Community drinking water fluoridation in the Southern Cape and Karoo Region: A feasibility study.

A dissertation submitted for the degree
MSc (Dent) in Community Dentistry
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Declaration

I declare that the Community drinking water fluoridation in the Southern Cape and Karoo Region: A feasibility Study *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 by complete references.

Gilbert J Dennis ***November 2002***

Abstract

The prevalence of dental decay is high among lower socio-economic groups in the Southern Cape and Karoo region. 70 – 80% of State employed dentists' time in this region is spent on attempting to reduce the pain and sepsis within the communities for which the primary treatment modality is extraction of the tooth under emergency conditions. In developing countries the prevalence of dental decay is still high. There is a general downward trend of dental decay in developing countries; and it is associated with combinations of: exposure to fluoridated water and/ or other forms of fluoride exposure (e.g. in fluoridated tooth paste), the provision of preventive oral health services, an increase in dental awareness through organized oral health education programs and the readily available dental resources. This study looked at the feasibility of implementing community water fluoridation in the Southern Cape and Karoo Region by describing the primary drinking water sources, the population distribution around these sources and the actual levels of fluoride found in the water samples. Each sample was coded and with the use of a global positioning system (GPS), a set of co-ordinates obtained for each. Other options with regard to fluoride supplementation were explored as an attempt to provide an alternative intervention option for exposure to fluoride where community drinking water fluoridation was not the first option.

This information will be used to record and update existing tables for fluoride levels in community drinking water of the communities in the Southern Cape and Karoo region that is currently used as a guide for prescribing fluoride supplementation as a means of prophylaxis for the prevention and reduction of dental decay.

This study re-iterated the diverse set of variables that communities living in rural areas have to live with. It supports the trend that in developing countries the DMFT (12 years) and dmft (6 years) are higher than those in the same age cohorts of developed countries.

This study shows that the fluoride level in borehole water is generally higher than that of dams or reservoirs.

Fluoride supplementation is required in the bigger, densely populated areas as the fluoride levels of the water in these areas are below optimal and their water systems can accommodate fluoridation. The long term gains of community water fluoridation at optimal levels for entire communities by far out way the risk of developing fluorosis at above optimal levels.

There needs to be a systematic review of treatment needs and treatment modalities for each community so that at some point the need for prevention strategies will be sought out by program managers as best practice for improving the general health (i.e. and oral health) of their communities.

There is no single approach for solving issues in communities with different sets of variables determining their needs and so too to the question of community water fluoridation. The recommendation is that at the community level (i.e. the communities should be empowered to do their own situational analysis and prioritize their needs) people need to make decisions for themselves with regard to the type of preventive strategy that they implement. Once they have the data and an intervention option is arrived at, they should lobby with their local health provider to implement that intervention option (e.g. Exposure to fluoride as a means of improving dental health) that they have identified in their towns or villages.

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Literature Review

1.1 Introduction

The fluoride level in the community drinking water in Mossel Bay has been suggested to be below 0.3ppm by many of the local pharmacists (i.e. 5 out of the 5 pharmacists). This, with the many patients seen per session (i.e. children and adults) for the extraction of their teeth under local anaesthetic and with the region gaining autonomic status as a region in this Province, has lead to this study. The profession promotes the idea of fluoride supplementation as a means of reducing and preventing dental decay. Before this can happen there needs to be baseline data available that serves as a guide for prescribing the dosages that are to be recommended for fluoride supplementation.

The average 12-year-old in underdeveloped countries, where 80 % of the world's children live; have a higher dental caries score than their counter parts in industrialized countries. Urban communities are often regarded as developed communities as opposed to rural communities that are regarded as developing communities. In the developing communities the prevalence of caries is found to be higher than that found in developing communities (Moola and Vergotini, 1988). A survey conducted in the Langkloof (Carstens, Hartshorne, Louw and Kruger, 1993) showed a different picture of caries prevalence among 12-year-old children in rural parts of the Western Cape. Caries, rather than periodontal disease constitute the major cause of tooth loss among children (Baelum and Fejerskov, 1986; Manji et al., 1988: Tirwomwe et al., 1988).

In South Africa numerous researchers (Reddy, Van Wyk and Grobler, 1979; Cleaton-Jones et al., 1987; Cleaton-Jones et al., 1984;Hartshorne et al., 1987;Cleaton-Jones et al., 1989a;Martin, 1991;Hartshorne, Carstens and Laubscher, 1991;Du Plessis et al., 1993;Carstens, Hartshorne, Louw and Kruger, 1993; Grobler, Dreyer, Blignaut, 2001) have found the dmft and DMFT scores to be excessively high in rural coloured communities. The recorded data for the rural South African regions show a high DMFT and even higher dmft scores. Hartshorne et al., (1991) showed that the DMFT for 12 year-old rural black children to be 3.68. Sixty to eighty percent of six-year-old children in Soweto, Cape Town and Port Elizabeth suffer from tooth decay (Chikte, 1997).

A study done on rural coloured children (Martin, 1991) found the dmft to be 9,51 which is very high when compared to WHO's global goal that was to aim at having at least 50 percent of 5-6 year old children caries free at the turn of the century. This data supports the backlog of children under the age of 6 (i.e. in this region) that are booked to have multiple carious teeth extracted. Carstens, et al., (1992) showed that the DMFT in the Langkloof area is 4.72 at age 12. Table 1 shows the DMFT for 12 year-olds in various parts of the world. The DMFT scores for some of the developing countries that are listed in the table are higher than the values for their developed counter-parts. For the prevention and reduction of dental caries there are five common solutions viz.; modifying the diet to reduce non-milk extrinsic sugar intake, fluoride utilization, fissure sealants, and oral hygiene programs (Murray JJ, 1993).

It would appear that out of the above options, given the staff and financial shortages; the option most likely to be deployed by the Department of Health in the Southern Cape and Karoo region as a means of reducing and preventing dental caries has to be one that is preventive, has cost benefits and would not be labour intensive. The oral health team in the Southern Cape and Karoo region operates with a disproportionate staff member to patient ratio, a large geographical area to service, poor spread of clinical facilities where patients can be treated, insufficient state funding to implement and sustain labour intensive and cost efficient interventions to reduce and prevent dental decay.

Table 1.1 The severity of dental caries in various populations.

Author	Country	Age	DMF T	DF MS
Vanobbergen J,Martens L,Declerk D. (May 2001)	Belgium	12	1.93	
Barbachan e Silva B,Maltz M. (Jul-Sept 2001)	Brazil – Porto Alegre	12	2.22 ± 0.08	
Sales-Peres SH,Bastos JR. (Sept-Oct 2002)	Brazil – Sao Paulo	12	4.82	
Rigonatto DD,Antunes JL,Frazao P. (Mar-Apr 2001)	Brazil - Xingu	11-13	5.9	
Sampaio FC,Hossain AN, von der Fehr FR,Arneberg P.(Aug 2000)	Brazil –Paraiba: F<0.2ppm F 0.7–1.0ppm	12	3.9 2.5	9.2 5.4
Tapsoba H,Bakayoko-Ly R. (Mar 2000)	Burkino Faso - Kadiogo	12	1.72 ± 0.12	
Wang HY,Poul EP,Jin-You B,Bo-Xue Z. (Aug 2002)	China –National survey	12	1.0	
Pitts NB,Evans DJ,Nugent ZJ,Pine CM. (Mar 2002)	England & Wales	12	0.63 – 1.31	
Singh et al., (Mar 1999)	India – Rural Haryana	12-16	1.03	
Goel P,Sequeira P,Peter S. (Mar 2000)	India -Karnataka	12-13	1.87 ± 2.01	
Albashaireh Z,al-Hadi Hamasha A. (Mar 2002)	Jordanian	12-13	2.51	
Irigoyen ME,Sanchez-Hinojosa G. (Jul-Aug 2000)	Mexico	12	2.47	
al-Banyan RA,Echeverri EA,Narendran S,Keene HJ. (Mar 2000)	Saudi Arabia - Riyadh	5-12	2.0 ± 1.9	3.1 ± 3.7
al-Shammery AR. (1999)	Saudi Arabia (urban) (rural)	12-13	2.69 2.65	
NGBO (1987)	South Africa-Mossel bay Langkloof	12	4.2 6.1	
Hartshorne et al.,(1991)	South Africa: rural black	12	3.68	
Louw et al., (1991)	South Africa: Dagbreek De Villiers	12	4.38 4.96	
Carstens IL,Hartshorne JE,Louw AJ, Kruger., (1992)	South Africa; Langkloof	12	4.72	
Carstens IL,Louw AJ,Kruger E.,(1995)	South Africa (Fraserburg NW Cape)	12	0.22 ± 0.86	
Grobler SR,Louw AJ,van Kotze TJ., (2001)	South Africa: Leeu Gamka Kuboe, Sanddrif	10-15	1.98 ± 0.22 1.54 ± 0.24 1.64 ± 0.30	
Brindle R,Wilkinson D,Harrison A,Connolly C,Cleaton-Jones P., (Feb 2000)	South Africa –KwaZulu/Natal Hlabisa	12	0.4	
Beiruti N,Taifour D,van Palenstein Helderman WF,Frencken JE.,(Feb 2001)	Syria	12	1.9 – 2.3 (estimated)	
Petersen PE,Hoerup N,Poomviset N,Prommajan J,Watanapa A. (Apr 2001)	Thailand – Surattani Province	12	2.4	

