Perceptions of Dental Fluorosis in the Central Karoo District of the Western Cape Province

by

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A thesis submitted in partial fulfilment of the requirements for the degree of MSc (Dent) in Dental Public Health, University of the Western Cape

July 2013

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Dedication

This research is dedicated to the communities of the Central Karoo District. One can never forget your roots. My parents who have motivated and supported me throughout my studies and everything else I attempt in life.

Last but definitely not least my uncle, Pat Wicomb and my grandfather, Prim-John Rickers who have always motivated me to be ambitious and pursue life.
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Keywords

Perceptions

Dental Fluorosis

Geographic Location

Deans Fluorosis Index

Self-rated appearance

Clinical Defined Fluorosis

Public Health Concern

ppmF (parts per million Fluoride)
Abstract

Dental fluorosis is an endemic condition in a number of regions of South Africa, varying in degree of affliction according to the drinking water fluoride concentration in the area.

Objective: While a number of South African studies have reported on the relationship between fluorosis and fluoride concentration in the drinking water, the purpose of this study was to determine perceptions of dental fluorosis in the Central Karoo District of the Western Cape.

Methods: Learners aged 12-15 years and who had been lifelong residents in their respective areas were selected from schools in Leeu Gamka, Merweville, Nelspoort and Murraysburg. All the children meeting the inclusion criteria were included realizing a total sample of 189. Drinking water fluoride concentration of each town was determined and concomitant fluorosis affliction was assessed. An interviewer administered questionnaire was used to determine respondents’ self rated perceptions of fluorosis as well as their responses to a set of statements on clinically defined fluorosis. To this end four photographs, each depicting a different degree of fluorosis: (No fluorosis; Mild fluorosis; Moderate fluorosis; Severe fluorosis) were shown to the respondents.

Results: In Leeu Gamka, with the highest fluoride concentration ([F] = 1.62ppm), 82% of respondents were aware of fluorosis stains as opposed to 6%-20% awareness in Merweville ([F] = 0.68), Nelspoort ([F] = 0.70) and Murraysburg ([F] = 0.56). Two thirds of respondents in Leeu Gamka found the appearance of their teeth embarrassing compared to only 2%-10% in the other 3 areas. The majority of respondents in Leeu Gamka (82%) indicated that they would want to remove the fluorosis spots with only 4%-20% in the lower fluoride areas. Two thirds (67%) of the Leeu Gamka respondents were teased compared to 2%-6% in the other areas. Most of the respondents have not tried to do anything to the appearance of the teeth, even in the higher fluoride area of Leeu Gamka. The average response varied little for all the photographs across the geographic areas (the minimum and maximum scores varied between 4.00 and 5.00) and reflected a greater tendency towards strongly disagreeing with the statement on aesthetics-even for the photographs depicting no fluorosis and mild fluorosis. The average response varied between 1 and 2 among all four geographic regions showing a tendency to “agree” and “strongly agree” to the statement on embarrassment. The average response to the statement on neglect varied little for all the photographs across the geographic areas as the minimum and maximum average response scores varied between 1.36 and 2.39 (agree and strongly agree). The response to the statement on disadvantage varied little for all the four photographs across the geographic areas (minimum=1.00, maximum=2.07) and reflected a greater tendency toward strongly agreeing and agreeing with the statement.
Conclusion: The respondents from the higher fluoride area were more aware of dental fluorosis, had a greater perception of embarrassment and the strongest desire to remove the fluorosis staining. There was little variation in the average response to the statements on clinically defined fluorosis across the geographic areas. The learners erroneously believed that dental fluorosis was due to neglect, which is an indication that many learners are not aware of the cause of dental fluorosis in their community. The general consensus of the communities was that fluorosis was judged with feelings of negativity (embarrassment and a disadvantage for the child into adulthood).
Declaration

I, Brandon Glenn Rickers, declare that *Perceptions of Dental Fluorosis in Central Karoo District of the Western Cape Province* is my own work, that it has not been submitted before for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged as complete references.

Full name: Dr Brandon Glenn Rickers

Signed:

Date: 08 July 2013
Acknowledgements

I wish to acknowledge all those who have contributed to the success of this project in various ways:

My profound gratitude to goes to my mentor Prof AJ Louw for his support, guidance, encouragement and availability for any assistance I needed throughout the course of the program. I wish to also thank all my other mentors who gave me the necessary guidance during the course, Prof Sudeshni Naidoo, Prof Neil Myburgh and Dr Rob Barrie for their support. Thank you for your kindness and patience.

I want to thank all the headmasters, staff and every scholar of the schools who participated in the project and helped me in my research. Your co-operation was appreciated.

Thank you all
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Chapter 1
Introduction

1.1 Background to the study

Dental Fluorosis is a very common condition in the Central Karoo town of Leeu Gamka. In the Central Karoo towns of Nelspoort, Murraysburg and Merweville dental fluorosis is also found but the less severe types are more common.

While a number of studies have reported on fluorosis and fluoride concentration in the drinking water not many studies have been done on the South African public’s perception of dental fluorosis, if they do consider dental fluorosis to be aesthetically objectionable or even if the South African public considers dental fluorosis to be a public health problem at all.

Studies previously done in South Africa focused on the relationships that exist between dental caries, fluorosis experience and the fluoride concentration in the drinking water (Ockerse, 1941; Ockerse and Meyer, 1941; Van der Merwe et al, 1977a; Van der Merwe et al, 1977b; Grobler et al, 1986; Lewis et al, 1992; Lewis and Chikte, 1995; Du Plessis et al, 1996; Grobler et al, 2001)

Severe forms of fluorosis and even mild forms can cause concern among the public and may lead to embarrassment of afflicted individuals and have a negative impact on their quality of life. The perceptions of lay persons concerning fluorosis should be assessed in South Africa.

There exists a scarcity of data in the literature on the perception of dental fluorosis of the South African public and the psychological impact it might have on the people living with the condition (Mothusi 2000; Chikte et al, 2001).

1.2 Aim: To determine the perception of dental fluorosis in the Central Karoo District of the Western Cape Province of South Africa.

1.3 Objectives:

- To determine the prevalence and degree of fluorosis in the in the Central Karoo District.

- To assess opinions amongst learners about their self-rated appearance of dental fluorosis at different degrees of severity.

- To determine the opinions on clinically defined dental fluorosis (normal, mild, moderate and severe).

- To assess the relationship between self-rated appearance and clinically defined dental fluorosis at different diagnostic points.
1.4 Possible Impact of findings

- Perceptions of the local community and to see if they consider dental fluorosis as a public health problem.

- To raise awareness among the general public about the etiology of dental fluorosis and raise awareness on the risk of fluorosis.

- By raising awareness, put pressure on local government and urging national government to address this issue for safe drinking water.

- Influence local government to take action in finding an alternative water source for safe drinking water.

- To inspire more detailed research on this subject in South Africa.
2.1 Dental Fluorosis

Enamel mottling was first recognized as a condition on the basis of the characteristic appearance of the teeth of children who had lived in certain areas (Black and McKay, 1916; Dean, 1942a; Riordan, 1993).

The relationship with fluoride became known in 1931, and the term ‘dental fluorosis’ was taken into use in the mid-1930's (Dean and Elvolve, 1935; Riordan, 1993).

Dean (1934), who devised his classification of fluorosis, subsequently initiated epidemiological studies to ascertain the distribution of dental fluorosis in various United States populations, and reported that mild fluorosis affected about 10% of the child population where fluoride concentrations were about 1mg/L in drinking water (Dean, 1936). Dean considered that this concentration of fluoride in water was the minimal threshold of endemic fluorosis (Dean et al., 1941; Riordan, 1993).

