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THE ECONOMIC ASSESSMENT OF WATER FLUORIDATION IN SOUTH AFRICA AND ITS IMPACT ON HUMAN RESOURCES AND ORAL HEALTH SERVICE DELIVERY

by

JEROEN KROON

submitted in fulfilment of the requirements for the degree

PHILOSOPHIAE DOCTOR

in the

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DECLARATION

I, Jeroen Kroon, declare that the thesis, "THE ECONOMIC ASSESSMENT OF WATER FLUORIDATION IN SOUTH AFRICA AND ITS IMPACT ON HUMAN RESOURCES AND ORAL HEALTH SERVICE DELIVERY", which I hereby submit for the degree Philosophiae Doctor at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

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Jeroen Kroon

April 2008

SUMMARY

THE ECONOMIC ASSESSMENT OF WATER FLUORIDATION IN SOUTH AFRICA AND ITS IMPACT ON HUMAN RESOURCES AND ORAL HEALTH SERVICE DELIVERY

by

JEROEN KROON

Supervisor:	**Professor PJ van Wyk**
Department:	**Community Dentistry**
Degree for which the thesis is submitted:	**Philosophiae Doctor**

Water fluoridation has been confirmed by three recent reviews as one of the most cost-effective and safe primary preventive measure against dental caries. Despite this evidence no artificially fluoridated water scheme exists in South Africa. The economic impact of water fluoridation in times of a reduction in dental caries should be weighed against its benefits. A minimum package of oral care has been proposed for implementation in the public oral health services. Irrespective of the implementation of water fluoridation and/or a minimum package or oral care, it will impact on the required oral health human resources.

The aim of this study was to investigate the economic viability of the implementation of water fluoridation and the delivery of the minimum package of oral care and the impact this will have on human resources planning for oral health in South Africa.

Computerised simulation models were developed for this study. Per capita cost, cost-effectiveness and cost-benefit of the implementation of water fluoridation was calculated for seventeen major metropolitan cities, towns and water boards in South Africa. Treatment need data was converted to a per capita cost to express the delivery of the minimum package of oral care as a monetary value. The World Health Organization/Fédération Dentaire Internationale and a “Service Targets

Method" model were used to calculate the oral health human resources required to deliver the minimum package of oral care.

The average per capita cost of water fluoridation for the total population is R2.08. At an anticipated 30% caries reduction achieved with water fluoridation, average cost-effectiveness is R33.16 and cost-benefit was calculated as 0.18. Cost-benefit equals or exceeds 0.8 for only three municipalities or water boards at an anticipated 10% caries reduction as a result of the implementation of water fluoridation.

The average per capita cost to provide the minimum package of oral care is R245.95 without the impact of water fluoridation and R186.03 at an anticipated 30% caries reduction due to water fluoridation.

Oral hygienists represent more than 50%, dental therapists between 30 to 40% and dentists less than 10% of the total oral health human resources required to deliver the minimum package of oral care. At an anticipated caries reduction of 30% due to the introduction of water fluoridation, the number of dentists required decrease by 29%, dental therapists between 27.5 and 29.8% and oral hygienists between 2.1 and 10.5%. This converts to a saving in salaries of R14,8 million per year.

It is recommended that water fluoridation remains a viable option for South Africa, even if only a 10% caries reduction as a result of its introduction is achieved. All provinces should actively pursue the introduction of the minimum package of oral care with appropriate modes of delivery by creating a number of posts as well as incentives to attract especially oral hygienists and dental therapists to the public service. The impact of the introduction of water fluoridation on human resources should always be considered in planning the number of oral health professionals to be trained.

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"Your biggest break can come from never quitting. Being at the right place at the right time can only happen when you keep moving toward the next opportunity."
Arthur Pine

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My parents, I dedicate this thesis to you for providing me with the opportunities in life.

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Soli Deo Gloria

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LIST OF ABBREVIATIONS

ANC	African National Congress
ART	Atraumatic Restorative Technique
BER-BCI	Bureau for Economic Research's Building Cost Index
CBA	Cost-benefit analysis
CCS	Compulsory Community Service
CEA	Cost-effectiveness analysis
CEO	Chief Executive Officer
CPI	Community Periodontal Index
CPITN	Community Periodontal Index of Treatment Need
CSIR	Council for Scientific and Industrial Research
CSS	Central Statistics Service
DASA	Dental Association of South Africa
dmft/DMFT	decayed, missing and filled teeth
FDI	Fédération Dentaire Internationale
FTE	Full-time equivalents
GDC	General Dental Council
HPCSA	Health Professions Council of South Africa
IADR	International Association for Dental Research
JFIC	Joint Fluoridation Implementation Committee
MEDUNSA	Medical University of Southern Africa
MRC	Medical Research Council
NAMDA	National Medical and Dental Association
NCOHS	National Children's Oral Health Survey
NFC	National Fluoridation Committee

NHRP	National Human Resources Plan for Health
NOHS	National Oral Health Survey
NRPL	National Reference Price List
PHC	Primary Health Care
ppm	parts per million
SAAWU	South African Association of Water Utilities
SADA	South African Dental Association
SADJ	South African Dental Journal
SALGA	South African Local Government Association
SAMDC	South African Medical and Dental Council
STATOMET	Bureau for Statistical and Survey Methodology
UK	United Kingdom
UPFS	Uniform Patient Fee Schedule
USA	United States of America
WHO	World Health Organization

CHAPTER 1: PROBLEM STATEMENT, AIMS, RESEARCH DESIGN AND STRUCTURE

1.1 Problem statement

Since the "discovery" of fluoride and conclusive evidence provided by Dean and Elvove (1935) on the caries reducing potential of natural fluoride in drinking water, in excess of 100 studies have been conducted in more than 40 countries indicating similar results with the artificial fluoridation of drinking water (Murray, Rugg-Gunn and Jenkins, 1991a). Three recent reviews have confirmed water fluoridation as the most cost-effective and safe primary preventive measure against dental caries (Forum on Fluoridation, 2002; Medical Research Council, 2002; NHS Centre for Review and Dissemination, 2000).

Despite all this evidence in favour of water fluoridation and a Commission of Inquiry into water fluoridation recommending the fluoridation of public water supplies to the optimal fluoride concentration (Republic of South Africa, 1966), no artificially fluoridated water scheme exists in South Africa. A National Fluoridation Committee (NFC) was appointed by the Minister of Health in 1996 to finalise regulations for water fluoridation. These regulations were promulgated on 8 September 2000 (Republic of South Africa, 2000). Water providers are compelled by the regulations to fluoridate public water supplies, but may apply for exemption under special circumstances such as optimal natural fluoride levels already being present. These regulations were repealed with the repealing of the Health Act of 1977 and have been amended and will follow the normal legal process for approval (Smit, 2007).

Both the United Kingdom (UK) Medical Research Council (MRC) (Medical Research Council, 2002) and University of York reports (NHS Centre for Review and Dissemination, 2000) have concluded that there is a need to extensively research the economic impact of water fluoridation where the cost

of the programme should be weighed against its benefits, especially in times of a trend of a reduction in dental caries and exposure to other fluoride products.

Dental caries was included in a South African National Children's Oral Health Survey (NCOHS) (Department of Health, 2003b) to determine reliable baseline data and monitor trends in oral health status in all provinces of South Africa. The report on this survey concluded that caries in the primary dentition was more severe than in the permanent dentition. Caries severity for 12-year-olds ranged between very low to low according to the World Health Organization (WHO) classification (Barmes, 1977). High levels of untreated caries were however recorded. The report recommended that the implementation of water fluoridation be evaluated for South Africa taking into account caries levels in areas where water is supplied by water providers, cost of water fluoridation, levels of fluorosis and trends in dental caries prevalence and severity (Department of Health, 2003b).

The cost and consequences of water fluoridation in any assessment model are dependent on the perspective of the analysis by society, the public health sector, a third-party payer or a particular segment of the population (White, Antczak-Bouckoms and Weinstein, 1989). Guidelines to calculate the cost of water fluoridation based on 44 communities in Florida, United States of America (USA) (Ringelberg, Allen and Brown, 1992) were used to develop a computerised simulation model to evaluate the cost of water fluoridation for Gauteng (Van Wyk, Kroon and Holtshousen, 2001).

The White Paper for the Transformation of Health Services in South Africa presents implementation strategies to meet the basic needs of the population. It recognises dental practitioners, oral hygienists, dental therapists, technicians and dental assistants as members of the oral health workforce delivering these services. Adoption of the Primary Health Care (PHC) approach and reducing the incidence of common oral diseases through a minimum package of care, water fluoridation, and reduction of the

consumption of refined sugar have been identified as the main principles to address oral health (Republic of South Africa, 1997b).

A package of PHC services was agreed to at a meeting of the Provincial Restructuring Committee in Bloemfontein on 13 April 2000 (Pick et al., 2001) and have been published in separate documents (Department of Health, 2001a; Department of Health, 2001b). For oral health it consists of:

- Oral examination and charting of dental status;
- Intra-oral radiographs;
- Scaling and polishing of teeth;
- Promotive and preventive oral health services;
- Basic curative services including emergency relief of pain and sepsis (including dental extractions);
- Simple restorations (1-3 tooth surfaces);
- Treat traumatic injuries to teeth; and
- Treat post-extraction bleeding.

Irrespective of the implementation of water fluoridation and/or a minimum package or oral care, it will impact on human resources required in future. Three studies have been conducted in South Africa over the past number of years investigating human resources required.

Booyens (1994) applied the WHO/Fédération Dentaire Internationale (FDI) needs model (World Health Organization/Fédération Dentaire Internationale, 1989) to the 1988/89 National Oral Health Survey (NOHS) data (Department of Health, 1994) to provide quantitative and qualitative information regarding oral health human resources needs for South Africa. This study concluded that more oral hygienists should be trained to address the need for more primary preventive dental services.

Van Wyk (1996) developed a model to determine the future human resources needs for optimal oral health care for the total population of South Africa where the actual demand for services was used as a point of departure. This

study concluded that the levels of human resources required for 2011 would be difficult to attain and a programme of optimal fluoridation was suggested as an absolute necessity to address oral health to the population of South Africa.

Kissoon-Singh (2001) also used the WHO/FDI needs based model (World Health Organization/Fédération Dentaire Internationale, 1989) and the basic oral health care package (Department of Health, 2001a) to plan human resources for oral health care for KwaZulu-Natal. This study concluded that there was a gross shortage of oral health personnel to meet the oral health needs of this province.

The majority of reports on human resources in South Africa have highlighted the inequitable distribution between urban and rural on the one side and the private and public sectors on the other.

The recently published National Human Resources Plan for Health (NHRP) identifies human resources planning and development as a key priority area and provides a framework to guide all stakeholders to provide an adequate workforce in partnership with government (Department of Health, 2006a).

The NHRP proposes annual productions for the various members of the oral health team (Department of Health, 2006a). In doing so it recognises that targets may appear high, but consideration has to be given to mobility of health professionals to and from the private sector, migration overseas and other attrition factors. The recommendations contained in the NHRP have been criticised by the Chief Executive Officer (CEO) of the South African Dental Association (SADA) (Campbell, 2006).

The challenge to any planner of health and oral health programmes and services is to establish a health system which is available, accessible, affordable and acceptable to all citizens and meets the needs and demands in the most cost-effective way to lead to improved health for all.

1.2 Aims and objectives of the study

The aim of this study was to perform an economic assessment of the implementation of water fluoridation and the delivery of the minimum package of oral care and the impact this will have on human resources planning for oral health in South Africa.

The objectives of the study were:

- To determine per capita cost, cost-effectiveness and cost-benefit of the implementation of water fluoridation for seventeen major metropolitan cities, towns and water boards in all nine provinces of South Africa by way of a model taking into account operating cost, opportunity cost and capital depreciation;
- To determine the per capita cost of delivering the minimum package of oral care to 4- to 15-year-old children based on the treatment needs as determined in the 1999-2002 NCOHS and National Reference Price List (NRPL) and Uniform Patient Fee Schedule (UPFS) fees;
- To calculate human resources needed for the implementation of the minimum package of oral care to 4- to 15-year-old children based on the WHO/FDI model (World Health Organization/Fédération Dentaire Internationale, 1989) and a “Service Targets Method” model (Bui Dang Ha Doan, 1981; Hall, 1978). Both models considered different scenarios for caries reduction achieved through water fluoridation.

1.3 Research design

This study was conducted in three parts based on the three objectives of the study:

- **Part 1:** Cost evaluation for the implementation of water fluoridation in the metropolitan areas and larger towns of South Africa;
- **Part 2:** Costing the delivery of the minimum package of oral care (Department of Health, 2001a; Department of Health, 2001b);
- **Part 3:** Calculate the oral health human resources needs for the implementation of the minimum package of oral care.

The following databases and information documents were used in this study:

- 2006 South African mid-year population estimates (Statistics South Africa, 2006);
- 1999-2002 NCOHS (Department of Health, 2003b);
- Council for Medical Schemes' 2006 NRPL (Council for Medical Schemes, 2006);
- 2006 UPFS (Gauteng Provincial Government, 2005); and
- Minimum package of oral care (Department of Health, 2001a; Department of Health, 2001b).

1.4 Structure of thesis

Chapter 2 presents a literature review on water fluoridation (including a historical perspective, water fluoridation in South Africa and economic assessment), human resources planning (including approaches, the WHO/FDI model, a South African perspective and human resources distribution and trends) and South African policy documents on health and oral health service delivery.

Chapter 3 describes a model, results and discussion of the per capita cost, cost-effectiveness and cost-benefit of the implementation of water fluoridation for seventeen major metropolitan cities, towns and water boards in all nine provinces of South Africa.

Chapter 4 describes a model, results and discussion of the per capita cost of delivering the minimum package of oral care to 4- to 15-year-old children taking into account different scenarios for caries reduction achieved through water fluoridation.

Chapter 5 describes two models, results and discussion to calculate the oral health human resources required for the implementation of the minimum package of oral care to 4- to 15-year-old children taking into account different scenarios for caries reduction achieved through water fluoridation.

Chapter 6 describes the conclusions and recommendations from this study linked to water fluoridation and delivering the minimum package of oral care.

1.5 Summary

This chapter provided the background, aims and objectives and a brief overview of the three phases of this study.

Chapter 2 will present a literature review of water fluoridation, human resources planning and South African policy documents on health and oral health service delivery.

CHAPTER 2: LITERATURE REVIEW

2.1 Overview of water fluoridation

2.1.1 Historical perspective

a) The early years

The classic epidemiological study involving research conducted independently by Dr Frederick McKay (a dentist from Colorado Springs, USA), Mr H.V. Churchill (chief chemist from the ALCOA Company) and Dr H. Trendley Dean (a dentist from the United States Public Health Service) is well document and is described in detail in all major textbooks dealing with preventive dentistry, fluoride and dental public health. Without repeating this entire study into the "discovery" of fluoride in community water supplies and its relationship between dental caries and dental fluorosis, key findings of this study, spanning from 1900 to 1942, are summarised in Table 1.

Table 1: Summary of early studies into the relationship between fluoride in community water supplies, dental caries and dental fluorosis

Year	Description
Early 1900s	Dr Frederick McKay describes the "Colorado Stain" in his patients seen in his Colorado Springs, Colorado practice (Murray, Rugg-Gunn and Jenkins, 1991b)
1916	McKay enlists the collaboration of Dr G.V. Black who describes this phenomenon as "mottled enamel" (Black and McKay, 1916)
1918	McKay concludes that a "mysterious element" in the community water supply is responsible for mottled enamel (McKay, 1918)
1928	McKay observes a reduced caries experience in patients with mottled enamel (McKay, 1928)
1931	Mr H.V. Churchill identifies high fluoride levels in water samples sent to him by McKay for analysis (Churchill, 1931)
1931	Dr H. Trendley Dean is appointed as the first dentist of the newly established National Institute of Health's Dental Hygiene Unit which became the National Institute of Dental Research in 1948 (Burt and Eklund, 2005)
1933	Dean publishes his first report of the distribution of mottled enamel in the United States (Dean, 1933)
1934	Dean describes his seven-point, ordinal scale index of fluorosis (Dean, 1934)
1935	Dean starts using the term "fluorosis" to replace mottled enamel (Dean and Elvove, 1935)

Table 1: (continued)

1936	Dean concludes the minimal threshold of fluoride in water should be 1 ppm (Dean, 1936) and that fluorosis in communities where fluoride levels were below this threshold were of no public health significance (Dean and Elvove, 1936)
1938	Dean's first report on the inverse relationship between dental caries and dental fluorosis (Dean, 1938)
1939	Dean and McKay provide conclusive and direct proof that fluoride in public water supplies is the primary cause of dental fluorosis (Dean and McKay, 1939)
1941/1942	Dean reports on his "21 cities study" indicating that dental caries experience decreases sharply as fluoride concentration increases towards 1 ppm (Dean, Arnold and Elvove, 1942; Dean et al., 1941) which led to the adoption of 1.0-1.2 ppm as the appropriate concentration of fluoride in drinking water in temperate climates

b) North American studies

This initial phase linked to natural fluoride in drinking water, was followed by the first controlled fluoridation trials in the United States and Canada commencing in 1945 and 1946 in Grand Rapids, Michigan (Muskegon as control), Newburgh, New York (Kingston as control), Evanston, Illinois (Oak Park as control) and Brantford, Ontario (Sarnia as control) (Burt and Eklund, 2005). All of these studies, some reporting results of up to fifteen years after the commencement of controlled fluoridation, clearly indicated a sharply reduced caries experience in each of the study populations (Arnold et al., 1962; Ast and Fitzgerald, 1962; Blayney and Hill, 1967; Hutton, Linscott and Williams, 1956). These studies, all of which were of a sequential cross-sectional design, also reported fluorosis levels of between 7-16% as described by Dean in earlier studies at a fluoride concentration of 1 parts per million (ppm).

c) The Dutch Tiel-Culemborg study

The first truly longitudinal study into the controlled fluoridation of public water supplies was conducted in The Netherlands in the towns of Tiel (fluoridated) and Culemborg (control). This study also described the caries inhibitory effect of fluoride in drinking water being of more benefit to smooth surfaces compared to pits and fissures and confirmed the benefits of lifelong exposure to water fluoridation on oral health. Evidence from this study suggests that

adequate ingestion of fluoride during enamel formation is important to prevent pit and fissure caries, but is of less importance where smooth surface caries is concerned (Backer Dirks, Houwink and Kwant, 1961; Backer Dirks, 1967; Kwant et al., 1972; Kwant et al., 1974).

d) The New Zealand Hastings study

This was a retrospective study reporting on baseline examinations conducted in 1954, 1964 (10 years after the introduction of fluoridation) and 1970 after 16 years of fluoridation. This study indicated a caries reduction of 49% between 1954 and 1970 and also demonstrated the selective caries inhibitory effect of fluoride on different tooth surfaces (Ludwig, 1965; Ludwig, 1971).

e) United Kingdom studies

The earliest studies in the UK confirmed Dean's findings. Caries in South Shields was reported to be 50% lower than in North Shields (Weaver, 1944). Similar finding were reported from studies in the North-East of England (Weaver, 1950) and other parts in Britain where fluoride levels varied from 0.9 to 5.8 ppm (Forrest, 1956).

A study conducted in East Anglia confirmed the benefits of continuous exposure to fluoride compared to those exposed to fluoride in drinking water for different periods of time (James, 1961).

A British Government mission to the USA to study fluoridation in operation recommended that water fluoridation should be implemented in selected communities first before general implementation. Watford, Kilmarnock and a part of Anglesey were chosen. Fluoride was added to the drinking water in 1955-1956. After 5 years a report confirmed that fluoridation of water supplies was highly effective in reducing dental caries (Murray et al., 1991b).

f) The World Health Organization and water fluoridation

The WHO has always taken a keen interest in this public health topic and in 1958 produced their first report endorsing the findings that water containing approximately 1 ppm was a practical and effective health measure to reduce dental caries (World Health Organization, 1958).

A report on fluoridation was submitted to the World Health Assembly which resulted in the adoption of the following resolution on 22 July 1969:
"The World Health Organization recommends member states to examine the possibility of introducing and where applicable to introduce fluoridation of those community water supplies where the fluoride intake from water and other sources for the given population is below optimal levels, as a proven public health measure, and where fluoridation of community water supplies is not practicable to study other methods of using fluoride for the protection of dental health" (World Health Organization, 1969).

This resolution was reaffirmed in the Report of the WHO Director General in 1975 (Murray et al., 1991b).

The 2003 World Oral Health Report confirmed the evidence that long-term exposure to an optimal level of fluoride results in diminishing levels of caries in both children and adults. This report did however recognise the various sources of fluoride and requests public health administrators to maximise caries reduction and at the same time minimise dental fluorosis. This report estimated that 210 million people benefit from fluoridated water (Petersen, 2003).

g) Current status of community fluoridation throughout the world

It came as no surprise that the favourable results of initial studies led to many other communities adding fluoride to their public water supplies. It was estimated that by 1981 approximately 210 million people worldwide were exposed to fluoridated water (Murray, 1986).

A summary of the world status of fluoridation shows (Burt and Eklund, 2005):

- According to the FDI 34 countries reaching 246 million people had fluoridated water;
- Fluoridation in Singapore reached 100% of its population in 2004;
- Ireland is the only nation with a mandatory fluoridation law;
- More than 50% of the population in Australia, Ireland, Malaysia, New Zealand and the USA are reached by water fluoridation;
- 10% of the population in Spain (mainly Seville and Córdoba) and the UK (Birmingham and Newcastle) received fluoridated water;
- Fluoridation projects in Eastern European and South and Central American countries are of uncertain status; and
- By the end of 1992, 135 million persons in the USA were served by fluoridated water with a further 10 million having naturally fluoridated water.

WHO in collaboration with the FDI and the International Association for Dental Research (IADR) hosted a global consultation on “Oral Health through Fluoride” from 17-19 November 2006. The aim and objectives of the Consultation were to (World Health Organization, 2006):

- Review and highlight successes in promoting oral health through the use of fluoride;
- Identify barriers for making fluoride available to all;
- Explore effective strategies for making fluoride available and affordable to all; and
- Develop an action plan for fluoride promotion and advocacy.

A declaration from this consultation reaffirmed the efficiency, cost-effectiveness and safety of the daily use of optimal fluoride and that access to fluoride for dental health forms part of the basic human right to health (Fédération Dentaire Internationale, 2006).

2.1.2 Caries prevention from water fluoridation

The extensive literature on the effectiveness of water fluoridation reports mostly on studies conducted in children (Burt and Fejerskov, 1996). A summary of studies of artificial fluoridation throughout the world showed that of the 113 studies conducted in 23 countries, 66 reported on the effect on deciduous teeth and 86 on permanent teeth (Murray et al., 1991a). More than half of these studies were conducted in the USA. Modal percentage caries reduction for deciduous teeth was 40 to 49% and 50 to 59% for permanent teeth. Reports from these studies as well as the four pioneering studies described earlier, has led to the statement "water fluoridation reduces dental caries by half" (Burt and Eklund, 2005).

A review of the effectiveness of water fluoridation in the USA between 1979 and 1989 found that caries reduction varied from 8 to 37% amongst adolescents (Newbrun, 1989). Since the early days of water fluoridation, caries has declined in both fluoridated and non-fluoridated communities, mainly due to:

- the diffusion of fluoridated water to areas through bottling and processing of foods and beverages; and
- the widespread use of fluoride toothpaste (Horowitz, 1996).

McKay was the first to report on the beneficial effect of water fluoridation on adults. He reported a 60% difference in mean decayed, missing and filled teeth (DMFT) scores between adults in naturally fluoridated Colorado Springs and the non-fluoridated town of Boulder (McKay, 1948). Increased retention of teeth in ageing populations can lead to an increase in the prevalence of root caries. Studies which indicated a reduction in root caries in fluoridated areas are therefore important to emphasise its benefits to adults and the elderly as well (Burt, Ismail and Eklund, 1986; Stamm, Banting and Imrey, 1990).