1.2 Fluoride concentration in drinking water of the South Cape and Karoo.

Frederick McCay (1901-1933) saw a defect in enamel; "Colorado brown stain"; that was later attributed to the chronic exposure to fluoride. H Trendley Dean (1933-1945) looked at the relationship between naturally occurring fluoride concentrations in the drinking water, enamel fluorosis and dental caries. By balancing the caries preventive benefits achieved by fluoride and the risk of fluorosis, the range of optimal fluoridation was set between 0.7 and 1.2 ppm. From this range and depending on the fluoride levels in the drinking water, one could either supplement fluoride exposure or look at ways to de-fluoridate the drinking water. Around 1945 Grand Rapids Michigan became the first city in the world to adjust its drinking water fluoride concentrations to a level expected to promote dental health. This set a global trend, with more countries embarking and implementing fluoridation of community drinking water. Murray and Rugg-Gunn (1956-1979) and Newbrun (1979) showed that there is enough clinical evidence available to conclude that there are benefits to deciduous teeth from water fluoridation. The dmf(t) prevalence for Grand Rapids 6 year-olds; the peak age for caries prevalence of deciduous teeth; was reduced by 54 percent when compared to pre-fluoridation values.

The Southern Cape and Karoo- this is a rural area with similar burdens that plague the urbanized settings, i.e. high levels of unemployment and poverty. Towns are geographically far apart (Appendix 2) and there is no reliable public transport system in place to commute between them. The primary water sources for many of these communities range from municipal-supplied piped water systems to bore holes. There are many informal settlements around most of the towns as people settle there in an attempt to find employment. These communities have an impact on the health services in that area as well as how those services will be set up to accommodate them. Several national studies were done (Dreyer and Grobler, 1984, 1988;Grobbler, Kotze, Kleymaet, 1991) to set up baseline tables with regard to the fluoride concentrations in community drinking water. As with all nationally driven surveys, only the bigger towns and villages are targeted and valuable information that smaller towns have to offer, are lost.

1.3 The nature of dental services in the region.

80 % of the dentists' clinical time in this region is devoted to extractions (1998 PAWC dental care Statistics.). There is a backlog of cases where children under the age of six (i.e. rural dmft for coloured children are above 9. (Grobler SR, et al., 2001)) are placed on waiting lists (Theatre sessions for general anaesthetic are booked at least 3 months in advance, unpublished regional statistical data) to go to theatre for full dentectomies. This region as a whole (i.e. especially the coastal belt) is experiencing an influx of people from other areas (Growth at a rate of approximately 17.9% per annum for the past 5 years i.e. Mossel Bay) as a result of the lower crime rate in this region. This against an ever shrinking health care allocation of the budget for oral health services (This region has been overspending as reported by the regional director on general service delivery of health care for the past three years- Department of Health's Regional office George) and the low dentist to patient ratio in the region, little support staff (i.e. 2 full-time, 4 voluntary community dentists and 1 part-time oral hygienists) forces us as a team to look for ways and means to utilize the little funding more efficiently and with better outcomes in the long run. Community drinking water fluoridation has been hailed as the least expensive way in which to expose entire communities to fluoride as part of a preventive program in order to reduce dental decay (The National Fluoridation Committee, 1997; Klein et al., 1985; Foch et al., 1984; Ringelberg et al, 1992). We know what causes dental decay and that it is relatively cheap to prevent and control, but that dental treatment without proper educare is also reasonably ineffective (i.e. with poor oral hygiene the intra-oral environment still promotes tooth decay and therefore the scenario for the development of new and secondary lesions are good). With a community orientated approach and the focus on prevention, this study will look at the feasibility of fluoridating community drinking water in the Southern Cape and Karoo as a means of exposing the local communities to optimal levels of fluoride as part of the drive to prevent and reduce dental decay in a region where the prevalence of this disease is high (Grobler SR, et al., 2001).

1.4 The size of the population and its relevance.

The population size will influence the intervention option that is chosen to reduce and prevent dental decay. The smaller the population size, the higher the costs per capita to implement and maintain exposure to optimal levels of fluoride. Community water fluoridation would not be the intervention option of choice for a very small community since it is costly to set up and to maintain such an intervention option (Griffin SO, Jone K, Tomar SL. 2001). Alternatives for those communities should be high-risk patient specific e.g. school-based brushing programs with the use of a fluoridated toothpaste, or fluoride rinses at schools in lower socio-economic environments where the prevalence of dental decay is high and the entire school needs to be targeted, or alternatively salt fluoridation could be implemented as a preventative strategy to reduce and prevent tooth decay in these communities, etc. The Mossel bay area alone has experienced a population growth of 17.9 % over the past 5 year period i.e. 1977 - 2001 (Local Authority of Mossel Bay 2002).

1.5 The public health importance of oral disease.

The intervention method must be justified in that the issue (e.g. dental caries) must affect enough people to warrant its implementation. According to the Government Gazette (1998) it is reported that 93 % of the adult population of South Africa suffers from dental decay.

Table 1.2 The Public Health Importance of Oral Disease. (Sheiham A, 1997)

High prevalence
Impact on individuals and society is great:
Pain, discomfort, functional limitation and handicap are common.
They affect the quality of life.
Financial cost to individuals and the community is considerable.
Dental diseases are more expensive to treat than heart diseases and cancer
Preventable: simple and cheap public health methods available to prevent and control.
Causes are known – Diet, Dirt and cigarettes.
Easy to evaluate treatment.
Easy to detect
Treatment relatively ineffective.

1.6 Fluoride and dental caries prevention.

Fluoride has a strong affinity for biological apatite. The fluoride can easily substitute the hydroxyl component of calcium hydroxyapatite crystal of enamel. Approximately one-third of the total hydroxyl ions in enamel can be replaced by fluoride ions. The resulting fluoroapatite structure is more resilient to acid breakdown.

The fluoride content of tooth tissues reflects the biologically available fluoride at the time of tooth formation. Once entrapped in the enamel during development, the fluoride levels remain constant after the eruption of the tooth (Murray JJ, 1993;Stephan KW, 1993;O'Mullane DM, 1994). Fluoride achieves its anti-caries activities in several ways; it reduces the solubility of enamel in acid by converting hydroxyapatite into less soluble fluoroapatite, it exerts an influence on dental plaque by reducing the ability of plaque organisms to produce acid, and it promotes the remineralization of tooth enamel in areas that have been decalcified by acids. It more than likely has its effect by combinations of these activities.