The features of fluorosis cover a continuum of changes from the normal. Thylstrup and Fejerskov (1978) reported that in the mildest cases, fine white lines lying parallel to the perikymata are apparent in dried enamel; often these are difficult to observe in wet enamel. The presence of mild dental fluorosis does not impair the teeth’s functionality. In more severe cases, the fine white lines merge to produce opaque areas in the enamel which are visible in wet teeth (Riordan, 1993). Occasionally such enamel may fracture after tooth eruption to give pits in the tooth surface, and the pits may become discoloured and occasionally carious (Eklund et al., 1987). In the most severe cases, much of the surface of the tooth may be discoloured and pitted, and the teeth are of displeasing appearance to many people but such fluorosis is not widespread (Riordan 1993). According to Fejerkov et al. (1988) the brown stain often found in moderate fluorosis is a post eruptive feature that results when certain dietary ingredients are picked up by proteins in the porous outer enamel and it is only seen when porous enamel has formed prior to eruption (Burt and Eklund, 2005).
Endemic dental fluorosis is caused by the excessive ingestion of fluorides due to the contamination of soil, air and water (Velasquez et al, 2006; de Castilho et al, 2009). Dental fluorosis is a dose-response condition which translates to the higher the Fluoride intake during the critical period of tooth development (22 months) and extends for periods of up to several years after that for later-developing teeth. The more severe the fluorosis and, depending on the quantity and timing of fluoride ingestion during this period, the clinical appearance of fluorosis can range from barely noticeable changes to an ugly brown stain with pitting and flaking of friable enamel (Dean, 1942b; Eklund et al, 1987; Larsen et al, 1987; Fejerkov et al, 1988; Evans and Stamm, 1991; Burt and Eklund, 2005).

The use of fluorides in dentistry has led to a decline in dental caries prevalence in industrialized countries with the use of optimally fluoridated community water supplies and fluoridated oral health products. But with the multiple vehicles available for fluoride delivery, the increase of dental fluorosis in both fluoridated and non-fluoridated communities is a reason for concern (McGrady et al, 2012; Milsom et al, 2000; Clark et al, 1993; Mcknight et al, 1999).

In dental fluorosis, fluoride combines to form calcium fluoroapatite in place of part of the hydroxyapatite (Cawson and Odell, 1998). Damage to ameloblasts that leads to defective matrix formation is seen only when the concentrations of fluorides are exceptionally high (Cawson and Odell, 1998). At intermediate levels (2-6ppm) the matrix is normal in structure and quantity. The form of the tooth is unaffected, but there are patches of incomplete calcification beneath the surface layer. These appear as opacities because of high organic and water content. Where there are high concentrations of fluorides (over 6 ppm) the enamel is pitted and brittle, with severe and widespread staining.

Deciduous teeth are rarely mottled because excess fluoride is taken up by the maternal skeleton. However, when fluoride levels are excessively high (over 8 ppm), as in parts of India, mottling of deciduous teeth may be seen (Cawson and Odell, 1998). With severe mottling of the enamel, other effects of excessive fluoride intake, especially sclerosis of the skeleton, may develop. Radiographically, increased density of the skeleton may be seen in areas where the fluoride content of the water exceeds 8 ppm (Cawson and Odell, 1998). The intervertebral ligaments and muscle insertions calcify, causing stiffness (particularly of the back) and pain. Histologically, the bone changes are somewhat similar to those of Paget’s disease (Cawson and Odell, 1998).
Khandre et al (2005) investigated severe bone deformities in young children from vitamin D deficiency and fluorosis in Bihar, India and found that the clinical manifestations of the study sample exposed to high levels of fluoride in the drinking water was dental mottling of various grades and different types of skeletal deformities prevalent to different age groups. The population of Bihar was not fully aware of the harmful effects of fluoride and therefore, the household defluoridators supplied by government were not used. Khandre et al (2005) also found that all subjects were physically handicapped and psychologically traumatized and added a burden to the family, thereby causing a social problem. Hussain et al (2010) found that dental fluorosis (alone) is more common at the age below 30, while skeletal fluorosis is more common after age 50. Hussain et al (2010) explained that the overdose of fluoride affects the ameloblasts and damage to these cells leads to hypomineralization of the enamel therefore dental fluorosis is more likely to occur in the teeth forming age while skeletal fluorosis occurs after a prolonged exposure to high fluoride contaminated water.

It is important to determine at which point dental fluorosis becomes a public health problem. There is no reason to call it such in a community where it is found only in its mildest forms, even in U.S. communities where the prevalence is around 50% in children (Burt and Eklund, 2005). On the other hand, its high prevalence and severity make it a public health problem in countries of East Africa (Olsson, 1979; Wenzel et al, 1982; Chibole, 1987) and parts of India (Chandra et al, 1980; Subbareddy and Tewari, 1985). It is an urgent problem in those regions of Ethiopia and India (Jolly et al, 1968; Haimanot et al, 1987) where skeletal fluorosis is found, which can be a debilitating condition (Burt and Eklund, 2005).
2.2 Dental fluorosis in South Africa and Africa

In South Africa, Grobler et al (2001) investigated the relationship between caries experience, degree of fluorosis and different concentrations of fluoride in the drinking water of children. Grobler et al (2001) found a positive association between high fluoride levels in drinking water and dental caries and that in the two low fluoride areas investigated there was a low caries experience and no difference in DMFT (Decayed Missing and Filled Teeth) and fluorosis.

As discussed earlier, the relationship between fluorosis, fluoride concentration in the drinking water, the cariostatic effect of fluoride and the relationship with dental caries, are well documented in South Africa (Ockerse, 1941; Ockerse and Meyer, 1941; Van der Merwe et al, 1977a; Van der Merwe et al, 1977b; Grobler et al, 1986; Lewis et al, 1992; Lewis and Chikte, 1995; Du Plessis et al, 1996; Grobler et al, 2001). There is a scarcity of data on the perception (self-rated or clinically defined fluorosis) of dental fluorosis, and its impact on the Oral Health Related Quality of Life (OHRQoL) in South Africa.

In Africa, Shitumbanuma et al (2007) conducted a study to investigate the high incidence of mottled teeth in the residents of an area in the Choma District of the Southern Province of Zambia. The authors found a highly significant association between the subject’s main sources of drinking water between birth and age 7 and the incidence of discoloured teeth. The authors reported that all pupils (100%) who drank from hot springs before age 7 had moderate to severe fluorosis, while the majority (96.7%) of the pupils who drank water from other sources had no dental fluorosis. Fluoride concentrations ranged from 5.95 to 10.09 mg/l in water from hot springs, and from 0.03 to 0.6 mg/l in water from other sources (Shitumbanuma et al, 2007).

In South-western Nigeria Gbadebo (2012) found that the high fluoride content of the groundwater resulted in severe dental fluorosis and increased dental decay among residents. In the Nakuru District of Kenya, Moturi et al (2002) concluded although a great percentage (48%) of the study sample was afflicted with severe dental fluorosis, most people did not know the etiology of dental fluorosis. The author suggested that the community should be educated on the causes of dental fluorosis and to put strategies in place to address this issue for safe drinking water, for example, more rainwater harvesting, treating drinking water with alum, or using clay pots for storage of drinking water.

Birkeland et al (2005) undertook a study to assess the effect of fluoride on the severity of caries among children exposed to different concentrations of fluoride in the drinking water and living in the rural areas in Sudan. The authors found that there was no difference in caries prevalence between the lowest and the highest fluoride area. The authors also mentioned that the study failed to demonstrate an effect of fluoride in drinking water on caries experience when the end point was molars indicated for extraction or missing because of caries.
2.3 Perceptions of dental fluorosis

2.3.1 General

According to Riordan (1993), mild dental fluorosis has long been accepted as a side effect of water fluoridation and has been recognised as a consequence of other fluoride-based caries-preventive strategies.

Dental health professionals traditionally do not consider mild dental fluorosis as being of any public health importance and tend to downplay it as a slight cosmetic defect due to the benefits of fluoride’s cariostatic properties (Riordan 1993; Clark et al, 1993; McKnight et al, 1999; Milsom et al, 2000; Chankanka et al, 2010; McGrady et al, 2012). Ripa (1991) also stated that the mildest forms of dental fluorosis maybe unimportant since it is generally considered that only those defects deemed to be of cosmetic concern are of any relevance (Hawley et al, 1996).

Riordan (1993) conducted a study where he sought the views of lay people and dentists who examined, at conversational distance, a group of children with fluorosis ranging from Thylstrup Fejerskov (TF) scores of 0-3. Teeth with a score of 2 and more were easily noticed and a score of 3 was considered by the most observers to be aesthetically objectionable (Riordan 1993). Riordan (1993) also found that dentists did not feel the treatment of mild dental fluorosis was warranted, only moderate to severe dental fluorosis need treatment. Levy et al (2002) reported that fourth-year dental students generally had more favourable aesthetic perceptions of mild dental fluorosis and other conditions than they had reported as entering students.

