluoridation Compliance Index.

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Marketing Family Planning Services in New Orleans

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Synopsis ....

The health care profession is witnessing a shift in focus from the interests and needs of the service provider to those of the potential consumer in an effort to attract and maintain clients. This study illustrates the role that marketing research can play in the development of program strategies, even for relatively small organizations. The study was conducted for Planned Parenthood of Louisiana, a recently organized affiliate that began offering clinical services in May 1984, to provide information on the four Ps of marketing: product, price, place, and promotion.

Data from telephone interviews among a random sample of 1,000 women 15-35 years old in New Orleans before the clinic opened confirmed that the need for family planning services was not entirely satisfied by existing service providers. Moreover, it indicated that clinic hours and the cost of services were in line with client interests. The most useful findings for developing the promotional strategy were (a) the relatively low name recognition of Planned Parenthood and (b) a higher-than-expected level of interest that young, low income blacks expressed in using the service.

THERE IS A GROWING AWARENESS of the importance of marketing in the health care profession. To attract and maintain clients, service providers are increasingly interested in learning how their service or product can be made more attractive to potential clients. Although there was some initial