1.7 Vehicles for fluoride supplementation.

There are various ways in which communities can be exposed to fluoride. The table below highlights the more common fluoride delivery systems.

Keeping in mind the local scenario (i.e. high unemployment, poverty, poor hygiene (also oral hygiene), a large sector of the local communities are children, the low dental personnel to patient ratio, budgetary constraints and the high prevalence of dental caries.) we have to source a fluoride exposing vehicle that has the best cost benefits and reaching a large sector of the community which is at risk of developing dental caries and also keeping in mind that it should not be labour intensive.

Table 1.3 Various vehicles for fluoride delivery.

Fluoride	Application	Pros	Cons	Researchers
Fluoridated milk	Infants & children at home/crèche/school feeding schemes, especially where children make up a large proportion of a community. Where the caries prevalence is high or the children in the community are at risk of developing dental decay.	A suitable vehicle for supplementing fluorides.	A high degree of expertise to produce and control the fluoride content. This method of supplementing fluoride is expensive.	Kunzel 1993, WHO 1994, Chikte 1998
Tablets / drops	Infants and children.	Under 2/younger showed a preventive effect of 60% in primary teeth. Fluorides taken from birth –7 yrs showed caries reduction of 39-80%. Sucking the tablet before swallowing showed better caries preventive results	Compliance with this form of supplement-ation is a problem. This method of fluor-idation is expensive. There needs to be supervision to ensure proper dosages.	Stephan 1993, WHO 1994
Fluoridated toothpaste	Every one in a community can use it.	Makes up 95 % of toothpaste sales. Children tend to ingest quite a bit of toothpaste, which also then provides systemic effects for them. High caries risk children have been shown to have significantly less caries after particip-ating in a supervised tooth-brushing program using fluoridated toothpaste. Subsidizing free toothpaste (1.450 ppm fluoride) provides significant clinical benefit for high-risk caries children in non-fluoridated areas.	Toothpaste is expensive and not readily available to lower socio-economic groups. Requires a behavioral change and compliance is a problem. In younger children it needs to be done under supervision.	Holtta et al 1992 Konig 1993, Louw et al 1995, Bosma et al 1997, Carnow et al 2002, Davies et al 2002
Topical Fluorides	Very useful in reducing the risk of developing dental decay high caries communities could be targeted, also especially orthodontic patients with fixed prosthesis, geriatric patients who are prone to root caries and then patients who had undergone radiation therapy and suffer from xerostomia.	Renders the enamel crystal more resilient to the effects of acidic plaque.	Topical fluorides are expensive. This needs to be supervised and or professionally applied.	Arends et al 1983, 1990, Featherstone et al 1990, Wei et al 1993, Lincir et al1993, Lo et al 2001, Seppa 2001
Fluoride varnish	Applied to high caries communities.	Inhibits caries by 40 %. Uptake and retention of fluoride is better when compared to other topical fluorides.	Has to be profession-ally re-applied every 3 months to sustain its effectiveness as an option for the proph-ylaxis of dental caries	Peterson 1976, Modeer et al 1984, Stookey 1990, Zimmer et al 1999

Table 1.3 (cont.)

Fluoride	Application	Pros	Cons	Researchers
Slow releasing dental materials	Could be used in high caries risk communities, especially the children in these communities.	The material (Glassionomer) releases the fluoride in the mouth for approximately 1 year but after that the levels of fluoride that is released drops. Copolymer membrane released fluoride for up to 180 days. Fluoride glass released fluoride for up to 2 years.	Has to be applied by a trained professional. Time consuming. It has to be re-applied after a while.	Toumba et al 1993, Bashir 1988, WHO 1994
Fluoride mouth rinses	Very useful in low fluoride areas where moderate to high caries risk children live. Could be part of a school-preventative program.	The cost benefit is high and can be improved by delegating its application to auxiliary staff members. There are reductions in decay of both the proximal and occlusal surfaces	Time consuming. Must be supervised to reduce risk of toxicity. Swallow-ing reflex should be established. Can't be used in young children.	Ripa et al 1983, Petersson 1993, Chikte et al 1996, Adair 1998
Fluorides mouth rinse combined with fissure sealants.	In communities where the children represent a large proportion & caries prevalence is high.			Goggin et al 1991, Morgan et al 1998
Fluoridated salt	Entire communities (high caries risk) that have several drinking water sources.	The fluoride can be adjusted to accommodate lower levels of salt to be ingested (i.e. fluoride would be a variable in the salt). Produces results similar to water fluoridation at a lower cost.	Requires modern technology and expertise to control the dosage of fluoride in the salt.	WHO 1994, Hescot et al 1995, Fabien et al 1996, Stephan et al 1998, Terekhova 2000
Fluoridated water	Entire communities where the fluoride levels in the drinking water are low and the prevalence of dental decay is moderate to high.	Reductions of 54 % have been shown in primary teeth and 40 – 60 % in permanent teeth. Fluoride in the water works without the recipient having to do anything other than ingesting it. Reduces the need for additional supplement-ation. Enormous cost benefits in the reduced treatment cost that need not be addressed as a result of the water fluoridation program. Water fluoridation costs USA +/- 51 pp/year and the estimated costs for this in Gauteng is R0.73 pp/year (total population) and R2.93 pp/year (children < 15 yrs).	There needs to be a single piped water supply as that communities primary drinking source. The initial capital layout is high and so many communities cannot afford the initial layout and/or the finances to maintain the system.	Newbrun 1989, Rippa 1993, Mc Donagh 2000, Queste et al 2001, Grobler et al 2001

1.7.1.Fluoridated milk

Milk fluoridation has been shown to reduce and prevent dental caries dental but at great costs in terms of the technology needed to provide it and also the personnel.

1.7.2. Fluoride supplementation (Tablets / drops)

As with milk fluoridation, this form of supplementation on a large scale is really not affordable to the lower socio-economic groups.

1.7.3.Fluoridated toothpaste

Of all the fluoride products and strategies, fluoridated toothpaste has been subjected to the most rigorous clinical testing. Clinical results suggest that the increased benefit in the reduction in the incidence of dental caries in 6% for every 500 ppm over 1000 ppm fluoride. In 1997 the European Commission suggested an upper limit of 1500-ppm fluoride be placed on over the counter toothpaste. Fluoridated toothpaste is expensive and therefore is not readily available to the lower socio-economic groups of the population.

1.7.4.Topical fluorides

This is a very useful vehicle for delivering fluoride to high caries risk communities. Its action is essentially topical and therefore has to be applied regularly making it labour intensive and not high on the list as an intervention option.

1.7.5.Fluoride Varnish

Because of the frequency for reapplication by trained personnel, fluoride varnish as a vehicle for fluoride delivery is person specific and therefore becomes labour intensive given the prevalence of dental caries in our communities.

1.7.6.Slow releasing fluoride materials

This entails having an intraoral fluoride-releasing vehicle that releases fluoride at various rates and for certain periods.

Table 1.4 was taken from the work of Toumba, et al., (1993) and shows the various materials and their fluoride releasing capacity. All of these materials require one on one chair time with the patient, skilled operators, expensive equipment and materials but in most of the cases the effects of the fluoride that is released is short-lived.

Table 1.4 Previous reports on slow-releasing fluoride dental materials.

Study	System	Effect
Fazzi et al. (1977)	Amalgam	Released fluoride, decreased with time; affects properties
Harry and Friedman (1984)	Acrylic plates (orthodontic)	Released fluoride, but frequent applications required
Masuhara et al. (1985)	Cements	Variable rate of fluoride release, short-term
Cooley et al (1988)	Composite resin	Burst effect only
Cooley et al (1989)	Orthodontic cements	Doubtful
Cooley et al (1990)	Fissure sealants	Release for 7 days
McCourt et al.(1990)	Liners and bases	Transitory
Hatibovic-Kofman & Koch (1991)	Glassionomer cements	Release up to 1 year

1.7.7.Fluoride mouth rinsing

This form of supplementing is very useful if low-fluoride communities; school-based fluoride rinsing programs have delivered good results (Petersson LG, 1993; Chikte UM, et al., 1996). This form of fluoride supplementation is recommended but only after an assessment of the economic and caries status of that particular community is assessed.