The concern of dental fluorosis increased as the severity of dental fluorosis increased (Riordan, 1993; Edwards et al, 2005; Browne et al, 2011; McGrady et al, 2012). In Canada, parents expressed concern with the appearance of teeth with a TSIF (Tooth Surface Index of Fluorosis) score of 1 and became increasingly concerned as the scores increased (Clark et al, 1993). Lalumandier and Rozier (1998) found that parents whose children had a TSIF score greater than 0 had more than twice the odds of reporting dissatisfaction with the dental aesthetics than the parents of children who had a score of 0 (Shulman et al, 2004).

Clark (1995) also conducted a study and asked a group of children, parents and dental professionals, to view slides of teeth with different TSIF scores and all were able to distinguish between teeth with and without fluorosis and found that severe types of fluorosis were found to be a concern. Fluorosis indices do not focus on the child’s or the parents’ perception of the tooth’s aesthetics. This omission is unfortunate because aesthetics is the only significant consequence of dental fluorosis - at least within the levels of fluorosis commonly found in North America (Shulman et al, 2004). Edwards et al (2005) also found that teenagers can discriminate between the various degrees of fluorosis.
According to Shulman et al (2004), researchers often assumed that the primary measure of significance was the presence or absence of dental fluorosis. However, certain discrete levels are detectable by dentists and lay persons and fluorosis itself does not necessarily translate into dissatisfaction with the appearance of the teeth, for either the professional or the layperson (Shulman et al, 2004). The authors further found that dentists rated teeth aesthetics better than the parents for low levels of fluorosis or for non-fluorosis problems, and the parents on their part rated it better than the children did.

Hawley et al (1996) stated that the opinions of dental epidemiologists may not reflect those of the public or those affected. Dentists should not assume that what they identify as an aesthetic problem would be seen as such by parents or patients. Conversely, parents or patients may identify an aesthetic problem that a dentist does not consider critical (Shulman et al, 2004). Although there is no full agreement, the consensus is that substantial consideration should be given to people’s perception of what their needs are, based on self-assessment of their oral health status and satisfaction with the appearance of their teeth (Gilbert 1994). Lay people hardly notice mild dental fluorosis in another person however this might not be the case in self-perception of mild dental alterations (Gleber-Netto et al, 2011).

Chankana et al (2009) stated that authors of an early epidemiological study (Ast et al, 1956) commented that very mild and mild fluorosis is difficult for lay persons to detect. But there is increasing evidence in recent studies that very mild/mild fluorosis can be identified by lay persons (Clark et al, 1993; Chikte et al, 2001 and Sigurjons et al, 2004). According to Chankanka et al (2009) dental fluorosis is not a condition that causes pain or has clinical symptoms and the effects of mild fluorosis are subjective, thus reports on dental fluorosis prevalence and severity alone does not give enough information to understand the effects at a public health level.

After reviewing the literature, Chankanka et al (2009) came to the conclusion that in the earlier studies not focused on OHRQoL (Oral Health Related Quality of Life), there were varied results from subjects concerning perceptions of very mild to mild fluorosis. Respondents could distinguish mild fluorosis from non-fluorosis when cued by the examiner. There were reports of low levels of fluorosis to be more acceptable, some equally acceptable and others less acceptable when compared with no fluorosis. Participants did not perceive very mild to mild dental fluorosis as having a negative effect on OHRQoL, evidence suggesting no negative effect on OHRQoL with mild dental fluorosis.
According to Chankanka et al (2009) severe fluorosis was consistently reported to be viewed as less acceptable and perceived as having negative effects on subjects’ OHRQoL. Mild and very mild dental fluorosis are more common in the United States and other nations with low levels of fluoride in the drinking water, therefore it does not adversely impact on the OHRQoL of the community. For these reasons Dental Public Health and Paediatric Dentistry leaders in those countries/areas need to focus on the appropriate use of fluorides for caries prevention and preventing moderate/severe dental fluorosis (Chankana et al, 2009).

De Castilho et al (2009) reported on the perceptions of dental fluorosis of Brazilian adolescents suffering from severe dental fluorosis. These authors found that the affected individuals were embarrassed to smile at strangers due to a presumed association between fluorosis and a lack of dental hygiene, conflicts between affected and non-affected students at school, problems in pursuing romantic relationships and uncertainties regarding a professional future. According to de Castilho et al (2009) lesions from severe dental fluorosis appear to be a stigmatizing factor and have contributed toward suffering and self-exclusion among an entire generation of adolescents. Anguilar et al (2011) reported that severe fluorosis affects smile aesthetics and produce functional problems that affect self-confidence, causing discomfort and probably disturbing social roles from a young age. Robinson et al (2005) found that socially noticeable fluorosis was associated with high impacts on QoL (Quality of Life) and around the age of 8 children begin to perceive the impact of their ill health on social activities and relationships. The children started developing a global judgement of self-perception and self-worth.

Bhagyajyothi and Pushpanjali (2009) concluded that with an increase of severity of dental fluorosis there was an increase of concern among subjects. They also found that the perceptions and concerns of dental fluorosis among the subjects (age group 12-15 years) appear to be of an aesthetic concern, making it essential for dental professionals and government to focus on this issue and to intervene.

McGrady et al (2012) found that the participants in their study have a preference for white, blemish free teeth even within the age group where many of them are still in the mixed dentition stage. The mildest forms of fluorosis may not be associated with aesthetic concerns but as the severity of dental fluorosis increased participants rating and the level of acceptance worsened. Aguilar-Diaz et al (2011) confirmed that malocclusion, caries and fluorosis were associated with a negative impact on the children’s QoL (Quality of Life). Mild and moderate dental fluorosis had a negative aesthetic effect on the studied population, leading to a strong desire to seek dental treatment to change the appearance of affected teeth (Gleber-Netto et al, 2011). Rodd et al (2011) stated that untreated visible enamel defects can have a negative psychological impact on children afflicted with it but simple non-invasive dental treatment can have a positive effect on appearance-related satisfaction.
2.3.2 In South Africa and Africa

In South Africa the study done by Chikte et al (2001) was aimed to determine the perception of fluorosis as a part of a comprehensive survey determining the relationship between caries, fluorosis and nutritional status in South African communities with different fluoride levels in the drinking water. According to Chikte et al (2001) the children and parents were aware of the discolouration on the children’s teeth and that it is a matter of concern in all areas (high and low fluoride areas) but more so in the high fluoride areas. Children with Dean’s fluorosis scores of 4 and 5 expressed the most concern and awareness for dental fluorosis. Lewis and Chikte (1995) commented on the behavioural impact of fluorosis where the children affected with severe dental fluorosis attempted to remove the stains by using files and abrasives. The authors reported that some children also used battery acid and commercially prepared bleach (Jik) and other corrosive agents in an attempt to remove the stains from the labial surfaces of the teeth. The authors also reported that children covered their mouths with their hands when talking, smiling and laughing.

Mothusi (2000) found that the psychological effect in terms of the unsightly, brown-stained teeth has induced the adolescents with fluorosed teeth to demand that these teeth be extracted and replaced with dentures.

There were also some studies done in Africa on the perceptions of dental fluorosis. Wondwossen et al (2003a) did a study on the perception of dental fluorosis of adolescents living in the urban areas of Ethiopia, Africa. They reported that their findings confirm that fluorotic teeth constitute a social problem among junior secondary school children residing in low-fluoride as well as in high-fluoride areas in Ethiopia and thereby corroborate the public concern for safe drinking water. Wondwossen et al (2003 b) also did a study on the perception of dental fluorosis amongst Ethiopian children and their mothers. This study found that children living in high- as well as low-fluoride areas of Ethiopia are aware of fluorotic defects of enamel and that children from areas of endemic fluorosis are more tolerant towards milder forms of dental fluorosis but are also most embarrassed with severe fluorosis. The results indicated that dental fluorosis is an aesthetic concern to Ethiopian schoolchildren and their mothers. The mothers’ and their children’s concern about appearance increased as the fluorosis score increased and was generally at corresponding levels. The authors further reported that mothers were more critical of severe fluorosis than were their children. According to Wondwossen et al (2003b) the association between self-rated discolouration and clinically defined dental fluorosis was, at best, moderate indicating that lay people’s views of oral health appear to be different to professionally defined needs and clinical measurement of disease.
Yoder *et al* (1998) found that participants with TFI (Thylstrup Fejerskov Index) scores of 7-9 appeared to have abraded their anterior teeth with a stone in an attempt to remove the pitting and discolouration caused by fluorosis.

