Fluoride Consumption: The Effect of Water Fluoridation

Executive Summary:

Full fluoride data from the National Diet and Nutrition Survey 2000-2003 were used to examine questions outstanding from the Fluoridation of Water Supplies review process.

- Fluoride consumption from all sources exceeds the safe intake defined by the Committee on Medical Aspects of Food Policy in a quarter of the population, regardless of water fluoride concentration.
- In areas supplied with fully fluoridated water, fluoride intake exceeds safe intake in nearly two thirds of consumers.

The implications are discussed and recommendations are made.

Introduction

The systematic review of water fluoridation[1] identified a need for information about consumption of fluoride from all sources. During the consequent MRC Working Party the results of the 2000 National Diet and Nutrition Survey (NDNS)[2] were awaited. This periodic survey of a random sample of people from England and Scotland included for the first time a 24-hour urine collection in which fluoride concentration was determined. The MRC working group commented[3] "Additional recommendations for future research will depend to some extent on whether results (from the NDNS urinary fluoride analyses) are in line with existing estimates of total fluoride intake." They suggested, whatever the outcome from the NDNS, that

- periodic 24 hour urinary fluoride sampling should remain a feature of at least some national diet surveys
- fluoride ingestion (from all sources) … and fluoride retention should be measured in children
- the relative importance of water as a source of fluoride ingestion in children should be determined.

Method

As a member both of the Advisory Panel to the original systematic review, and of the MRC Working Group, the author obtained and re-analysed the raw data on urinary analytes from the NDNS[4]. An error came to light in the interpretation of urinary fluoride concentration[5], which The Food Standards Agency acknowledged and corrected[6]. Tap water fluoride concentration, which had been measured for most of the NDNS sample, had not been further analysed by Henderson et al, but the original data were obtained by courtesy of the Chief Dental Officer and merged with the urine data. The sample populations were compared with the provisional findings for the Census 2001, stratified to match the sampling frame for the NDNS. The consolidated data were then tabulated according to total fluoride consumption and water fluoride concentration.

Results

1: Excessive Fluoride Intake

The NDNS sample of 1725 subjects who completed a food diary was confirmed not to be significantly different in respect of age and gender from the expected population reconstructed from the Census 2001 (χ^2 11.37, 7 degrees of freedom, $p>0.1$).

The 1459 subjects for whom urine data were complete[7], and the 1395 for which both urine data and tap water fluoride were known, both differed very significantly from the interview sample (χ^2 80 with 7 degrees of freedom, $p<<0.001$). Men up to age 34 were under-represented, in favour of those aged 35-49. The difference from census expectation was less marked (χ^2 54) but still highly significant.

The 1395 subjects providing both urine and tap water samples were no different from the 1459 providing urine only (χ^2 0.197, $p>0.995$)[8].

Because fluoride was only one of several analytes of interest in the urine study, it seems unlikely that any selection error, due for example to interest in the issue of water fluoridation, would account for the difference between these subjects and the population at large. It seems most likely that collection of a 24-hour urine sample raised insuperable difficulties for some subjects in full-time employment.

A detailed recalculation of NDNS Table 4.4[9] has not been published. The author has avoided this because NDNS Table 4.4 does not allow for a weight-related safe intake, the value of 0.05mg/kg/day established by CoMA for the UK[10]. The NDNS team used a safe intake of 3μM/kg/day, 14% higher than the established definition.

A corrected version of Table 4.4 is given in Table One, using the higher NDNS value of safe intake (SI):

TABLE ONE: NDNS Urine collection subjects
Proportion Consuming more that 3μMF/kg/day, if 90% of ingested fluoride is assimilated, 50% of that is sequestered in calcified tissues and only the remainder is excreted in urine

Age/gender group	At or below SI	>SI	Total	%>SI
Male 19-24	39	4	43	9.3
Male 25-34	114	11	125	8.8
Male 35-49	224	48	272	17.6
Male 50-64	152	52	204	25.5
All Males	**529**	**115**	**644**	**17.9**
Fem 19-24	56	5	61	8.2
Fem 25-34	136	31	167	18.6
Fem 35-49	240	77	317	24.3
Fem 50-64	180	60	240	25.0
All Females	**612**	**173**	**785**	**22.0**
TOTAL	**1141**	**288**	**1429**	**20.2**

This finding is an order of magnitude higher than the figures (1% for males, 3% for females) published in the original NDNS report. But the proportion of subjects

consuming more than the lower, better-established CoMA definition of safe intake was higher still, at 25.05%.

2: Relevance of Water Fluoride

Data from 1373 subjects were available for cross-tabulation of tap water fluoride concentration and daily fluoride consumption. Of these only 75 lived in fully fluoridated areas of the West Midlands, with water supplies containing 0.8 parts per million fluoride (ppmF) or more. Another 38 received water at around 0.4ppmF, mainly in North Tyneside. The remaining 1260 subjects received tap water of lower fluoride concentration.

Table Two summarises total fluoride intake in the sample ranked according to tap water F concentration.

TABLE TWO:

		Total F Intake	
Tap Water F conc'n		**>CoMA SI**	
ppm	Number	number	%
<0.3	1260	275	21.8
0.3<0.8	38	20	52.6
0.8+	75	49	65.3
Total	1373	344	25.1

At any level of water fluoride above 0.3ppm the proportion of consumers receiving more than the CoMA safe intake of fluoride rises steeply. The differences are highly significant (χ^2 65, 2 degrees of freedom, p<<0.001). The 1260 recipients of lower tap water fluoride concentrations were subdivided into 0.02ppmF intervals but showed no trend in relation to their total fluoride intake.