1.7.8.Fluoridated salt

The case for fluoridated salt as a vehicle for providing exposure to fluoride has been well documented (Stephen, Macpherson, Gorzo, Gilmour, 1998; Hescot P, et al., 1995;Fabien V, et al., 1996;Stephan KW, et al., 1998;Terekhova TN. 2000) . The results from these researchers suggests that the effectiveness of salt fluoridation in inhibiting dental caries is substantial and similar to fluoridated water if the appropriate concentration and use is achieved.(Fluoride and Oral Health WHO, 1994;Hescot P,Roland Fabien, Obry-Musset, Hedelin, Cahen, 1996;Terekhova TN, 2000). Difficulties arise with salt fluoridation when multiple drinking water sources exists and they have optimal or excessive fluoride concentrations occurring naturally. Salt fluoridation requires refined salt produced with modern technology and a level of expertise similar to that required when adding iodine to salt. Adding fluoride to salt is no more expensive than adding iodine and so it does not have to cost the consumer more. Salt fluoridation at a community level does not require a community water supply and so the individual can still accept or reject it since non-fluoridated salt would still be available to the entire community. A concentration of 200 mg F /kg salt may be regarded as a minimum level when several types of salt (domestic, confectioneries and restaurants and other large kitchens) are fluoridated but twice this concentration may be appropriate when only domestic salt is fluoridated. Approximately 25 % of salt consumed comes from domestic intake (Mexican study discussion). The fluoride concentration can be manipulated i.e. in the salt intake is reduced via health promotion campaigns for healthier living, then the fluoride concentration in the salt can still be increased to optimal levels. Fluoride remains a variable in salt i.e. if for health reasons it is advocated that less salt is consumed then the fluoride concentration can be increased to accommodate this.

1.7.9. Water Fluoridation

Fluoride when added to community water supplies is the most effective public health measure (Newbrun, 1989;Rippa L W, 1993;Mc Donagh, 2000;Queste A, et al., 2001;Grobler SR, et al., 2001) to assist in preventing tooth decay. It costs a community approximately one rand per person a year and helps persons of all ages. Both Murray and Rugg-Gunn; and Newbrun showed that there is enough clinical evidence available to conclude that there are decided benefits to deciduous teeth from water fluoridation. The dmf (t) prevalence for Grand Rapids 6 year-olds; the peak caries prevalence age for deciduous teeth; was reduced by 54 per cent compared to the pre-fluoridation level.

Newburgh and Evanston demonstrated caries reductions of between 40 to 65 per cent in permanent teeth (Grobler SR, et al., 2001). The greatest reductions occurred on the proximal surfaces (Rippa L W, 1993). The case for exposure to fluoride at the correct dose as a means of preventing and reducing dental decay is there. In order to supplement fluoride (Grobler SR, et al., 1991, 1992) it is equally important to know what the existing levels in the drinking water are so that the dosage for supplementation can be established. The dental benefits at optimal levels of fluoride exposure is a decrease in the prevalence of dental caries (Horowitz HS, 1996;Louw AJ, 2002) by preserving tooth structure, therefore reducing pain and sepsis and reducing the need and costs for treatment. Other advantages include the effectiveness for all, ease of delivery, safety, equity, and the low cast. In the USA it costs +/- 51 cents per person/per year. It is estimated to cost R0.73 per person/per year (i.e. the total population) and R2.93 per person/per year (children <15 years).

Of the various vehicles for fluoride delivery, it seems that all of them play a role in reducing and or preventing dental decay. Most of them are one to one patient specific and need trained personnel to apply or monitor their use. Salt fluoridation and community water fluoridation appears to be the only vehicles that do not need the individual to really make a contribution in the vehicle working other than ingesting it. Salt fluoridation requires special technology and trained personnel to ensure correct dosage levels are maintained. Community water fluoridation has come out as the best vehicle for exposing entire communities to fluoride and having every individual benefit from it. In terms of running costs it is the cheapest. In terms of benefits, there is in excess of 50 years of research showing the effect that it has on preventing and reducing dental caries.

1.8 The type of water source.

In rural areas with huge geographical distances between places and populations sparsely distributed in remote places, the infrastructures are poorly developed. The water sources range from piped to bore holes as primary sources of drinking water.

WHO (Murray 1994) assigned this researcher to identify the pre-requisites for implementing community drinking water fluoridation. This helps with establishing the feasibility for the implementation of community water fluoridation. Table 1.5 assists in the decision-making when doing a situational analysis. In our region the prevalence of dental decay is high which does lead to pain and discomfort; patients usually only visit the dental clinic when there is very little that can be done to save the tooth except to extract it under emergency conditions (i.e. huge facial swelling as a result of the dento-alveolar abscess).

Table 1.5 Pre-requisites for implementing community drinking water fluoridation.

The practicality of implementing community water fluoridation depends on several pre-requisites that have to be in place. (Murray – WHO, 1994)

There must be a municipal water supply reaching a reasonable number of homes.;

- People drink this water rather than water from individual wells or rain water tanks;
- Suitable equipment must be available in the water treatment plant or pumping station;
- A continuous supply of fluoride chemical is assured;
- There are workers in the water treatment plant that are able to maintain the system and keep adequate records;
- There is sufficient money available for the initial installation and the running costs.

1.10 Selecting the appropriate level of fluoride for drinking water.

In areas where there is not enough fluoride in the drinking water (i.e. below the range of 0.7 –1.2ppm), it is important to supplement the exposure to fluoride and if the practical pre-requisites (Murray, 1994) are in place then community drinking water fluoridation is an intervention option. If on the other hand the fluoride levels that a community is exposed to is above (i.e. in excess of 1.2 ppm could lead to fluorosis and an increased incidence of dental caries) the range at which they are to benefit from in terms of prevention and reduction of dental decay, then there has to be looked at de-fluoridating their drinking water. Depending on where the fluoride levels are, intervention options costs money and this has budgetary implications for service providers who often are not well funded to start out with and so exposure to fluoride is not seen as an important service in terms of those departments' priorities. Quite often the people who take decisions around community priority needs are pre-occupied with immediate gratifying types of solutions so that they can be seen to be making a difference in terms of the services that they are delivering. Community water fluoridation will take a bit longer to show its real benefits and this does not go down well with justifying budgetary expenditure year-on-year.

1.11 Mapping of water samples by GPS location.

With the aid of a hand-held GPS the co-ordinates for each water source was obtained that gave an accurate location of the site of a particular sample so when comparative future studies are to be done the source could be relocated accurately. It will also help with tracking the extent to which our database covers this region so that future studies will attempt to expand the database. This information is to be punched into a GIS, which is a software package that accurately maps out the source site using the co-ordinates, gathered using the GPS. (The Department of health in this region does not yet have the means to this technology i.e. GIS and so the co-ordinates are to be kept until such time that we do have access to it).

Chapter 2

Method

2.1 Aim

The aim of this study is to determine the best means of delivering fluoride to communities in the Southern Cape and Karoo.

In order to do this there are certain prerequisites that must be known (e.g. the fluoride concentration that is already in the drinking water, the demographic data around the water source, the type of water source, the prevalence of dental caries and what each community can afford to spend on their prevention program) in order for that community to make a decision with regards to a prevention strategy.

Given the manner in which people are geographically spread across this region, the diverse conditions that these communities live with (i.e. from one town or village to the next), their socio-economic status (some of the poorest communities in the Western Cape reside in this region), by taking these variables into account attempt to develop a decision matrix that will assist the different communities in their decision making process with regard to a fluoride supplementation strategy.