Van Palenstein *et al* (1993) undertook a study in Tanzania to assess the impact of severe dental fluorosis on people’s perception of well-being and on their treatment wants. The authors found that feelings of distress, worry and hindered smiling were more pronounced in children exhibiting severe fluorosis, this was thought to be that adolescents are more critical on their appearance. Adults expressed less distress, worry and hindered smiling, possibly because of the acceptance of unsatisfactory looks changed with age. Van Palenstein *et al* (1993) found that all the children and 56% of adults who were unsatisfied with the appearance of their teeth wanted treatment for it but none of them had actually sought dental treatment. The reasons given for not seeking dental treatment were that dental fluorosis is not painful and that cosmetic dentistry was not available.
Chapter 3
Methodology

3.1 Study Design

A cross-sectional study design with an analytical component was used for the purpose of the study.

Cross-sectional studies can be descriptive or in this case can include an analytic component. The goal of an analytical cross-sectional study is to examine the relationship between an exposure and an outcome (Ehrlich and Joubert, 2007).

Unlike cohort and case-control studies, a cross-sectional study does not assess and compare occurrence of new cases (incidence) of disease in two groups. Rather, it assesses and compares the prevalence of disease or exposure across the two groups (Ehrlich and Joubert, 2007).

3.2 Study Population

The following inclusion criteria were selected for the study population:

- Learners aged 12-15 years from schools in the Central Karoo District (Merweville, Leeu-Gamka, Nelspoort and Murraysburg) who had been living in the area since birth were selected.
- Participants had to have similar background and socio-economic circumstances.

This age group was chosen because the children’s comprehension at this age is better than their younger counterparts.

The study population had to have lived in the area since birth because they had to have been exposed to the fluoride content in the local drinking water during tooth development because the effects of fluorosis are developed in the early years of life when tooth formation takes place.

3.3 Study Sample

A sample of 200 learners aged of 12-15 years, living in the area since birth, with the same background and socio-economic circumstance was originally proposed. (50 children from each of the four different sites which included Merweville, Leeu Gamka, Nelspoort and Murraysburg).
3.4 Measurements

Water samples were collected from the four sites by the method of first letting the water run for a few seconds and then collecting it in plastic containers. At Murraysburg and Leeu Gamka more than one water sample was taken because there was potentially more than one drinking water source.

The fluoride concentration of the drinking water was determined potentiometrically according to the method described by Nicholson and Duff (1981) at the laboratory of the Dental Faculty of the University of the Western Cape.

3.4.1 Questionnaire (Appendix 1)

A structured questionnaire in the local language which is Afrikaans was used to interview each child to gather information related to:

1. The level of awareness of dental fluorosis.
2. If they consider dental fluorosis being a problem at all

The questionnaire was divided into a self-rated response and clinically defined fluorosis response to gauge the perceptions of dental fluorosis of the subjects (See Appendix 1 for further details on the questionnaire).

Self-rated response is the self-assessment by the participants of their own teeth. This was adopted from similar methodology used by Chikte et al (2001) and Wondwossen et al (2003b).

For the clinically defined fluorosis response, images shown on a laptop screen depicting predetermined clinically defined dental fluorosis (unknown to the learners) of anterior teeth were used (Appendix 4). Images (Appendix 4) were taken from Oral Health Surveys, Basic Methods, 4th Edition (World Health Organization, 1997).

Four statements were made and the participants were asked if they agreed or disagreed with the statements based on a five point Likert-scale (Appendix 1). The examiner asked the questions and showed the images to participants requiring responses individually. Each image was subjected to the four statements and the Likert-scale (1= Strongly Agree, 5= Strongly Disagree). This was adapted from similar methodology used by Wondwossen et al (2003a), Wondwossen et al (2003b) and Browne et al (2011).
3.5 Clinical examination

The Dean index (according to the World Health Organization’s criteria) was used to determine the prevalence and severity of the fluorosis (World Health Organization, 1997). For the purpose of this study a questionable dental fluorosis score (score 1) was considered as a normal score (score =0). It was decided if a professional had difficulty in distinguishing between no fluorosis and questionable fluorosis, the general public (lay persons) would struggle more to do so.

A variation on the Dean index was used for the purpose of this study where the six anterior maxillary teeth were examined and from the two teeth most affected by dental fluorosis, if not equally affected, the one less affected was recorded (appendix 1). Teeth were dried with gauze and were clinically examined under a mixture of natural and fluorescent light.

Fluorosis scores were recorded by one examiner who had been standardized and calibrated by an expert. The examiner agreement was calculated using the kappa statistic (Fleis, 1981). A kappa score of 0.54 was attained indicating a moderate agreement according to Landis and Kock (1977) which was deemed acceptable for this study.

3.6 Data Analysis

Data was captured and analysed using Microsoft Excel®.

Relationships between variables were determined using Chi-squared test with statistical significance set at the 5% level.

3.7 Ethical Considerations

Permission to carry out the study was obtained from the Research Committee and the Faculty of Dentistry of The University of the Western Cape, registration number is 09/7/28. Written assent (Appendix 3) and consent (Appendix 2) were obtained from the participants and their parents respectively.
Chapter 4

Results

4.1 Sample distribution

Table 1. Distribution of sample according to Geographic location

<table>
<thead>
<tr>
<th>Location</th>
<th>Leeu Gamka</th>
<th>Merweville</th>
<th>Nelspoort</th>
<th>Murraysburg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (n=189)</td>
<td>49</td>
<td>59</td>
<td>29</td>
<td>52</td>
</tr>
</tbody>
</table>

A final sample of 189 participants for the research project was obtained. The reasons for not reaching the planned 200 participants were the small number of participants who met the inclusion criteria (below the ages 12-15 years and not living in the area since birth), lack of co-operation of the parents and children to complete the necessary consent and assent forms (Appendix 2 and 3), lack of cooperation of the children during the clinical screening. The total number of participants in Nelspoort was 29, well below the proposed 50 participants per site. The reasons for the low number of participants were that consent and assent forms were not completed by the learners and parents, learners were absent from school and the low number of learners who met the inclusion criteria (many learners were below ages 12-15 years and did not live in the area since birth). This led to the inclusion of all the available participants across the geographic locations that met the inclusion criteria.
4.2 Fluoride concentration

Table 2. Fluoride concentrations according to Geographic area

<table>
<thead>
<tr>
<th>Geographic area</th>
<th>Fluoride concentration (ppmF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leeu-Gamka School Borehole</td>
<td>1.88</td>
</tr>
<tr>
<td>Leeu-Gamka Railway (Domestic)</td>
<td>2.22</td>
</tr>
<tr>
<td>Leeu-Gamka Bitterwater (Domestic)</td>
<td>1.48</td>
</tr>
<tr>
<td>Murraysburg Domestic</td>
<td>0.56</td>
</tr>
<tr>
<td>Murraysburg Clinic</td>
<td>0.58</td>
</tr>
<tr>
<td>Merweville Domestic</td>
<td>0.68</td>
</tr>
<tr>
<td>Nelspoort Domestic</td>
<td>0.70</td>
</tr>
</tbody>
</table>

Table 2 shows the fluoride concentration of the water samples collected at the four geographic locations. Fluoride concentration of the drinking water was not weighted for Nelspoort, Merweville and Murraysburg only for Leeu Gamka. From the fluoride concentrations obtained from the clinic and domestic source at Murraysburg it was decided to use the 0.56 ppm F concentration as the frequency of water consumption from the clinic source was only occasional.