2.1.3 Recent international reports

a) University of York (2000)

The York review was the first systematic review to be undertaken on water fluoridation. The protocol and all stages were subject to external review (Treasure et al., 2002).

The aim was to assess available evidence on both the positive and negative effects of water fluoridation as a strategy to prevent dental caries. The world-wide-web and 25 electronic databases were searched, 214 studies met the inclusion criteria for one of the 5 objectives of this review (McDonagh et al., 2000).

Objective 1: Effect of water fluoridation on dental caries

The best evidence found suggested that fluoridation of drinking water does reduce caries incidence as measured by the proportion of children who are caries free and by the mean change in dmft/DMFT scores. The degree to which this applied was not clear from this review. Evidence from studies after withdrawal of water fluoridation suggested an increase in caries prevalence levels approaching that of low fluoride groups (Treasure et al., 2002).

Objective 2: Beneficial effect of water fluoridation over and above other interventions

This review found no difference in the mean dmft/DMFT or percentage caries free individuals in studies conducted before or after 1970, suggesting that water fluoridation may still be of benefit after the introduction of fluoride toothpaste during the 1970's (Treasure et al., 2002).

Objective 3: Equity of water fluoridation

No longitudinal studies were found to investigate this. Cross-sectional studies were limited to the UK. Where dmft/DMFT was used, it seemed as if water fluoridation did reduce the inequalities in dental health in social classes aged 5 and 12. The authors suggested that caution should be taken in interpreting

these results due to the few studies which investigated equity of water fluoridation (Treasure et al., 2002).

Objective 4: Possible negative effects of water fluoridation

Dental fluorosis is regarded as the most widely reported negative effect of water fluoridation. This report identified a significant dose-response relationship between water fluoridation and dental fluorosis with a prevalence of 48% at a level of 1 ppm, fluorosis of aesthetic concern at this level was 12.5%. At 0.1 ppm the corresponding figures were 15% (prevalence) and 6% (aesthetic concern). Altitude and temperature were not found to be significant factors affecting dental fluorosis (Treasure et al., 2002).

The majority of studies investigating bone fractures as a consequence of water fluoridation were divided into hip and other fractures. No clear association could be found between hip or other fractures and water fluoridation. The majority of studies reported a small variation around the no effect outcome (Treasure et al., 2002).

No clear association could be indicated between any form of cancer and water fluoridation (Treasure et al., 2002).

This report concluded that studies of a much higher quality needed to be conducted to be conclusive of any negative effects of water fluoridation (Treasure et al., 2002).

Objective 5: Differences between natural and artificial water fluoridation

Very few studies compared natural to artificial fluoridation, no major differences were apparent, however evidence was found to be inadequate (Treasure et al., 2002).

In summary this report concluded that little high quality research had been conducted into public water fluoridation, including any negative effects. It was suggested that future studies should include ethical, environmental, ecological, cost and legal issues of the implementation of water fluoridation.

None of these aspects were included in this review (McDonagh et al., 2000). It was concluded however that water fluoridation does prevent caries and is associated with dental fluorosis (Treasure et al., 2002).

b) Ireland Forum on Fluoridation (2002)

This forum was established by the Ireland Minister of Health in May 2000 with the overall objective to review fluoridation of public water supplies in Ireland to inform the public, legislators and health professionals about the benefits and risks of fluoridation for human health. This would be the first major review of fluoridation in Ireland since its introduction in 1964 (Forum on Fluoridation, 2002). It was prompted by an increased interest among the public and advocacy groups leading to a subsequent increase in media coverage (Clarkson, McLoughlin and O'Hickey, 2003). The report covered scientific, technical and ethical issues relating to fluoridation.

The overall conclusions of the final report were (Forum on Fluoridation, 2002):

- Fluoridation was very effective to improve oral health of children, adults and the elderly;
- The best evidence suggested that at the maximum permitted level of 1 ppm human health was not adversely affected; and
- Dental fluorosis is well recognised and evidence suggested that it was on the increase in Ireland.

Two of the eight recommendations referred to water fluoridation with the remaining six aimed at fluoride toothpaste, the oral health care industry, infant formula, fluoride research, education, information and public participation and public health and professional practice. All were aimed to achieve maximum protection against dental caries and minimising the occurrence of dental fluorosis (Forum on Fluoridation, 2002). Only those applicable to this study are highlighted:

- **Policy aspects of water fluoridation:** Fluoridation should continue, but the optimal level should be amended from 0.8 to 1.0 ppm to between 0.6

and 0.8 ppm. This level should be sufficient to maintain low caries levels and reduce the prevalence of dental fluorosis (Clarkson et al., 2003).

- **Technical aspects of water fluoridation:** Guidelines should be developed to support ongoing quality assurance and external audit of fluoridation plants should be put in place. Fluoride monitoring and reporting procedures should be updated.
- **Fluoride toothpaste:** The continued use of fluoride toothpaste was recommended due to the additive benefit from the combination of this and water fluoridation. Fluoride toothpaste should not be used up to the age of 2 and parents should supervise the brushing of their children's teeth between ages 2 and 7 with only a pea-sized amount of toothpaste used. Swallowing of fluoride toothpaste should be avoided during these ages.

c) United Kingdom Medical Research Council (2002)

Following on the York report commissioned by the Chief Medical Officer of the UK Department of Health, the MRC was requested to investigate what further research would be required to improve the evidence base of fluoride and health in light of the conclusions and recommendations of the York report, the results of which were published as a separate report. The following recommendations were made (Medical Research Council, 2002):

- **Risk assessment, management and perception:** Evaluate methods for gauging public opinion, especially relating to water fluoridation, increase understanding on how to engage the public when planning research, assess methods to communicate results to the public and improved involvement of public opinion in reaching policy decisions.
- **Total fluoride exposure and uptake:** Differences in bioavailability and absorption of fluoride from natural compared to artificially fluoridated sources, calculate lifetime intake of fluoride, trends in fluoride exposure as a result of the use of discretionary fluorides such as fluoride toothpaste by infants.
- **Dental caries:** Effect of fluoridation against a background of widespread use of other fluoride sources, effect of water fluoridation on differences in

social class, impact of fluoridation on caries in adults and root caries in the elderly, impact of fluoridation on quality of life and economic indices.

- **Dental fluorosis:** Determine levels of fluorosis in both fluoridated and non-fluoridated communities, the public's perception of dental fluorosis and what level is aesthetically acceptable, fluorosis to be included as an outcome measure in any prospective study into water fluoridation.
- **Potential negative health outcomes:** Does bio-availability of fluoride from artificial and natural sources affect health differently, the relation between hip fractures and long-term consumption of artificially fluoridated water, update analysis of UK data on water fluoridation and cancer rates.

2.1.4 Water fluoridation in South Africa

a) The history of water fluoridation from 1935-1996

The history of water fluoridation for this period can be categorised into three phases (Moola, 1996).

During **Phase 1 (1935-1968)** the presence of fluorosis in children in high fluoride areas, delineation of areas of endemic fluorosis, levels of fluoride in different areas in South Africa and the observation of dental caries in these areas were reported (Ockerse, 1941; Ockerse, 1942; Ockerse, 1944; Ockerse and Meyer, 1941). This work led to an investigation by the Council for Scientific and Industrial Research (CSIR) into the desirability of water fluoridation, the report of which approved the suggestions to add fluoride to community water supplies as a preventive health measure to reduce dental caries (Staz, 1963).

Towards the end of this phase, in view of the divergence of opinions between those who supported and those with objections to fluoridation of public water supplies, a Commission of Inquiry was appointed by the State President to report on (Republic of South Africa, 1966):

- The maximum exposure to fluoride which was safe for the human body;

- Possible short and long-term beneficial and detrimental effects on the health of human beings of all ages; and
- Safe methods of utilising the possible advantages of the use of fluoride.

The Commission was overwhelmingly in favour of fluoridating the drinking water and the report recommended (Republic of South Africa, 1966):

- Local authorities should be encouraged, advised and assisted to fluoridate the water supplies of their communities as soon as possible;
- Fluoridation schemes should aim to achieve optimal concentration of fluoride in the drinking water for the prevalent climatic conditions;
- Where fluoride was naturally present in public water supplies, adjustment should not exceed the recommendations published in the report;
- Where natural fluoride concentrations exceeded the recommended levels, defluoridation should be considered;
- Consumers should be informed of the best means of obtaining the beneficial effects of fluoride;
- Where supplementation of fluoride in drinking water was practiced, the average concentration should be kept within the upper and lower limits as recommended in the report;
- Regulations should be developed and published to ensure the monitoring and safe and uniform standards were maintained in fluoridation plants;
- Local authorities should be legally authorised to decide whether or not the public water supplies over which they have jurisdiction should be fluoridated.

No action was taken by the then government of the day to implement water fluoridation.

Phase 2 (1978-1989) was characterised by a number of reports and symposia (Moola, 1996). A publication on the views of the profession and the Department of Heath (Taljaard, 1978) triggered public debate from those opposed to water fluoridation. This prompted a National Symposium on Water Fluoridation which ended inconclusively with no clear mandate to government

to implement water fluoridation (Department of Health, 1979). During this phase considerable research was conducted into the levels of fluoride in drinking water as well as research supported by the MRC on alternative sources of fluoride (Dreyer and Grobler, 1984; Grobler and Dreyer, 1988; Grobler et al., 1994; Grobler, Van Wyk Kotze and Cleymaet, 1991; Janse van Rensburg et al., 1991; Louw and Van Wyk, 1984; Zietsman, 1991).

Phase 3 (1990-1996) occurred during major political change in South Africa (Moola, 1996). Water fluoridation was discussed at the National Medical and Dental Association (NAMDA) and the MRC organised another symposium (Medical Research Council, 1991; National Medical and Dental Association, 1990). The National Health Plan of the African National Congress (ANC) included water fluoridation as a PHC measure (African National Congress, 1994a). In 1995 the Oral Health Committee, appointed by the Ministry of Health, recommended that government implement water fluoridation as part of its Reconstruction and Development Programme (African National Congress, 1994b). Subsequent to this the Oral Health Committee set up a Subcommittee on Water Fluoridation to oversee the implementation of water fluoridation. This committee was renamed the National Fluoridation Committee (NFC) shortly after.

Towards the end of this phase, a number of journal articles reported on the effectiveness of water fluoridation in South Africa (Du Plessis, 1995; Du Plessis et al., 1996; Du Plessis et al., 1995). Children from the black and white population groups on the Free State Goldfields (0.54 ppm fluoride) showed respective caries reductions of 85% and 31% when compared to children in the coastal areas (<0.01 ppm fluoride). From this study it was concluded that an acceptable level of fluoride in public water supplies on the Free State Goldfields should not exceed 0.7 ppm. As part of a severe drought in the coastal city of Port Elizabeth (<0.1 ppm fluoride), water from the Orange/Fish/Sundays River schemes was transferred to this city. This water has a natural fluoride concentration of on average 0.62 ppm. A study investigated caries prevalence in children receiving the high fluoride water compared to the low fluoride water 16 months after this change was made.

No statistically significant difference could be indicated for the primary dentition. In the permanent dentition, 12- and 15-year-old children consuming the higher fluoride concentration water respectively had 14% and 7.8% less caries compared to the lower fluoride group.

b) The history of water fluoridation from 1996

One of the main objectives of the NFC of the Department of Health was to draft regulations for the fluoridation of water supplies. On 8 September 2000 the Minister of Health approved these regulations as part of Health Act No. 63 of 1977. These regulations were published in the Government Gazette (Republic of South Africa, 2000) and compelled every water supplier to initiate fluoridation unless exempted thereof, in writing by the Director General: Health.

An advisory committee to the NFC, called the Joint Fluoridation Implementation Committee (JFIC), was formed in 2002 consisting of members from the South African Association of Water Utilities (SAAWU), South African Local Government Association (SALGA), Department of Health and the Department of Water Affairs and Forestry. The JFIC was chaired by the CEO of the Water Research Commission. The JFIC drafted criteria for the identification of "front runner sites" for the safe implementation of water fluoridation (Smit, 2007). Cape Town, Port Elizabeth, East London and Durban, (coastal areas) were identified as potential front runner sites (Department of Health, 2003a).

A new Health Act (Act No. 61 of 2003) for South Africa (Republic of South Africa, 2003) necessitated an amendment to the regulations on fluoridating water supplies, since the previous regulations were repealed with the repealing of the Health Act of 1977. SAAWU and SALGA also demanded a change to the regulations as certain legal and technical aspects in the original regulations had to be amended. They furthermore complained that the regulations were an unfunded mandate and that that they did not have the funds to implement water fluoridation. The regulations have now been

amended and will follow the normal legal process of consultation through the invitation of comments, including via the Government Gazette. The NFC will consider inputs received, where after the regulations will be submitted to the Minister of Health for promulgation (Smit, 2007).

c) Attitudes to water fluoridation in South Africa

A National Fluoridation Survey was conducted in 1998 prior to the publication of the Regulations on Fluoridating Water Supplies. The findings were presented in three parts (Chikte and Brand, 1999; Chikte and Brand, 2000; Chikte et al., 2000).

This survey found that 25.6% of the population surveyed had heard or read about fluoridation, 65.6% had not, with 8.9% unsure. In terms of racial classification 62.6% of the white population group had heard about fluoridation, whilst 72.2% of the black population group had not. The highest percentage of respondents who had heard about fluoridation resided in the Western Cape (46.3%), the highest no response (82.8%) was found in North West province.

The electronic media were the most dominant source of information (40%), followed by the print media (27%). More than a third of respondents (36%) could identify the purpose of water fluoridation correctly, 28% believed it to purify water, 29% were unsure.

The majority of respondents (61.9%) agreed that fluoride should be added to water, 9% disagreed with the remaining 29.1% unsure. The main reasons for a support vote was given as prevention of tooth decay (30%) and affecting health positively (30.6%), whilst the main reasons for a negative response was that water should stay as it is (26.1%), it will create bigger problems as it remains in the water (15.6%) and it affects health negatively (12.3%). The majority of respondents who were uncertain of adding fluoride to water could not provide a reason (90%).

As was expected a strong relationship was found between educational level and knowledge of and attitude towards fluoride with 59% of respondents in the highest educational group having heard or read about fluoridation. Similar trends were found related to income (70%) and occupation (68% of professional/executive).

When compared to previous similar studies (Chikte, 1997; Gilbert and Chikte, 1993), this study concluded that support for water fluoridation has increased. Educational programmes on water fluoridation should be aimed at lower educational and income groups with the electronic media as the vehicle of choice. A small resistant, yet influential, group existed which opposed fluoridation. Especially in South Africa, water fluoridation is needed to address inequalities in oral health and based on these results health authorities and policy makers should proceed with its implementation.

2.1.5 The economics of water fluoridation

Costing water fluoridation and its benefits is a complex process looked upon differently by city councils, proponents of fluoridation, dental practitioners and even those opposed to fluoridation (Burt and Eklund, 2005). In general per capita cost of fluoridation is affected by the size of the community, number of fluoride injection points, amount and type of equipment required, amount and type of fluoride chemical as well as its transport and storage, training and expertise of personnel required to run the plant.

Although the actual cost of water fluoridation cannot and should not be ignored, estimates of saving in treatment cost may be more important than per capita cost. Health economists at the conclusion of a 1989 workshop in Michigan concluded that water fluoridation was one of a few public health measures where it actually saved more money than it cost to operate (Anonymous, 1989).

Benefits from fluoridation can be expressed in several ways (Davies, 1974):

- Saving in the cost of dental treatment based on the reduction in number of restorations and extractions;
- Saving in the oral health worker's working time or salary as a result of the reduction in treatment required; and
- Less pain and discomfort and a reduction in loss of time from school and industry. This is difficult to express in monetary terms.

Cost- effectiveness and cost-benefit analysis in relation to dental procedures are defined as follows (Horowitz and Heifetz, 1979):

- Cost-effectiveness analysis (CEA) is expressed as the cost per person per year to save 1 DMFT; and
- Cost-benefit analysis (CBA) is expressed as the cost of implementing the procedure divided by the savings in the cost of treatment.

CEA and CBA frequently overlap and are sometimes difficult to distinguish. Where CBA is used to make broad decisions about competing programmes, CEA assists in choosing among alternative programmes to achieve the same outcome, for example as defined by Horowitz and Heifetz (1979) to save 1 DMFT. While costs can usually be accurately assessed with CBA, it has the disadvantage that the benefit to an individual's freedom from pain, discomfort or inconvenience cannot be reliably established in monetary terms. CEA is therefore the less complicated technique (Fédération Dentaire Internationale, 1981).

Saving in the costs of dental treatment, working time and CBA for the fluoridation studies conducted in Hastings (New Zealand), Newburgh (USA), Watford (United Kingdom), Tiel (Netherlands) and Basel (Switzerland) are shown in Table 2. It should be noted that cost-benefit ratios vary because of differences in cost of dental treatment between countries, in all cases however the value of the benefits substantially exceeded the cost of implementation (Davies, 1974).

Table 2: Savings in cost of dental treatment, working time and cost-benefit analysis for water fluoridation studies in five countries (Davies, 1974)

Study (country)	Savings in cost of dental treatment per child	Savings in working time	Cost-benefit analysis
Hastings (1965) (New Zealand)	NZ$1.79 (2.5-13.5-year-olds) NZ$ 5.72 (13.5-15-year-olds)	0.65 whole-time dental nurse per 1,000 children	NZ$4.4 saved for every NZ$ spent on water fluoridation
Newburgh (1966/70) (USA)	US$4.81-8.17 (5-year-olds) US$1.99-9.40 (6-year-olds)	16.7 minutes per child per year	US$4.1 saved for every US$ spent on water fluoridation
Watford (1962) (United Kingdom)	£1.62 (age 3) to £4.32 (ages 6-7)	Not available	£2.5 saved for every £ spent on water fluoridation
Tiel (1972) (Netherlands)	26 Dutch Guilder (age 7) to 229 Dutch Guilder (age 15)	Not available	10 Dutch Guilder saved for every Dutch Guilder spent on water fluoridation (age 7)
Basel (1967) (Switzerland)	90.75 Swiss Francs over 5 years	70% in dentist man-hours over 5 years	4.4 Swiss Francs saved for every Swiss Franc spent on water fluoridation

A decrease in caries prevalence is reported from both fluoridated and non-fluoridated communities. Especially where limited resources is an issue, the continued adjustment of water fluoride levels in public water sources should be investigated in terms of the economic outcomes of the investment (White et al., 1989).

Cost estimates of water fluoridation should include the following (White et al., 1989):

- To initiate a new fluoridation program, costs for a referendum and associated campaigns should be included, although this is a once off activity only;
- The number of employee hours required to adjust the level of fluoride, maintain equipment and to monitor fluoride levels linked to the hourly wage rate or salary for these employees;
- Choice of chemical, cost per unit, amount of chemical needed per year and the cost of transporting these chemicals;
- Equipment needed, expected annual maintenance costs, expected length of time this equipment can be used and the replacement cost;

- Opportunity cost of purchasing equipment (and not other things) as well as depreciation costs as the equipment loses value over time;
- Overhead costs such as electricity, rent, insurance, shared space costs, etc.;
- Cost of testing equipment to measure compliance, expected length of time this equipment can be used and the replacement cost;
- Amount of natural fluoride in water affects both cost and consequences of the fluoridation programme;
- Temperature of the region affects water consumption which will impact on cost as more or less chemical will be needed;
- Number of injection sites required for fluoridation; and
- Cost of installation and consulting engineers' fees.

In a study of 44 fluoridated Florida communities it was estimated that per capita costs ranged from US $0.31 (communities more than 50,000 residents) to US $2.12 (communities less than 10,000 residents) and was still regarded as the most cost-effective in terms of cost per saved tooth surface (Ringelberg et al., 1992). An economic analysis in the United States estimated that the prevention of dental caries, largely attributed to fluoridation and fluoride-containing products, led to a saving of $39 billion in dental care expenditures from 1979 to 1989 (Brown, Beazoglou and Heffley, 1994).

A more recent study in the USA to determine if the reduction in cost of restorative care due to averted disease still exceeded the program cost of water fluoridation in a time where caries reductions were observed in both fluoridated and non-fluoridated communities, came to the conclusion that water fluoridation was still cost saving with the exception of communities with less than 5,000 residents (Griffin, Jones and Tomar, 2001).

A similar study conducted in New Zeeland (Wright et al., 2001) still regarded water fluoridation as cost-saving for communities for 1,000 residents or above and was also higher for lower socio-economic communities and a high

proportion of children. This study also indicated that the break-even point for five fluoride injection points, was a community of 10,000 residents.

A UK study expressed the benefits of water fluoridation projects in the context of population sizes of 60,000, 120,000 and 600, 000 (Birch, 1990). For these communities the ratio of cost to benefit implies that the fluoridation programme would reduce dental caries at an average cost of £4.80 per dmft per person per year avoided for a population of 60,000, £3.07 for a population of 120,000 and £1.60 for a population of 600,000 in high caries areas. In low caries areas the discounted costs were £19.46, £12.44 and £6.49 respectively for population sizes of 60,000, 120,000 and 600,000. This study concludes that with all things being equal, caries reduction as a result of water fluoridation would cost four times as much in a low caries area compared to a high caries area, suggesting that considerable economies of scale exist in terms of the reduction in cost per unit of benefit as population size increases.

Although population sizes as low as 1,000 have traditionally been considered as unfavourable for the introduction of water fluoridation, technological advances are resulting in new and more cost-effective options in its delivery. An Australian study reported on the feasibility, costs of installation and operation of fluoridation units over two years in two remote Indigenous communities in the Northern Territory of Australia (Ehsani and Bailie, 2007). These communities had populations of 2,000 and 1,300 respectively at the time of the study. Several technical, operational and policy issues were identified which need to be addressed. Capital cost for each of the two fluoridation plants was estimated to be US$130,000, with annual operational and maintenance cost of about US$11,800. The authors concluded that this investment should lead to a substantial and significant improvement in oral health of remote Indigenous Australian communities in the medium to long run.

Based on previous studies (Davies, 1973; Doessel, 1985; Ringelberg et al., 1992), an economic model for the implementation of water fluoridation for Gauteng, South Africa was developed (Smalberger, 1998). This model took into account:

- **Factors which modify input variables:**
  Natural fluoride content
  Rainfall
  Pollution
  Labour action
  Remuneration
  Exchange rates
  Inflation
  Population size and growth
  Health profile

- **Input variables:**
  Opportunity costs
  Cost of water
  Chemical cost
  Capital cost
  Financing

- **Process variables:**
  Labour cost
  Expertise
  Maintenance
  Financing

- **Output variables:**
  Per capita cost
  Saving per person
  Cost-effectiveness

The output variables for Gauteng as found in this study were (Smalberger, 1998):

- Per capita cost: R0.11 – R2.40
- Saving per person: Estimated 55% caries reduction: R25.86 – R61.36
  Estimated 35% caries reduction: R16.41 – R38.15
  Estimated 25% caries reduction: R11.70 – R26.60

In another South African study a computerised simulation model, based on the studies by White et al. (1989) and Ringelberg et al. (1992), was developed to report on cost-effectiveness and cost-benefit (Horowitz and Heifetz, 1979) of water fluoridation for Gauteng (Van Wyk et al., 2001). The results of this study for adjusting the fluoride level to 0.7 ppm are summarised in Table 3.

