Nationwide Water Sampling for Fluoride and Trace Element Composition Data

P.R. Pehrsson, R. Cutrufelli, K.Y. Patterson, N.J. Miller-Ihli, J.M. Holden, D. Trainer, J. Wilger, ARS, USDA, Beltsville, MD, C.R. Perry, NASS, USDA, Fairfax, VA, and J. Heilman, U of Iowa, Iowa City, IW

ABSTRACT

Objective: The Nutrient Data Laboratory recently conducted two nationwide studies for the estimation of fluoride and trace elements in the US municipal water supply. This presentation summarizes the sampling approach and implementation. **Methods and Materials:** The first sample collection was conducted collaboratively with the Food Composition Laboratory (FCL), USDA, to determine the variability of the mineral content of municipal water supplies. The self-weighted, population-based, stratified sampling design used was developed with National Agricultural Statistics Service (NASS) statisticians for the National Food and Nutrient Analysis Program (NFNAP), a NIH-USDA program to expand and improve the USDA National Nutrient Databank. Water samples were collected from a total of 26 locations over 3 seasons. The second collection, conducted in 2003, was part of a collaborative effort with the Nutrition Coordinating Center (NCC) at the University of Minnesota, as part of the National Fluoride Database and Intake Assessment Study (NFDIAS) and supported by the NIH-National Institute of Dental and Craniofacial Research and the National Heart, Lung, and Blood Institute (Interagency Agreement #Y1-HV-8116). A larger scale sampling frame was developed and modeled after the NFNAP design, employing results of mixed model analyses of the original data. A total of 288 water samples were obtained from 72 counties in the 48 conterminous states, including 2 locations per county and 2 pickups over time. Steps taken to assure water sample integrity included: development of rigorous shipping protocols for the water samples; coordination of sample handling and quality control; and development of easy-to-use water collection materials. Integral to the study approval (federal Office of Management and Budget), the actual water collection and participant completion of a household water survey was an effort to maximize respondent rates. **Results**: Preliminary data on fluoride content and variability in municipal water supplies are presented. **Significance**: Data on the mineral content of water have been included in the USDA National Nutrient Database for Standard Reference Release 16, 2003. Under the NFDIAS, the fluoride data will be released in the National Fluoride Database and adapted to support the NCC fluoride intake assessment methodology. Standardized sampling procedures will allow the development of reliable, nationally representative data on the mineral and fluoride content of drinking water, and provide crucial information for clinical and dental applications and research.

BACKGROUND

The National Food and Nutrient Analysis Program (NFNAP) is a research program dedicated to long-sought improvements to the USDA National Nutrient Databank, through comprehensive revisions of scientific concepts and technical approaches. Through this program, better estimates of the mean nutrient content of foods and variance indicators will permit improved accuracy in assessment of nutrient intakes of individuals in the U.S. This will enhance the ability to detect etiologic relationships, assess time trends in nutrient intakes, and define and serve populations at nutritional risk. Among these nutrients, the importance of representative fluoride data for drinking water and water used in recipes and formulations in the database is crucial to supporting research and treatment in dental and bone health. The goals of this research are to are to generate highly representative, unbiased national estimates of fluoride content of selected foods and beverages consumed by the US population and reliable estimates of variability. Sampling plans were developed for those foods and beverages that are considered significant contributors of fluoride. These data will be used to support USDA's database and the University of Minnesota's Nutrition fluoride intake assessment software - National Fluoride Database and Intake Assessment Study, or NFDIAS. To support NFNAP, trace mineral values were also generated from these samples.
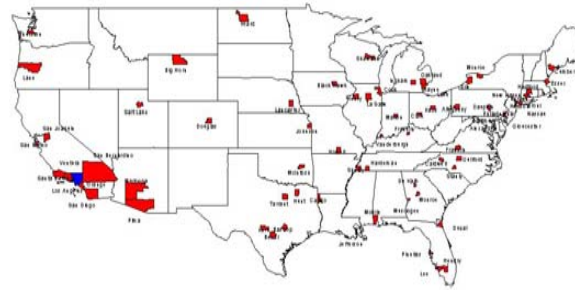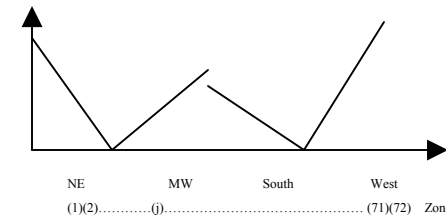
Figure 1.