In Leeu Gamka the sample individuals were exposed to three drinking water sources with notable differences in concentration (Table 2). To determine a uniform fluoride exposure for this area a weighted average exposure concentration was calculated. This calculation was based on the annual number of hours individuals were exposed to each of the three different fluoride levels. The total number of hours of exposure per year (denominator) for the weighting was assumed to be the hours that individuals are generally awake. On the assumption that people on average sleep 6 hours per day the awake time was taken as 16 hours yielding a total of 5840 hours (16 × 365) per year. Exposure to the school water source (1.88 ppm F) was taken as 6 hours per day for 200 school days per year yielding an exposure time for all learners of 1200 hours. With 1200 hours of the awake time at school it left 4640 of the total awake hours for at home exposure to fluoride levels of either 2.22 ppm F for those living in the Railway settlement or 1.48 ppmF for those living in the main settlement of Bitterwater. It was further estimated that approximately 10% of individuals live in the Railway settlement with 90% in Bitterwater. Using the above assumptions and numbers a uniform weighted fluoride exposure concentration for Leeu Gamka of 1.62 ppmF was calculated (Equation 1) and used as the average fluoride exposure concentration for Leeu Gamka.
Equation 1 (Weighting of fluoride exposure in Leeu Gamka)

\[
90\% (\text{School} [F] \times \text{school hours} + \text{Bitterwater} [F] \times \text{awake hours}) + 10\%
(\text{School} [F] \times \text{school hours} + \text{Railway} [F] \times \text{awake hours})
\]

Total annual hours awake

\[
= \frac{0.9 \times (1.88 \times 1200 + 1.48 \times 4640) + 0.1 \times (1.88 \times 1200 + 2.22 \times 4640)}{5840}
\]

\[
= 1.62 \text{ ppmF}
\]
### 4.3 Severity of Dental Fluorosis

**Table 3 Dental fluorosis prevalence and severity by geographic location**

<table>
<thead>
<tr>
<th>Deans Fluorosis Score</th>
<th>Geographic Location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Leeu Gamka</td>
</tr>
<tr>
<td></td>
<td>1.62 ppmF</td>
</tr>
<tr>
<td></td>
<td>n=49</td>
</tr>
<tr>
<td>0 ≡ Normal &amp; 1</td>
<td>0.0%</td>
</tr>
<tr>
<td>≡Maybe</td>
<td>6.1%</td>
</tr>
<tr>
<td>3 ≡ Mild</td>
<td>10.2%</td>
</tr>
<tr>
<td>4≡Moderate</td>
<td>42.9%</td>
</tr>
<tr>
<td>5≡ Severe</td>
<td>40.8%</td>
</tr>
</tbody>
</table>

**Average Dean’s Score**: 4.2 1.0 1.7 1.1

Table 3 illustrates the prevalence of dental fluorosis and severity according to geographic distribution. In the high fluoride area more of the moderate and severe types of fluorosis (83.68%) were present and nobody had any fluorosis. In the low fluoride areas almost two thirds of the participants had no fluorosis with very mild and mild fluorosis dominating except in Nelspoort with a comparatively small sample size.
In Figure 1 the median slope of 3.2 over the fluoride exposure (weighted in Leeu Gamka) interval of 0.5 ppmF to 1.75 ppmF resulted in an increase of the average Dean’s fluorosis score from 1-4 with a maximum of 5. For any of the four bivariate determinations variability or error exists.
4.4 Self Rating Responses

These responses reflect what the learners thought about the appearance of their own teeth.

Table 4. Learners’ response to question: Are you aware of the “spots” on your teeth?

<table>
<thead>
<tr>
<th>Response</th>
<th>Leeu Gamka</th>
<th>Merweville</th>
<th>Nelspoort</th>
<th>Murraysburg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.62 ppm F</td>
<td>0.68 ppm F</td>
<td>0.70 ppmF</td>
<td>0.56 ppmF</td>
</tr>
<tr>
<td></td>
<td>n=49</td>
<td>n=59</td>
<td>n=29</td>
<td>n=52</td>
</tr>
<tr>
<td>No=0</td>
<td>9</td>
<td>53</td>
<td>23</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>18.4%</td>
<td>89.8%</td>
<td>79.3%</td>
<td>94.2%</td>
</tr>
<tr>
<td>Yes=1</td>
<td>40</td>
<td>6</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>81.6%</td>
<td>10.2%</td>
<td>20.7%</td>
<td>5.8%</td>
</tr>
</tbody>
</table>

In Leeu Gamka, with a higher fluoride level in the drinking water, the majority (81.6%) of learners were aware of fluorosis affliction of their teeth compared to the majority of learners not being aware (79%-94%) of such affliction in the other three areas with the lower fluoride content (0.56-0.70ppmF).
Table 5. Learners’ response to question: Are you embarrassed by the appearance of your teeth?

<table>
<thead>
<tr>
<th>Response</th>
<th>Geographic Location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Leeu Gamka</td>
</tr>
<tr>
<td></td>
<td>1.62 ppmF</td>
</tr>
<tr>
<td></td>
<td>n=49</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>NO=0</th>
<th>YES=1</th>
<th>Excluded=9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7</td>
<td>33</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1</td>
<td>49</td>
</tr>
</tbody>
</table>

14.3% 3.4% 10.3% 3.9%

67.3% 6.8% 10.4% 1.9%

18.4% 89.8% 79.3% 94.2%

Table 5 indicates that most of the learners (67.3%) in the high fluoride area (Leeu Gamka ([F] = 1.62 ppm) were embarrassed by the appearance of their teeth. The low proportions of learners in the other three areas ([F]= 0.56-0.7 ppm) is due to the fact that most learners in these areas indicated that they were not aware of fluorosis spots on their teeth (Table 4) and therefore were excluded from the rest of the selfrating questions (as reflected in the “excluded” row of the tables 5-8).
Table 6. Learners’ response to question: Do you want to remove the spots on your teeth?

<table>
<thead>
<tr>
<th>Response</th>
<th>Geographic Location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Leeu Gamka 1.62 ppmF n=49</td>
</tr>
<tr>
<td>No=0</td>
<td>0 2 0 1</td>
</tr>
<tr>
<td>Yes=1</td>
<td>40 4 6 2</td>
</tr>
<tr>
<td>Excluded=9</td>
<td>9 53 23 49</td>
</tr>
</tbody>
</table>

Table 6 indicates the majority (81.6%) of Leeu Gamka learners indicated that they would want to remove the fluorosis spots compared to low proportions in the other three areas with Nelspoort being the highest of these at 20.7%. There were no Nelspoort and Leeu Gamka learners who were aware of dental fluorosis affliction, who did not want to remove the spots from their dentition. The excluded proportions are the same learners excluded due to their response as explained under Table 5.
Table 7. Learners’ response to question: Do people tease you about the spots on your teeth?

<table>
<thead>
<tr>
<th>Response</th>
<th>Leeu- Gamka</th>
<th>Merweville</th>
<th>Nelspoort</th>
<th>Murraysburg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.62 ppmF</td>
<td>0.68 ppmF</td>
<td>0.70 ppmF</td>
<td>0.56 ppmF</td>
</tr>
<tr>
<td></td>
<td>n=49</td>
<td>n=59</td>
<td>n=29</td>
<td>n=52</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>No=0</th>
<th>Yes=1</th>
<th>Excluded = 9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7</td>
<td>33</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>1</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1</td>
<td>49</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>14.3%</th>
<th>67.3%</th>
<th>18.4%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.4%</td>
<td>6.8%</td>
<td>89.8%</td>
</tr>
<tr>
<td></td>
<td>17.2%</td>
<td>3.5%</td>
<td>79.3%</td>
</tr>
<tr>
<td></td>
<td>3.9%</td>
<td>1.9%</td>
<td>94.2%</td>
</tr>
</tbody>
</table>

Table 7 indicates that more than two thirds (67.3%) of the learners in Leeu Gamka indicated that they were being teased compared to the low proportion being teased in the other areas (1.9% - 6.8%)
Table 8. Learners’ response to question: Have you or your parents tried to do anything about the way your teeth look?

<table>
<thead>
<tr>
<th>Response</th>
<th>Geographic Location</th>
<th>Leeu-Gamka</th>
<th>Merweville</th>
<th>Nelspoort</th>
<th>Murraysburg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1.62 ppmF</td>
<td>0.68 ppmF</td>
<td>0.70 ppmF</td>
<td>0.56 ppmF</td>
</tr>
<tr>
<td></td>
<td>n=49</td>
<td>n=59</td>
<td>n=29</td>
<td>n=52</td>
<td></td>
</tr>
<tr>
<td>No=0</td>
<td></td>
<td>35</td>
<td>4</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>71.4%</td>
<td>6.8%</td>
<td>17.2%</td>
<td>5.8%</td>
</tr>
<tr>
<td>Yes=1</td>
<td></td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10.2%</td>
<td>3.4%</td>
<td>3.5%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Excluded=9</td>
<td></td>
<td>9</td>
<td>53</td>
<td>23</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18.4%</td>
<td>89.8%</td>
<td>79.3%</td>
<td>94.2%</td>
</tr>
</tbody>
</table>

Table 8 indicates that of the learners who were aware of the fluorosis stains on their teeth a small proportion (0-10%) tried to do something about it, even in Leeu Gamka with the higher fluoride content and more severe types of dental fluorosis.