2.2 Objectives.

- To establish the fluoride levels in community drinking water in the Southern Cape and Karoo region (44 towns and villages).
- To describe the sources of the drinking water samples by location (using a Global Positioning System), type of water supply and the population it serves.
- To establish if fluoride supplementation/de-fluoridation is required for any of these towns and/or villages.
- To develop a decision matrix that will enable a community to look at their set of conditions and arrive at an intervention option for the reduction and/or prevention of dental decay.

2.3 Implementation of this study.

The water samples were collected over weekends over a two-month period. The villages were chosen because of their proximity to a road that was accessible by motorcar. A mid-stream water sample was collected from a tap and stored in a 100 ml polypropylene bottle. Each sample was numerically coded and the GPS co-ordinates that were obtained, recorded alongside this numerical code. The water source was also recorded. The demographic data was obtained from the Department of Health's' regional office.

2.4 Study design

This is a descriptive study, analyzing the fluoride concentration in community drinking water of 44 towns and villages in the Southern Cape and Karoo Region. The water source was also recorded as well as an approximate demographic figure for that particular area using the 1996 census data that was obtained from the Department of health.

2.5 Study sample

Water samples were collected from 44 towns and villages as indicated in Table 3.2. A total of 2056 km was traveled by road to obtain these samples Appendix 2.

2.6 Ethical considerations

Neither persons nor animals participated in this study and no ethical issues were encountered.

The Southern Cape and Karoo community will receive feedback by being provided with a copy of this report. A copy of this report will be delivered to the Regional office of the Southern Cape and Karoo and from there copies should be sent out to the various districts within this region.

2.7 Measurements

The water samples were analyzed at the Peninsula Technicons' analytical chemistry department. The water samples were coded to blind the team who did the analysis to the origin of these samples. Each sample was analyzed twice to corroborate initial results. The results were then tabulated by location, GPS co-ordinates and fluoride concentration of the sample.

The water samples were analyzed for its fluoride concentration using a fluoride-ion specific electrode (FISE). The procedure for measuring the fluoride levels in the sample was as follows:

- 20ml of TISAB (Total Ionic Strength Adjustment Buffer) is accurately measured and placed on the magnetic stirrer.
- The electrodes are then immersed into the solution and the automatic standard addition is initiated.
- The standard addition for the calibration curve is set up between the concentration ranges of 0.05-0.5 mg/L.
- A 2mg/L Fluoride standard is used for this calibration.
- Once the 12 points on the calibration curve are plotted, the samples can then be analyzed.
- The analysis of the water samples is determined by direct measurements.
- 10ml of sample and 10ml of TISAB is used for the analysis.
- Between analyses, a control standard is also analyzed to ensure the accuracy of the results.
- The fluoride electrode is conditioned with the TISAB solution for 5 min between analyses.
- Each sample was measured twice to the ensure reliability of the data and to reduce analyzing errors.

Chapter 3

Results

The results obtained are presented either in the form of tables or a graph. The results reflect on the water sources of these towns and villages, the demographics around the water source, the GPS co-ordinates for that source and then also the ranges of fluoride found in the water samples.

Table 3.1. The water source frequency table of 44 towns and villages in the Southern Cape and Karoo region.

Water source	Number of towns / villages
Reservoir	22
Municipal	10
Bore hole	9
River	2
Source unknown	1

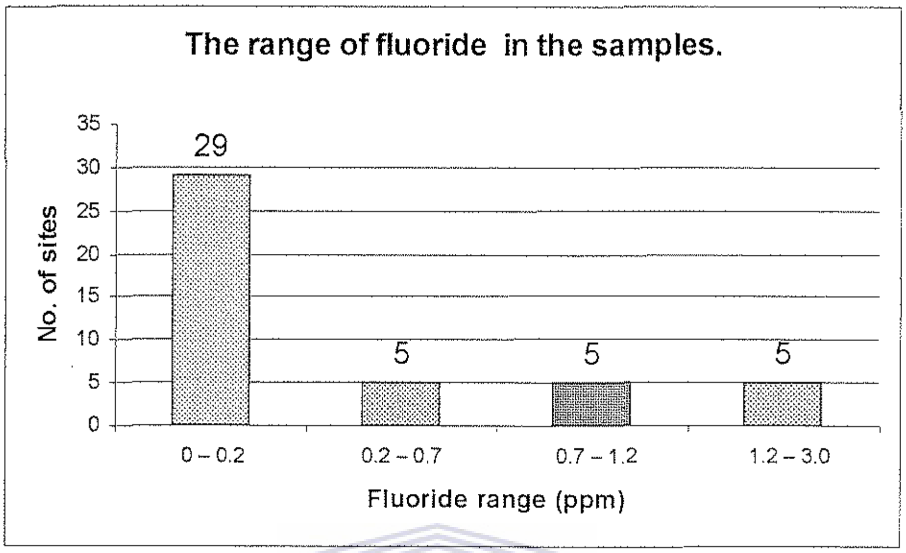
Of the 44 samples, only 10 came from towns where the primary drinking water source was provided by the local municipality (i.e. piped from a controlled central location). 22 of the water samples came from sources that were supplied by a reservoir, 9 water samples came from bore holes, 2 water samples came from a river and for 1 of the samples the source was unknown.

In Table 3.2 the towns and villages are listed ascending according to the fluoride level that was in the sample collected from that town or village.

Table 3.2 The list of 44 towns and villages where samples were drawn from, the GPS co-ordinates for each of the samples and the levels in the water.

Code	Place	Date	Water Source	South	East	[F] in mg/l
28	Haarlem	19/09/98	Reservoir	33 44'33.6"	23 20'08.8"	0.016
24	Plettenberg Bay	19/9/98	Municipal	34 03'00.2"	23 21'32.2"	0.017
18	De Rust	12/9/98	Reservoir	33 29'18.6	22 31'55.6"	0.019
25	Wittedrift	19/9/98	Municipal	34 00'32.1"	23 20'10.0"	0.019
21	Touwsranten	19/9/98	Reservoir	33 57'15.5"	22 37'06.9"	0.02
38	Riversdal	10/10/98	Reservoir	34 05'29.5"	21 14'59.6"	0.02
26	Buffels Nek	19/9/98	Reservoir	33 53'02.2"	23 09'50.7"	0.022
30	Herold	10/10/98	Reservoir	33 50'40.9"	22 26'44.0"	0.024
37	Heidelberg	10/10/98	Reservoir	34 05'51.6"	20 57'40.4"	0.024
2	Ruiterbos	11/9/98	Reservoir	34 03'34.7"	22 03'07.3"	0.0261
27	Avontuur	19/9/98	Reservoir	33 43'54.5"	23 10'02.1"	0.03
35	Ladismith	10/10/98	Reservoir	33 29'51.3"	21 15'55.5"	0.034
23	Knysna	19/9/98	Municipal	34 03'01.0"	23 05'01.7	0.035
3	Oudtshoorn	11/9/98	Municipal	33 57'34.5"	22 04'21.6"	0.039
29	Union Dale	19/09/98	Reservoir	33 39'32.3"	23 07'09.7"	0.046
22	Sedgefield	19/9/98	River	33 00'56.4"	22 48'17.4"	0.046
40	Albertinia	10/10/98	Reservoir	34 12'46.2"	21 35'11.0"	0.048
42	Great Brak	19/9/98	Municipal	34 02'28.2"	22 13'20.9"	0.05
20	Wildernis	19/9/98	Municipal	33 59'48.8"	22 34'26.5"	0.064
43	Mossel Bay	19/9/98	Municipal	34 10'56.2"	22 09'28.7"	0.066
41	George	19/9/98	Municipal	33 57'40.8"	22 27'28.4"	0.072
19	Dyssels Dorp	12/9/98	Reservoir	33 34'12.8"	22 26'03.1"	0.073
4	Schoemanspoort	11/9/98	River	33 53'09.8"	22 06'07.7"	0.078
31	Volmoed	10/10/98	Reservoir	33 39'17.4"	22 05'04.7"	0.081
1	Brandwag	11/9/98	Reservoir	34 06'46.2"	22 03'20.0"	0.0878
32	De Hoop	10/10/98	Reservoir	33 36'32.5"	22 02'36.9"	0.089
39	Still bay	10/10/98	Bore hole	34 22'14.1	21 24'24.9"	0.12
5	Prince Albert	11/9/98	Municipal	33 38'22.4"	22 04'45.1"	0.141
33	Calitzdorp	10/10/98	Reservoir	33 11'48.2"	20 51'32.8"	0.166
17	Klaarstroom	12/9/98	Bore hole	33 19'44.8"	22 31'33.9"	0.409
11	Murreesburg	12/9/98	Reservoir	31 57'59.6"	23 45'34.0"	0.554
44	Beaufort West	11/9/98	Municipal	32 21'21.9"	22 35'01.4"	0.565
12	Toorfontein	12/9/98	Bore hole	32 00'25.2"	23 36'21.5	0.594
36	Lainsburg	10/10/98	Reservoir	33 11'48.2"	20 51'32.8"	0.646
6	Merverville	11/9/98	Reservoir	33 30'03.3"	22 00'09.5"	0.725
10	Nelspoort	11/9/98	Reservoir	33 09'07.5"	22 09'18.5"	0.832
34	Zoar	10/10/98	Reservoir	33 29'57.2"	21 26'09.8"	0.832
16	Seekoegat	12/9/98	Reservoir	33 03'38.7"	22 30'44.6"	0.997
9	Letjiesbos	11/9/98	Bore hole	33 22'55.4"	21 59'50.8"	1.01
13	Kraaifontein	12/9/98	Bore hole	31 59'43.2"	23 27'36.6"	1.23
7	Groot Kruidfontein	11/9/98	Bore hole	33 26'59.7"	21 59'31.6"	1.33
14	Kareebosch	12/9/98	Bore hole	32 00'39.6"	23 23'25.9"	1.4
15	Kruidfontein	12/9/98	Bore hole	32 03'02.0"	23 18'30.8"	1.44
8	Leeu Gamka	11/9/98	Bore hole	33 23'36.9"	21 59'26.1"	2.61

