Determining Optimum Fluoride Concentrations

DONALD J. GALAGAN, D.D.S., M.P.H., and JACK R. VERMILLION, M.P.H.

On the basis of the fluid intake study in Antioch and Brentwood, Calif., reported on pp. 484–490, Dr. Galagan and Mr. Vermillion, of the Public Health Service, have developed the method described here for determining optimum fluoride concentrations in water supplies. This method takes into account the effect of environmental temperature on water consumption among children.

THE FLUID intake study among children in Antioch and Brentwood, Calif., in 1953–54 provides a basis for determining the optimum fluoride concentration in water supplies in relation to environmental temperature. This study showed that for every degree increase in maximum daily temperature between 50° and 100° F. water intake increased, on the average, by 0.062 ounces per pound of body weight. For example, the average daily water consumption per pound of body weight was 0.272 ounces when the maximum daily temperature was 50° F. and 0.334 ounces when the maximum daily temperature was 60° F.

The relationship between maximum temperature and water intake for the California children was described by the estimation equation "ounces of water per pound of body weight= $-0.038+0.0062$ temperature." The validity of this equation should perhaps be checked by studies in other areas of the country, but in the meantime it can be used to illustrate the calculation of optimum fluoride concentrations. As will be pointed out later in the paper, results obtained with the equation in the Chicago area, where optimum fluoride concentration is known from epidemiological studies, indicate that it is reasonably reliable.

The basic structure of the formula developed for estimating optimum fluoride concentrations is: parts per million of fluoride=optimum water consumption÷estimated water consumption. Thus, the optimum fluoride concentration for a given community is equal to a constant (the average amount of water containing 1 p.p.m. fluoride that affords optimum protection against dental caries) divided by the estimated water consumption of children in a given community. Both measures are in ounces of water consumed daily per pound of body weight.

If daily maximum temperature data for the Chicago area are applied to the water estimation equation, it is possible to calculate a denominator value for the formula, that is, the average amount of water that would be consumed daily per pound of body weight by children in the Chicago area aged 10 years or less. The number derived, although it has no particular meaning in itself, may also serve as the constant for the formula, since it is known from epidemiological data that the optimum fluoride concentration for the Chicago area is 1 p.p.m. The constant, or numerator, in the formula must equal the estimated water consumption, or denominator, for the optimum fluoride concentration to be 1 p.p.m.

The estimated water consumption for the Chicago area children is based on weather data for two towns, Maywood and Joliet. Since both of these towns were included in the early studies of Dean (*1*), the fluoride concentration

Table 1. Mean maximum temperatures and calculated optimum fluoride concentrations for selected communities in the United States

Community	Mean maximum temperature [1]	Calculated optimum fluoride concentration
Arizona:		
Chandler Heights	85.3	0.7
Tucson	82.6	.7
California:		
Los Angeles	73.9	.8
San Francisco	61.7	1.0
District of Columbia	68.7	.9
Illinois:		
Joliet	61.6	1.0
Maywood	61.8	1.0
Louisiana:		
New Orleans	78.7	.8
Shreveport	77.7	.8
Montana:		
Billings	59.1	1.0
Butte	51.7	1.2
North Carolina:		
Charlotte	72.7	.8
Rocky Mount	73.2	.8

[1] Based on temperature data for the 5-year period 1951–55 from U. S. Weather Bureau publications entitled "Climatological Data."

and the fluorosis index are known. Although both communities have more than 1 p.p.m. of fluoride in their water supplies, 1 p.p.m. is considered the optimum concentration.

The estimated average water consumption, the denominator of the formula, which is hereafter called E, is calculated by obtaining the mean maximum temperature for at least a 5-year period for the community in question and substituting this figure in the estimation equation $E = -0.038 + 0.0062$ temperature. The resulting value represents the average number of ounces of water per pound of body weight that children through 10 years of age would be expected to drink daily under the temperature conditions of the community. The E value for both Maywood and Joliet is 0.34, and, as explained previously, this number may serve as the constant for the formula.

