FLUORIDE AND FLUOROSIS: THE STATUS OF RESEARCH IN SOUTH AFRICA

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SUMMARY: The public health aspects of fluoride and the issues of fluoridation and defluoridation of drinking water in South Africa have been recorded, debated and discussed since 1935. The levels of fluoride in the different areas in South Africa were recorded, e.g. 0.3 – 35 mg/L, as compared to observations of dental caries in these areas. The prevalence of dental caries was at least twice as high amongst children in low fluoride areas compared with children in areas with fluoride levels between 1.1 and 1.8 mg/L. Also the presence of fluorosis amongst children in high fluoride areas was reported and the areas of endemic fluorosis were identified. Fluorosis prevalence was reported to be up to 100 % in certain areas. Severe fluorosis was found to be a predisposing cause of dental caries. The prevalence varies according to the fluoride content of the drinking water. A surprisingly high fluorosis prevalence 33.5 % has been reported in association with relatively low F concentrations (0.54 mg/L and even 0.4 mg/L). The relationship between fluorosis prevalence and fluoride content of the drinking water was positive but the spatial variation in the prevalence was not fully explained by the variation in the fluoride content of the drinking water. Current studies with the objective of arriving at a proposal in terms of what should be regarded as an optimal level of fluoride indicate that the optimal fluoride level in terms of caries prevention and fluorosis for the prevailing conditions is lower than generally accepted. In order to minimise dental fluorosis, a level of 0.54 mg/L appears acceptable. In the event of concentration fluctuations the content could be controlled so as never to rise above 0.7 mg/L.

Key words: Optimum Fluoride Concentration; Fluorosis; Dental Caries; South Africa.

INTRODUCTION

The issues of fluoridation, fluorides and fluorosis in South Africa have been recorded, debated and discussed since 1935. These have raised emotions and invectives from antagonists and protagonists. During the past decades the general public has become familiar with fluorides because of the continuing debate, mainly on the issue of water fluoridation to prevent dental caries. The concentration of fluoride in the drinking water is therefore considered of substantial significance from a public health point of view. While at low concentrations it is beneficial in preventing dental caries, higher concentrations of fluoride in the drinking water are detrimental to health.[1] The effects of excess fluoride (F^-) in the drinking water are easily observed on the teeth and can be seen radiographically on skeletal and soft tissue. If drinking water containing more than 1 mg F/L is consumed during the period of permanent teeth calcification, it can lead to dental fluorosis. Severity of dental fluorosis is related to the fluoride concentration in the water and varies from mottling of enamel to gross calcification defects which weaken enamel and can eventually lead to loss of teeth.[2]

Other effects from high intake of fluoride are: 1) bone changes in the form of exostosis when water containing 8-20 mg F/L is consumed over a long period of time; 2) crippling fluorosis in the form of painful skeletal rigidity and deformities when water containing more than 20 mg F/L is consumed over a period of 20 or more years.[3] This report will present an overview of research status of fluoride and fluorosis in South Africa.

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HISTORICAL PERSPECTIVE

The research on water fluoridation, fluorides and fluorosis in South Africa can be categorised into three periods.[4] The first extends from 1935 to 1978. Maughan-Brown,[5] Staz[6] and Abrahams[7] reported the presence of fluorosis amongst children in high fluoride areas. The most comprehensive work was undertaken by Ockerse[8-10] and Ockerse and Meyer[11] delineating the areas of endemic fluorosis, the levels of fluoride in the different areas in South Africa and the observations of dental caries in these areas. Steyn and Reinach[12] and Steyn[13,14] devoted most of their efforts to the toxic effects of fluoride on human beings. It was Ockerse[8-10] however, who contributed to the body of knowledge on the relationship of endemic fluorosis (mottled enamel) and high levels of naturally occurring fluoride in the drinking water in many parts of Southern Africa. Ockerse[8] further demonstrated that schoolchildren residing in areas with varying levels of fluoride in the drinking water showed different levels of dental caries. Ockerse[15] reported that the prevalence of dental caries was at least twice as high amongst children in low fluoride areas compared with children in areas with fluoride levels between 1.1 to 1.8 mg/L.