Graph 3.1 The distribution of the concentration of fluoride found in the 44 samples of community drinking water in the Southern cape and Karoo Region.



Graph 3.1 shows the distribution of the fluoride concentration found in the samples of community drinking water in this Region. The number of sites that fall within a certain range of fluoridation is shown on the y-axis and the fluoride range appears along the x-axis. The 5 sample points above the optimal range on the graph came from bore holes as their source. Of the 5 samples that lie within the optimal range, 1 came from a borehole and the other 4 came from reservoirs. The samples obtained from piped municipal sources were all found to contain fluoride concentrations below the optimal range.

It also indicates how many of the water samples lie above the optimal, how many below and how many within the optimal range of fluoride concentration (i.e. 0.7 – 1.2 ppm). None of the samples that lie within this optimal range comes from the municipal piped water supplies. Thirty-four (77.3 %) of the samples lie below the optimal range for water fluoride concentration, 5 (11.4 %) of the samples lie within the optimal range and 5 (11.4 %) above this range. Of all the water samples, municipalities with a centralized piped system supplied only 10 communities in this region.

The population of this Region was broken down into high-, medium- and low populated areas as per 1998 census data provided by the Department of Health's Regional office in George. 7 (15.9 %) of the water samples came from areas that are densely populated, whereas 12 (27.3) and 25 (56.8) came from medium and low populated areas respectively. The higher populated areas are generally supplied with centralized piped water from their municipalities where as the other areas (low- and medium populated areas) rely on reservoirs, bore holes, and a river as their water supply.

Table 3.3 High populated areas with the water sample source vs. the concentration of fluoride in the water samples.

Water Source	**0 – 0.2 ppm**	**0.2 – 0.7 ppm**	**0.7 – 1.2 ppm**	**1.2 – 3.0 ppm**
Reservoir	1	0	0	0
Municipal	5	1	0	0
Borehole	0	0	0	0
River	0	0	0	0
Unknown	0	0	0	0

Table 3.3 shows the different water sources against the concentration ranges of the samples in the higher populated areas of this Region. This area is found to be generally very low in its fluoride concentration in the community drinking water.

Table 3.4 Medium populated areas with the water sample source vs. category of fluoride in the samples.

Water source	**0 – 0.2 ppm**	**0.2 – 0.7 ppm**	**0.7 – 1.2 ppm**	**1.2 – 3.0 ppm**
Reservoir	5	2	1	0
Municipal	3	0	0	0
Bore hole	0	0	0	0
River	1	0	0	0
Unknown	0	0	0	0

Table 3.4 shows the different water sources against the concentration ranges of the water samples in the medium populated areas of this Region. This area is found to be generally low in fluoride in the community drinking water. Only one reservoir is found to have a fluoride concentration within the optimal range.

Table 3.5 Low Populated areas with the water sample source vs. the fluoride range in the samples.

Water source	0 – 0.2 ppm	0.2 – 0.7 ppm	0.7 – 1.2 ppm	1.2 – 3.0 ppm
Reservoir	9	0	3	0
Municipal	2	0	0	0
Borehole	1	2	1	5
River	1	0	0	0
Unknown	1	0	0	0

Table 3.5 shows the different water sources against the concentration ranges of the samples in the low populated areas. This area for population break down is found to be yield excessive fluoride concentrations in the community drinking water. In four of the samples (i.e.3 reservoir and 1 bore hole) the fluoride concentration was found to be within the optimal range

Summary

The fluoride levels from the borehole water are above optimal levels and generally these areas are not densely populated. The water supplied by a centralized piped system (i.e. Municipalities) is below the optimal levels in terms of its fluoride concentration and these areas are densely populated.

Chapter 4

Discussion and Conclusions

The population of this region is scattered geographically, which makes service delivery very difficult. The service delivery points are situated in the more densely populated areas of this region. People are found to reside in pockets, which vary in numbers and for some of them it these services are not truly accessible.

4.1 Caries prevention

From the literature it is evident that fluoride exposure (at optimal levels) leads to a reduction and prevention of dental caries (Rippa L W. A; 1993;Crowley SJ., et al., 2000;Griffin SO., et al., 2001;Wright JC., et al.,2001;Louw AJ,2002). In children (i.e. systemically) fluoride exposure leads to the formation of larger enamel (apatite) crystals rendering the crown more resilient to acid attacks. In adults (i.e. topically) it leads to the prevention of root caries and will arrest active incipient carious lesions.

4.2 The drinking water fluoride concentration.

The graph 3.1 shows that 34 (75 %) of this regions, towns and villages that was sampled (i.e. including the bigger towns that are municipal controlled) have too little fluoride in their drinking water supplies to have the local communities benefit from it. The results from this study shows that the bigger towns (i.e.15.9 % of the sample area which is densely populated) have an infrastructure with piped water from that local authority / municipality and they also qualify according to the criteria, as set out by WHO (Murray 1994), to accommodate the implementation of community water fluoridation. In the bigger towns that are densely populated, community drinking water fluoridation would be the intervention option of choice, as it remains the most efficient and cost beneficial. These towns with the infrastructure that they have can with very little modification to their water purification plants, accommodate the implementation of community water fluoridation. Generally more people inhabit these bigger towns and being rural, we have a shortage of human resources to deliver and cope with the community needs with regards to oral health. Community water fluoridation will go a long way to reducing and preventing dental caries in these communities.

An alternative intervention option could be the implementation of school-based tooth brushing programs or school-based fluoride rinsing programs. Communities where the caries prevalence is high and a big sector of that community is made up children, they could look at buying into a combination of fluoride rinse and fissure sealant programs (for high-risk groups at school which has also shown very promising results.).

In the medium populated areas the predominant water source are reservoirs. To fluoridate these source points would be costly and therefore alternative intervention options need to be considered. The intervention option chosen would depend on the finances that are available to that community, specific target groups (e.g. scholars and crèche goers) and their commitment to buy into a long-term prophylactic program to reduce and prevent dental decay. This might not be as cost-effective as community water fluoridation per capita but will at least assist in developing healthier teeth and reduce the rise in dental caries among this group of patients. This will free the dentist from having to do many extractions and to concentrate on more specialized tasks within the clinic.