Table 3: Cost evaluation of the implementation of water fluoridation in Gauteng (Van Wyk et al., 2001)

Total annual cost		
A. Chemical cost per year	Sodium silicofluoride	R2,744,727.72
B. Labour cost	6 operators/1 hour per day	R38,824.40
C. Capital cost		R14,000,000.00
D. Maintenance cost	2.4% of capital cost	R366,000.00
E. Opportunity cost	13.5% of capital cost	R1,890,000.00
F. Capital depreciation	Buildings: over 15 years Mechanical/electrical/Instrumentation: over 8 years	R1,578,839.04
G. Operating cost	A + B + D	R3,119,552.12
H. Total cost	E + F + G	R6,588,391.16
Cost-effectiveness and cost-benefit analysis		
Total population for Gauteng		9,000,000
Cost per person per year for total population		R0.73
Cost per person per year younger than 15 years		R2.93
Cost-effectiveness analysis (cost per person per year to save 1 DMFT)	Estimated 50% caries reduction Estimated 30% caries reduction Estimated 10% caries reduction	R3.95 R6.58 R19.73
Cost-benefit analysis (cost of implementation of water fluoridation divided by saving in cost of treatment)	Estimated 50% caries reduction Estimated 30% caries reduction Estimated 10% caries reduction	0.04 0.07 0.22

Results of this study indicated that even at caries reductions of 10% and 30%, it would still be cost-effective and of benefit to implement water fluoridation for Gauteng. It recommended that water fluoridation should not be considered if the cost-benefit ratio approached, equalled or exceeded one (Van Wyk et al., 2001).

2.2 Human resources planning

2.2.1 Brief overview

Demands for health care is increasing rapidly in virtually all countries due to population growth, rising social expectations, socio-economic development, advances in health technology and a shift in patterns of disease from acute to chronic illnesses. Human resources is one of the critical elements needed for the provision of health care to all citizens of any country and consume a significant portion of the total health expenditure. A lack of human resources is therefore one of the most obvious constraints in any health service.

Human resources planning can be defined as “the process of estimating the number of persons and the kind of knowledge, skills and attitudes they need to achieve predetermined health targets and ultimately health status objectives” (Mejía and Fülöp, 1978).

Human resources cannot be improvised and the three components of the development process (planning, production and management), must be brought into closer and more functional relationships with each other and with developments in the health services themselves (Mejía and Fülöp, 1978).

These three components involve the following (Van Wyk, 1996):

- **Planning:** The end result should be to develop and implement a human resources plan that will fulfil the needs and demands of the health services. This process is dynamic and feedback mechanisms are required to be able to make changes to it.

- **Production:** Involves the training and education of the workforce. It is controlled by both the health and educational sectors which necessitates coordination to ensure that the needs and demands of the public are met.
- **Management:** Involves employment, utilisation and motivation of all categories of health workers and determines the productivity of the health system and ability to retain its workforce.

The interaction between these three components is illustrated in Figure 1 (Mejía and Fülöp, 1978).

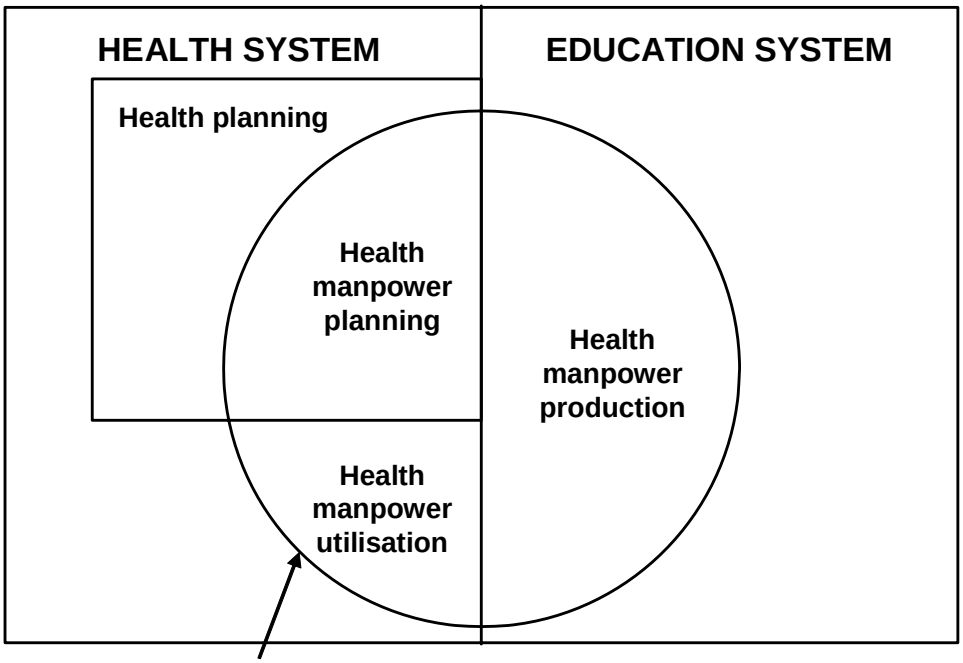


Figure 1: The health manpower system (Mejía and Fülöp, 1978)

Any human resources model should take into account the influences of a number of other systems (Mejía, 1978):

- The political system: through formal legislative and executive procedures and informal political influence of individuals and organisations;
- The education system: the manner in which human resources for health are produced and utilised;
- Professional bodies: exerts influence by control over licensing, curricula, career structures, income by way of fee structures and standards of practice;

- Health service agencies: regard themselves as qualified to determine population needs and demands; and
- Health services consumers.

2.2.2 Approaches to human resources planning

Human resources planning is influenced by a number of factors (Hall, 1978):

- Demographic: Size, distribution, density, growth rate, age structure, gender ratio with population size and distribution being regarded as the most important;
- Economic: Driven by supply and demand based on disposable income and demand for services;
- Social and cultural: These may influence the degree to which the public is aware of the availability of health services and the value placed on obtaining it;
- Health status of the population;
- Accessibility to health services;
- Resource availability; and
- Health care technology.

When applied to human resources planning, need and demand can be defined as follows (Hall, 1978):

- Need: An estimation based on professional judgement and current medical technology of the number of workers or amount of services necessary to provide an optimum standard of health care.
- Demand: The sum of the amounts of the various types of health services that the population of a given area will seek and has the means to purchase at the prevailing prices within a given time period.

Based on these definitions of need and demand, four methods for estimating humans resources have been described (Hall, 1978):

- Human resources to population ratio approach;
- Health needs approach;

- Health demands approach; and
- Service targets approach.

The health needs, service targets and health demands approaches convert people into the health services that they desire which are then converted into human resources. The human resources to population approach converts people directly into human resources (Hall, 1978). The main differences between these approaches are presented in Figure 2.

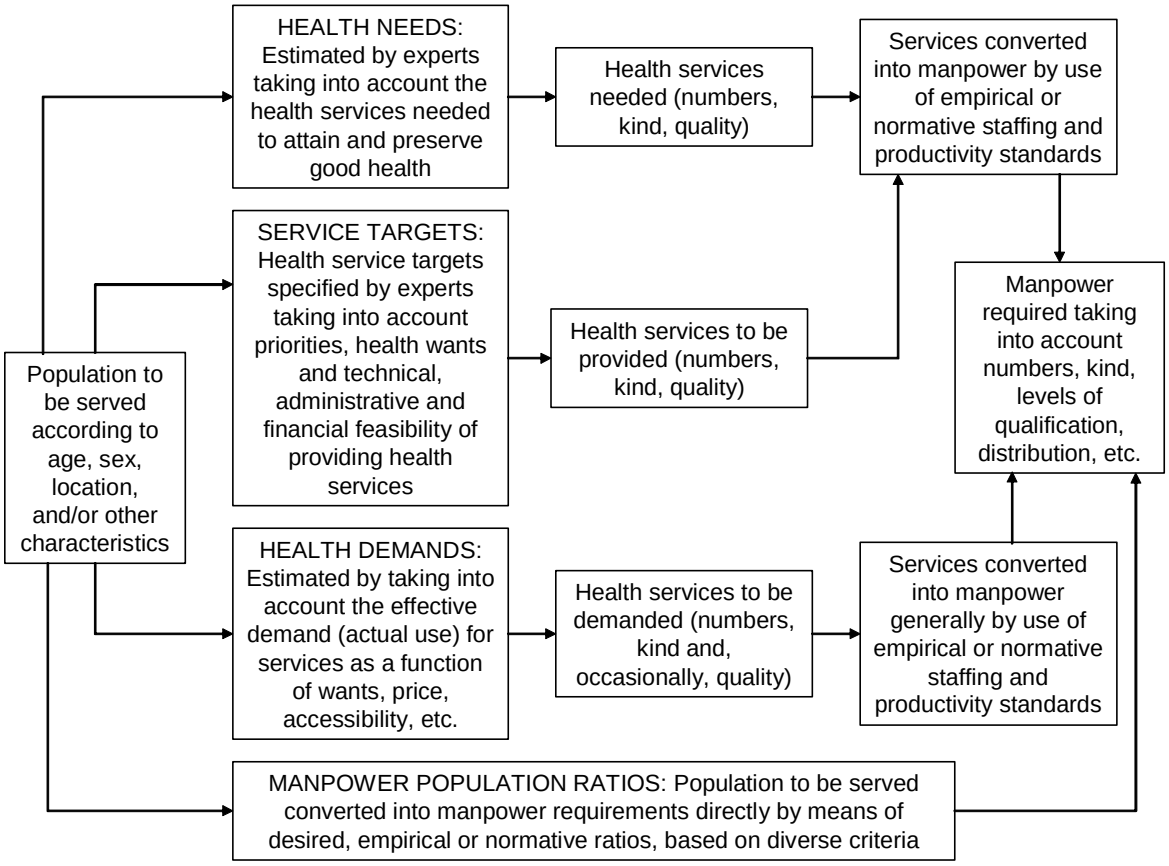


Figure 2: Schematic representation of the four approaches to human resources planning (Hall, 1978)

a) Human resource to population ratio approach

This method is very simple, low cost and easy to interpret and requires (Hall, 1978):

- Projected population;
- Number of human resources present; and

- A desired human resources to population ratio.

b) Health needs approach

This approach is normative and based on the perception that health professionals are best equipped to determine the health needs of a population. This approach requires (Hall, 1978):

- Disease-specific mortality and morbidity rates;
- Norms and standards which affect the number, kind, frequency and quality of services to be provided;
- Staffing norms to convert the various services required into the amount of time needed for each category of health worker to provide the service;
- Total personnel hours needed in a target year for the projected population; and
- The average number of hours worked annually per person.

c) Health demands approach

This approach is based on projections of health services that users are willing to pay or ask for, regardless of their need for these services (Bui Dang Ha Doan, 1981). This is determined by factors such as disposable income, costs of services, access to services, level of education and membership of medical aid schemes. This approach is more predictive than normative and this approach requires (Hall, 1978):

- Observation and quantification of present demand;
- Projection of demand for an entire year; and
- Change of demand for services into demand for personnel.

d) Service targets approach

This approach involves the setting of targets for the production and delivery of specific health services and then converting these into human resources requirements by means of staffing and productivity standards. Is normative and many regard it as micro-analytical since it considers each of the various

components of the health sector separately with a primary focus on provision of services. It attempts to strike a balance between needs and wants of the population, available technology and what can be delivered. This approach requires (Hall, 1978):

- Targets for production and delivery of services;
- A description of the planned services;
- Calculation of the sum of services required;
- Types and mix of human resources needed to deliver the service; and
- Consideration of productivity.

The main advantages, disadvantages and indications of each of these methods is summarised in Table 4 (Hall, 1978; Kissoon-Singh, 2001).

Table 4: Summary of advantages, disadvantages and indications of the four approaches to human resources planning (Hall, 1978; Kissoon-Singh, 2001)

	Advantages	Disadvantages	Indications
Human resources to population approach	- Easy to use and interpret to others - Requires modest data - If current health situation is adequate, it can be used to justify the *status quo* - Useful to provide baseline projections for different kinds of human resources required - Can be a useful short to medium term planning instrument if used together with a more precise method	- Easy to select unrealistic ratios - Generally used with single occupational categories only - Relatively difficult to estimate cost - Will inevitably show a human resources shortage - Overlooks the relevance of demand - Does not address productivity, distribution, utilisation and relevance of services - Fails to recognise accessibility of services to the population - Adequate ratios do not automatically provide good health	- Countries with fairly satisfactory health status and adequate health systems - A stable health sector - Limited planning resources - Either an active or passive approach to health services - Either public or private sector dominance - Applicable where fairly similar international models have been used

Table 4: (continued)

	Advantages	Disadvantages	Indications
Health needs approach	- Easy to understand, based on scientific knowledge, logical and workable - Ethical to consumers since it is based on services to entire population - Emphasis is on production of services, not human resources - Encourages evaluation of health technology - Encourages allocation of resources where needed most - Useful in design of educational programmes - Promotes concern about quality of care - Facilitates cost estimation - Facilitates health team planning	- Costly and requires extensive and detailed data - Does not consider cultural, economical and other barriers that will prevent need being converted to demand - May encourage detailed planning - Setting of standards complicated by a possible lack of consensus - Gives little attention to alternatives - Likely to result in requirements in excess of country's ability to provide them - Based on physician's model for health services delivery which are mainly curative	- Countries with sophisticated data systems, survey capabilities and planning expertise - An adequate health services delivery system is required - Active government policy required - Dominant public sector with control over human resources and services - Elevated awareness of public health matters - Applicable where prevention, promotion and specific health programmes are in place
Health demands approach	- Facilitates understanding of demand - Allows for separate consideration of different components - Produces economically realistic projections - Results in a good estimate of minimum growth in demand likely to occur - Some variants of this approach are simple - Provides useful information for comparing economic returns with those in other fields - Identifies and quantifies market forces which affect consumers and suppliers - Applicable in a fee-for-service system	- Some variants require sophisticated data and can be complicated and costly - May neglect political and societal reasons for health services distribution and delivery - Does not take into account quality of services or their relevance - May neglect ways to improve productivity - May be difficult to explain rationale and results to authorities and public - Often arduous to collect reliable data from the private sector - May enhance or continue inequalities in access to care - Changes within the health services could alter projections of demand - Cannot assess changes in health status	- Dominant private sector - Passive government attitude towards service delivery - Where health care system provided equally for all sectors - Promotes allocation of human resources to entire health team - Relatively minor imbalances in delivery of services to different segments of the population

Table 4: (continued)

	Advantages	Disadvantages	Indications
Service targets approach	- Various components of demand are separated with most suitable method chosen for each - Facilitates study of productivity, utilisation, staffing ratios - Emphasis on production of services, not human resources - Simple to explain and easy to interpret - Cost estimation is simpler - Readily usable with other planning methods - Facilitates planning for the total health team - Facilitates demand model revision when data is updated - Requires modest data and planning capabilities	- Standards set more on what people perceive is needed rather than reality - Assumes the utilisation of services - Restricted where poor government regulation and control over health services exists - May encourage excessively detailed planning	- Dominant public sector with control over human resources and service - Active government role required - More useful in prevention, but can also be used for curative services

2.2.3 World Health Organization/Fédération Dentaire Internationale planning model

In 1970 the WHO took a leading role in planning health services and more specifically human resources when a Scientific Group on the Development of Studies on Health Manpower was established with the request to review development and methods of health manpower studies and to recommend future lines of research to WHO. One of the recommendations of the Scientific Group was that WHO should promote health manpower planning in member states (World Health Organization, 1971).

A WHO Expert Committee report identified five steps of planning a public dental health services which served as basis for future WHO planning models (World Health Organization, 1976). These steps are:

- Situation analysis;
- Problem identification and formulation of objectives;
- Formulation and analysis of alternative strategies;

- Strategy selection; and
- Programme formulation.

Following on this the WHO publication “Planning Oral Health Services” was aimed at the more practical aspects of planning taking into account resources, including human resources. It recognises manpower production goals as an integral part of the planning process where the human resources are divided into professionals (dentists, stomatologists), operating auxiliaries (dental therapists, dental hygienists), non-operating auxiliaries (dental assistants, dental technicians) and other supporting staff (health auxiliaries, teachers, parents). It also recognised the setting of goals based on existing resources and identified five options of care from “Type 1”, where a minimal service is rendered every five years, to “Type 5”, where services are based on a six monthly recall (World Health Organization, 1980).

The acceptance of the concepts and approaches of “Health for All by 2000” through PHC led to a joint WHO/FDI publication describing a human resources model based on the needs and demands of a population and placing a much bigger emphasis on prevention and control of disease, maintenance of health and high quality restorative care. Figure 3 illustrates a planning flow chart of this model (World Health Organization/Fédération Dentaire Internationale, 1989).

This model translates need into full-time equivalents (FTE) of oral health human resources required to provide a calculated level of care. The model makes provision for modifying factors. Recommendations for time estimates are based on the prevailing conditions in a country. Variables in the model can be altered to suit the situation of that country. Limitations of this model include (Kissoon-Singh, 2001) :

- Calculations are made for the general population and do not take into account different communities such as urban, peri-urban and rural;
- The model may over-projects human resources; and
- Model doesn’t take into account the capacity of training institutions.

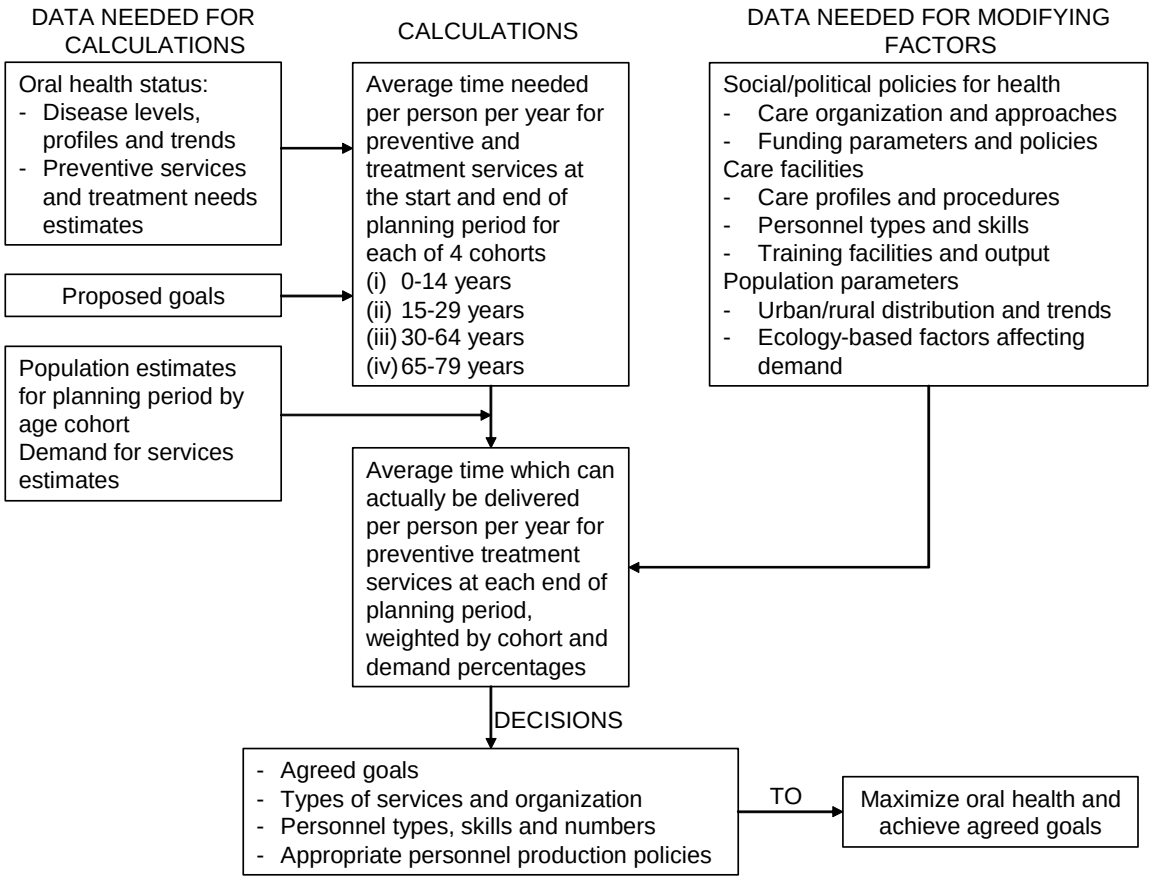


Figure 3: Flow chart of the WHO/FDI human resources planning model (World Health Organization/Fédération Dentaire Internationale, 1989)

2.2.4 A South African perspective on human resources planning

a) Historic overview

The historical development of the provision of health services in South Africa since 1652 can be divided into three phases (Van Wyk, 1996):

- **Phase 1: 1652 to 1918:** The first 150 years of this phase was characterised by the establishment of a health service under the influence of the Dutch settlers. The last 100 years commenced with the British occupation of the Cape Colony and was characterised by the expansion, consolidation and control over health services, including registration of health providers.
- **Phase 2: 1918 to the second half of the seventies:** This phase commenced with the unification of the four colonies of South Africa and was characterised by technological advances in health care, the

establishment of a curative approach in health services and public and private sectors of delivering health care to the community. This phase was also characterised by government accepting responsibility for the delivery of health services.

- **Phase 3: Second half of the seventies to 1993:** This phase coincided with the "health for all" era and concluded with the run-up to the first democratic election in South Africa in 1994. During this phase government accepted responsibility for the delivery of certain oral heath services. Similar to other countries it was soon realised that resources were not available to deliver all services to the entire population, leading to the development of more cost-effective approaches such as training of auxiliary oral health workers. During this phase the PHC approach and more emphasis on prevention was also adopted with the aim of reducing curative services.

A detailed description of all three phases can be found in Van Wyk (1996). Landmark developments in the delivery of health services and human resources development in South Africa during phases 2 and 3 are summarised in Table 5 (Van Wyk, 1996).

Table 5: Summary of landmark human resources developments in South Africa from 1910 to 1993 (Van Wyk, 1996)

Year	Description
1919	Proclamation of "Act on Population Health" (Law 36 of 1919) follows on the influenza epidemic of 1918 and leads to the establishment of a separate Ministry and Department of Health in addition to provincial health administrations
1928	"Act on Doctors, Dentists and Pharmacists" provides for the establishment of a Medical and Dental Board which replaced the four provincial medical boards
1942 - 1944	The National Health Services Commission (Gluckmann Commission) follows on the Great Depression and its findings can be summarised into four main areas: i) Lack of coordination between the seven parties involved in health services delivery ii) A lack of services in general, especially in black rural and urban areas iii) The curative nature and emphasis on profit in the private sector leading to a maldistribution of services iv) Inappropriate emphasis on curative services and priorities The main recommendation was for a national health service – this was never implemented
1962	Commission of Enquiry into the high cost of medical services and medicines makes 50 recommendations. Three of these are aimed at oral health: • Training of auxiliary personnel to address the shortage of dentists • Fixed tariff structure for delivery of services in the private sector • Training of district health nurses in terms of oral health with the purpose to refer

Table 5: (continued)

Year	Description
1967	Commission of Enquiry into dental services and training of non-white dentists under chairmanship of Dr J.F. van de Sandt de Villiers. The recommendations formed the backbone of the development and delivery of oral health services over the next 30 years.
1974	National Oral Health Policy formulated under the leadership of the first Chief Dentist of the Republic of South Africa, Dr L.T. Taljaard. Approved by Cabinet in 1975 and served as the official oral health policy for the next 15 years. Classifies all services as education, preventive, curative or supplementary and identifies target groups.
1980, 1986	Brown Commission of Enquiry into health services emphasises excessive fragmentation of services, lack of central policy, inappropriate allocation of resources, insufficient communication, lack of emphasis on preventive and PHC services, overemphasis on expensive secondary and tertiary services, over regulation of services in the private sector, shortage of certain services (including dentistry), shortage of health workers of the non-white population groups, shortage of statistics on the health services. A separate oral health working group chaired by Prof L.T. Taljaard made recommendations on dentistry to the commission.
1982	Interdepartmental committee into dental services and training (Venter Committee) made recommendations regarding the future training of dentists, dental therapists and oral hygienists for the white, black, coloured and asian population groups with specific emphasis on employment in the public sector. The human resources to population ratio approach was used in the calculations.
1984	Committee of Enquiry into facilities for medical and dental training. Builds on the recommendations of the Venter Committee with specific recommendations for each of the dental schools. It also recommends a review of oral health human resources every five years.
1986	National Health Plan. Results from the recommendations of the Brown Commission. Places a big emphasis on appropriate resources on each of the six levels of health care delivery.
1986	Report of an ad hoc committee of Federal Council of the Dental Association of South Africa emphasises appropriate intake of students of all population groups, defining the future role of the dental therapist, expansion of services for the oral hygienist, creation of oral health educators, expansion of public oral health services.
1988 - 1991	Committee of Dental Deans 2020 Seminars. Three seminars were held culminating in a report after the 1991 seminar which recommended: • Emphasis on the 15-year-old age group in terms of prevention, pain relief and 1- to 2-surface restorations • Oral health workforce consisting of oral health educator, dental assistant, oral hygienist, dental therapist, dentist, dental specialist, dental technician – minimum training requirements were formulated for each • Reduction of dentists, increase in dental auxiliaries and closer monitoring within the public and private sectors • Job descriptions for each category of oral health worker • Consideration of a “denturist” for the provision of dentures (to practice independently) • Training of community health workers for extractions and procedures to relieve pain ad sepsis • Compulsory community service provided adequate facilities and posts are created

Most commissions and committees during phases 2 and 3 commented on the fragmentation of services as well as lack of adequate preventive services. The majority of reports concluded that oral hygienists are mostly employed in the private sector and that dental therapists and dentists placed a too large emphasis on curative services (Van Wyk, 1996).