The value 0.34 for the constant is reasonable from the standpoint of optimum fluoride ingestion through water. For example, again in terms of average phenomena, 0.34 ounces of water fluoridated at 1 p.p.m. contains approximately 0.011 mg. of fluoride. In the fluid intake study in California, the average body weight of children studied was about 46.5 pounds. At this weight, the children ingest about 0.5 mg. of fluoride daily through their drinking water. This amount is similar to other estimates of the amount of fluoride that should be ingested through water for optimum dental health (*2*). This fact tends to strengthen confidence in both the constant and the water estimation equation from which it was derived.

With the formula "parts per million of fluoride$=0.34 \div E$," optimum fluoride concentrations have been calculated for selected communities representing various geographic areas throughout the United States. The results are shown in table 1. For the cities listed, the lowest concentration, 0.7, is suggested for the Arizona communities; the highest, 1.2, for Butte, Mont.

To obtain a fluoride concentration lower than 0.7 p.p.m. with this formula, the mean maximum temperature would have to average at least 90.6° F. To obtain one greater than 1.2 p.p.m., the mean maximum temperature would have to be lower than 50° F. The possibility of the occurrence of either of these extremes in the United States seems remote. Consequently, it is not expected that the optimum concentration for any community would be outside the range 0.7–1.2 p.p.m. generally recommended for fluoridation.

In the practical application of the method described here for determining optimum fluoride concentrations, it is not necessary to make calculations for each community. Opti-

Table 2. Mean maximum temperatures and corresponding recommended optimum fluoride concentrations

Mean maximum temperature (degrees Fahrenheit)	Recommended optimum fluoride concentration (parts per million)
50.0–53.7	1.2
53.8–58.3	1.1
58.4–63.8	1.0
63.9–70.6	.9
70.7–79.2	.8
79.3–90.5	.7

mum fluoride levels for ranges of mean maximum temperatures from 50° through 90.5° F. are presented in table 2. The optimum fluoride concentration for a community may be determined simply by obtaining the mean maximum temperature for a 5-year or longer period from appropriate publications of the United States Weather Bureau and then referring to this table.

Two points must be stressed in the application of this method. First, the temperature figure should be at least a 5-year average for the figure to be truly representative. Second, the mean maximum temperature in degrees Fahrenheit is the only measure that can be used since the method is based on an equation for estimating water consumption in which this measure is used.

Summary

The following formula, which takes into account variations in environmental temperature, is suggested for determining optimum fluoride concentrations for community water supplies:

$$\text{parts per million of fluoride} = \frac{0.34}{E}$$

The figure 0.34 (optimum water consumption) was calculated from data for an area where the optimum fluoride concentration is known. E is the estimated average daily water intake for children through 10 years of age in ounces per pound of body weight. It may be calculated from the estimation equation $E = -0.038 + 0.0062$ temperature, where temperature is the mean maximum temperature in degrees Fahrenheit.

A table showing suggested optimum fluoride concentrations for communities with 5-year mean maximum temperatures of 50° through 90.5° F. is presented.

REFERENCES

(1) U. S. National Institutes of Health: Epidemiological studies of fluoride waters and dental caries. Collection of eight previously published papers by various authors. Washington, D. C., U. S. Government Printing Office, 1949.

(2) McClure, F. J.: Ingestion of fluoride and dental caries. Quantitative relations based on food and water requirements of children 1 to 12 years old. Am. J. Dis. Child. 66: 362–369, October 1943.

Training in Care of Prematures

The institutes for physicians and nurses in the care of premature infants at the New York Hospital-Cornell Medical Center will begin their ninth year in the fall of 1957. The institutes are sponsored by the New York State Department of Health and the Children's Bureau.

The training is designed for physicians and nurses in charge of hospital premature nurseries and premature centers, and medical and nursing directors and consultants in State and local premature programs.

Attendance at each institute is limited to six physician-nurse teams. The program for physicians lasts 2 weeks and that for nurses, 4 weeks. Participants pay no tuition fee, and stipends are provided to help cover expenses during attendance. Institutes are scheduled to start on September 30, 1957, November 18, 1957, and January 6, 1958. If the number of applicants is sufficient, fourth and fifth institutes will be scheduled, beginning March 3, 1958, and late in April or May 1958.

For additional information write to Box 143, Institute in the Care of Premature Infants, New York Hospital, 525 East 68th Street, New York 21, N. Y.