In the Central Karoo (rural area not densely populated) there are few service delivery points and people geographically live kilometers apart, the main water source is either a reservoir or a borehole. From the results of this study, the fluoride concentration of the borehole water samples generally had a higher than optimal concentration of fluoride. The oral health status of these communities still need to be assessed to see the effects of more than optimal doses of fluoride in their drinking water on their teeth over a protracted period of time. One would expect to find some of the people in those communities presenting with dental fluorosis. If this were true then one would consider de-fluoridation of the drinking water in these areas water. De-fluoridation for entire communities are expensive in terms of both materials and equipment. Given that these places (i.e. where bore hole water is the primary drinking water source) are sparsely populated, the de-fluoridation process can be pitched at household level using granulated bone charcoal.

There exist in a strong link between salt intake, hypertension and the high prevalence of cardiovascular related problems in South Africa. From the studies done by the Pan American Health Organization (PAHO) it is clear that salt fluoridation is a likely solution to fluoridating areas where there is no piped system for community drinking water to be fluoridated. Salt fluoridation is cheaper than fluoridating drinking water and its results are as good as those that are obtained by community drinking water fluoridation.

From the side of the community, the level of dental caries must be significantly high, or the risk of increasing prevalence of caries must be sufficiently grim in order for that community to spend its financial resources on a measure that might not be the most practical for their scenario. Only with proper community participation will a project like community water fluoridation stand a chance to survive the short-term implementation and the long-term sustainability.

The services that are delivered should be planned in accordance with the Declaration of Alma Ata (WHO, 1978) i.e. services should be equitably distributed, the communities for whom it is planned must participate in this planning, the focus must be placed on prevention, the use of appropriate technology must be deployed and a multi-sectoral approach must be maintained between concerned parties (i.e. communities, municipalities, engineers, etc.).

This study produced an updated database of the Fluoride levels in the community's drinking water of 44 towns and villages around this region. Recorded along with this were other variables such as the water source for each of the samples (except one sample), the GPS co-ordinates and the demographic data for each source.

4.3 Summary

From the literature review (Murray 1994) and the data collected in this study it is clear that communities require various different bits of information in order for them to make a decision with regards to the most appropriate fluoride intervention option in order to reduce and prevent dental caries. To assist with this process, a decision matrix was designed so that the data could be plugged into the decision matrix for each and every community and through a logical process, assists them to arrive at a good decision with regards to the fluoride intervention option that is best suited to their situation.

The water fluoride concentrations measured in this study were initially expected to provide adequate guidance on which water supplies should be fluoridated. However it was soon recognized that each community has its own unique combination of circumstances. These needed to be taken into account before taking a decision to fluoridate the drinking water. It was therefore decided that a decision matrix would be a more flexible and meaningful framework for such decision-making, instead of attempting to simplistically impose a uniform decision to fluoridate based exclusively on the fluoride concentration of each water supply. The result of this enquiry is therefore a a matrix model (Table 4.1) which provides a mechanism for the systematic arrival at a decision as to the type of fluoride intervention options that could be implemented to promote a reduction and/or prevention of dental decay.

In the smaller towns where the community drinking water has a fluoride concentration of less than 0.7 ppm fluoride, the various intervention options should be considered on the merits of variables for that town/village. For these towns/villages for example it might be more affordable to render a target group specific strategy (e.g. school-based programs) that is managed (i.e. implemented and supported) by dental auxiliary staff in conjunction with the local teachers. The literature shows that for very small numbers of people (i.e. except where monetary cost are not the only yardstick for measuring gains) community water fluoridation will still show a return in terms a reduction and prevention of dental decay in that community. This would still be dependant on the criteria as set out by Murray (1994).

In the towns and villages where the fluoride concentration in the drinking water is in excess of 1.2ppm, more research needs to be conducted to see what effects the sustained high dose of fluoride has on the dental status of those communities.

From this study the low populated areas that rely on boreholes as their primary source of water are not many so inexpensive de-fluoridation equipment and materials need not be bought. De-fluoridation of the drinking water of these particular communities could rather be pitched at a household level using granulated bone charcoal alternatively if the drinking water sources are in close proximity to each other, then the one with the closest to optimal concentration should be used as the primary source of drinking water and the other boreholes closed down.

In the larger towns/villages where the fluoride levels in the drinking water are below the optimal levels (i.e. the it makes sense to consider community drinking water fluoridation. The literature (Rippa LW. et al., 1993; Mc Donagh MS. et al., 2000; Louw AJ, 2002) supports this on the basis that community drinking water fluoridation is still the most effective and cost beneficial intervention option. It is reported to reduce the incidence of dental caries by 65%, reduces the need for multiple restorations, crowns and extractions and significantly increases the number of children who are completely caries-free.

Table 4.1 A decision matrix for selecting the most appropriate fluoride intervention for each different set of circumstances.

<table>
<tr><th>Population size</th><th>Water Source</th><th>Above optimal fluoride levels</th><th>Optimal fluoride levels</th><th>Below the optimal fluoride levels</th></tr>
<tr><td rowspan="3">Densely Populated Areas
-Single piped system
-Multiple inputs into the system.
-Generally rain water-low in minerals and salts</td><td>Reservoir</td><td rowspan="9">The intervention option would be to defluoridate the drinking water. In the case of bore holes, close down those with excessive amounts of fluorides in them and one bore hole sunk in a lower fluoride containing area and this then used as the primary drinking water source of that community.</td><td rowspan="3">No intervention required except continuous monitoring</td><td>Community water fluoridation</td></tr>
<tr><td>Bore hole</td><td>Depending on the demographic data, prevalence of dental caries, if lots of children then look at school-based programs and select an affordable vehicle</td></tr>
<tr><td>River</td><td>Depending on the demographic data, prevalence of dental caries, if lots of children then look at school-based programs and select an affordable vehicle</td></tr>
<tr><td rowspan="3">Medium Populated Areas
-Many water sources shared among several people.
-Either and/or combinations of boreholes and reservoirs.</td><td>Reservoir</td><td rowspan="3">No intervention required except continuous monitoring</td><td>Depending on the demographic data, prevalence of dental caries, if lots of children then look at school-based programs and select an affordable vehicle</td></tr>
<tr><td>Bore hole</td><td>Depending on the demographic data, prevalence of dental caries, if lots of children then look at school-based programs and select an affordable vehicle</td></tr>
<tr><td>River</td><td>Depending on the demographic data, prevalence of dental caries, if lots of children then look at school-based programs and select an affordable vehicle</td></tr>
<tr><td rowspan="3">Poorly Populated Areas
-Often one water source per household.
-Usually either rain tank or borehole.
-Hard water – high in minerals and salts.</td><td>Reservoir</td><td rowspan="3">No intervention required except continuous monitoring</td><td>Depending on the demographic data, prevalence of dental caries, if lots of children then look at school-based programs and select an affordable vehicle</td></tr>
<tr><td>Bore hole</td><td>Depending on the demographic data, prevalence of dental caries, if lots of children then look at school-based programs and select an affordable vehicle</td></tr>
<tr><td>River</td><td>Depending on the demographic data, prevalence of dental caries, if lots of children then look at school-based programs and select an affordable vehicle</td></tr>
</table>

Table 4.1 allows a community to measure a selected number of variables and enter these in the matrix in order to select the best an intervention option for the reduction and/or prevention of dental caries in their community.

Table 4.2 The scale of intervention vs. efficacy and the approximate costs.