In summary, the history of health services and human resources planning in South Africa can be considered against the three components of the human resources development process. Although production of oral health human resources commenced in 1927 with the establishment of a dental school at the University of the Witwatersrand, little planning for oral health related human resources was done until the 1970s (Van Wyk, 1996).

It is clear from the available literature that despite several committees and commissions reporting on oral health, very few have been taken seriously and only a limited number of recommendations have been implemented.

b) Human resources studies, reports and publications since 1994

After a 1992 referendum effectively brought about an end to “apartheid”, citizens of all races took part in the first democratic elections in 1994. Since then several postgraduate studies and reports into human resources for the new South Africa have been published. These are briefly summarised below.

- **Booyens (1994)**

  The purpose of this study was to determine human resources needed for delivering primary preventive services by using needs as determined by the 1988-89 NOHS, slightly modified by demand from the same survey (Department of Health, 1994). A modified version of the WHO/FDI human resources model was used for the calculations (World Health Organization/Fédération Dentaire Internationale, 1989).

  Since oral health status varies between the different population groups, separate calculations were done based on the WHO variables for an

industrialised country with stable caries for the white population group, a developing country with increasing caries for the black, asian and coloured population groups (Scenario I) and an industrialised country with stable caries for all population groups (Scenario II), both assuming a 1,750 hour working year per operator. Results are summarised in Table 6 (Booyens, 1994; Booyens, 1996).

This study concluded that the need for oral health personnel was not in line with the human resources available at the time of the study based on registration with the South African Medical and Dental Council (SAMDC).

Table 6: Human resources required for the delivery of oral health services in South Africa based on the WHO/FDI model (Booyens, 1996)

Population group	Scenario I *	Scenario II **
White	1,860	1,860
Black	4,094	4,594
Asian	196	225
Coloureds	550	583
Total	**6,700**	**7,262**
* Highly industrialised country, stable caries (white) / developing country, increasing caries (black, asian, coloured)		
** Highly industrialised country, stable caries (all population groups)		
Suggested percentage distribution of oral health personnel needed for South Africa		
	Suggested %	**Registered with SAMDC (1992)**
Specialists	6 – 8%	6%
Dentists	21 – 24%	77%
Dental Therapists	22 – 27%	3%
Oral Hygienists	42 – 49%	14%

- **Van Wyk (1996)**

  The purpose of this study was to determine human resources needed based on the principles of supply and demand taking into consideration modifying factors, treatment needs and trends. Demand data was obtained from the 1988-89 NOHS (Department of Health, 1994).

  Based on this study, 5,594 oral health personnel would be needed in 2011 to address demand for oral health services. Based on personnel and attrition rates, between 2,482 and 2,923 oral health personnel have to

be trained between 2000 and 2011, an average of between 207 and 244 per year, to address the demands as reflected in the 1988/89 NOHS (Van Wyk, 1996).

The need for oral health personnel by 2011 as found in this study is summarised in Table 7 (Van Wyk, 1996).

Table 7: The need for oral health personnel in South Africa by 2011 (Van Wyk, 1996)

	Needed by 2011	Training per year (2000-2011)
Dentists	3,337	29 – 66
Dental therapists	2,515	160 – 170
Oral hygienists	1,040 – 1,267	16 – 30
Dental technicians	1,001	15
Dental assistants/oral heath educators *	4,982	294

* Public sector only

- **Dental Association of South Africa (DASA), Federal Council (1996)**
  This report by the Health Services and Dental Education Committees of the DASA expressed a concern that by 2010 there would be an over-supply of dentists (Rossouw, 1996). Based on the needs-based study by Booyens (1994), the report justified not to increase the number of dentists trained. Based on demand as determined in the 1988/89 NOHS (Department of Health, 1994), the report stated that utilisation of dental services by the white population group had reached levels as described for industrialised countries such as Canada, Ireland, Norway and the USA. It also concluded that since 75% of the population of South Africa is state dependent, access to the public dental services should be improved and that these services could adequately be rendered by dental therapists. According to dentists surveyed during the 1988/89 NOHS, 88% were of the opinion that there were enough white dentists already, 54% felt that there were not enough black dentists. This report estimated that the greatest demand for dental services will come from the state dependent section of the black population group (Rossouw, 1996).

In terms of human resources to population ratio, two studies were quoted in this report indicating that only 4 of the 156 main metropolitan areas/cities in the nine provinces had not yet reached a dentist to population ratio of 1:3,600 (Rossouw and Van Rensburg, 1995; Van Wyk, Kroon and Cleaton-Jones, 1994). Some of these cities/areas had reached a dentist to population ration where similar ratios in industrialised countries had led to the closing of dental schools. On the other hand several rural areas have extremely unsatisfactory ratios (1:10,000+). These results indicated a persistent maldistribution of dentists (Rossouw, 1996).

This report concluded that dental schools should reduce the number of dentists trained, increase the number of auxiliaries trained and that the use of models should continue to monitor human resources for oral health. It further recommended that DASA facilitate efforts to establish a consensus view regarding the over-supply and distribution of dentists and contribute to efforts to establish agreement between all role players regarding future supply of dentists (Rossouw, 1996).

- **Committee of Dental Deans (1996 – 1997)**

  In a guest editorial the Committee of Dental Deans cautioned against action following on the study by Van Wyk (1996) and the DASA Federal Council report (Rossouw, 1996) until this contentious issue has been further debated and totally clarified (Anonymous, 1996).

  This resulted in a report where the annual growth in oral health care workers (dentists/specialists, dental therapists and oral hygienists) over a period of fifteen years up to the end of 1996 was calculated as 160 per year, comprising of 104 dentists, 42 oral hygienists and 14 dental therapists. At the same time the total clinically available oral health care workforce for 2010 was projected at 5,828 consisting of 4,000 dentists, 556 dental therapists, 972 oral hygienists and 300 specialists. In order to achieve this the expansion of present academic oral health centres to deliver a larger output of dental therapists and oral hygienists was recommended (Dreyer, Rossouw and Chikte, 1997).

- **Compulsory Community Service reports (1999-2005)**

  In terms of the Medical, Dental and Supplementary Health Service Professions Amendment Act, 1997 (Act 89 of 1997) (Republic of South Africa, 1997a), every person registering for a profession shall perform remunerated community service in terms of the regulations of the Act, and shall, on completion of such service, be entitled to practice the profession in question.

  An audit was undertaken prior to the introduction of Compulsory Community Service (CCS) for dentists by way of a self administered questionnaire to seek information on physical, human and financial resources and their distribution within each of the nine provinces. Site visits were undertaken to validate information supplied (Gugushe, 1999).

  Of the 368 dentists employed within the public sector in 1999 (excluding academic oral health centres), 267 were full time, 63 part time and 38 had patients referred to their practices by agreement with the province. A total of 213 auxiliaries (100 dental therapists and 113 oral hygienists) were employed of which close to 90% full time. Approximately 70% of public dental clinics were urban based, with 38.9% in urban districts and 30% in peri-urban districts. The most frequently utilized clinical procedure was dental extractions (Gugushe, 1999).

  The outcome of this study indicated a variation by province in the organizational structure and management of oral health services. This report identified several problems and constraints and recommended that a national operational team be appointed for the national planning, organisation, implementation and control of CCS for dentists. Availability of adequate financial support from the national department of health was identified as a prerequisite for the successful implementation of CCS for dentists (Gugushe, 1999).

  Following on this audit CCS for dentists was introduced in July 2000. A cross-sectional descriptive study was conducted at the end of the first

year of CCS. Response rate was only 35%, with 45% of respondents of the opinion that the allocation process was not handled efficiently. Only 52% were provided with accommodation and 26% described the condition of the clinics as poor. Almost a quarter did not have a full set of instruments, 10% did not have an autoclave or high-speed hand piece and 50% reported that equipment broke down often without immediate repairs being done. Although 75% felt their clinical competence was enhanced, more than three-quarters reported that they had lost some form of clinical competence during the year of CCS (Naidoo and Chikte, 2002).

A "Dentist Satisfaction Survey" was administered to the 2003 cohort of graduates from the Medical University of Southern Africa (MEDUNSA) shortly before graduation and upon completion of their year of CCS. Comparison of the two surveys revealed a general downward trend in the level of job satisfaction upon completion of CCS. In this study 62% of CCS dentists were dissatisfied that they were unable to practice dentistry to its full potential with too much emphasis on extractions. CCS dentists also commented on the lack of respect from medical colleagues who appeared ignorant on the extent to which dentists are trained (Harris and Zwane, 2005).

- **Kissoon-Singh (2001)**

  In a similar study to Booyens (1994), this study reported on a human resources plan for oral health care for the province of KwaZulu-Natal based on the primary oral health care package (Department of Health, 2001a) and the results of the 1988/89 NOHS (Department of Health, 1994) and 1999-2002 NCOHS (Department of Health, 2003b). The joint WHO/FDI human resources model was used for the calculations (World Health Organization/Fédération Dentaire Internationale, 1989). Human resources requirements calculated for 2000 and 2010 for selected procedures of the minimum package of oral care are indicated in Table 8 (Kissoon-Singh, 2001).

Table 8: Human resources requirements for KwaZulu-Natal (2000 and 2010) for selected procedures of the basic oral health care package (Kissoon-Singh, 2001)

Year	Human resources	Dental operators	Oral hygienists
2000 complete package (optimal number, baseline data for planning process)	404	184	220
2010 with current DMFT levels (selected procedures to target groups)	309	196	113
2010 with reduced DMFT due to fluoridation (selected procedures to target groups)	294	181	113
2010 with current DMFT levels (selected procedures to target groups and simple fillings provided to the first two cohorts only)	219	106	113

This study concluded that a gross shortage and inequitable distribution of oral health personnel existed within the public service of KwaZulu-Natal with only 6% of dentists in this province working in this sector and 78% of the population dependent on this service for oral care. Due to this shortage not even the minimum package of oral care could be implemented. Training of the correct number and an appropriate mix of oral health personnel, intersectoral collaboration, continuing education courses, equitable distribution of resources, CCS, cooperation within the department of health, community health workers and water fluoridation were just some of the recommendations of this study to alleviate the problems of oral health care delivery (Kissoon-Singh, 2001).

- **Pick Report (2001)**

  This report served as a first attempt to provide a national strategy on human resources for health and resulted as an outcome of a 1999 workshop of the Provincial Health Restructuring Committee and the Heads of Human Resources for Health in the nine provinces and is based on the underpinning philosophy of PHC. It proposed a strategy to better utilise existing resources, focused strongly on the needs of the underserved and attempted to produce greater synergy between knowledge, skills, attitudes and behaviour of health workers and population health care needs (Pick et al., 2001).

Computer simulation models developed by the WHO and historical information from registers of the statutory councils were used to project supply of a number of health workers (including oral health) over a 30 year period to the year 2029 using different demographic assumptions (Pick et al., 2001).

In terms of training and education it regarded the following as major challenges (Pick et al., 2001):

1. Revision of admission criteria and training programmes to develop skills relevant to the delivery of PHC;
2. Attraction and retention of previously disadvantaged persons, firstly as students and then as staff; and
3. Provision of continuing professional development with a minimal disruption in service delivery.

According to this report the supply of dentists exceeded population growth (assuming an annual 2% population growth rate and a 25% net loss of graduates to other countries). It also emphasised the unequal distribution between the public and private sectors and mentioned the introduction of CCS to dentists as a possible solution.

The report suggested (Pick et al., 2001):

1. The creation of a single dental auxiliary to replace the oral hygienist and dental therapist;
2. A downward revision of the annual intake of dental students;
3. Dental assistants in underserved areas should receive a 1 year training by dentists to perform simple procedures such as the Atraumatic Restorative Technique (ART);
4. The scope of the dental therapist should be expanded to include placement and removal of sutures and removable orthodontic appliances and care of wounds (It should be noted that this recommendation contradicts recommendation 1); and
5. A projected requirement for 2029 of 6,413 dentists and 435 oral hygienists.

- **A National Human Resources Plan for Health (2006)**

  Chapter 7 of the National Health Act of 2003 (Act 61 of 2003) (Republic of South Africa, 2003) mandates the Minister of Health to take steps to develop and manage human resources in the national health system. Building on the Pick report (Pick et al., 2001), the NHRP identified human resources planning and development as a key priority area and provided a framework to guide all stakeholders to provide an adequate workforce in partnership with government (Department of Health, 2006a).

  A set of 11 core guiding principles underpin the NHRP (Department of Health, 2006a):

  1. Stewardship for health care lies with the National Department of Health;
  2. South Africans must enjoy a reliable supply of skilled and competent health professionals for self-sufficiency;
  3. Planning and development of human resources linked to the needs and demands of the health system must be strengthened;
  4. The optimal balance, equitable distribution and use of skilled health professionals to promote access to health services must be developed;
  5. Health workers must have the capacity and skills to render accessible, appropriate and high quality care at all levels;
  6. Work environments should be conducive to good management practice in order to maximise the potential for the health work force to deliver quality health services;
  7. South Africa's role in international health issues contributing to leadership, scientific advances and global health professions is critical;
  8. South Africa's contribution in the short to medium term to the global health market must be managed in such a way that it contributes to the skills development of health professionals;
  9. Mobilisation of funding to ensure successful implementation of the plan;
  10. The Department of Health must ensure that it has the technical expertise necessary to lead health workforce planning; and

11. There must be adequate remuneration of health professionals and good work conditions to enable them to regard the public health sector as employer of choice.

The NHRP proposed the following annual productions for the various members of the oral health team (Department of Health, 2006a):

Dental practitioners: Reduce to 120 by 2008. It is the opinion that maintaining current levels will be adequate for both the public and private sectors with aggressively recruiting dentists back to the public sector.

Dental Therapists: Increase to 600 by 2009. Dental Therapists are regarded as critical to the provision of PHC services related to oral health. Training must occur at every dental school. Career mobility must be improved in the public sector.

Dental Technicians: Current levels to be maintained.

Oral Hygienists: Increase to 150 by 2009.

Dental Assistants: 300 by 2008.

The NHRP recognised that targets may appear high, but consideration had to be given to mobility of health professionals to and from the private sector, migration overseas and other attrition factors.

By way of an editorial in the South African Dental Journal (SADJ), the CEO commented as follows on the NHRP (Campbell, 2006): "…, but alas, those who know little to nothing about dentistry have yet again elected to ride rough-shod over the advice advanced by dental educators and the profession itself." This editorial continued to compare the suggested reduction in number of dentists to be trained to similar experiences in The Netherlands and the UK which eventually led to massive shortages in both countries, ironically two countries favoured by South African qualified dentists as a possible option for employment upon graduation. The editorial did however welcome the suggestion for an increase in number of oral hygienists to 150 per year, but questioned where the figure originated from. It furthermore expressed great concern on the suggested number of dental therapists to be trained, especially since current facilities

were only equipped to train 300 dentists/dental therapists per year. It referred to a SADA position paper on dental therapists (South African Dental Association, 2000) which recommended an immediate moratorium on the training of dental therapists until all key stakeholders had debated future training and urged the Health Professions Council of South Africa (HPCSA) to rescind a previous decision to allow dental therapists to practice independently which was not in the best interest of the public sector, especially since the intention was that dental therapists be employed by this sector.

2.2.5 Human resources distribution and trends in South Africa

a) Number of dentists to be trained

The majority of reports on human resources in South Africa have highlighted the inequitable distribution between urban and rural on the one side and the private and public sectors on the other. Recommendations were put forward by the Commission of Enquiry into the Dental Services and the Training of Non-White Dentists as a result of which three new dental schools were opened and existing facilities expanded. The Commission predicted that 1,708 dentists would be registered in South Africa by 1980 (Republic of South Africa, 1967). Another study indicated that this figure had already been reached in 1973 and that South Africa would be faced with an overproduction of dentists by 1983 (Germishuys, 1979).

Reports and opinions on training of dentists in South Africa continued during the 1980s. In 1984 it was suggested that no new dental schools be established, but that existing faculties be expanded and opened to all ethnic groups (Dreyer, Lemmer and Dreyer, 1984). An ad hoc committee of the DASA warned that an overproduction of white dentists might become a reality and that intake of white students had to be reduced (Dreyer et al., 1986).

During the 1990s there was a shift in emphasis on dentists as the main dental service providers to an oral health care workforce consisting of health

educators, assistants, oral hygienists, dental therapists, dentists, specialists and technicians. A 50% decrease in the number of dentists trained was suggested with a corresponding increase of 250 auxiliaries per annum over the next 5 to 10 years (Dreyer et al., 1992).

b) Dentist to population ratios

A comparison of the geographical spread of dentists in South Africa between 1972 and 1982 confirmed a decrease in dentist to population ratio from 1:12,133 in 1972 to 1:9,868 in 1992 (Smith and Cleaton-Jones, 1985). A follow-up study indicated that this had further decreased to 1:7,991 in 1992 (Van Wyk et al., 1994). Both these studies highlighted the maldistribution of dentists in South Africa.

The number of dentists increased by 135.6% from 1,599 in 1972 to 3,767 in 1992. When dental therapists were included (112 in 1992), the operator to population ratio decreased further to 1:7,991. This represented 1.25 dentists/operators per 10,000 of the population (Van Wyk et al., 1994).

Any health system attempts to achieve the objective of equitable distribution of resources. Table 9 summarises the dental operators to population ratios for magisterial districts with the lowest (all urban) and the highest (all rural) ratios. It clearly illustrates the extent of maldistribution of dental operators in South Africa (Van Wyk et al., 1994).

Table 9: Magisterial districts with the lowest and highest operator to population ratios in South Africa (Van Wyk et al., 1994)

Lowest operator : population ratio			Highest operator : population ratio		
Magisterial district	**Operators**	**Operator : population ratio**	**Magisterial district**	**Operators**	**Operator : population ratio**
Cape Town	169	1:1,069	Seshego	2	1:151,338
Pretoria	486	1:1,374	Nongoma	1	1:169,153
Bellville	151	1:1,788	Witsieshoek	2	1:171,443
Durban	252	1:1,880	Morokeng	1	1:446,155
Hermanus	11	1:1,965	Ntuzuma	1	1:458,529

It was estimated that 78% of all oral health personnel are employed in the private sector with the remaining 13% in the public sector required to serve 65 to 80% of the total population (Rossouw, 1995).

Based on information from the 1988/89 NOHS (Department of Health, 1994), 57% of dentists practice within the five major metropolitan areas of South Africa with male dentists dominating the profession (92.8%). Of the dentists responding to the questionnaire, 68.5% qualified after 1970 and 38% after 1980. Only 12.8% of dentists employed an oral hygienist on a full-time and 11% on a part-time basis. There was a perception amongst dentists that there was no need to employ oral hygienists (62%), with 11% of dentists indicating they did not do so because of unavailability. Conservative dentistry was the most frequently practiced service (91.6%) followed by scaling and polishing (74.2%). Topical fluoride application and placement of fissure sealants were ranked low (Rudolph, Brand and Gilbert, 1995).

A Health Systems Trust report estimated the distribution of public sector dentists per 100,000 of the public sector dependent population decreased from 1.7 in 2000 to 1.58 in 2003. Some provinces had 4 times as many dentists in the public sector compared to others. The 2003 ratios for the Eastern Cape and KwaZulu-Natal were 0.7 and 0.99 respectively, compared to 2.79 and 3.35 for Gauteng and the Western Cape. Despite the introduction of CCS for dentists in 2000, the number of dentists in the public sector had steadily declined. Based on a 2% population growth per annum, a 25% net loss of graduates to other countries and using WHO simulation models, this report estimated that the dentist to population ratio would decrease from 1:9,400 in 1999 to 1,7800 by 2029 (Padarath, Ntuli and Berthiaume, 2004).

c) South African qualified dentists in the United Kingdom

Shortly after the emergence of the new democratic South Africa, several concerns were expressed on the political arena about the so called “brain drain” of professionals to other countries. A Central Statistics Service (CSS) report published in the lay press estimated that 3,000 people left South Africa

during the first quarter of 1996, 1.3% of these belonged to the medical and dental professions (Beeld, 1996). This was followed by an attempt by the Minister of Health to stop qualified health professionals from working and living in the UK (Rapport, 1996). It was estimated that between 1989 and 1997 nearly 250,000 people left South Africa for Australia, New Zealand, Canada, the UK and the USA. Of the total health workforce in the UK, 6% were South African qualified (Padarath et al., 2004).

Information on South African qualified dentists living abroad is essential for human resources planning. The 1967 Commission of Enquiry into Dental Services estimated that 9% of dentists registered with the then SAMDC were practising in the UK (Republic of South Africa, 1967). Little information is available on this for the seventies and eighties, but a 1992 editorial referred to a “massive brain drain” of final year dental students to the UK (Wiltshire, 1992). The same editor one year later reported an increase in total number of dentists due to a massive influx from India and Eastern Europe (Wiltshire, 1993). Following on this editorial, it was reported that 726 South African qualified dentists were registered with the General Dental Council (GDC) in London (Holtshousen, 1993). Another study reported that 80% of dentists who qualified in South Africa during the period 1962 to 1991 were still registered with the SAMDC with the majority of the remaining 20% practicing in the UK (Germishuys, 1994).

A study into the number of South African qualified dentists registered with the GDC reported that this figure had increased from 726 in January 1992 to 1,160 in December 1995, an increase of 59.8% over a 4 year period. Of these dentists 49.3% still had addresses in South Africa listed with the GDC. When expressed as a percentage of the number qualified during the same period, the number of South African dentists registered with the GDC increased from 4.6% for the period 1940 to1949 to 32.4% for the period 1990 to 1995. Of the dentists qualifying in South Africa between 1990 and 1995, 76.3% registered with the GDC during this same period. Less than 50% of these were actually working or living in the UK (Holtshousen and Van Wyk, 1997).

Reasons why professional people were leaving South Africa since 1990, especially dentists in the UK, were the high levels of crime, followed by economical considerations, either their own or the general economy of the country and uncertainty about economical, political, professional and the educational future of their children (Van Wyk, Holtshousen and Geldenhuys, 1999). The reasons given were no different to findings of other reports dealing with the same subject.

d) Gender and race distribution of dentists and specialists

Two recent studies reported on the pre-democracy (1985 to 1994) and post-apartheid (1995 to 2004) gender and race distribution of dental graduates and first year dental students (2000 to 2005) as well as dental specialist training in South Africa (Lalloo et al., 2005; Lalloo, Naidoo and Myburgh, 2006). A total of 3,353 dentists graduated from the five dental training institutions between 1985 and 2004 of which 64% were male. Based on racial group, 59% were white, 17% black, 17% asian and 8% coloured. The breakdown for each of the two periods under study as well as first year students for the period 2000 to 2005 and dental specialists (1985 to 2004) is found in Table 10. The number of female and black students entering and graduating from the dentistry programme had increased since 1994, but this needed to continue for black students to reflect the national population distribution. This also applied to specialist training.