There was a varied response amongst the small percentage of learners who actually sought treatment on what they actually did and it varied from using Jik (Domestic bleaching agent), ash and stone in an attempt to enhance the aesthetics of the teeth. There were isolated cases of learners that mentioned that their parents took them to the dentist and requested the removal of the affected teeth and that they wanted the extracted teeth to be replaced with dentures.
4.5. Response to clinically defined fluorosis using photographs with predetermined fluorosis scores (Dean’s: 0; 3; 4; 5)

Table 9. Learners’ response to statement: The appearance of these teeth is pleasing and looks nice

<table>
<thead>
<tr>
<th>Geographic Location</th>
<th>Photographs of Clinically Defined Fluorosis (Dean’s Index)</th>
<th>Leeu Gamka</th>
<th>Merweville</th>
<th>Nelsport</th>
<th>Murraysburg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.62 ppmF</td>
<td>0.68 ppmF</td>
<td>0.7 ppmF</td>
<td>0.56 ppmF</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Average of Response to No fluorosis</th>
<th>4.06</th>
<th>4.75</th>
<th>4.28</th>
<th>4.19</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average of Response to Mild fluorosis</td>
<td>4.10</td>
<td>4.71</td>
<td>4.03</td>
<td>4.48</td>
<td></td>
</tr>
<tr>
<td>Average of Response to Moderate fluorosis</td>
<td>4.33</td>
<td>4.83</td>
<td>4.00*</td>
<td>4.63</td>
<td></td>
</tr>
<tr>
<td>Average of Response to Severe fluorosis</td>
<td>4.98</td>
<td>4.95</td>
<td>4.97</td>
<td>5.00**</td>
<td></td>
</tr>
</tbody>
</table>

* Minimum average score
** Maximum average score

The response to this statement varied little for all four photographs across the geographic areas as the minimum and maximum average scores varied between 4.00 and 5.00 (Disagree to strongly disagree).

The response to the photograph depicting severe fluorosis reflected a somewhat greater tendency towards strongly disagreeing with the statement with the average response score varying from 4.95-5.00 for the different geographic areas.

It is further notable that in all the geographic areas the response to the photographs depicting no and mild fluorosis, revealed that the learners did not find such teeth aesthetically pleasing.
Table 10. Learners’ response to statement: I think a child with teeth like these would be embarrassed by their appearance

<table>
<thead>
<tr>
<th>Geographic Location</th>
<th>Leeu Gamka</th>
<th>Merweville</th>
<th>Nelspoort</th>
<th>Murraysburg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photographs of Clinically Defined Fluorosis (Dean’s Index)</td>
<td>1.62 ppmF</td>
<td>0.68ppmF</td>
<td>0.7ppmF</td>
<td>0.56ppmF</td>
</tr>
<tr>
<td>Average of Response to No fluorosis</td>
<td>1.53</td>
<td>1.24</td>
<td>1.28</td>
<td>1.60</td>
</tr>
<tr>
<td>Average of Response to Mild fluorosis</td>
<td>1.69</td>
<td>1.34</td>
<td>2.14 **</td>
<td>1.46</td>
</tr>
<tr>
<td>Average of Response to Moderate fluorosis</td>
<td>1.51</td>
<td>1.19</td>
<td>1.62</td>
<td>1.31</td>
</tr>
<tr>
<td>Average of Response to Severe fluorosis</td>
<td>1.00*</td>
<td>1.00*</td>
<td>1.14</td>
<td>1.15</td>
</tr>
</tbody>
</table>

*Minimum average score

**Maximum average score

For all photographs the response to this statement varied between 1 and 2 (Strongly agree or Agree) among all four geographic regions.

The response to the photograph depicting severe fluorosis revealed that learners from all the geographic areas “strongly agreed” with the statement that such teeth would be embarrassing with the average response score varying between 1.00 and 1.15.

It was further observed that for the milder forms of fluorosis, including the photograph depicting no fluorosis, the learners from all the geographic areas “agreed” to “strongly agreed” that teeth would be embarrassing with average response scores varying between 1.19 to 2.14.
Table 11. Learners’ response to statement: Teeth like these indicate that the child has neglected his/her teeth

<table>
<thead>
<tr>
<th>Geographic Location</th>
<th>Leeu Gamka</th>
<th>Merweville</th>
<th>Nelspoort</th>
<th>Murraysburg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photographs of Clinically Defined Fluorosis (Dean’s Index)</td>
<td>1.62 ppmF</td>
<td>0.68 ppmF</td>
<td>0.7 ppmF</td>
<td>0.56 ppmF</td>
</tr>
</tbody>
</table>

| Average of Response to No fluorosis | 1.80 | 1.39 | 1.52 | 1.40 |
| Average of Response to Mild fluorosis | 2.08 | 1.39 | 1.66 | 1.54 |
| Average of Response to Moderate fluorosis | 2.39 ** | 1.36 | 1.93 | 1.50 |
| Average of Response to Severe fluorosis | 2.16 | 1.36 * | 1.55 | 1.37 |

*Minimum average score

**Maximum average score

The response to this statement varied little for all the photographs across the geographic areas as the minimum and maximum average response scores varied between 2.39 and 1.36 (agree and strongly agree). The response to the photographs depicting no- and mild fluorosis reflected that the learners from all the geographic areas agreed with the statement with the average response varying from 1.39- 2.08.

It is further notable that in all the geographic areas the response to the photographs depicting moderate – and severe dental fluorosis revealed that the learners from all the geographic areas agreed that individual’s own negligence was responsible for the appearance of their teeth with average response scores varying between 1.36 and 2.39.
Table 12. Learners’ response to statement: To have front teeth like these would be a disadvantage as the child goes into adult life

<table>
<thead>
<tr>
<th>Geographic Location</th>
<th>Leeu Gamka</th>
<th>Merweville</th>
<th>Nelspoort</th>
<th>Murraysburg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photographs of Clinically Defined Fluorosis (Dean’s Index)</td>
<td>1.62 ppmF</td>
<td>0.68ppmF</td>
<td>0.7ppmF</td>
<td>0.56ppmF</td>
</tr>
<tr>
<td>Average of Response to No fluorosis</td>
<td>1.96</td>
<td>1.39</td>
<td>1.48</td>
<td>1.44</td>
</tr>
<tr>
<td>Average of Response to Mild fluorosis</td>
<td>1.90</td>
<td>1.41</td>
<td>2.07**</td>
<td>1.40</td>
</tr>
<tr>
<td>Average of Response to Moderate fluorosis</td>
<td>1.53</td>
<td>1.20</td>
<td>1.83</td>
<td>1.38</td>
</tr>
<tr>
<td>Average of Response to Severe fluorosis</td>
<td>1.16</td>
<td>1.17</td>
<td>1.00*</td>
<td>1.00*</td>
</tr>
</tbody>
</table>

* Minimum average response
** Maximum average response

The response to this statement varied little for all four photographs across the geographic areas as the minimum and maximum average scores varied between 1.00 and 2.07 (Strongly Agree to Agree).

The response to the photograph depicting severe fluorosis reflected a somewhat greater tendency towards strongly agreeing with the statement.

Notably for photographs depicting no –and mild fluorosis there was a tendency towards strongly agreeing to this statement given the average response varying between 2.07 and 1.39
Chapter 5
Discussion

5.1 Study sample and limitations

The final number of participants was 189 (originally 200 were proposed) for the study. All the participants who met the inclusion criteria were included in the study due to the limited numbers available. A further limitation of the study sample was the small number of participants at Nelspoort compared to the other geographic areas. This was despite numerous efforts to secure a larger sample size. The limited overall sample size, compounded further by the even smaller number in Nelspoort, may affect the generalizability of inferences from the study.

5.2 Instrument for data collection

All the questions were asked by one examiner in a standardized method. The images depicting different degrees of fluorosis were shown independently to each participant in a standardized method (Appendix 4).