Abrahams[7] confirmed much of Ockerse's findings in his studies in the North Western Cape. The work of Ockerse and Staz had prompted the Council for Scientific and Industrial Research (CSIR) to consider an investigation into the desirability of systemic water fluoridation.[16] Staz[17] reported that the CSIR: "records its approval of the suggestions to add fluorides to community water supplies as a positive preventive health measure to reduce the ravages of dental caries". In 1966 the report by the Commission of Inquiry into the Fluoridation of Water[18] recommended that: a) steps should be taken to encourage, advise and assist local authorities to fluoridate the water supplies of their communities as soon as possible and b) local fluoridation schemes should aim to achieve an optimal concentration of fluoride in the drinking water for the prevalent climatic conditions according to the criteria laid down. After publication of the report no action was taken by the government. During the 1970's a number of studies further explored the relationship between fluoride concentration in enamel, degree of fluorosis and DMFT in selected high and low fluoride areas in South Africa.[19-22]

The second period extends from 1978 to 1989 during which time Taljaard[23] reported on the views of the profession and the Department of Health's future policy, which triggered public debate from those who opposed the implementation of water fluoridation. This public debate prompted the Secretary of Health to organise a National Symposium on Water fluoridation in 1979 in Pretoria.[24] The symposium ended inconclusively with no clear mandate to the government to implement water fluoridation. This was a watershed period for the pro-fluoridation lobby in South Africa. However, the resilience of the dental profession encouraged considerable further research into the levels of fluoride in drinking water in South Africa.[25-28] Simultaneously, the Medical Research Council and other organisations supported further research on fluorides in South Africa.[25,27-31] During this period some studies further explored the issues of fluorosis as a sequel to the ingestion of fluoride through drinking water sources.[32-34]

The third period stretches from 1990 to date. Following political changes the issue of water fluoridation, with its accompanying questions on fluorosis and fluoride in general was taken up once more. In 1991 the Medical Research Council organised a symposium on water fluoridation at which meeting a working group was formed to promote water fluoridation.[35] The Several political organisations[36] proposed the implementation of water fluoridation as a primary health care measure. In 1995, the Oral Health Committee

appointed by the Ministry of Health[37] recommended that the government implement water fluoridation as part of the Reconstruction and Development Plan.[38] A Sub-Committee on Water fluoridation was subsequently set up to oversee the implementation of water fluoridation in South Africa.

SOME PROMINENT RESEARCH FINDINGS

Table 1 reflects a summary of prominent research findings.

In the Northern Cape province Ockerse[8] found a much higher prevalence of dental caries in Upington compared to Kenhardt and Pofadder areas. Fluorosis prevalence also varied according to the fluoride content of the drinking water. He concluded that with fluorosis prevalence a 100 % in certain areas in and around Kenhardt and Pofadder, fluorosis is so severe that it is a predisposing cause of dental caries.

In the Pilanesberg area (North West Province) Ockerse and Meyer[11] found fluoride in the drinking water to vary between 0.33-35 mg/L. They also found climatic condition influences on the fluoride levels i.e. lower after heavy rain. This could also explain why at higher levels of fluoride 10.45 mg/L only moderate and not as expected severe fluorosis was observed (lower fluoride levels during early calcification).

TABLE 1. Prominent Research Findings

References	Age	Country/ Region	Fluoride (mg/L)	Index	Fluoros. (%)	Moderate Severe,%
Ockerse & Meyer[11]	6-15	Pilanesberg	0.33-35	Dean	49	57
Ockerse[8]	6-17	Upington	0.38	Dean	16	3
	6-16	Kenhardt	6.8	Dean	100	70
	6-16	Pofadder	2.5 (av)	Dean	94	53
Bischoff *et al*[19]	14-23	Saulspoort	0.4-6	Dean	83	60
Van d. Merwe *et al*[20]		Saulspoort (H)	0.4-6	Dean	83	60
		Mabeskraal (L)	0.02-0.2	Dean	11.4	22
Retief *et al*[22]	14-17	Kenhardt	3.2	Dean	94	58
Zietsman[31]	5-20	Northwest Province (5 villages)	0.5 - 1.6	Dean and TF	53	20
Lewis *et al*[32] Lewis & Chikte[33]	6-18	KwaNdebele (H)	8 - 9	Dean	88	54
		KwaNdebele (L)	0.6 - 1.6		90	3