Table 10: Number and percentage of South African dental graduates, first year students and dental specialists by gender and racial group (Lalloo et al., 2005; Lalloo et al., 2006)

	Dental graduates			First year students	Dental specialists
	Pre-democracy (1985-1994)	Post-apartheid (1995-2004)	Total		
Male	1,043 (79%)	1,104 (54%)	2,147 (64%)	674 (43%)	266 (86%)
Female	271 (21%)	926 (46%)	1,197 (36%)	895 (57%)	43 (14%)
Asian	121 (9%)	451 (22%)	572 (17%)	456 (29%)	44 (14%)
Black	77 (6%)	476 (24%)	553 (17%)	424 (27%)	18 (6%)
Coloured	93 (7%)	163 (8%)	256 (8%)	147 (9%)	19 (6%)
White	1,018 (78%)	932 (46%)	1,950 (58%)	542 (35%)	228 (74%)

e) Dental therapists

The first dental therapists qualified in 1977 and although this had increased to 294, only 158 were registered with the SAMDC in 1993 (Van Wyk, 1996). Of these 117 were employed by the public services. This represented a loss of 60.2% of trained dental therapists. Poor salaries and limited career opportunities were listed as the main reasons (Prinsloo, 1994).

Regulations were changed during 1993 to allow dental therapists to enter the private sector and open their own practices. It is difficult to estimate their geographical distribution, but it can be assumed that this will have changed from the original intention of being employed by the public sector in mainly rural areas to be similar to dentists with a preference for urban and metropolitan areas.

f) Oral hygienists

The first group of oral hygienists qualified at the end of 1973. At the end of 1991 a total of 682 were registered with the SAMDC at which stage 450 were employed by dentists in the private sector (Van Wyk, 1996). It is safe to assume that the majority will still be employed in the private sector in urban and metropolitan areas.

g) Current registrations of oral health professionals with the HPCSA

A summary of the number of oral hygienists, dental therapists and dentists registered with the HPCSA as on 30 March 2007 is presented in Table 11 (Health Professions Council of South Africa, 2007).

Table 11: Oral health professionals registered with the HPCSA on 30 March 2007 (Health Professions Council of South Africa, 2007)

	Oral Hygienists	Dental Therapists	Dentists	Total
	961 (15.5%)	**456 (7.3%)**	**4,792 (77.2%)**	**6,209**
By gender				
Female	949	198	1,322	**2,469 (39.8%)**
Male	12	258	3,470	**3,740 (60.2%)**
By racial classification				
Asian	55	74	570	**699 (11.3%)**
Black/African	117	190	444	**751 (12.1%)**
Coloured	45	2	87	**134 (2.2%)**
White/European	518	26	1,650	**2,194 (35.3%)**
Other/Unknown/Left blank	226	164	2,041	**2,431 (39.2%)**
By province				
Western Cape	301	3	1,092	**1,396 (22.5%)**
Northern Cape	10	6	69	**85 (1.4%)**
Eastern Cape	39	11	249	**299 (4.8%)**
Free State	45	24	173	**242 (3.9%)**
KwaZulu-Natal	83	149	649	**881 (14.2%)**
Gauteng	369	148	2,027	**2,544 (41%)**
North West	32	31	158	**221 (3.6%)**
Mpumalanga	45	27	211	**283 (4.6%)**
Limpopo	37	57	164	**258 (4.2%)**

This information clearly illustrates the domination of dentists who make up 77.2% of the total oral health workforce. The oral health profession also continues to be dominated by white males. The maldistribution of oral health professionals is also clear with 41% indicating Gauteng as their registered address. Information on how many of these oral health professionals practice their professions overseas, but who are still registered with the HPCSA, is impossible to obtain.

2.3 South African policy documents on health and oral health service delivery

2.3.1 Transformation of health services

The White Paper for the Transformation of the Health System in South Africa (Republic of South Africa, 1997b) presented a set of policy objectives and principles upon which the national health system of South Africa would be based. It also presented implementation strategies to meet the basic needs

of the population and was guided by the principles of PHC and decentralising the management of health services with emphasis on a district health system.

The chapter on oral health recognised dental practitioners, oral hygienists, dental therapists, technicians and assistants as members of the workforce delivering these services. Two main principles were identified to address oral health and will be discussed briefly (Republic of South Africa, 1997b).

a) Adoption of the Primary Health Care approach in the development of oral health services

- **Prioritisation of service delivery:** Mothers, children, pregnant women, physically and mentally disabled and the elderly were identified as priority groups for preventive and other services. These priority groups should be provided with at least a minimum package of services. An equitable distribution of services should be reached in the shortest possible time.
- **Focus on prevention:** Cost-effective and innovative preventive strategies should be employed which include purchasing services from the private sector. Based on oral disease profiles most treatments could be delivered by oral hygienists and dental therapists, staffing levels at clinics should keep this in mind.
- **Integration of oral health care:** Oral health services should be integrated with other health services at all levels of care. A basic package of oral health services should be provided at all PHC facilities. When PHC facilities were planned, oral health facilities should be included.
- **Training of oral health personnel:** It was recommended that training should be reviewed to prepare professionals for different environments and to work amongst different sections of the population. Deployment and utilisation of oral health personnel should meet everyone's needs and be based on the new focus of oral health service delivery.

b) Reducing the incidence of common oral diseases

It was suggested that this be achieved through health promotion, prevention of oral diseases and the provision of basic curative and rehabilitative oral health services. Implementation strategies to achieve this included:

- **Minimum package of oral care:** Should consist of an annual examination, bitewing radiographs, cleaning of teeth, simple 1- to 3-surface restorations, fissure sealants and emergency relief of pain and infection control.
- **Water fluoridation:** It was suggested that water fluoridation be implemented immediately in the major metropolitan areas with the remaining areas being phased in systematically. Alternative methods of fluoridation such as use of fluoridated toothpaste and mouth rinses should be introduced in schools and among priority groups. Legislation to enable fluoridation of milk and salt should be pursued and dietary supplements should be included as part of the integrated nutrition programme.
- **Reduction of the consumption of refined sugar:** A call was made for a nutrition programme to reduce levels of sugar in infant and baby foods, medicines, fruit juices, vitamin preparations and common foods and to ensure the availability of accurate information of sugars and their levels on food labels.

2.3.2 National Oral Health Policy

The South African National Oral Health Strategy (Department of Health, 2005) was approved by the Minister of Health and the provincial representatives for health in February 2004 with the aim to improve the oral health of the South African population by promoting oral health and to prevent, appropriately treat, monitor and evaluate oral diseases.

a) Oral health functions

Specific oral health functions on the different levels of government were identified (Department of Health, 2005):

- **National level**

  Formulation, implementation and review of the national oral health strategy process;

  Formulation, implementation, monitoring and evaluation of a national water fluoridation programme and alternative fluoride measures in collaboration with the NFC; and

  National norms and standards.

- **Provincial level**

  Formulation, implementation and review of provincial oral health operational strategies;

  Prevention of oral diseases and oral health promotion as priority including water fluoridation, alternative fluoride programmes, identify and develop collaborative approaches to disease based on common risk factors, raise awareness of oral disease risk and integrate oral health into programmes and policies;

  Co-ordinate the oral health care system in the province;

  Plan, support and evaluate district oral health services;

  Collect data from districts for own and national use; and

  Implement national norms and standards for oral health delivery.

- **District level**

  Provision of appropriate disease prevention and health promotion measures based on the minimum package of care and cost-effective and evidence-based strategies;

  Devise an appropriate oral health plan for each health setting;

  Collect appropriate data; and

  Establish an adequate referral system for advanced and specialised oral health services.

b) National goals

National goals set for 2010 included:

- An increase of PHC facilities delivering oral care services through district hospitals, community health centres and clinics, mobile or portable dental units;
- An increase the percentage of children who were caries free at age 6 to 50%;
- Reduce the mean DMFT at age 12 to 1.0;
- 60% of the population on piped water systems to receive optimally fluoridated water; and
- 100% of clinics offer the primary oral health care package.

c) Resources

The South African National Oral Health Strategy suggested that oral health human resources should form part of the integrated health human resources plan. In terms of financial resources the national directorate for oral heath has its own budget and oral health at provincial levels should have cost centres for budgeting purposes. Provinces would be responsible for capital expenditure and equipping oral health facilities. It was furthermore suggested that patients will be charged for services rendered according to the UPFS. Oral health programme managers should be consulted in the planning of clinics and upgrading programmes (Department of Health, 2005).

d) Links between national and provincial health authorities

To facilitate better communication between the national and provincial health authorities, it was suggested that (Department of Health, 2005):

- The national Directorate of Oral Health met with provincial oral health programme managers at national office at least three times per year;
- The national Directorate of Oral Health visited provinces to assist and guide provincial oral health services;

- The national Department of Health would be responsible to annually assess the implementation and outcomes of this strategy and make recommendations accordingly; and
- The national Department of Health was also responsible for collating information provided by provincial health authorities and to disseminate summary data reports.

e) Guidelines for oral health personnel

A previous version of the oral health policy recommended ratios for delivery of oral health services. These are summarised in Table 12 (Department of Health, 1999)

Table 12: Recommended ratios for oral health personnel in the public sector (Department of Health, 1999)

Human resource	Ratio
Specialist : Population	1:1,000,000
Dentist : Population	1:60,000
Oral Hygienist : Population	1:50,000
Dental Therapist : Population	1:12,000
Dentist : Dental Therapist	1:5
Dentist : Oral Hygienist	1:1.2
Dental Therapist : Oral Hygienist	5:1
Clinical : Dental Assistant	1:1.5
Dentist : Dental Technician	6:1

2.3.3 Primary oral health care package

A package of PHC services was agreed to at a meeting of the Provincial Restructuring Committee in Bloemfontein on 13 April 2000 (Pick et al., 2001). It was fully recognised that the better-endowed provinces might be in a position to provide more services than stated with others only able to deliver some elements of the PHC package. The basic elements of the PHC package and associated norms and standards were published in separate documents (Department of Health, 2001a; Department of Health, 2001b).

A minimum package of oral care was first mentioned in the White Paper for the Transformation of Health Services in South Africa (Republic of South

Africa, 1997b). A summary of procedures included in this minimum package of oral care as well as its translation to personnel requirements appears in Table 13 (Department of Health, 2001a; Pick et al., 2001).

Table 13: The minimum package of oral care (Department of Health, 2001a; Pick et al., 2001)

Components of work	Skills and knowledge requirements	Personnel requirements for skills
• Oral examination and charting of dental status • Intra-oral radiographs • Scaling and polishing of teeth • Promotive and preventive oral health services • Basic curative services including emergency relief of pain and sepsis (including dental extractions) • Simple restorations (1-3 tooth surfaces) • Treat traumatic injuries to teeth • Treat post-extraction bleeding	• Communication skills (verbal and non-verbal e.g. oral health education, charting of dental status) • Clinical skills e.g. oral examination, history taking, taking of intra-oral radiographs • Practical skills e.g. medicine prescription, dental extractions and simple restorations, treat traumatic injuries and post-extraction bleeding, scaling and polishing of teeth	**Communication skills:** • Dentist at District Hospital, Community Health Clinic • Dental Therapist • Oral Hygienist • Dental Assistant **Clinical Skills:** • Dentist • Dental Therapist • Oral Hygienist **Practical Skills: (extractions/restorations/traumatic injuries/post-extraction bleeding)** • Dentist • Dental Therapist **(scaling and polishing of teeth)** • Dental Therapist • Oral Hygienist

A recently published editorial suggests that from a public health perspective large inequalities in dental disease and a large variation in the amount of restorative care provided to children are two problems which impact on improving the oral health of young children in the UK (Tickle, 2006). Effective population-based interventions such as water fluoridation are recognised strategies to address inequalities. Far less is known on how to address the latter problem, this results in a wide variation of the amount of restorative care provided. This editorial continues by quoting two independently conducted studies which both reported that 80% of diseased primary teeth exfoliate without causing pain. This suggests that a less interventionist approach may be more appropriate. The provision of dental care to children should strike a balance between effective treatment and minimising any harm to the patient.

Until more evidence is available as to which approach is most effective, it should be accepted that the provision of the minimum package of oral care to South African children is appropriate.

2.4 Summary

This chapter provided a brief overview of the three main elements of this study.

For water fluoridation a historical perspective (including South Africa) was presented as well as an overview of caries prevention, recent international reports and the economics of this well recognised community-based preventive measure.

For human resources planning the different approaches described by Hall (1978) and the WHO/FDI planning model (World Health Organization/Fédération Dentaire Internationale, 1989) was presented. As part of a South African perspective on human resources planning several previous studies, reports and publications were summarised including the recently published NHRP (Department of Health, 2006a). Human resources distribution and trends in South Africa were also discussed.

The final part of this chapter was dedicated to South African policy documents on health and oral health service delivery. These include the White Paper for the Transformation of Health Services (Republic of South Africa, 1997b) which adopted the PHC approach as part of health services, National Oral Health Strategy (Department of Health, 2005) and the primary oral health care package.

Chapter 3 will present a model, outcomes and discussion of the economic variables of the implementation of water fluoridation for seventeen major metropolitan cities, towns and water providers from all nine South African provinces taking into account operating cost, opportunity cost and capital depreciation.

CHAPTER 3: COST EVALUATION OF THE IMPLEMENTATION OF WATER FLUORIDATION IN SOUTH AFRICA

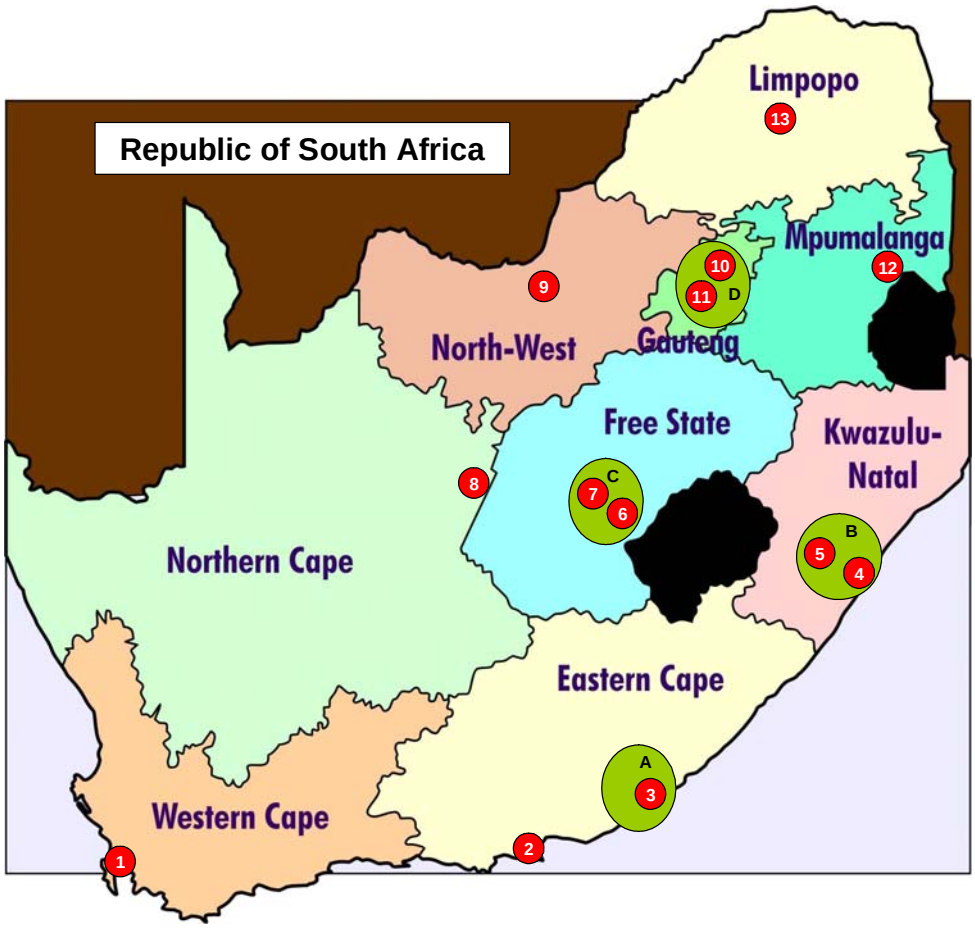
3.1 Introduction

This chapter describes a model to determine the per capita cost, cost-effectiveness and cost-benefit of the implementation of water fluoridation for seventeen major metropolitan cities, towns and water boards from all nine South African provinces. It takes into account operating cost, opportunity cost and capital depreciation. This model is an expansion of the simulation model developed to report on cost-effectiveness and cost-benefit of water fluoridation for Gauteng (Van Wyk et al., 2001), which was based on the principles of similar models described by White et al. (1989) and Ringelberg et al. (1992).

In general per capita cost of fluoridation is affected by the size of the community, number of fluoride injection points, amount and type of equipment required, amount and type of fluoride chemical (including its transport and storage) and training and expertise of personnel required to run the plant. Although the actual cost of water fluoridation cannot and should not be ignored, estimates of saving in treatment cost may be more important than per capita cost. The model presented in this chapter calculates both.

3.2 A model to calculate per capita cost, cost-effectiveness and cost-benefit of the implementation of water fluoridation in South Africa

Figure 4 provides an indication of the location of the seventeen major metropolitan cities, towns and water boards from all nine South African provinces included in this study.



Province	Cities/Towns	Water boards
Western Cape	1: City of Cape Town Metropolitan Municipality	
Eastern Cape	2: Nelson Mandela Bay Metropolitan Municipality (Port Elizabeth only) 3: Buffalo City Municipality (East London only)	A: Amatola Water
KwaZulu-Natal	4: eThekwini Metropolitan Municipality (Durban) 5: Pietermaritzburg Msunduzi Municipality	B: Umgeni Water
Free State	6: Motheo District Municipality (Botshabelo only) 7: Mangaung Local Municipality (Bloemfontein)	C: Bloem Water
Northern Cape	8: Solplaatje Municipality (Kimberley)	
North West	9: Mafikeng Local Municipality	
Gauteng	10: Tshwane Metropolitan Municipality (Pretoria) 11: City of Johannesburg Metropolitan Municipality	D: Rand Water
Mpumalanga	12: Ehlanzeni District Municipality (Nelspruit only)	
Limpopo	13: Polokwane Municipality	

Figure 4: Location of cities, towns and water boards

Table 14 presents all the input variables used in the model. Each variable has been allocated a unique number (in square brackets) which indicates where it is used in the different formulas. Variables have been grouped as follows:

(A) Chemical cost
(B) Labour cost
(C) Maintenance cost
(D) Opportunity cost
(E) Capital depreciation
(F) Operating cost
(G) Total cost
(H) Per capita cost
(I) Caries data
(J) Cost-effectiveness
(K) Cost-benefit ratio

Table 14: A model to calculate per capita cost, cost-effectiveness and cost-benefit of the implementation of water fluoridation

Variable		Formula
(A) CHEMICAL COST		
[1]	Daily water purification rate (litre per day)	
[2]	Natural fluoride content of water (mg F/litre)	
[3]	Adjustment of fluoride level to (mg F/litre)	
[4]	Fluoride needed per day (metric tonne)	[1] x ([3] - [2]) / (1 x 10^9)
[5]	Fluoride needed per year (metric tonne)	[4] x 365
[6]	Chemical needed per year (metric tonne)	[5] / (% available fluoride x % purity)
[7]	Cost of chemical (Rand per metric tonne)	
[8]	Percentage handling fee by agent	
[9]	Delivery cost (metric tonne)	
[10]	Total delivery cost of chemical	[7] + ([7] x [8] / 100) + [9]
(A)	**Cost of chemical per year**	[6] x [10]
(B) LABOUR COST		
[11]	Average operator salary	
[12]	Number of operators needed	
[13]	Annual operator salary for number of operators needed	[11] x [12]
[14]	Number of hours needed per operator per day	
(B)	**Annual labour cost for number of hours needed per day**	[13] / 8 x [14]

Table 14: (continued)

Variable		Formula
(C) MAINTENANCE COST		
[15]	Capital cost per Mega litre of water processed	
[16]	Percentage cost of buildings and storage	
[17]	Cost of buildings and storage	[1] / 1,000,000 x [15] x [16] / 100
[18]	Percentage cost of mechanical and electrical plant	
[19]	Cost of mechanical and electrical plant	[1] / 1,000,000 x [15] x [18] / 100
[20]	Total capital cost	[17] + [19]
[21]	Percentage	
(C)	**Maintenance cost: % of total capital cost**	[20] x [21] / 100
(D) OPPORTUNITY COST		
[22]	Prime Overdraft Rate of Banks	
(D)	**Opportunity cost: % of total capital cost**	[20] x [22] / 100
(E) CAPITAL DEPRECIATION		
[23]	Years for building and storage	
[24]	Capital depreciation of buildings and storage	[17] / [23]
[25]	Years for mechanical and electrical plant	
[26]	Capital depreciation of mechanical and electrical plant	[19] / [25]
(E)	**Total capital depreciation per annum**	[24] + [26]
(F) OPERATING COST		
	Chemical cost + Labour cost + Maintenance cost	(A) + (B) + (C)
(G) TOTAL COST		
	Opportunity cost + Capital depreciation + Operating cost	(D) + (E) + (F)
(H) PER CAPITA COST		
[27]	Population served by water provider	
[28]	**Per capita cost for total population**	(G) / [27]
[29]	Percentage of population younger than 15 years	
[30]	Population served by water scheme younger than 15 years	[27] x [29] / 100
[31]	**Per capita cost younger than 15 years**	(G) / [30]
(I) CARIES DATA		
[32]	DMFT	
[33]	Age for DMFT score	
[34]	DMFT increment per year	[32] / ([33] - 6)
(J) COST-EFFECTIVENESS (the cost per person per year to save 1 DMFT)		
[35]	Decrease in caries incidence (%)	
[36]	Decrease in DMFT per child per year	[35] / 100 x [34]
(J)	**Cost-effectiveness for total population**	[28] / [36]
(J)	**Cost-effectiveness for population younger than 15 years**	[31] / [36]
(K) COST-BENEFIT RATIO (the cost of the implementation of water fluoridation divided by the savings in cost of treatment)		
[37]	Cost of a 2 surface amalgam restoration	
[38]	Cost of a 2 surface anterior resin restoration	
[39]	Cost of a 2 surface posterior resin restoration	
[40]	Average cost of a 2 surface restoration	([37] + [38] + [39]) / 3
(K)	**Cost-benefit ratio for total population**	[28] / ([36] x [40])
(K)	**Cost-benefit ratio for population younger than 15 years**	[31] / ([36] x [40])

Microsoft Excel software was used to computerise this model. An example of the model applied to the City of Tshwane Metropolitan Municipality (Pretoria) is presented in Annexure 1.

3.2.1 Chemical cost (Variable Group (A))

a) Chemicals used in water fluoridation

Any compound which easily forms fluoride ions in solution can be used for the artificial adjustment of fluoride in water. The three commonly used fluoride chemicals are sodium fluoride, sodium fluorosilicate and fluorosilicic acid. These compounds have been approved for use in the artificial fluoridation of public water supplies in South Africa (Republic of South Africa, 2000).

The properties of these three fluoride compounds are presented in Table 15 (Department of Health, 2003c; Pelchem, 2007).