5.3 Prevalence and Severity

The reason for weighting at Leeu Gamka was to make a calculated estimate (weighted estimate) of the fluoride concentration of the drinking water the population was exposed to because there were three potential sources of drinking water (with varying fluoride concentrations) and two communities to consider for this area. The method of weighting was explained in detail in the results (Equation 1).

Table 3 and Fig 1 illustrate that there exists a direct relationship between dental fluorosis and the levels of fluoride concentration in the drinking water, where the affliction and severity of dental fluorosis increased as the fluoride concentration of the drinking water increased. This finding is in agreement with previous research (Chikte et al. 2001; Grobler et al. 2001; Shitumbanuma et al. 2007; Gbadebo. 2012). In Leeu Gamka (high fluoride area), 83.7% of participants had moderate and severe fluorosis compared to the low fluoride areas where 5.1% of participants for Merweville, 31.0% for Nelspoort and 9.6% for Murraysburg had moderate to severe fluorosis. The reason for the percentage of severe and moderate fluorosis at the low fluoride areas might be that during the warmer seasons the participants consumed more water because of the elevated daily temperatures in the Central Karoo (Grobler et al, 2001). It is also known that fluoride concentrations during periods of drought can increase (Louw et al, 2002). This could also have been a contributing factor.
While it is also known that dietary practices such as use of naturally occurring salt deposits containing high levels of fluoride prevail in Africa (Yoder et al, 1998), this was not the case in this study and no apparent fluoride contribution from the diet could be found.

5.4 Perceptions of Fluorosis (Self Rating)

Table 4 illustrates that a higher percentage (81.6%) of the participants from the high fluoride area were aware of dental fluorosis when compared to the low fluoride areas. Many participants of the low fluoride areas were not even aware of fluorosis affliction, the reason being that these participants are afflicted with the less severe types of dental fluorosis. This is in agreement with the findings of Clark et al (1993), Chikte et al (2001) and Wondwosen et al (2003b) that participants are aware of dental fluorosis and it is of a concern in all geographic areas (high - and low fluoride areas) but the awareness and concern are expressed mostly by participants afflicted by the more severe types of dental fluorosis. Table 4 further indicates that the largest proportion of individuals from the three low fluoride areas were not aware of fluorosis spots on their teeth and therefore had to be excluded from the remainder of the selfrating responses (tables 5-8) rendering low numbers of responses in these areas.

Table 5 reflects that a higher percentage of the participants (67.3%) in Leeu Gamka admitted being embarrassed by the appearance of their teeth compared to the other three low fluoride areas. The average Dean’s fluorosis scores (Table 3) indicates that Leeu Gamka participants were mostly afflicted with moderate to severe dental fluorosis compared to the other geographic areas. Previous research found that the worse the clinically defined oral health status in terms of increasing TF/ TSIF (Thylstrup Fejerskov/Tooth Surface Index of Fluorosis) scores, the worse the self-ratings of distress, worry and embarrassment become (Van Palenstein and Mkasabuni, 1993; Chikte et al, 2001; Wondwosen et al, 2003b and Bhagyajyothi and Pushpanjali, 2009; Aguilar-Diaz et al, 2011). Therefore the more severe the fluorosis affliction the more embarrassed participants seem to become.

All the participants in the high fluoride area who were aware of the fluorosis affliction wanted the fluorosis stains removed from their teeth (Table 6), whereas in the low fluoride areas only a small proportion of the participants wanted the stains removed. Van Palenstein and Mkasabuni (1993) found that all the children in their study sample and 56% of adults wanted treatment for the fluorosis stains on their teeth. De Castilho et al (2009) and Bhagyajyothi and Pushpanjali (2009) also found that there existed a great need for treatment of dental fluorosis amongst the children afflicted with the severe types of dental fluorosis.
Table 7 shows that 67.3% of participants of Leeu Gamka who were aware of the fluorosis stains, admitted to being teased because of the appearance of their teeth compared to a small percentage in the other areas. De Casthilho et al (2009) found that there were conflicts between students at a Brazilian school between the affected and non-affected due to teasing and stigmatizing. Coffield et al (2005) found a large percentage (93%) of children who admitted to being teased about the appearance of their teeth due to enamel defects. It was found that of the participants who were aware of fluorosis affliction only a small portion actually sought treatment for the removal of the fluorosis stains across the geographic areas. At Leeu Gamka only 10.2% of the participants sought treatment where the more severe type of fluorosis are more common. The reasons for this might be the distance from the dental service situated at Beaufort West (70km from Leeu Gamka, 50 km from Nelspoort and 165 km from Murraysburg and Merweville) or the children might have adapted to the appearance of fluorosis and consider it to be “normal” because it is such a common finding in their area. Van Palenstein and Mkasabuni (1993) found that even though most of the participants wanted treatment, none of them actually sought dental treatment with reasons being that the aesthetic disorder was not painful and that cosmetic dentistry was not available or affordable. The Central Karoo is also a rural area and these reasons can be applicable to the area as well.

The actions taken by the parents and children varied from going to the dentist (for dental extractions), brushing with domestic bleaching agents (Jik), brushing with abrasives for example ash or wood in an attempt to enhance the appearance of the teeth. This is in agreement with previous research (van Palenstein and Mkasabuni, 1993; Lewis and Chikte, 1995; Yoder et al, 1998; Mothusi, 2000).

5.5 Perceptions of Fluorosis (Clinically Defined Fluorosis)

It is notable that in all the geographic areas the response to the photographs depicting no and mild fluorosis revealed that the learners did not find such teeth aesthetically pleasing (Table 9). The average response score varied between 4.03-4.75 for the photographs depicting normal and mild fluorosis across all the geographic areas which reflected a greater tendency to “disagree” to “strongly disagree” with the statement.

The participants were concerned with the “yellow” appearance of the photographs depicting normal teeth and mild fluorosis. The media could be a determinant in this finding because the teeth shown by the media are normally unnaturally white in appearance and this is perceived by the community to be healthy and the norm. Children of a certain age are critical of their own appearance and the appearance of others and they are usually in their adolescent years (Wondwosen et al, 2003a) and the greater proportion of the study sample was adolescents.
Browne et al (2011) and McGrady et al (2012) found that uniform white teeth, where the degree of whiteness could only be attained by bleaching, had the highest preference by adolescents. The learners across the geographic areas had dissatisfaction with the appearance of photographs depicting no fluorosis. This finding was consistent with findings of Clarkson and O’Mullane (1992) and Riordan (1993). These authors attributed this to the possibility that the observers became confused or distracted by other attributes of the face and mouth of the children considered. This “dissatisfaction” had an effect consistently throughout the clinically defined fluorosis response in this study. Another reason could be the quality of the images shown to the learners because the images were photos from a book.

There was a strong tendency across the geographic areas to “disagree” to “strongly disagree” for “moderate” fluorosis. There was also a strong tendency across the geographic areas to “strongly disagree” on this statement (Table 9) for the photograph showing severe dental fluorosis. This is in agreement with previous research that with an increase in fluorosis severity there is a decline in acceptance and the participants consider fluorosis to be aesthetically objectionable (Riordan, 1993; Clark et al, 1993; Wondwossen et al, 2003a; Wondwossen et al, 2003b; McGrady et al, 2012; Browne et al, 2011).

The finding in Table 10 that no fluorosis and mild fluorosis was considered to be an embarrassment by the learners across the geographic areas (low- and high fluoride areas) can be due to reasons stated earlier i.e.: adolescents prefer uniform white teeth, the learners became confused or distracted by other attributes of the face and mouth of the children considered and the possibility of the quality of the images shown to the participants. The finding of no fluorosis and mild fluorosis being a source of embarrassment for the participants across the geographic areas differs from the findings of Wondwossen et al (2003a). According to Wondwossen et al (2003a) learners from a high fluoride area (Nazreth) were less critical of mild fluorosis as a source of embarrassment because they themselves were afflicted and therefore have a higher threshold of tolerance to the cosmetic effects of dental fluorosis, contrary to the learners from the low fluoride area (Addis Ababa) where the learners were more critical of mild fluorosis and perceived it to be a source of embarrassment. Learners perceived severe and moderate fluorosis to be an embarrassment to the individual. The increase of fluorosis severity might lead to a decline in preference by the learners and the photographs depicting moderate and severe fluorosis were perceived less favourable (Riordian, 1993; Wondwossen et al, 2003a; Wondwossen et al, 2003b; McGrady et al, 2012; Browne et al, 2011; Aguilar-Diaz et al, 2011).
The responses to the statement on neglect (Table 11) illustrates that across the geographic areas learners selected “agree” to “strongly agree” for all the photographs. Learners erroneously believed that the appearance of the teeth was due to neglect on the part of the child. This is in agreement with the findings of Wondwossen et al (2003a) and Wondwossen et al (2003b). Riordan (1993) also found that participants indicated that more severe dental fluorosis was due to neglect on the part of the child. Wondwossen et al (2003b) found that more than 50% of participants of the low fluoride area (Addis Ababa) “agree” and “strongly agree” that teeth depicting TF (Thylstrup Fejerskov) scores of 5 and 7 was due to neglect on the part of the child.