TABLE 2. Perceptions of parents

Questions	Response	Sub (%)	Optimal (%)	Supra (%)
Aware stains	Yes	69	62	92
Other	No	31	38	8
Of concern	Yes	54	54	78
	No	13	9	14
Aware stains	Yes	38	45	83
Own child(ren)	No	62	55	17
Of concern	Yes	33	39	75
	No	5	6	10

The higher than expected prevalence of fluorosis at Saulspoort[19] compared to findings in Austria was ascribed to the effect that higher mean maximum daily temperatures have on water consumption and subsequent incidence of fluorosis. Females were found to have less fluorosis than males. This was due to physical factors where females tried to remove the unsightly stains through manual abrasion with sand or ash and not due to internal genetic differences.

Van der Merwe *et al*[20] also observed a higher fluorosis prevalence (11.4%) than generally would be expected at Mabeskraal a low F area (0.02-0.2 mg F⁻/L). Two possible explanations were given: a) poor diet which was found to be a doubtful explanation and b) a possibility that the mottling observed was not dental fluorosis. The study also confirmed a higher caries level at the low fluoride area of Malbeskraal compared to Saulspoort the high fluoride area.

TABLE 3. Perceptions of 12 - 15 years old children.

Question	Response	Sub (%)	Optimal (%)	Supra (%)
Aware stains	Yes	44	61	84
Other	No	56	39	16
of Concern	Yes	31	46	58
	No	14	15	26
Aware stains	Yes	15	45	69
Own hild(ren)	No	85	55	31
Of Concern	Yes	10	34	53
	No	5	10	16

These findings were also confirmed by Retief *et al*[21] in Kenhardt. They observed no differences of fluoride levels between the two maxillary incisors, nor did they find any differences for gender. This study in Kenhardt also indicated that in a high fluoride area such as this the severity of the fluorosis may be a predisposing factor to caries development. There was also a tendency for caries to decrease with increased enamel fluoride concentration in pupils with no or mild fluorosis.

Looking at spatial variation of fluorosis and fluoride content of water in an endemic area (5 villages in the North West Province) Zietsman[31] found a surprisingly high fluorosis prevalence 33.5 % in association with absolutely and relatively low F concentrations (0.54 mg/L and even 0.4 mg/L). The relationship between fluorosis prevalence and fluoride content of the drinking water was positive but the spatial variation in the prevalence was not fully explained by the variation in the fluoride content of the drinking water. It would seem as though a high prevalence was caused by the absence of water with low F content (<0.4 mg/L), rather than being either the presence of some sources with very high F content or a high mean F content.

Lewis *et al*[32] found similar prevalences of fluorosis in two areas with significantly different levels of fluoride in the drinking water, but significant differences existed in severity.

CURRENT STUDIES

Wide spread studies are currently being conducted among various communities in the Northern Cape Province with varying levels of fluoride in the drinking water with the objective of arriving at a proposal in terms of what should be regarded as an optimal level of fluoride.

One of these studies also looked at the perceptions of the people in these communities regarding the appearance of fluoride exposed individuals, as well as the relationship of nutritional status and fluorosis.

Table 2 reflects some of the findings in terms of perceptions. Among the parents, the awareness of staining on the teeth of other individuals as well as on the teeth of their own children is highest in the supra-optimal communities. The concern parents had about the stains was also highest in the high fluoride areas. The same tendency was observed

among 12-15 years old children (Table 3). The caries experience (DMFT) was lower in the 15-year-olds from the optimal F areas but showed an increase for both 12- and 15-year-olds from the optimal to the supra-optimal area. The 12-year-olds from the sub-optimal and optimal areas are very similar (Table 4). This may already be an indication that cariostatic benefit from the sub-optimal fluoride levels may be comparable to the generally accepted optimal levels of around 1 mg/L. It may also be an indication that the optimal fluoride level in terms of caries prevention and fluorosis for the prevailing conditions is lower than generally accepted. This thinking is in agreement with Du Plessis[34,39] stating that a level of 0.54 mg/L appears acceptable and in the event of fluctuations if the fluoride content could be controlled so as never to rise above 0.7 mg/L, dental fluorosis should not be a problem.