Table 15: Properties of the three commonly used fluoridation chemicals (Department of Health, 2003c; Pelchem, 2007)

	Sodium fluoride	Sodium fluorosilicate	Fluorosilicic acid
Chemical formula	**NaF**	**Na_2SiF_6**	**H_2SiF_6**
Molecular mass	42	188.06	144.08
Available fluoride in formula	45.2%	60.6%	79.1%
Commercial purity	90-95%	>99%	40%
Packaging		25 kg bags	210 L drums
Appearance	White odourless hygroscopic powder or crystal	White odourless non-hygroscopic crystalline powder	Straw-coloured transparent, corrosive liquid with sour pungent odour
General	• Widely used in water fluoridation • Mainly in small installations • Not used in large plants because of high cost and bulky saturators • Dust control is necessary	• Usually the cheapest fluoridation chemical • Used in large installations • Dosed with dry feeder • Dust control is necessary	• Inexpensive • Simple to dose • Suitable for both large or small installations

For the purpose of this study, fluorosilicic acid (H_2SiF_6) will be used in the calculations due to it being relatively inexpensive, requiring a simple dosing technique and its suitability for both large and small water plants.

b) Daily water purification rate (Variable [1])

This information was obtained from metropolitan, district and local municipalities and water boards where water is provided to more than one municipality. A combined water purification rate (expressed as litre per day) was used where more than one plant supplies the municipality with water.

Based on the total daily water purification rate, municipalities and water boards were classified as follows:

- **Category A:** Water purification rate of more than 700 Mega litre per day
- **Category B:** Water purification rate of less than 700 and more than 100 Mega litre per day
- **Category C:** Water purification rate of less than 100 Mega litre per day

A summary of the classification of all municipalities and water boards, the number of water purification plants and the total combined daily water purification rates is presented in Table 16. Detailed information on the number of water plants, water purification rate and population served by municipalities and water boards is presented in Annexure 2.

Table 16: Number of water purification plants and daily water purification rate per municipality or water board

Municipality/ water board	Number of water purification plants	Water purification rate (Mega litre per day)
Category A		
Cape Town	11	850.3
Umgeni Water	11	1,107.5
Durban/Pietermaritzburg combined	6 (Umgeni Water)	1,083
Durban	8 (Umgeni Water)	971.5
Rand Water	2	3,558
Johannesburg	2 (Rand Water)	1,280
Tshwane (Pretoria)	5 (1 Rand Water)	722
Category B		
Port Elizabeth	7	282
Amatola Water	14	102.2
Pietermaritzburg	2 (Umgeni Water)	118
Bloem Water	7	165.7
Bloemfontein	2 (Bloem Water)	106.8
Kimberley	2	129.7
Category C		
Buffalo City (East London)	3 (Amatola Water)	79
Botshabelo	1 (Bloem Water)	27.9
Mafikeng	2	37
Nelspruit	2	42
Polokwane	5	24

c) Natural fluoride content of water (Variable [2])

Natural fluoride content of water as published by Grobler et al. (2006) were used for this study, although a number of municipalities did not return their samples and information. These included Bloemfontein and Botshabelo. For both as well as for Bloem Water the natural water fluoride content was obtained from the Department of Water Affairs and Forestry database (Erasmus, 2004).

Table 17 presents the values used in this study. It should be noted that the fluoride concentration of drinking water for a number of coastal municipalities was found to be less than 0.1 ppm (mg/litre) (Grobler, Chikte and Louw, 2006). Where this applied a value of 0.1 ppm was used in the calculations. The highest natural fluoride concentration was 0.47 ppm for Polokwane and 0.26 ppm for Kimberley.

Table 17: Natural fluoride content of municipalities and water boards (Erasmus, 2004; Grobler et al., 2006)

Municipality / water board	Natural fluoride content (milligram / litre)
Category A	
Cape Town	< 0.1
Umgeni Water	0.1
Durban / Pietermaritzburg combined	0.1
Durban	0.1
Rand Water	0.2
Johannesburg	0.2
Tshwane (Pretoria)	0.2
Category B	
Port Elizabeth	< 0.1
Amatola Water	< 0.1
Pietermaritzburg	< 0.1
Bloem Water	0.3
Bloemfontein	0.3
Kimberley	0.26
Category C	
Buffalo City (East London)	0.18
Botshabelo	0.3
Mafikeng	0.15
Nelspruit	< 0.1
Polokwane	0.47

d) Adjustment of fluoride level (Variable [3])

For the purpose of this study fluoride levels of community water supplies for all municipalities and water boards was adjusted to 0.7 ppm which is in line with the recommendation for the optimal fluoride concentration as published in the regulations for the fluoridation of water supplies (Republic of South Africa, 2000).

e) Chemical needed (Variables [4] to [6])

The amount or chemical needed expressed as metric tonnes was calculated for fluorosilicic acid (H_2SiF_6) by applying the formulas as indicated.

- **Fluoride needed per day (Variable [4]):**
  Daily water purification rate x (Adjusted fluoride level – Natural fluoride content) / (1×10^9)

The factor of 1 x 10^9 converts the amount of fluoride needed per day from milligram to metric tonne.

- **Fluoride needed per year (Variable [5]):**
  Fluoride needed per day x 365

- **Chemical needed per year (Variable [6]):**
  Fluoride needed per year / (% available fluoride from H_2SiF_6 x % purity of H_2SiF_6)

f) Total delivery cost of chemical (Variables [7] to [10])

The cost of fluorosilicic acid (H_2SiF_6) (Variable [7]), percentage handling fee charged by the agent (Variable [8]) and the delivery cost per metric tonne (Variable [9]) were supplied by Pelchem and Süd-Chemie (De Klerk, 2006; Leopold, 2006).

The total delivery cost of fluorosilicic acid (H_2SiF_6) (Variable [10]) was calculated by applying the formula:
Cost of chemical + (Cost of chemical x Percentage handling fee by agent) + Delivery cost

g) Cost of chemical per year (Variable Group (A))

The cost of the chemical needed per year was calculated by applying the formula:
Chemical needed per year x Total delivery cost of chemical

Table 18 presents the total delivery cost of fluorosilicic acid used as supplied by Pelchem and Süd-Chemie.

Table 18: Total delivery cost of chemical per metric tonne (De Klerk, 2006; Leopold, 2006)

		Cost of fluorosilicic acid per metric tonne (Pelchem):	**R7,044.00**
		Agent's handling fee (Süd-Chemie):	**12.5%**
Municipality / water board	**Delivery cost per metric tonne (Süd-Chemie)**	**Total delivery cost per metric tonne**	**Cost of chemical per year**
Category A			
Cape Town	R1,050.00	R8,974.50	R5,281,898.86
Umgeni Water	R510.00	R8,434.50	R6,465,628.05
Durban/Pietermaritzburg combined	R510.00	R8,434.50	R6,322,596.10
Durban	R510.00	R8,434.50	R5,671,654.77
Rand Water	R180.00	R8,104.50	R16,632,539.53
Johannesburg	R180.00	R8,104.50	R5,983,600.51
Tshwane (Pretoria)	R180.00	R8,104.50	R3,375,124.66
Category B			
Port Elizabeth	R820.00	R8,744.50	R1,706,835.75
Amatola Water	R820.00	R8,744.50	R618,576.64
Pietermaritzburg	R510.00	R8,434.50	R688,888.59
Bloem Water	R410.00	R8,334.50	R637,262.61
Bloemfontein	R410.00	R8,334.50	R410,740.18
Kimberley	R510.00	R8,434.50	R555,232.53
Category C			
Buffalo City (East London)	R820.00	R8,744.50	R414,401.97
Botshabelo	R410.00	R8,334.50	R107,300.10
Mafikeng	R470.00	R8,394.50	R196,801.48
Nelspruit	R470.00	R8,394.50	R244,034.80
Polokwane	R470.00	R8,394.50	R53,455.24

3.2.2 Labour cost (Variable Group (B))

a) Operator salary and number of operators required (Variables [11] to [13])

The Department of Water Affairs and Forestry would be responsible for the standard of training of personnel involved in water purification. Based on the requirements of the regulations on fluoridating water supplies, the lowest rank of an operator involved in monitoring water fluoride content would be a plant superintendent (Republic of South Africa, 2000).

Information on the annual salary and benefits of a plant superintendent as well as the number of plant superintendents required to manage the fluoridation process was provided by municipalities and water boards. This

information varied greatly between water providers. In an attempt to standardise on the number of plant superintendents required per water purification plant to monitor this process over a 24 hour period of time and based on the daily water purification rate of each plant, the following was used as a guideline in this study (Variable [12]):

- Water purification rate of more than 250 Mega litre per day: 4 plant superintendents
- Water purification rate between 100 and 249 Mega litre per day: 3 plant superintendents
- Water purification rate between 50 and 99 Mega litre per day: 2 plant superintendents
- Water purification rate less than 50 Mega litre per day: 1 plant superintendent
- Water purification rate less than 1 Mega litre per day: Serviced by superintendents from other plants

Remuneration rates were provided by water boards and municipalities in 2004. These were adjusted by 4.6% for 2005 and a further 5.3% for 2006 according to the annual salary adjustments recommended by the Department of Public Service and Administration for post levels 1 to 12 (Department of Public Service and Administration, 2005; Department of Public Service and Administration, 2006).

Based on these guidelines and linked to the daily water purification rate of each plant, the average annual salary of a plant superintendent was calculated (Variable [11]) for each municipality and water board. More detailed information can be found in Annexure 2.

Where only part of the water processed by a water board is supplied to a municipality, the same proportion was used to calculate the number of operators needed to process the water supplied to that municipality. For example both the Rand Water Zuikerbosch and Vereeniging plants require 4 operators each, but only 36% of the water processed by these plants is

provided to Johannesburg Municipality, which would then require 2.88 operators (36% of 8 operators).

The annual operator salary for the number of operators required (Variable [13]) was calculated by applying the formula:
Average operator salary x Number of operators needed

b) Number of hours needed per operator per day (Variable [14])

Labour costs were based on an operator spending one hour per working day (or eight hour shift) on the fluoridation process (Ringelberg et al., 1992).

c) Annual labour cost for number of hours needed per day (Variable Group (B))

The majority of municipalities indicated that a working day or shift for a plant superintendent would be eight hours. The annual labour cost for the number of hours needed per day was calculated by applying the formula:
Annual operator salary for number of operators needed / 8 hours per day x 1 hour needed per day per operator for fluoridation process

Table 19 presents the average annual operator salary (Variable [11]), number of operators required (Variable [12]), the annual operator salary for the number of operators required (Variable [13]) and the annual labour cost for the number of hours needed per day for the municipalities and water boards included in this study.

Table 19: Average operator salary, number of operators required, annual operator salary and annual labour cost

Municipality / water board	Average annual operator salary	Number of operators required	Annual operator salary	Annual labour cost
Category A				
Cape Town	R186,079.14	18	R3,349,424.49	R418,678.06
Umgeni Water	R255,069.85	19	R4,846,327.20	R605,790.90
Durban/Pietermaritzburg combined	R267,492.09	14	R3,744,889.20	R468,111.15
Durban	R256,726.44	14	R3,594,170.20	R449,271.28
Rand Water	R275,359.50	8	R2,202,876.00	R275,359.50
Johannesburg	R275,359.50	2.88	R793,035.36	R99,129.42
Tshwane (Pretoria)	R255,162.87	6.12	R1,561,596.77	R195,199.60
Category B				
Port Elizabeth	R201,563.15	10	R2,015,631.54	R251,953.94
Amatola Water	R132,172.56	9	R1,189,553.04	R148,694.13
Pietermaritzburg	R275,359.50	2	R550,719.00	R68,839.88
Bloem Water	R237,392.93	9	R2,136,536.39	R267,067.05
Bloemfontein	R237,392.93	2.68	R636,213.06	R79,526.63
Kimberley	R151,535.84	4	R606,143.36	R75,767.92
Category C				
Buffalo City (East London)	R132,172.56	3	R396,517.68	R49,564.71
Botshabelo	R215,530.00	0.93	R200,442.90	R25,055.36
Mafikeng	R137,679.75	2	R275,359.50	R34,419.94
Nelspruit	R132,172.56	2	R264,345.12	R33,043.14
Polokwane	R109,477.43	5	R547,387.15	R68,423.39

3.2.3 Maintenance cost (Variable Group (C))

a) Capital cost (Variables [15], [16] and [18])

Calculation of the capital cost for a fluoridation plant was based on information from three previous studies/reports:

- Cost-effectiveness and cost-benefit of water fluoridation for Gauteng (Van Wyk et al., 2001);
- A 2002 estimation of the cost of fluoridating water and daily water processing rates by Rand Water (Rand Water, 2002a; Rand Water, 2002b);
- A 2003 cost estimate for the NFC for Nelspruit based on the Van Wyk et al (2001) model for Gauteng.

Based on daily water processing rates, both Gauteng and Rand Water are classified as Category A water boards (> 700 Mega litre/day) with Nelspruit classified as a Category C provider (<100 Mega litre/day). Information from the three cost estimates for Gauteng, Rand Water and Nelspruit were used to calculate the capital cost per Mega litre of water processed (Variable [15]) as well as the percentage contribution of capital cost of buildings and storage (Variable [16]) and mechanical and electrical plant (Variable [18]) towards the total capital cost. The average percentage of Category A and C provider values were used for Category B providers.

The Bureau for Economic Research's Building Cost Index (BER-BCI) is generally accepted as a valid indicator of inflation for the building industry (Bureau for Economic Research, 2006). The year-on-year BER-BCI was applied to the 2002 Rand Water capital cost estimates with a 12%, 10% and 19% adjustment for 2003, 2004 and 2005 respectively (Davis Langdon & Seah International, 2006). The daily water purification rate for Rand Water for 2005 was then used to calculate a revised capital cost per Mega litre of water processed for 2005. A BER-BCI of 13.2% was predicted for 2006 (Institute of Estate Agents of South Africa, 2006). The 2005 capital cost was adjusted with this percentage to calculate capital cost for 2006. A rounded value of R8,750.00 per Mega litre water processed per day (Variable [15]) was used in this study.

Table 20 presents the values for capital cost per Mega litre water processed, percentage cost of buildings and storage and percentage cost of the mechanical and electrical plant used in this study for Category A, B and C water providers.

Table 20: Capital cost for a water fluoridation plant for Category A, B and C water providers

	Category A		Category B	Category C
	Rand Water (2002)	**Gauteng (1998)**		**Nelspruit (2003)**
Capital cost	R18,850,000.00	R14,000,000.00		R274,130.00
Daily water purification rate (Ml)	3,400	2,800		44
Capital cost per Mega litre water	**R5,544.12**	**R5,000.00**		**R6,230.23**
Buildings and Storage		R2,897,338.00 **(21% of capital cost)**	**29%**	R100,000.00 **(36% of capital cost)**
Mechanical and Electrical		R11,102,662.00 **(79% of capital cost)**	**71%**	R174,130.00 **(64% of capital cost)**
Adjustment of 2002 Rand Water capital costs for 2005				
BER-BCI 2003: 12%		R21,112,000.00		
BER-BCI 2004: 10%		R23,223,200.00		
BER-BCI 2005: 19%		R27,635,608.00		
2005 daily water purification rate (Ml)		3,558		
2005 Capital Cost per Mega litre water		**R7,767.17**		
Adjustment of 2005 Rand Water capital cost per Mega litre water for 2006 (Projected BER-BCI 2006: 13%)				
2006 Capital Cost per Mega litre water		**≈ R8,750.00**		

b) Cost of buildings, storage, mechanical and electrical plant (Variables [17], [19] and [20])

These costs were calculated from previous variables by applying the following formulas:

- **Cost of buildings and storage (Variable [17]):**

  Daily water purification rate / (1 x 10^6) x Capital cost per Mega litre of water processed x Percentage cost of buildings and storage

  The factor of 1 x 10^6 converts the daily water purification rate from litre to Mega litre.

- **Cost of mechanical and electrical plant (Variable [19]):**

  Daily water purification rate / (1 x 10^6) x Capital cost per Mega litre of water processed x Percentage cost of mechanical and electrical plant

  The factor of 1 x 10^6 converts the daily water purification rate from litre to Mega litre.

- **Total capital cost (Variable [20]):**
  Cost of buildings and storage + Cost of mechanical and electrical plant

c) Maintenance cost (Variable Group (C))

Maintenance and repair costs were calculated at 2.4% (Variable [21]) of total capital costs (Ringelberg et al., 1992) by applying the formula:
Total capital cost x Percentage

3.2.4 Opportunity cost (Variable Group (D))

Opportunity cost is defined as the next best alternative for that amount of money (Ringelberg et al., 1992). For this study the South African Reserve Bank Prime Overdraft Rate of Banks (as on 3 August 2006) of 11.5% (Variable [22]) was used in the calculations (South African Reserve Bank, 2006). Opportunity cost was calculated by applying the formula:
Total capital cost x Prime Overdraft Rate of Banks

3.2.5 Capital depreciation (Variable Group (E))

Capital depreciation was calculated using a fifteen year turnover for buildings and storage (Variable [23]) and an eight year turnover on mechanical and electrical equipment (Variable [25]) (Van Wyk et al., 2001) by applying the formulas:

- **Capital depreciation of buildings and storage (Variable [24]):**
  Cost of buildings and storage / Years for building and storage

- **Capital depreciation of mechanical and electrical plant (Variable [26]):**
  Cost of mechanical and electrical plant / Years for mechanical and electrical plant

- **Total capital depreciation per annum (Variable Group (E)):**
  Capital depreciation of buildings and storage + Capital depreciation of mechanical and electrical plant

3.2.6 Operating cost (Variable Group (F))

Operating cost was calculated from the sum of the cost of chemical per year (Variable Group (A)), annual labour cost for the number of hours needed per day (Variable Group (B)) and maintenance cost (Variable Group (C)) (Ringelberg et al., 1992).

3.2.7 Total cost (Variable Group (G))

Total cost was calculated from the sum of the opportunity cost (Variable Group (D)), capital depreciation (Variable Group (E)) and operating cost (Variable Group (F)) (Ringelberg et al., 1992).

Table 21 presents the operating and total cost of water fluoridation for each of the municipalities and water boards.

Table 21: Operating and total cost of water fluoridation

Municipality / water board	Operating cost	Total cost
Category A		
Cape Town	R5,879,139.92	R7,573,628.39
Umgeni Water	R7,303,993.95	R9,511,033.80
Durban/Pietermaritzburg combined	R7,018,137.25	R9,176,353.19
Durban	R6,324,941.04	R8,260,958.39
Rand Water	R17,655,079.03	R24,745,505.91
Johannesburg	R6,351,529.93	R8,902,329.93
Tshwane (Pretoria)	R3,721,944.26	R5,160,754.88
Category B		
Port Elizabeth	R2,018,009.69	R2,568,467.82
Amatola Water	R788,732.77	R988,225.04
Pietermaritzburg	R782,508.46	R1,012,842.00
Bloem Water	R939,126.66	R1,262,569.61
Bloemfontein	R512,694.81	R721,166.18
Kimberley	R658,235.35	R911,387.52
Category C		
Buffalo City (East London)	R480,556.68	R631,940.43
Botshabelo	R138,214.46	R191,677.84
Mafikeng	R238,980.92	R309,786.35
Nelspruit	R285,897.94	R366,380.44
Polokwane	R126,918.64	R172,908.64

3.2.8 Per capita cost (Variable Group (H))

Information on the total population served by the water providers (Variable [27]) was obtained from the municipalities and water boards included in this study. Detailed information can be found in Annexure 2.

Amatola Water could not provide this information. Their website estimated the population in their catchment area as 2.47 million (Amatola Water, 2005). According to the 2001 South African census data, 49% of the population of the Eastern Cape province had access to a centralised water supply within 200 metres of their dwelling (Statistics South Africa, 2003). With this information the population served by Amatola Water was calculated as 1.2 million people.

Per capita cost for the total population (Variable [28]) was calculated by applying the formula:
Total cost / Population served by water provider

Information on the percentage of the population younger than fifteen years of age (Variable [29]) (Statistics South Africa, 2006) was used to calculate the population served by the water provider for this age cohort (Variable [30]) with the formula:
Population served by water provider x Percentage of population younger than 15 years

Per capita cost for those younger than fifteen years was calculated with the formula:
Total cost / Population served by water scheme younger than 15 years

Results for the per capita cost for the total population as well as those younger than fifteen years are presented in section 3.3.2 of this chapter (see p 89).

3.2.9 Caries prevalence (Variable Group (I))

The 1999-2002 NCOHS recorded caries prevalence for the permanent dentition for 6-, 12- and 15-year-olds by way of the DMFT caries index (Department of Health, 2003b; Van Wyk, Louw and Du Plessis, 2004). Weighted mean DMFT scores for 15-year-olds (Variable [32]) per district and province, as reported or calculated from the Bureau for Statistical and Survey Methodology (STATOMET) database of the NCOHS, were used in this study. These values are presented in Table 22.

Table 22: Caries prevalence (DMFT) for 15-year-olds per district and province: 1999-2002 NCOHS

Province / District	DMFT for 15-year-olds	DMFT for 15-year-olds used for:
South Africa	1.86	
Western Cape	3.99	
Cape Metro	4.05	Cape Town
Eastern Cape	2.01	
Eastern Cape Western	2.01	Amatola Water, Port Elizabeth, Buffalo City (East London)
Northern Cape	2.88	Kimberley
Free State	1.92	
Region A (Bloemfontein)	1.53	Bloem Water, Bloemfontein, Botshabelo
KwaZulu-Natal	1.87	Umgeni Water, Durban/Pietermaritzburg combined
Durban	1.95	Durban
Pietermaritzburg	1.26	Pietermaritzburg
Gauteng	1.81	Rand Water, Johannesburg, Tshwane (Pretoria)
North West	1.20	
Mafikeng	2.30	Mafikeng
Mpumalanga	1.66	
Lowveldt	2.25	Nelspruit
Limpopo	0.86	
Central Region	0.61	Polokwane

The DMFT increment per year (Variable [34]) was calculated over a nine year period (age 15 – age 6) by applying the formula:

DMFT / (Age for DMFT score – 6)

3.2.10 Cost-effectiveness (Variable Groups (J))

Cost-effectiveness is defined as the cost per person per year to save one DMFT (Horowitz and Heifetz, 1979).

a) Decrease in caries incidence (Variable [35])

This value was preselected and represents the anticipated caries reduction expected after the introduction of water fluoridation. For this study cost-effectiveness was calculated for anticipated caries reductions of 10%, 30% and 50%.

b) Decrease in DMFT per child per year (Variable [36])

This value was calculated from previous variables by applying the formula:
% decrease in caries incidence x DMFT increment per year

c) Cost-effectiveness (Variable Group (J))

This value was calculated from previous variables for the total population as well as for those younger than fifteen years by applying the formula:
Per capita cost for total population or for those younger than 15 / Decrease in DMFT per child per year

The results for cost-effectiveness for the total population as well as those younger than fifteen years are presented in section 3.3.3 of this chapter (see p 92).

3.2.11 Cost- benefit (Variable Groups (K))

Cost-benefit is defined as the cost of implementing the procedure divided by the savings in the cost of treatment (Horowitz and Heifetz, 1979). Should the cost-benefit ratio approach one or be larger than one, this measure should not be considered. Alternatively cost-benefit can also be described as the monetary value spent on water fluoridation to save one monetary unit of the cost of treatment (Van Wyk et al., 2001).

a) Cost of a two surface restoration (Variables [37] to [40])

The average cost of a two surface restoration (Variable [40]) calculated from the average 2006 NRPL fee for an amalgam (Code 8342) (Variable [37]), anterior resin (Code 8352) (Variable [38]) and posterior resin (Code 8368) (Variable [39]) restoration was used in this study (Council for Medical Schemes, 2006). These fees are presented in Table 23.

Table 23: Average cost of a two surface restoration (Council for Medical Schemes, 2006)

Description	NRPL Code	2006 item fee
2 surface amalgam restoration	8342	R155.90
2 surface anterior resin restoration	8352	R174.60
2 surface posterior resin restoration	8368	R186.20
Average cost of a 2 surface restoration:		**R172.23**

b) Cost-benefit (Variable Group (K))

This value was calculated from previous variables for the total population and for those younger than fifteen years by applying the formula:
Per capita cost for total population or for those younger than 15 / (Decrease in DMFT per child per year x Average cost of a two surface restoration)

The results for cost-benefit for the total population as well as those younger than fifteen years are presented in section 3.3.4 of this chapter (see p 94).