The data were then ranked in order of total fluoride intake to set water fluoride in perspective. The results are shown in Table Three.

TABLE THREE:

		> NDNS-SI		Ppm F in water supply			
Daily F mg	No	No	%	0-0.29	0.30+	Total	% 0.3+
10.0+	19	19	100.0	11	7	18	38.9
8.0-9.9	28	28	100.0	19	7	26	26.9
6.0-7.9	80	78	97.5	56	19	75	25.3
5.0-5.9	80	70	87.5	63	15	78	19.2
4.0-4.9	117	41	35.0	97	16	113	14.2
3.0-3.9	174	25	14.4	147	22	169	13.0
2.0-2.9	325	1	0.3	300	15	315	4.8
1.0-1.9	376	0	0.0	346	10	356	2.8
<1.0	232	0	0.0	217	2	219	0.9
TOTAL	1431	262		1256	113	1369.0	8.3

The steeply rising proportion of higher-consuming subjects receiving fluoridated water is highly significant (χ^2 120, 8 degrees of freedom, $p<<0.001$). Almost all subjects consuming 5mg F/day or more are receiving more than either definition of Safe Intake.

Discussion

These results are in line with a recent Irish study that replicated the NDNS method in three fully-fluoridated neighbourhoods of County Donegal. Fluoride consumption for 22 of the 30 subjects (73%) was at or above the NDNS safe intake[11].

Various authors have related fluoride exposure to various grades of impairment, but recently most refer to Smith and Hodge[12], who were chiefly concerned with rapid occupational exposures. They noted an asymptomatic stage with some radiological signs, at concentrations up to 5,500ppm fluoride in bone ash. Joint pain and stiffness, with radiological osteosclerosis, were noted at concentrations around 6000-7000ppm. More chronic symptoms with ligamentous calcification supervened between 7,500-9000ppm. Severe disability began at above this level.

The rate of exposure required to achieve these accumulated concentrations has been controversial. Hodge maintained that it would take consumption of 20-80mgF/day for 10-20 years to produce crippling skeletal fluorosis. He repeatedly quoted this figure up to 1979[13] [14] and attributed it to Møller[15]. However in the same paragraph he acknowledges Roholm's[16] contrasting estimate of 0.2-0.35mg fluoride/kg body weight/day. He may have mistakenly equated this to Møller's figure, by using weights in pounds (100-229) rather than kilograms (45-100). He did in 1979 eventually adjust his figure without explanation to 10-25 mgF/day for 10-20 years[17]. Later authorities[18] have followed Roholm more closely, at 10-20 mgF/day for 10 years or more. This is a factor of five lower than Møller's 1932 figure.

In the light of this body of opinion, the data presented here strongly suggest that we seriously under-estimated the extent and danger of public exposure to fluoride. 14% of this sample, regardless of water fluoride, consumes more than 5 mg fluoride daily and 1.3% more than 10 mg daily, which is indisputably sufficient to cause concern. Lesser chronic exposures are likely to have consequences in proportion. There is no definite rate of exposure below which fluoride accumulation in bone might not impair bone health eventually, during a productive life spanning six decades or more.

Besides all of which, if the chemical mechanism of fluoride toxicity relates in part to disruption of hydrogen bonding, vague global debility may well be a further insidious result. This kind of ill-health is usually unexplained, and seems to be increasing in prevalence. A possible relation to fluoride accumulation has so far received no serious consideration.

The reaction of the Food Standards Agency, on discovering that their data implied such high levels of exposure, was to widen the goalposts by quoting higher levels of safe intake maintained in other jurisdictions. These run as high as 7mg per day, which would give a therapeutic ratio no higher than 3. Much higher ratios would be mandatory in regulated pharmaceuticals for medical or dental prescription. Fluoride exposure is out of proportion to the public health measures designed to influence it, out of control and unmonitored. So low a margin of safety in such circumstances is completely unacceptable.

The data presented in Table Three suggest that a daily fluoride consumption of 5mg or more will certainly exceed the safe intake defined in the UK. Table Two suggests

that fluoridating water pushes the majority of consumers into excessive fluoride intake.

Data from this NDNS cannot answer questions about children. Between age 6 months and six years the safe intake of fluoride is considered by CoMA to be 0.12mg/kg/day, and in younger infants 0.22mg/kg/day[19]. Small children retain up to 70% of ingested fluoride, making them more vulnerable to the long-term disbenefits of over-consumption.

It is, however, practical to measure urinary fluoride concentration at any age, a short series of which in any individual will seldom give totally misleading results.

Conclusions

1. Fluoride exposure from all sources in the UK is an order of magnitude higher than previously estimated.
2. Fluoridation of a water supply makes most of the population excessive consumers of fluoride.
3. We have no modern information about what health disbenefits this may have. A surveillance program should begin urgently in the West Midlands to relate the total fluoride consumption of individuals to their health experience
4. It would be highly desirable to add a test square to detect fluoride concentration to the strips produced for routine multi-testing of urine samples. The feasibility of this should be explored with manufacturers.
5. No further water fluoridation schemes should be started until results from (3) are available.

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Dr Peter Mansfield is a retired independent medical practitioner. He declares there to be no conflict of interest.
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