TABLE 4. DMFT by fluoride level and age.

Sub-optimal					
Age	n	D	M	F	DMFT
6	38	0.10	0	0	0.10
12	120	0.46	0.13	0.09	0.68
15	73	1.81	0.34	0.01	2.16
Optimal					
Age	n	D	M	F	DMFT
6	27	0.07	0	0	0.07
12	80	0.50	0.23	0	0.73
15	75	1.29	0.21	0.07	1.57
Supra-Optimal					
Age	n	D	M	F	DMFT
6	47	0.11	0	0	0.11
12	130	1.12	0.32	0.03	1.47
15	104	2.64	0.59	0.12	3.35

DEFLUORIDATION

A draft report dated 29 May 1997 on the 'Feasibility of Fluoridation of the Water Supplies of Medium and Small Towns in South Africa' was compiled for 'The National Fluoridation Committee' of the Department of Health, Republic of South Africa by Dr S O'Hickey. Although the main objective of this report was to make recommendations on the feasibility of water fluoridation it also stated that dental fluorosis is a public health problem in some areas where there is an excess of fluoride, above the optimal range in the drinking water. Defluoridation in such circumstances is strongly recommended. It is also stated that defluoridation technology/equipment can be fitted to a single tap or home. This is of particular importance for small towns and especially small rural communities.

Defluoridated water is available in very few areas and the use of such water by the local people has been remarkably low and no reasons for this phenomenon seem to be forthcoming. The author of the above mentioned report on tasting the defluoridated water found it to have a slight but definitely unpleasant metallic taste which could be caused by prolonged storage in defluoridaters due to lack of use. This is clearly something which will need to be taken into account when defluoridation is perused on a more widespread scale. In terms of the South African Water Quality Guidelines[40] it is recommended that the concentration of fluoride in potable water should never exceed 4 mg/L due to the likelihood of skeletal fluorosis with crippling as well as tooth loss. By implication this is understood to presumably mean that in the absence of an alternative water source potable water exceeding 4 mg/L should be defluoridated. However, taking into account the fluorosis findings from local studies[8,19,21] provisional findings of studies currently in progress, as well as empirical observations the authors of this paper are of

the opinion that defluoridation should be considered at a lower level of 3 mg/L. The main reason for this opinion is due to the severity of fluorosis that is prevalent at this level which is not only an aesthetic problem, but may also be a predisposing factor to caries.[8,21] If the maximum allowable limit for fluoride in potable water of 1.5 mg/L as recommended by the South African Bureau of Standards[41] and Committee for Scientific Industrial Research (CSIR)[42] is adhered to, than the cut-off levels for considering defluoridation should be even lower. This is also in agreement with the guidelines of the World Health Organisation (WHO).[43]

The work done thus far on defluoridation in South Africa,[44] albeit very scanty favours two processes: (a) activated alumina adsorption methods and (b) reverse osmosis (membrane separation method). The activated alumina appears most attractive because alumina is somewhat specific for fluoride and has a relatively high fluoride exchange capacity. Regeneration, which can be performed with caustic soda, is fairly straightforward and the process is reliable, safe and relatively simple to use. Cases have also been demonstrated where fluorides in the concentration range of approximately 4-20 mg/L in borehole waters could be reduced to potable standards with activated alumina treatment. Reverse osmosis has also been demonstrated to reduce fluoride from approximately 12 mg/L to potable standards.

CONCLUSION

Fluorosis definitely appears to be a public health problem in certain areas in South Africa which require the attention of authorities at the various levels of government. This attention will need to consider defluoridation of water especially in areas where alternative water sources are not available. By implication this calls for defluoridation demonstration programmes establishing the efficacy, effectiveness and feasibility of defluoridation.

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