3.3 Results

A model to determine per capita cost, cost-effectiveness and cost-benefit of the implementation of water fluoridation for seventeen major metropolitan cities, towns and water boards in all nine South African provinces, taking into account operating cost, opportunity cost and capital depreciation was described in the previous section.

This section presents the results for the total population and the population younger than fifteen served by each of the municipalities and water boards included in this study.

3.3.1 Total cost of water fluoridation

Table 24 presents a summary of the cost of chemicals, labour, maintenance, opportunity cost and capital depreciation as a monetary value as well as the percentage contribution of each to the total cost. Operating cost is calculated from the sum of the cost of chemicals, labour and maintenance. Total cost is calculated from the sum of operating cost, opportunity cost and capital depreciation.

Table 24: Cost of the introduction of water fluoridation

Municipality/ water board	Chemicals		Labour		Maintenance		Operating cost	
	A	%	B	%	C	%	D = A+B+C	%
Category A								
Cape Town	R5.28 m	69.7	R0.42 m	5.5	R0.18 m	2.4	R5.88 m	77.6
Umgeni Water	R6.47 m	68.0	R0.61 m	6.4	R0.23 m	2.4	R7.30 m	76.8
Durban/Pietermaritzburg combined	R6.32 m	68.9	R0.47 m	5.1	R0.23 m	2.5	R7.02 m	76.5
Durban	R5.67 m	68.7	R0.45 m	5.4	R0.20 m	2.5	R6.32 m	76.6
Rand Water	R16.63 m	67.2	R0.28 m	1.1	R0.75 m	3.0	R17.66 m	71.3
Johannesburg	R5.98 m	67.2	R99,129.42	1.1	R0.27 m	3.0	R6.35 m	71.3
Tshwane (Pretoria)	R3.38 m	65.4	R0.20 m	3.8	R0.15 m	2.9	R3.72 m	72.1
Category A Average		**67.9**		**4.1**		**2.7**		**74.6**
Category B								
Port Elizabeth	R1.71 m	66.5	R0.25 m	9.8	R59,220.00	2.3	R2.02 m	78.6
Amatola Water	R0.62 m	62.6	R0.15 m	15.0	R21,462.00	2.2	R0.79 m	79.8
Pietermaritzburg	R0.69 m	68.0	R68,839.88	6.8	R24,780.00	2.4	R0.78 m	77.3
Bloem Water	R0.64 m	50.5	R0.27 m	21.2	R34,797.00	2.8	R0.94 m	74.4
Bloemfontein	R0.41 m	57.0	R79,526.63	11.0	R22,428.00	3.1	R0.51 m	71.1
Kimberley	R0.56 m	60.9	R75,767.92	8.3	R27,234.90	3.0	R0.66 m	72.2
Category B Average		**60.9**		**12.0**		**2.6**		**75.6**
Category C								
Buffalo City (East London)	R0.41 m	65.6	R49,564.71	7.8	R16,590.00	2.6	R0.48 m	76.0
Botshabelo	R0.11 m	56.0	R25,055.36	13.1	R5,859.00	3.1	R0.14 m	72.1
Mafikeng	R0.20 m	63.5	R34,419.94	11.1	R7,759.50	2.5	R0.24 m	77.1
Nelspruit	R0.24 m	66.6	R33,043.14	9.0	R8,820.00	2.4	R0.29 m	78.0
Polokwane	R53,455.24	30.9	R68,423.39	39.6	R5,040.00	2.9	R0.13 m	73.4
Category C Average		**56.5**		**16.1**		**2.7**		**75.3**
Category A, B, C Average		**62.4**		**10.1**		**2.7**		**75.1**

Note: m = million

Table 24: (continued)

Municipality/ water board	Operating cost		Opportunity cost		Capital depreciation		Total cost
	D	%	E	%	F	%	G = D+E+F
Category A							
Cape Town	R5.88 m	77.6	R0.86 m	11.3	R0.84 m	11.1	R7.57 m
Umgeni Water	R7.30 m	76.8	R1.11 m	11.7	R1.09 m	11.5	R9.51 m
Durban/Pietermaritzburg combined	R7.02 m	76.5	R1.09 m	11.9	R1.07 m	11.6	R9.18 m
Durban	R6.32 m	76.6	R0.98 m	11.8	R0.96 m	11.6	R8.26 m
Rand Water	R17.66 m	71.3	R3.58 m	14.5	R3.51 m	14.2	R24.75 m
Johannesburg	R6.35 m	71.3	R1.29 m	14.5	R1.26 m	14.2	R8.90 m
Tshwane (Pretoria)	R3.72 m	72.1	R0.73 m	14.1	R0.71 m	13.8	R5.16 m
Category A Average		**74.6**		**12.8**		**12.6**	
Category B							
Port Elizabeth	R2.02 m	78.6	R0.28 m	11.0	R0.27 m	10.4	R2.57 m
Amatola Water	R0.79 m	79.8	R0.10 m	10.4	R96,653.52	9.8	R0.99 m
Pietermaritzburg	R0.78 m	77.3	R0.12 m	11.7	R0.11 m	11.0	R1.01 m
Bloem Water	R0.94 m	74.4	R0.17 m	13.2	R0.16 m	12.4	R1.26 m
Bloemfontein	R0.51 m	71.1	R0.11 m	14.9	R0.10 m	14.0	R0.72 m
Kimberley	R0.66 m	72.2	R0.13 m	14.3	R0.12 m	13.5	R0.91 m
Category B Average		**75.6**		**12.6**		**11.8**	
Category C							
Buffalo City (East London)	R0.48 m	76.0	R79,493.75	12.6	R71,890.00	11.4	R0.63 m
Botshabelo	R0.14 m	72.1	R28,074.38	14.6	R25,389.00	13.2	R0.19 m
Mafikeng	R0.24 m	77.1	R37,180.94	12.0	R33,624.50	10.9	R0.31 m
Nelspruit	R0.29 m	78.0	R42,262.50	11.5	R38,220.00	10.4	R0.37 m
Polokwane	R0.13 m	73.4	R24,150.00	14.0	R21,840.00	12.6	R0.17 m
Category C Average		**75.3**		**12.9**		**11.7**	
Category A, B, C Average		**75.1**		**12.8**		**12.1**	

Note: m = million

Figure 5 presents the cost of chemicals, labour and maintenance as well as opportunity cost and capital depreciation as a percentage of the total cost for Category A, B and C municipalities and water boards and well as a combined average for Categories A, B and C water providers.

Chemical cost contributes on average 62.4% to the total cost and are higher for Category A (67.9%) compared to Category B (60.9%) and C providers (56.5%). The opposite applies to labour cost where this represents 16.1% of the total cost for Category C compared to 12% for Category B and only 4.1% for Category A providers. The average contribution of labour cost to total cost for all providers is 10.1%.

Operating cost contributes 75.1% to the total cost and only varies slightly between the different categories of providers. On average opportunity cost and capital depreciation contribute 12.8% and 12.1% respectively to the total cost.

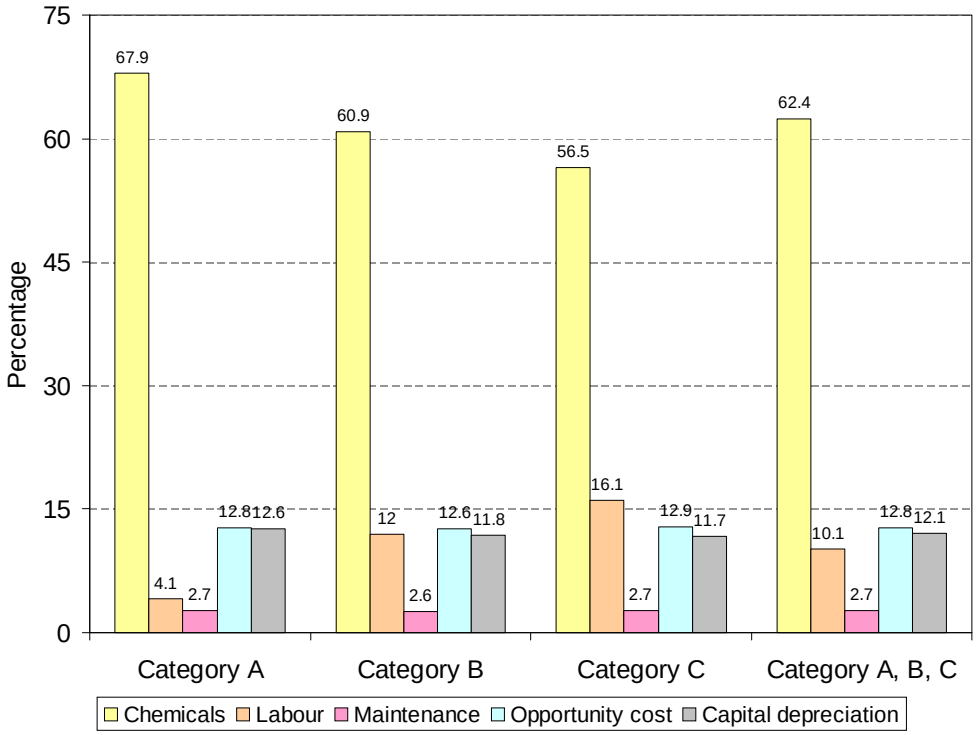


Figure 5: Cost of the introduction of water fluoridation for Category A, B and C municipalities and water boards as a percentage of the total cost

3.3.2 Per capita cost

The 2006 South African mid-year population estimates indicate the total population as 47.39 million people (Statistics South Africa, 2006). Municipalities and water boards included in this study provided information on the number of water purification plants which approximately serve 25 million people. This represents almost 53% of the total population of South Africa. Table 25 presents the per capita cost for the total population and the population younger than fifteen years of age.

Table 25: Per capita cost of water fluoridation for the total population and those younger than fifteen years

Municipality / water board	Population served by water scheme	Per capita cost (total population)	% of population <15 years	Population <15 years served by water scheme	Per capita cost (<15 years)
Category A:					
Cape Town	3,350,000	R2.26	28.18	944,030	R8.02
Umgeni Water	3,422,000	R2.78	34.32	1,174,430	R8.10
Durban/Pietermaritzburg combined	3,315,000	R2.77	34.32	1,137,708	R8.07
Durban	3,064,624	R2.70	34.32	1,051,779	R7.85
Rand Water	12,000,000	R2.06	26.46	3,175,200	R7.79
Johannesburg	3,225,608	R2.76	26.46	853,496	R10.43
Tshwane (Pretoria)	2,100,000	R2.46	26.46	555,660	R9.29
Category A Average		**R2.54**			**R8.51**
Category B					
Port Elizabeth	1,200,000	R2.14	34.93	419,160	R6.13
Amatola Water	1,210,286	R0.82	34.93	422,753	R2.34
Pietermaritzburg	500,000	R2.03	34.32	171,600	R5.90
Bloem Water	1,027,000	R1.23	30.55	313,749	R4.02
Bloemfontein	541,200	R1.33	30.55	165,337	R4.36
Kimberley	223,000	R4.09	31.24	69,665	R13.08
Category B Average		**R1.94**			**R5.97**
Category C					
Buffalo City (East London)	677,379	R0.93	34.93	236,608	R2.67
Botshabelo	306,900	R0.62	30.55	93,758	R2.04
Mafikeng	170,000	R1.82	32.05	54,485	R5.69
Nelspruit	95,000	R3.86	34.72	32,984	R11.11
Polokwane	200,556	R0.86	37.65	75,509	R2.29
Category C Average		**R1.62**			**R4.76**
Category A, B, C Average		**R2.08**			**R6.62**

Figure 6 presents the average per capita cost for Category A, B and C municipalities and water boards as well as a combined average for Categories A, B and C water providers for the total population as well as for those younger than fifteen years.

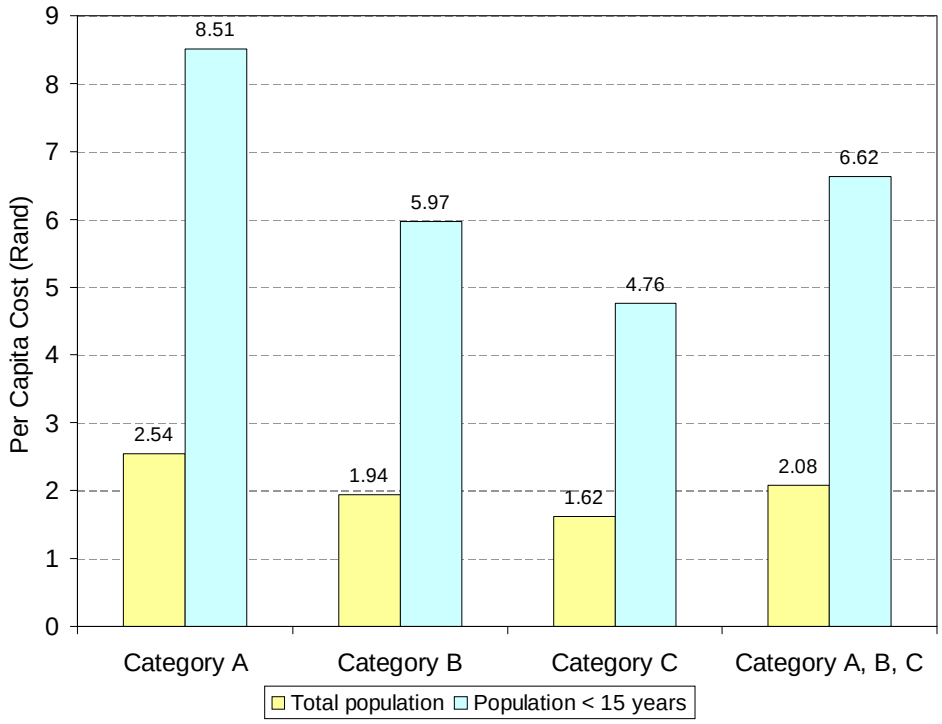


Figure 6: Per capita cost for the total population and those younger than fifteen years for Category A, B and C municipalities and water boards

The average per capita cost of water fluoridation for the total population for all category water providers combined is R2.08 and it ranges from R0.62 (Botshabelo), R0.82 (Amatola Water) and R0.86 (Polokwane) at the lower end to R3.86 (Nelspruit) and R4.09 (Kimberley) at the higher end. The average per capita cost is higher for Category A providers (R2.54) compared to Category B (R1.94) and Category C (R1.62) providers.

Per capita cost for the population younger than fifteen years, which represents 32% of the total population (Statistics South Africa, 2006), ranges from R2.04 (Botshabelo), R2.29 (Polokwane), R2.34 (Amatola Water) and R2.67 (Buffalo City) to R10.43 (Johannesburg), R11.11 (Nelspruit) and R13.08 (Kimberley). The average per capita cost for all category water providers combined is R6.62 with the highest for Category A (R8.51) and lowest for Category C (R4.76) providers.

3.3.3 Cost-effectiveness

In this study cost-effectiveness (cost per person per year to save one DMFT) was calculated for an anticipated caries reduction of 10%, 30% and 50% as a result of the introduction of water fluoridation.

Table 26 presents cost-effectiveness for the total population as well as for those younger than fifteen years. Figure 7 and Figure 8 present the average cost-effectiveness for Category A, B and C municipalities and water boards and well as a combined average for Categories A, B and C water providers for the total population and for those younger than fifteen years.

Table 26: Cost-effectiveness of water fluoridation

Municipality / water board	Total population			Population < 15 years		
	Estimated caries reduction			Estimated caries reduction		
	10%	30%	50%	10%	30%	50%
Category A						
Cape Town	R50.24	R16.75	R10.05	R178.28	R59.43	R35.66
Umgeni Water	R133.77	R44.59	R26.75	R389.76	R129.92	R77.95
Durban/Pietermaritzburg combined	R133.23	R44.41	R26.65	R388.19	R129.40	R77.64
Durban	R124.41	R41.47	R24.88	R362.50	R120.83	R72.50
Rand Water	R102.54	R34.18	R20.51	R387.52	R129.17	R77.50
Johannesburg	R137.23	R45.74	R27.45	R518.64	R172.88	R103.73
Tshwane (Pretoria)	R122.20	R40.73	R24.44	R461.81	R153.94	R92.36
Category A Average	**R114.80**	**R38.27**	**R22.96**	**R383.82**	**R127.94**	**R76.76**
Category B						
Port Elizabeth	R95.84	R31.95	R19.17	R274.37	R91.46	R54.87
Amatola Water	R36.56	R12.19	R7.31	R104.67	R34.89	R20.93
Pietermaritzburg	R144.69	R48.23	R28.94	R421.60	R140.53	R84.32
Bloem Water	R72.32	R24.11	R14.46	R236.71	R78.90	R47.34
Bloemfontein	R78.38	R26.13	R15.68	R256.58	R85.53	R51.32
Kimberley	R127.72	R42.57	R25.54	R408.82	R136.27	R81.76
Category B Average	**R92.58**	**R30.86**	**R18.52**	**R283.79**	**R94.60**	**R56.76**
Category C						
Buffalo City (East London)	R41.77	R13.92	R8.35	R119.59	R39.86	R23.92
Botshabelo	R36.74	R12.25	R7.35	R120.26	R40.09	R24.05
Mafikeng	R71.31	R23.77	R14.26	R222.48	R74.16	R44.50
Nelspruit	R154.27	R51.42	R30.85	R444.31	R148.10	R88.86
Polokwane	R127.20	R42.40	R25.44	R337.85	R112.62	R67.57
Category C Average	**R86.26**	**R28.75**	**R17.25**	**R248.90**	**R82.97**	**R49.78**
Category A, B, C Average	**R99.47**	**R33.16**	**R19.89**	**R313.00**	**R104.33**	**R62.60**

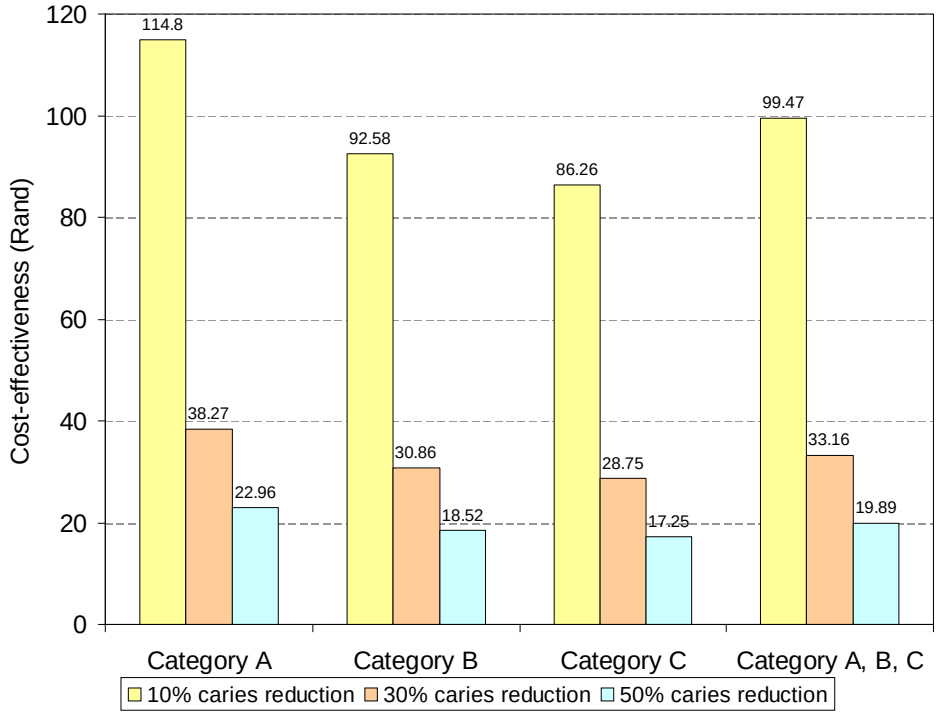


Figure 7: Cost-effectiveness of water fluoridation for the total population for Category A, B and C municipalities and water boards at three anticipated levels of caries reduction

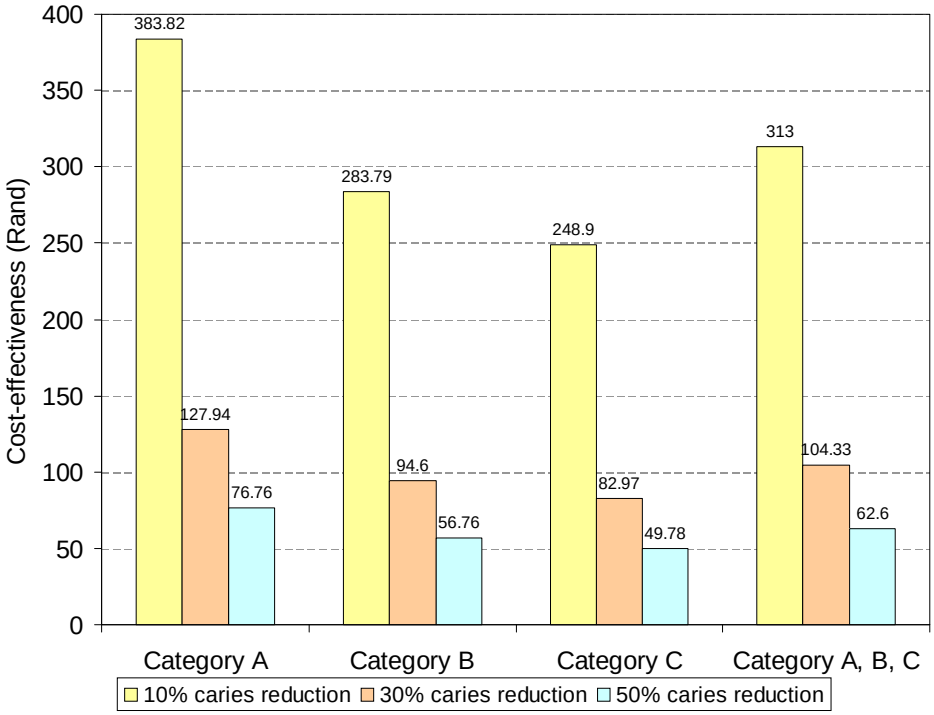


Figure 8: Cost-effectiveness of water fluoridation for those younger than fifteen years for Category A, B and C municipalities and water boards at three anticipated levels of caries reduction

As expected a better cost-effectiveness is achieved when the estimated caries reduction increases. For the total population the average cost-effectiveness for all water providers varies from R19.89 for a 50% caries reduction to R99.47 for a 10% caries reduction. For those younger than fifteen the average cost- effectiveness varies from R62.60 (50% reduction) to R313.00 (10% reduction).

When comparing different categories of water providers, it was slightly more cost-effective to introduce water fluoridation for Category C compared to Category A and B providers for the total population. The difference was larger for those younger than fifteen in favour of Category C providers.

Cost-effectiveness varies from R7.31 (total population) and R20.93 (younger than 15) for a 50% caries reduction for Amatola Water to R154.27 for Nelspruit (total population) and R518.64 for Johannesburg (younger than 15) for a 10% caries reduction.

3.3.4 Cost-benefit

Similar to cost-effectiveness, cost-benefit (the cost of implementing the procedure divided by the savings in the cost of treatment) was also calculated for an anticipated caries reduction of 10%, 30% and 50% as a result of the introduction of water fluoridation.

Cost-benefit for the total population as well as for those younger than fifteen years is presented in Table 27. Figure 9 and Figure 10 present the average cost-benefit for Category A, B and C municipalities and water boards and well as a combined average for Categories A, B and C water providers for the total population and for those younger than fifteen years.