Intervention option	Efficacy	Approximate costs
Fluoridated drinking water	Very effective at reducing and preventing caries. It is a silent worker and requires nothing from the recipient except to swallow it. Acts both systemically and topically.	R1.00 per person p.a.
Fluoridated milk	This is effective especially as part of a school based feeding program. Requires high degree of expertise within the milk industry to monitor optimal levels.	Very expensive
Fluoridated salt	The results are as good as those obtained from community drinking water fluoridation. Acts both systemically and topically.	Cheaper than community drinking water fluoridation.
Fluoridated toothpaste		18 times more expensive than community drinking water fluoridation.
Fluoride supplementation drops /tablets	Good for its systemic effects. The literature does support low doses at regular intervals during the day	Expensive
Topical fluorides		Expensive
Fluoride varnish		Expensive
Slow releasing fluoride dental materials		
Restoration of the carious tooth		61 times more expensive than fluoride.

4.4 Conclusion

Given the diverse sets of variables that communities in this region have to contend with, it is not advisable to simply impose the same uniform fluoridation method or levels on community drinking water fluoridation across the entire region.

This study shows that there is no single best approach to environments that are as diverse as those in this region. There needs to be a simple uncomplicated way in which communities can make decisions with regards to the types of issues that they want to address in their communities and how to priorities them in terms of urgency. The decision matrix is an attempt at enabling communities to arrive at intervention option for the reduction and prevention of dental caries. They should receive the necessary support and guidance from Regional departments because ultimately it will ensure that we not only reduce dental decay but also end up with an informed and better developed community who will in the long run take responsibility for their health and support the move towards primary health care.

The results from this study like with other studies show that water from bore holes, as the primary drinking source tends to have high levels of fluoride. Many of the smaller towns/villages are not densely populated (i.e. 25 of the sample points) and receive their drinking water from these boreholes. From the a public health perspective this makes it easy to target the majority of the communities in this region as they live in areas that have access to piped water. These sources can be fluoridated and a large part of the community of this region could be provided with protection against dental caries.

A uniform strategy cannot be implemented to deliver services with similar results as outcomes to communities with such a diverse set of variables.

4.5 Recommendations

Each community in the Region should look at the information needed to make a decision around a prevention strategy for the prevention and reduction of dental caries. The information that they don't have for their community, they should collect by conducting small surveys. This data can be submitted to the decision matrix which will enable them to select the best intervention options for the prevention and reduction of dental decay. When they have arrived at an intervention option that they can afford the decision matrix can provide the basis for lobbying with the local health providers to implement a strategy to deliver the particular intervention option.

Appendix 1

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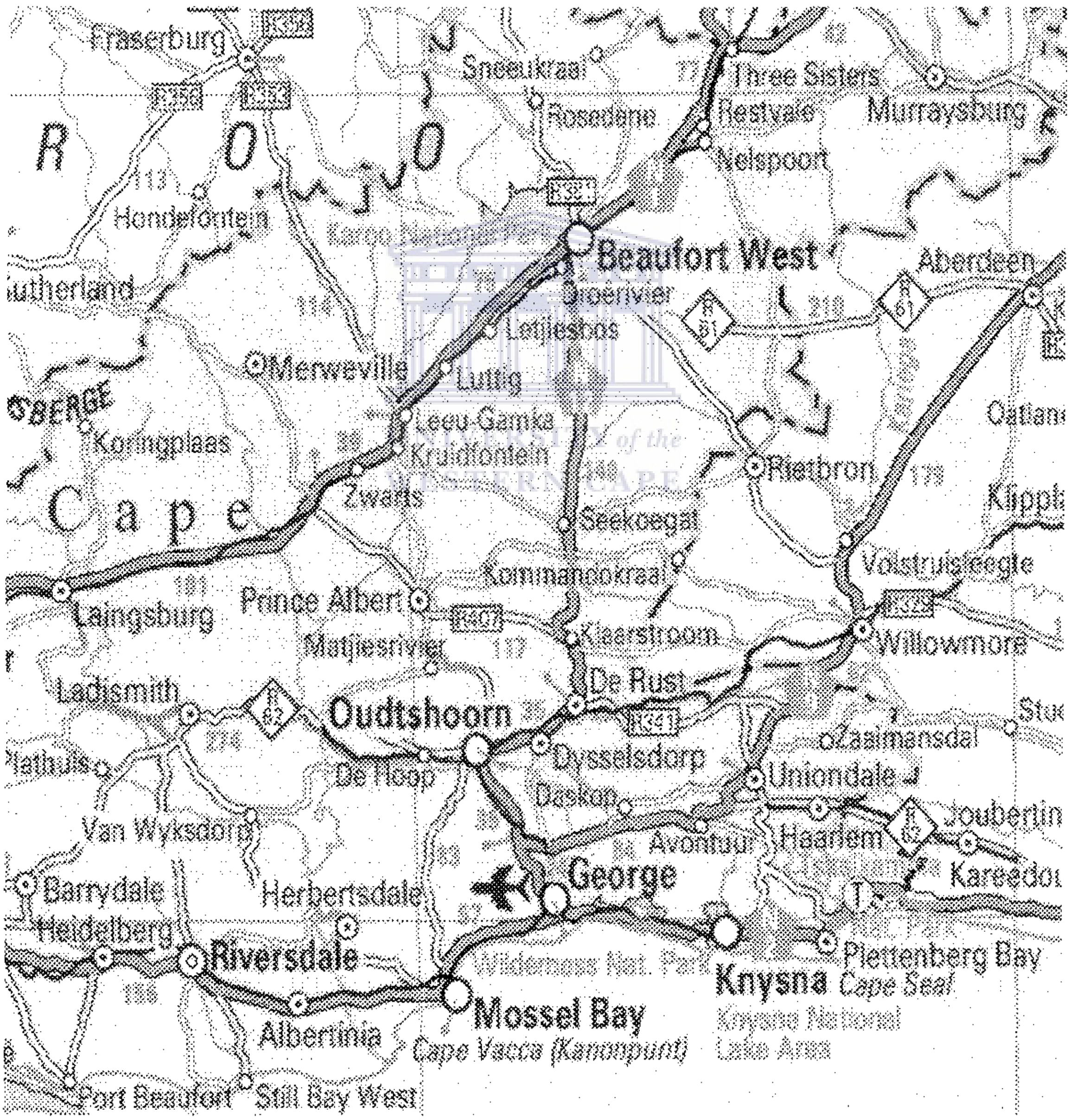
Appendix 2

Below is a map representing the Southern Cape and Karoo Region.

The borders extend from Heidelberg (in the South West) along the coast to Plettenberg Bay (in the South Wets) and then North to Murraysburg (North east from Plettenberg bay) and then with an imaginary line across South West to Merverville to Lainsburg and South to Heidelberg.



Appendix 3

Determination of fluoride with the ion-selective electrode.

INSTRUMENT AND ACCESSORIES

- pH/Ion Meter – 692 Metrohm
- Dosimat titration stand
- Magnetic stirrer
- Exchange unit
- Keypad
- Connecting Cables
- Fluoride ISE
- Ag/AgCI reference electrode with: inner electrolyte: c(KCI) = 3mol/L
  outer electrolyte: c(KCI) = 3mol/L
- Temperature sensor Pt 1000

REAGENTS USED

- Ultra pure de-ionized water
- Dilute TISAB which consisted of: 58g NaCI
  De-ionized water
  57ml of glacial acetic acid
  5mol/L NaOH

THE HANDLING OF THE ELECTRODE.

- The sensor part of the fluoride electrode is composed of a lanthanum fluoride crystal. To avoid fatty deposits, this should not be touched with the bare hands.
- If the electrode does not respond well after being used for a long period, then the sensor should be cleaned.
- The electrode should only be used in aqueous solutions.
- Before determining fluoride concentrations below 1 mg/L the electrode should be pre-conditioned in de-ionized water for approximately 30 min.
- All measurements are carried out under identical stirring conditions and at constant temperature.
- Rinse the electrode after each measurement and remove any adhering water droplets by dabbing with a soft paper towel.
- When conducting a series of measurements the electrode should be conditioned for 5 min in TISAB solution before each new measurement because a cumulative error on the high side can arise.