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summary

Strong association between water fluoride concentration and proportion of the population with dental fluorosis

McDonagh M, Whiting P, Bradley M, Cooper J, Sutton A, Chestnutt I, et al. *A Systematic Review of Public Water Fluoridation. September 2000. Publications Office, NHS Centre for Reviews and Dissemination, University of York, York YO10 5DD, UK. ISBN 1 900640 16 3*

Objective Does water fluoridation have negative effects? This objective was broken down into four sections: fluorosis, bone fracture and bone development effects, cancer, and other possible adverse effects.

Data sources See page 37.

Study selection A total of 88 studies met the inclusion criteria for fluorosis. All studies were level C, except one of level B. The mean validity score was only 2.8 out of 8.0.

Data extraction and synthesis Because the studies used different indices to assess fluorosis, the percentage prevalence of fluorosis was the outcome of interest. Regression analysis was used to investigate the association of water fluoride level with the prevalence of dental fluorosis. A multilevel model was used to combine studies.

Results Regression analysis showed a significant dose–response relationship for both methods of measuring the prevalence of fluorosis. The pooled estimate of the prevalence of fluorosis and fluorosis of aesthetic concern are shown in the Table 1 below.

A rough approximation of the number of people who would have to be exposed to water fluoride levels of 1.0 ppm when compared with 0.4 ppm for one additional person to develop fluorosis of any level is six [95% confidence interval (CI), 4–21 — the number needed to harm (NNH)]. This rises to 22 (95% CI, 14–28) for fluorosis of aesthetic concern. A sensitivity analysis of the regression analysis was conducted in which all data-points above 1.5 ppm were excluded it was suggested that the higher water fluoride levels could potentially force the regression line to show a relationship that may not actually exist for the lower levels of fluoride. The proportions predicted by this model are similar to the initial analysis but with wider CI (Table 2).

An increase in the prevalence of fluorosis over time was not seen in this analysis of water fluoridation studies. While this finding is counterintuitive, no explanation is evident from the data.

Table 1 Proportion (%) of the population affected by fluorosis

Fluoride level	Proportion (%) of the population affected by: Fluorosis (95% CI)	Fluorosis of aesthetic concern (95% CI)
0.1	15 (10–22)	6.3 (3.0–12.0)
0.4	33 (26–41)	8.2 (4.0–15.0)
0.7	42 (34–51)	10.0 (5.0–18.0)
1.0	48 (40–57)	12.5 (7.0–22.0)
2.0	61 (51–69)	24.7 (14.0–39.0)
4.0	72 (62–80)	63.4 (38.0–8x)

Table 2 Sensitivity analysis with all data points above 1.5 ppm excluded

Fluoride level	Population (%) of the population affected by fluorosis (95% CI)
0.1	18 (12–26)
0.2	25 (18–33)
0.4	33 (26–41)
0.7	41 (33–49)
1.0	46 (37–55)
1.2	49 (40–58)

Table 3 Numbers needed to harm*

	Fluorosis (95% CI)	Fluorosis of aesthetic concern (95% CI)
NNH	6 (2–21)	22 (14–∞)

*Estimates apply only to the comparison of 1.0 ppm with 0.4 ppm.

Conclusions These results show a strong association between water fluoride concentration and the proportion of the population with dental fluorosis.

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Address for reprints: Publications Department, NHS Centre for Reviews and Dissemination, University of York, Heslington, York YO10 5BB, UK.

Commentary

In the section of the York review dealing with the association between water fluoride concentration and the proportion of the population affected with dental fluorosis, the authors adopted a sensible strategy including studies at level C or above. Although the standard of the individual available studies was less than satisfactory, when taken together their findings must be taken seriously. Hence, the conclusion is justified that there is a strong association between levels of fluoride in the water and dental fluorosis. This is not unexpected when account is taken of the classical work of Dean and colleagues in the late 1930s and early 1940s and, in particular, their findings from the study of 21 US cities which had varying levels of naturally-occurring

fluoride in the water supplies. Based on this work, it was concluded that at one part per million fluoride in the water supply the maximum benefit (caries reduction) was achieved, while it was estimated that 50% of the population would be affected by either questionable or very mild fluorosis (the risk). When it was decided to add fluoride to water supplies as a public health measure for the control of dental caries, these facts were known and the benefits predicted in terms of caries prevention were considered to be justified, taking account of the likely level of risk.

The findings in the York review are likely to be quoted widely and it is perhaps unfortunate, therefore, that the authors of the review decided to include studies which used the DDE Index, which of course is a non-specific index designed to measure all enamel opacities and not fluorosis alone. Seven such studies were included in the analysis and it is likely that their inclusion inflated the prevalence of fluorosis in both fluoridated and non-fluoridated areas. Although the authors comment on this decision, their inclusion does detract from the overall credibility of this section of the review. Perhaps it would have been wiser to have only quoted figures for diffuse enamel opacities when these studies were included into the different analyses the authors used.

The authors rightly pay particular attention to dental fluorosis of aesthetic concern and, in the analyses for this aspect of the review, studies using the DDE index were excluded. In attempting to arrive at a decision on the level at which fluorosis could be judged to cause aesthetic concern the authors were hampered by the fact that little research has been reported on this important aspect of the benefit (caries reduction) and risk (enamel fluorosis) of water fluoridation. In the circumstances, therefore, it was not surprising that the views of 14-year-old Manchester adolescents reported in the study by Hawley *et al.*[1] should form the basis of their decision to regard scores of 3 or above in the Thylstrup and Fejerskov (TF) index as posing an aesthetic problem. A further assumption was then made that a score of 3 or more in the TF index translated as being equivalent to a Dean's score of Mild or Worse and a TSIF score of 2 or more. There are a number of difficulties when all these assumptions are taken into account. For example, the purist might question how the views expressed by 14-year-old Manchester adolescents represent those of the UK population as a whole. Also, it should be borne in mind that when using the TF index the teeth are dried and it would be interesting to ascertain the aesthetic impact of TF scores of 3 if the teeth were wet. Having said that, however, it is interesting that the results of the Manchester study are similar to those achieved in other settings[2].

It is likely that the statement contained in the report that 12.5% of the population will be affected by fluorosis of aesthetic concern in an area with fluoride in the water supply at 1 ppm will be widely quoted by those who wish to state that the risk (fluorosis) outweighs the benefit (caries reduction). Whereas it is important that the review has confirmed that there is a strong association between levels of fluoride in the water and dental fluorosis it is important to realise that the poor quality of the studies and the variety of indices used must raise concerns about the robustness of the summary data.

1. Hawley GM, Ellwood RP, Davies RM. Dental caries, fluorosis and the cosmetic implications of different TF scores in 14-year-old adolescents. Community Dental Health 1996; 13:189–192.
2. Ellwood RP, O'Mullane D. Enamel opacities and dental aesthetics, J Public Health Dent 1995; 55(3), Summer 1995.

Denis O'Mullane
Department of Oral Health and Development, and Oral Health Services Research Centre, University of Cork, Cork, Ireland