SAMPLED COUNTIES USING CENSUS STATE FRAME

Figure 2. Census ordering of gCMSAs (population by zone and region)

NE   MW   South   West
(1)(2)............(j)..(71)(72) Zones

METHODS AND MATERIALS

Step 1. Pilot study, Food Composition Lab/Nutrient Data Lab, USDA
• Residential water sampling in 24 locations; 3 pickups over 3 seasons.
• Analysis of fluoride (1) and trace mineral data.

Step 2. Mixed Model Analysis and ANOVA of pilot study (1) results:
• Most variabiity determined to come from among geographically close locations and over time, not among regions.
• At least 288 samples needed for 90% confidence level.

Step 3. Prepared Sampling Frame Data
• County and state code, name and 2000 Population Census
• Code, name, population of Census consolidated metropolitan statistical area (CMSA)
• Counties not in CMSA assigned county values and called generalized CMSA
• Local urbanicity indices (applied within CMSA)

Step 4. Sampling Design Development
• US population from 2000 Population Census ordered by county, divided into 72 equal zones
• 1 county selected from each zone with probability minimum replacement (PMR)
• 2 locations (residential or retail outlets) selected in each sampled county (Figure 1)
• Samples for residential water collected at 2 different times
• Substitution list used to replace refusals in water collection

Step 5. Census State Ordering
• Sort by Census regions, division, state; sort counties serpentinely by gCMSA size (Figure 2)
• Within gCMSA, sort serpentinely by urbanicity
• gCMSA in odd numbered states decrease in size; those in even numbered states increase in size
• Similar pattern for urbanicity within gCMSAs

Step 6. Survey approval, Office of Management and Budget (concurrent with above steps)
• Federal Register announcement of the study, approval by OMB of process, survey and incentives

Step 7. Subject Recruitment
• Phone call recruitment of participants from comprehensive phone listings of selected locations
• Phone listings clustered by neighborhood to assure likeness between primary contact (1st in list) and subsequent residents in list (when refusal conversion unsuccessful)
• Followup letters confirming date of pickup; Superior, Inc. agents contracted to pick up samples, surveys

Step 6. Water sample pickup and survey
• First pickup – February-March, 2003
• Second pickup – April-June, 2003

Table 1.Municipal Water: Trace Mineral Data, SR16*

Mineral	Mean ± se (mg/100g)	n
Ca (mg)	2 ± 0.1	149
Fe (mg)	0.00	153
Mg (mg)	1 ± 0.04	150
P	0	155
K	0	148
Na	2 ± 0.2	141
Zn	0.00	151
Cu	.007 ± .001	134
Mn	0.000	151

*"0" values indicate below reporting level.

RESULTS AND DISCUSSION

NDL and statisticians from the NASS developed a unique sampling plan for generating estimates of fluoride in specific retail foods and nutrients (2). The model for sampling of drinking water in 144 locations across the U.S. was based on the NFNAP sampling approach and was appropriate for the scope, funding and goals of the project. Advantages in using the Census State approach include standard regions and division,and the correct number of samples were allocated to each region, division and state. The disadvantage was that this approach does not necessarily guarantee a good distribution of samples across county population sizes. The 1999 pilot study, conducted collaboratively with FCL and for which trace mineral data are presented in Table 1, was the predecessor to the sampling design presented. These values have been reported in USDA Standard Reference, Release 16 and will be updated with new data from this research. The mean fluoride content for fluoridated (defined as >0.70 μg/ml) U.S. municipal water from the 1999 pilot research was 1.01 ± 0.15 μg/ml (1). Results also showed 40% of the water supply to be fluoridated, introducing the obvious challenge in managing data of non-normal distribution. The results also emphasized the need for the current study. As part of this research, 144 first samples and 142 second samples are currently being analyzed for fluoride content. Fluoride values will be released in the National Fluoride Database, on NDL's Home Page (www.nal.usda.gov/fnic/foodcomp) and in SR, Release 17, in early 2004.

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