The responses to the statement on disadvantage (Table 12) illustrated that learners across the geographic areas showed a strong tendency towards “agree” and “strongly agree” for all the photographs. Learners believed that the appearance of the teeth will be a disadvantage as the child goes into adult life even for the photograph depicting no fluorosis. Severe fluorosis was met with a unanimous negativity by all the learners across the geographic areas and the learners showed a strong tendency to “strongly agree”. The findings for severe fluorosis are in agreement with previous findings (Riordan, 1993; Wondwossen et al, 2003b).
Chapter 6
Conclusions

- There exists a positive relationship between dental fluorosis and fluoride concentration of the drinking water- fluorosis severity and affliction increased with an increase of fluoride concentration in the drinking water.

- Fluorosis was only a problem in Leeu Gamka (high fluoride area) and not the three other areas (low fluoride areas).

- Most of the learners were not aware of fluorosis affliction, which was a common finding in the three low fluoride areas.

- Only a small proportion of learners that indicated that they wanted treatment actually sought dental treatment.

- Across the geographic areas learners admitted to being teased due to dental fluorosis affliction.

- There was a consistent tendency across all the geographic areas that dental fluorosis will be an embarrassment for the child and that it will be a disadvantage for the child into adulthood.

- The learners erroneously believed that dental fluorosis was due to neglect on the part of the child.

- The general consensus of the communities was that fluorosis was judged with feelings of negativity.
Chapter 7
Recommendations

The fluoride content of the drinking water in Leeu Gamka (1.62ppmF) is higher than the WHO (1997) recommended optimum value of 0.7-1.2 mg/l depending on climate, diet and use of fluoride supplements. This is an unacceptable level of fluoride concentration of the drinking water and results in dental fluorosis in the area. Chikte et al (2001) reported that a proposed fluoride concentration of not more that 0.7 ppmF prescribed in the Regulations on Fluoridating the Water Supplies for South Africa would minimise the risk of dental fluorosis.

It is recommended that the use of rainwater harvesting for consumption and to use clay pots to store the drinking water in (helps to reduce the fluoride content of the drinking water by absorption of the fluoride of the clay minerals) (Wilkister et al. 2001). The consumption of rain water might be better but the Central Karoo is a water scarce area. Another option that can be explored is to find an alternative water source.

The people should also be educated on the etiology of dental fluorosis, the pathology and the importance of safe drinking water. De-fluoridation of the drinking water might prove to be too costly for the local government to maintain. Cheaper methods of treating the water source with raw bricks, rain water harvesting and storing the drinking water in clay pots might be more realistic approaches.
References


Hawley GM, Ellwood RP, Davies RM, 1996. Dental caries, fluorosis and the cosmetic implications of different TF scores in 14-year-old adolescents, *Community Dental Health* 13,189-192


Van der Merwe EHM, Bischoff JI, Fatti LP, Retief DH, Barbakow FH, Friedman M, 1977a. Relationship between fluoride in enamel, DMFT index and fluorosis in high- and low-fluoride areas in South Africa. *Community Dentistry and Oral Epidemiology*, 2 : 61-64


Appendix 1

Questionnaire

General Information

Identification number: 

Name: 

Date of Birth (DD/MM/YY): 

Age in years: 

Gender: (male=1, female=2) 

Geographic Location: (Leeu Gamka=1, Merweville=2, Nelspoort=3, Murraysburg=4) 

Dental Fluorosis (Deans Index):

0=normal, 1=questionable, 2=very mild
3=mild, 4=moderate, 5=severe
8=excluded, 9=not recorded

Self Rating Response (yes=1, no=0)

1. Are you aware of the “spots” of your teeth?

2. Are you embarrassed by the way your teeth look?

3. Do you want to remove the “spots” on your teeth?

4. Do people tease you about the “spots” on your teeth?

5. Have you or your parents tried to do anything about the way your teeth look?

(If you answered yes to question 5):

6. What did you do to your teeth? Specify:

Clinically defined Fluorosis Response (Strongly agree=1, Agree=2, Neither agree nor disagree=3, Disagree=4, Strongly disagree=5) (N=normal, M=mild, MO=moderate, S=severe)

Questions/statements

<table>
<thead>
<tr>
<th>Questions/statements</th>
<th>N</th>
<th>M</th>
<th>MO</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The appearance of these two teeth is pleasing and looks nice.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. I think a child with front teeth like these would be embarrassed by their appearance.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Teeth like these indicate that the child has neglected his/her teeth in the past</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>4. To have front teeth like these would be a disadvantage as the child goes into adult life</td>
<td></td>
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Appendix 2

CONSENT FOR ORAL EXAMINATION

Date:

Dear Parent of …………………………………………………………..,

I am a Masters Student in the Department of Community Oral Health at University of the Western Cape. We are interested in examining your child’s mouth and teeth to look for any problems related to staining. We are doing this to see if there are ways in which we can prevent any problems or help with any problems they may have.

The oral examination will take about 10 minutes. We may take photographs, but we will only take photographs of your teeth and no-one will be able to neither identify the child nor see the face on the photographs. There are no risks in participating and there should be no more discomfort than in a routine dental check up examination.

All information gathered in the study will be treated as strictly confidential. No one will have access to this information except the researcher. Neither your name nor anything that identifies you will be used in any reports of this study. All information collected will be maintained and stored in such a way as to keep it as confidential as possible.

If you would like your child to take part in the study, please sign the bottom of this letter. Please contact Dr B.G. Rickers at 0234143411(w) for any further enquiries.

Thanking you in advance for your co-operation

Yours sincerely

Dr BG Rickers

I ……………………………………………understand what will be required of my child to take part in the study. I agree to allow my child to participate in the research being undertaken by Dr BG Rickers. I understand that at any time I may withdraw my child from this study without giving a reason and without affecting his/her normal care, management or schooling.

Name: ............................................…………..               ............................................……….
(Print in block letters)

(Signature)

Date:     .............................................…………     Witness: ………………………………

Appendix 3

ASSENT FOR ORAL EXAMINATION

Date:

Dear Participant

I am a Masters Student in the Department of Community Oral Health at University of the Western Cape. We are interested in examining your mouth and teeth to look for any problems related to staining. We are doing this to see if there are ways in which we can prevent any problems or help with any problems you may have.

The oral examination will take about 10 minutes. We may take photographs, but we will only take photographs of your teeth and no-one will be able to neither identify you nor see the face on the photographs. There are no risks in participating and there should be no more discomfort than in a routine dental check up examination.

All information gathered in the study will be treated as strictly confidential. No one will have access to this information except the researcher. Neither your name nor anything that identifies you will be used in any reports of this study. All information collected will be maintained and stored in such a way as to keep it as confidential as possible.

If you would like to take part in the study, please sign the bottom of this letter. Please contact Dr B.G. Rickers at 0234143411(w) for any further enquiries.

Thanking you in advance for your co-operation

Yours sincerely

Dr BG Rickers

I ……………………………………………understand what will be required of myself to take part in the study. I agree to participate in the research being undertaken by Dr BG Rickers. I understand that at any time I may withdraw from this study without giving a reason and without affecting my normal care, management or schooling.

Name: ............................ .............................................

(Print in block letters)

(Signature)

Date: ............................ .............................................  Witness: ............................ .............................................
Appendix 4
Photographs Depicting Clinically Defined Fluorosis

(Dean’s Scores : 0, 3, 4, 5)

Image 1 : No Fluorosis (Dean’s score=0)

Image 2 : Mild Fluorosis (Dean’s score=3)

Image 3 : Moderate Fluorosis (Dean’s score=4)

Image 4 : Severe Fluorosis (Dean’s score=5)