Table 27 : Cost-benefit of water fluoridation

Municipality/ water board	Total population			Population < 15 years		
	Estimated caries reduction			Estimated caries reduction		
	10%	30%	50%	10%	30%	50%
Category A						
Cape Town	0.29	0.10	0.06	1.04	0.35	0.21
Umgeni Water	0.29	0.10	0.06	1.04	0.35	0.21
Durban/Pietermaritzburg combined	0.77	0.26	0.15	2.25	0.75	0.45
Durban	0.72	0.24	0.14	2.10	0.70	0.42
Rand Water	0.60	0.20	0.12	2.25	0.75	0.45
Johannesburg	0.80	0.27	0.16	3.01	1.00	0.60
Tshwane (Pretoria)	0.71	0.24	0.14	2.68	0.89	0.54
Category A Average	**0.60**	**0.20**	**0.12**	**2.05**	**0.68**	**0.41**
Category B						
Port Elizabeth	0.56	0.19	0.11	1.59	0.53	0.32
Amatola Water	0.21	0.07	0.04	0.61	0.20	0.12
Pietermaritzburg	0.84	0.28	0.17	2.45	0.82	0.49
Bloem Water	0.42	0.14	0.08	1.37	0.46	0.27
Bloemfontein	0.46	0.15	0.09	1.49	0.50	0.30
Kimberley	0.74	0.25	0.15	2.37	0.79	0.47
Category B Average	**0.54**	**0.18**	**0.11**	**1.65**	**0.55**	**0.33**
Category C						
Buffalo City (East London)	0.24	0.08	0.05	0.69	0.23	0.14
Botshabelo	0.21	0.07	0.04	0.70	0.23	0.14
Mafikeng	0.41	0.14	0.08	1.29	0.43	0.26
Nelspruit	0.90	0.30	0.18	2.58	0.86	0.52
Polokwane	0.74	0.25	0.15	1.96	0.65	0.39
Category C Average	**0.50**	**0.17**	**0.10**	**1.45**	**0.48**	**0.29**
Category A, B, C Average	**0.55**	**0.18**	**0.11**	**1.75**	**0.58**	**0.35**

Similar to cost-effectiveness cost-benefit is more favourable when the estimated caries reduction increases. For the total population the average cost-benefit for all water providers varies from 0.11 at a 50% caries reduction to 0.55 at a 10% caries reduction. For those younger than fifteen the average cost-benefit varies from 0.35 (50% reduction) to 1.75 (10% reduction) for all categories of water providers combined.

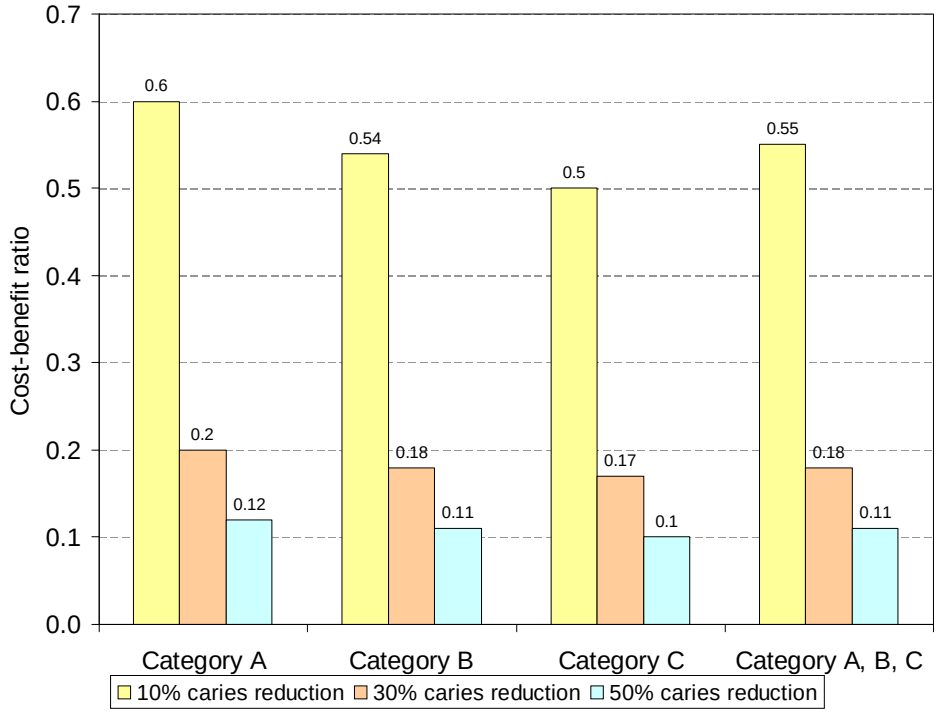


Figure 9: Cost-benefit of water fluoridation for the total population for Category A, B and C municipalities and water boards at three anticipated levels of caries reduction

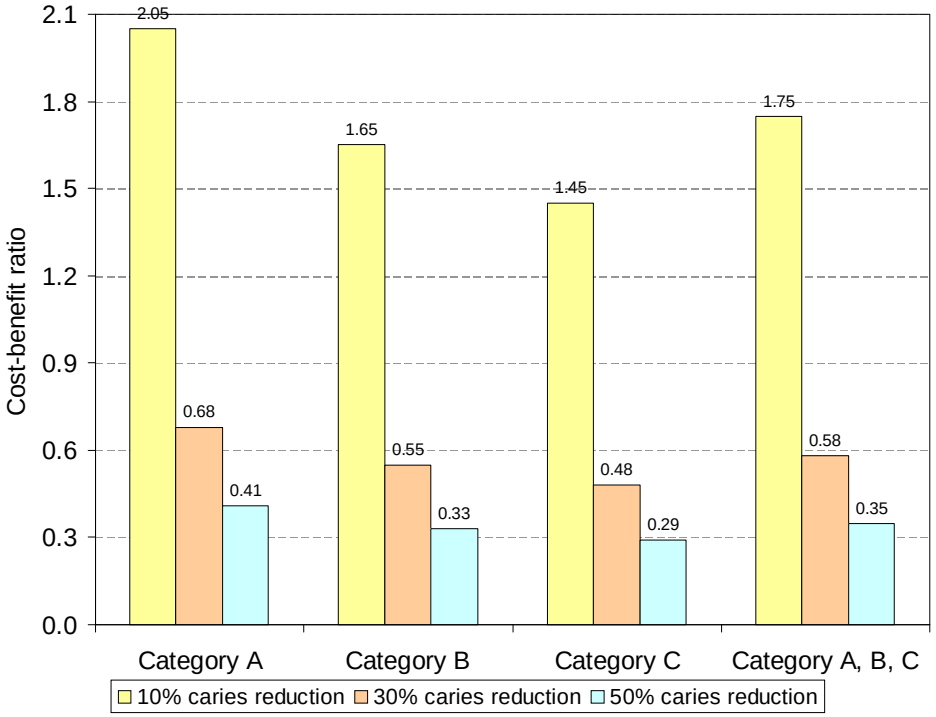


Figure 10: Cost-benefit of water fluoridation for those younger than fifteen years for Category A, B and C municipalities and water boards at three anticipated levels of caries reduction

For the total population cost-benefit exceeded 0.80 for the following municipalities/water boards (all at an estimated caries reduction of 10%):

- Nelspruit: 0.90
- Pietermaritzburg: 0.84
- Johannesburg: 0.80

For those younger than fifteen cost-benefit exceeded 0.80 for the following municipalities/water boards at an estimated caries reduction of 30%:

- Johannesburg: 1.00
- Tshwane (Pretoria): 0.89
- Nelspruit: 0.86
- Pietermaritzburg: 0.82

For those younger than fifteen years cost-benefit exceeded one at an estimated caries reduction of 10% for all municipalities/water boards except:

- Botshabelo: 0.70
- Buffalo City: 0.69
- Amatola Water: 0.61

For the total population cost-benefit did not vary much between different categories of water providers at all estimated caries reduction levels.

3.4 Discussion

3.4.1 Introduction

Water fluoridation is generally regarded as one of the ten greatest public health achievements in the 20th century (Centers for Disease Control and Prevention, 1999). Before 1980 communities with fluoridated water supplies typically experienced 50% less dental caries compared to non-fluoridated communities (Ripa, 1993) during which time economic evaluations of water fluoridation revealed this measure to be highly cost-effective.

Since then caries has declined in both fluoridated and non-fluoridated communities. Both the UK MRC (Medical Research Council, 2002) and University of York reports (NHS Centre for Review and Dissemination, 2000) into water fluoridation concluded that there is a need to extensively research the economic impact of water fluoridation, especially in times of a trend of a reduction in dental caries and exposure to other fluoride products. The 2003 World Oral Health Report confirmed the evidence that long-term exposure to an optimal level of fluoride resulted in diminishing levels of caries in both children and adults (Petersen, 2003). Despite fluoride being available in various delivery systems, only 20% of the world's population benefited from an appropriate exposure to fluoride (World Health Organization, 2006).

Caries prevalence for 12-year-old South African children declined from a mean DMFT of 1.7 in the 1988/89 NOHS (Department of Health, 1994) to 1.05 in the 1999-2002 NCOHS (Department of Health, 2003b) which is very low to low according to the WHO classification (Barmes, 1977).

The 1999-2002 NCOHS report recommended that the implementation of water fluoridation be evaluated for South Africa taking into account current caries levels and the cost of water fluoridation (Department of Health, 2003b).

Despite all this evidence in favour of water fluoridation and a Commission of Inquiry into water fluoridation recommending the fluoridation of public water supplies to the optimal fluoride concentration (Republic of South Africa, 1966), no artificially fluoridated water scheme exists in South Africa. Regulations for the introduction of water fluoridation in South Africa were promulgated on 8 September 2000 (Republic of South Africa, 2000) which compel water providers to fluoridate public water supplies. These regulations were repealed with the repealing of the Health Act of 1977 and have been amended and will follow the normal legal process for approval (Smit, 2007).

Based on the principles of models described by White et al. (1989) and Ringelberg et al. (1992), a model was developed to report on cost-effectiveness and cost-benefit of water fluoridation for Gauteng (Van Wyk et

al., 2001). This model served as the basis for this study to determine per capita cost, cost-effectiveness and cost-benefit of the implementation of water fluoridation for seventeen major metropolitan cities, towns and water boards from all nine South African provinces.

3.4.2 Total and per capita cost of the introduction of water fluoridation

To determine the total cost of the introduction of water fluoridation, cost of chemicals, labour and maintenance as well as opportunity cost and capital depreciation was taken into account.

For all categories of water providers combined, the cost of chemicals contributes 62.4% to the total cost (see Table 24, p 87). For the purpose of this study, fluoride levels of community water supplies for all municipalities and water boards was adjusted to 0.7 ppm which is in line with the recommendation for the optimal fluoride concentration as published in the regulations for the fluoridation of water supplies (Republic of South Africa, 2000).

It is therefore not surprising that for towns where the natural fluoride concentrations in drinking water is higher compared to others (see Table 17, p 73), for example Polokwane (0.47 ppm), Bloemfontein and Bosthabelo (both 0.3 ppm), the contribution of the cost of chemicals is lower (see Table 24, p 87), whereas the cost of labour then increases accordingly.

In general the cost of labour for Category A water providers is much lower (4.1%) compared to Category B (12%) and C (16.1%) providers. Plant operators are required to monitor the process of water fluoridation, irrespective of the daily water purification rate. Whereas water purification rate greatly influences the amount of chemical needed, it has less impact on labour requirements.

Information on the annual salary and benefits of a plant superintendent as well as the number of plant superintendents required to manage the

fluoridation process varied greatly between water providers. To standardise on the number of plant superintendents required per water purification plant, guidelines were developed for this study based on the daily water purification rate of each plant (see Section 3.2.2 a), p 75).

Operating cost is regarded as the cost of chemicals, labour and maintenance combined. For all category water providers combined, operating cost contributes 75.1% to the total cost with little variation between Category A, B and C providers (see Table 24, p 87). Opportunity cost and capital depreciation for all category water provides combined contribute 12.8% and 12.1% respectively to the total cost.

Total cost expressed as a per capita cost varies from R2.54 (Category A) to R1.94 (Category B) and R1.62 (Category C) with an average of R2.08 for all providers combined (See Table 25, p 90). The highest per capita cost is R4.09 (Kimberley) and the lowest R0.82 (Amatola Water) and R0.86 (Polokwane).

Kimberley is classified as a Category B water provider, similar to Bloemfontein. Bloemfontein however has more than double the population compared to Kimberley (see Table 25, p 90), whereas the total cost of the implementation of water fluoridation is slightly lower (R0.72 million) compared to Kimberley (R0.91 million) (see Table 24, p 87). This will obviously impact on the per capita cost for Kimberley (R4.09) compared to Bloemfontein (R1.33).

Amatola Water could not provide information on the population served by them and assumptions had to be made from the 2001 South African census data (Statistics South Africa, 2003) which might still be an overestimation leading to the low per capita cost of R0.82.

Polokwane has a high natural fluoride content (0.47 ppm) compared to the other cities and towns included in this study. This will require much less chemicals to increase the optimal fluoride level to 0.7 ppm. Since chemical

cost is the major contributor to total cost in the majority of cities and towns, it clearly impacts on the per capita cost resulting in a value of only R0.86.

Based on the information provided by municipalities and water boards, populations from towns and cities included in this study represent 53% of the total population of South Africa. There can be no argument that water fluoridation remains the cheapest fluoride vehicle to reach more than 50% of the South African population.

Per capita cost of the implementation of water fluoridation was also expressed for children younger than fifteen years, although it is well recognised that water fluoridation benefits all ages. The average per capita cost for all category water providers for this cohort is R6.62.

Although the actual cost of water fluoridation cannot and should not be ignored, estimates of saving in treatment cost may be more important than per capita cost. Health economists at the conclusion of a 1989 workshop in Michigan concluded that water fluoridation was one of only a few public health measures where it actually saved more money than it cost to operate (Anonymous, 1989).

Traditionally communities with populations as low as 1,000 have been considered as unfavourable for the introduction of water fluoridation. Birch (1990) concluded that caries reduction as a result of water fluoridation in the UK would cost four times as much in a low caries area compared to a high caries area, suggesting that considerable economies of scale exist in terms of the reduction in cost per unit of benefit as population size increases. Technological advances are however resulting in new and more cost-effective options in its delivery. Wright et al. (2001) still regarded water fluoridation as cost-saving for New Zeeland communities of 1,000 residents or above. A study in the Northern Territory of Australia concluded that an investment in fluoridation plants for remote Indigenous Australian communities of approximately 1,500 residents should lead to a substantial and significant

improvement in oral health in the medium to long run (Ehsani and Bailie, 2007).

3.4.3 Cost-effectiveness

Cost-effectiveness expressed as the cost per person per year to save one DMFT was calculated for an anticipated caries reduction of 10%, 30% and 50% as a result of the introduction of water fluoridation.

With low caries prevalence levels experienced in South Africa it would be unrealistic to expect a 50% caries reduction with the introduction of water fluoridation, similarly, if a caries reduction of only 10% is achieved, it will be considered as disappointing. It therefore seems appropriate to expect a caries reduction of 30% with the introduction of water fluoridation.

At an anticipated caries reduction of 30%, it would cost R33.16 to save one DMFT for all categories of water providers combined (see Table 26, p 92). Cost-effectiveness is higher for Category A providers (R38.27) compared to Category B (R30.86) and C (R28.75) providers. The lowest values were found for Amatola Water (R12.19), Botshabelo (R12.25), Buffalo City (R13.92) and Cape Town (R16.75). The highest values were found for Nelspruit (R51.42), Pietermaritzburg (R48.23) and Johannesburg (R45.74).

An estimated decrease in DMFT per child per year, calculated from the DMFT increment per year (see Table 14, p 68), linked to the per capita cost of introducing water fluoridation, are determining variables to calculate cost-effectiveness. DMFT values for 15-year-olds, as reported in the 1999-2002 NCOHS (Department of Health, 2003b) were used in this study (see Table 22, p 84).

The combined effect of these two variables leading to the lower cost-effectiveness values can clearly be seen for Cape Town (DMFT for 15-year-olds of 4.05) (see Table 22, p 84), Buffalo City, Amatola Water (both with a DMFT value of 2.01), and Botshabelo (DMFT of 1.53). Per capita cost for the

introduction of water fluoridation (see Table 25, p 90) is R2.26 for Cape Town, R0.82 for Amatola Water, R0.93 for Buffalo City and R0.62 for Botshabelo.

The opposite is also true where a different combination of DMFT at age fifteen and per capita cost led to the highest cost-effectiveness values for Nelspruit (DMFT 2.25; R3.86), Pietermaritzburg (DMFT 1.26; R2.03) and Johannesburg (DMFT 1.81; R2.76).

Despite higher cost-effective values for some cities and towns, the cost per person per year to save one DMFT for all municipalities and water boards, provided a caries reduction of at least 30% can be achieved as a result of the introduction of water fluoridation, is way below the average cost of R172.73 to restore a two surface restoration (see Table 23, p 86) (Council for Medical Schemes, 2006).

3.4.4 Cost-benefit

Cost-effectiveness and cost-benefit analysis frequently overlap and are sometimes difficult to distinguish. Similar to cost-effectiveness, cost-benefit expressed as the cost of implementing the procedure divided by the savings in the cost of treatment was also calculated for an anticipated caries reduction of 10%, 30% and 50% as a result of the introduction of water fluoridation. As explained in the previous section, only the results for an anticipated 30% caries reduction will be discussed in detail. Should the cost-benefit ratio approach one or be larger than one, this measure should not be considered.

Water fluoridation is most effective in preventing dental caries on the interproximal, buccal and lingual surfaces with limited effect on occlusal surfaces (Abernathy et al., 1986). For this study it was estimated that a saving of one DMFT equalled the cost of a 2 surface restoration (White et al., 1989). The cost to restore a two surface restoration (see Table 23, p 86) of R172.73 was used to calculate cost-benefit (Council for Medical Schemes, 2006).

At an anticipated caries reduction of 30%, the average cost-benefit for all categories of water providers is 0.18 with little variation between the different categories of water providers (see Table 27, p 95). The lowest values were found for Amatola Water (0.07), Botshabelo (0.07) and Buffalo City (0.08) with the cost-benefit for Cape Town and Umgeni Water (both Category A providers) calculated as 0.1. The highest values were found for Nelspruit (0.3), Pietermaritzburg (0.28) and Johannesburg (0.27).

Similar to cost-effectiveness an estimated decrease in DMFT per child per year calculated from the DMFT increment per year (see Table 14, p 68), linked to the per capita cost of introducing water fluoridation, are determining variables to calculate cost-benefit. The same cities and towns with the lowest and highest cost-effectiveness therefore also present with the lowest and highest cost-benefit ratios.

Results from this study indicate that if an caries reduction of at least 30% can be achieved through the introduction of water fluoridation, cost-benefit does not exceed 0.3 for any municipality or water board.

Even at an anticipated caries reduction of 10%, the average cost-benefit for all categories of water providers is 0.55 (see Table 27, p 95). Cost-benefit only equals or exceeds 0.8 for Nelspruit (0.9), Pietermaritzburg (0.84) and Johannesburg (0.8) at the 10% caries reduction level.

3.5 Summary

This chapter presented a model, results and discussion of the total and per capita cost, cost-effectiveness and cost-benefit of the implementation of water fluoridation for seventeen major metropolitan cities, towns and water boards from all nine South African provinces.

The average per capita cost of water fluoridation for the total population is R2.08. It ranges from R0.62 (Botshabelo), R0.82 (Amatola Water) and

R0.86 (Polokwane) at the lower end to R4.09 (Kimberley) and R3.86 (Nelspruit).

Per capita cost for the population younger than fifteen years ranges from R2.04 (Botshabelo), R2.34 (Amatola Water) and R2.67 (Buffalo City) to R10.43 (Johannesburg), R13.08 (Kimberley) and R11.11 (Nelspruit). The average per capita cost for all category water providers combined for this age cohort is R6.62.

Cost-effectiveness (cost per person per year to save one DMFT) and cost-benefit (the cost of implementing the procedure divided by the savings in the cost of treatment) was calculated for anticipated caries reductions of 10%, 30% and 50% as a result of the introduction of water fluoridation. For the total population average cost-effectiveness varies from R19.89 for a 50% caries reduction to R99.47 for a 10% caries reduction. For the total population the average cost-benefit varies from 0.11 for a 50% caries reduction to 0.55 for a 10% caries reduction. Cost-benefit equals or exceeds 0.8 for only three municipalities or water boards at an anticipated 10% caries reduction as a result of the implementation of water fluoridation.

Chapter 4 will describe a model, results and discussion of the per capita cost of delivering the minimum package of oral care to 4- to 15-year-old South African children.

CHAPTER 4: COST EVALUATION OF DELIVERING THE MINIMUM PACKAGE OF ORAL CARE TO SOUTH AFRICAN CHILDREN

4.1 Introduction

This chapter describes a model to express the delivery of the minimum package of oral health care to 4- to 5-, 6-, 12 and 15-year-olds as a per capita cost. The minimum package of oral care (see Table 13, p 64) consists of an annual examination, bitewing radiographs, cleaning of teeth (prophylaxis), one to three surface restorations, fissure sealants, emergency relief of pain and infection control (Department of Health, 2001a; Pick et al., 2001).

4.2 A model to calculate the per capita cost of delivering the minimum package of oral care

Since it is not possible to calculate the direct costs involved in delivering the minimum package of oral care, this model converts treatment need data from the 1999-2002 NCOHS (Department of Health, 2003b; Van Wyk et al., 2004) to a per capita cost by applying the 2006 NRPL (Council for Medical Schemes, 2006) and UPFS (Gauteng Provincial Government, 2005) treatment fees. All calculations were done on a national level as well as for all nine South African provinces.

Table 28 presents all the input variables used in the model. Each variable has been allocated a unique number (in square brackets) which indicates where it is used in the different formulas.

Microsoft Excel software was used to computerise this model. An example of the model applied to the 15-year-old age cohort is presented in Annexure 3.

Table 28: A model to calculate per capita cost of delivering the minimum package of oral care

Variable	Formula
[1] Population size	
[2] Treatment need	
[3] Treatment fee	
[4] Monetary value for each treatment need type	[1] x [2] x [3]
[5] Total expense to address treatment need	
[6] Total per capita cost to address treatment need	[5] / [1]
[7] % of total cost for each treatment need type	[4] / [5] x 100
[8] Per capita cost of each treatment need type	[6] x [7] / 100

4.2.1 Population size (Variable [1])

The 2006 South African mid-year population estimates by age and sex (national and per province) were used in this study (Statistics South Africa, 2006). Since these population estimates were published in five year age intervals, the mean value for each age interval was used to calculate the population estimates for the respective age cohorts.

Table 29 presents the population estimates for 4- to 5-, 6-, 12- and 15-year-olds as used in this study.

Table 29: 2006 South African mid-year population estimates by province (Statistics South Africa, 2006)

Province	4- to 5-year-olds	6-year-olds	12-year-olds	15-year-olds
Western Cape	182,980	90,540	84,440	84,980
Northern Cape	38,600	19,500	18,280	17,140
Eastern Cape	312,260	155,920	180,340	174,720
Free State	119,940	60,220	60,840	62,040
KwaZulu-Natal	440,360	220,320	227,620	215,760
Gauteng	348,300	159,460	139,080	139,400
North West	167,900	81,040	79,420	76,980
Mpumalanga	151,180	76,720	74,700	71,600
Limpopo	273,800	138,700	153,240	144,980
National	**2,035,320**	**1,002,420**	**1,017,960**	**987,600**

4.2.2 Treatment need (Variable [2])

Treatment need related to dental caries for children in the age groups 4 to 5, 6, 12 and 15 from the 1999-2002 NCOHS was presented as the percentage of children and the mean number of teeth needing care. Periodontal diseases

was also included in this survey for 15-year-olds only. Although this was a national oral survey, two of the provinces (Gauteng and Limpopo) conducted their own surveys independent from the national survey (Department of Health, 2003b).

Due to financial and human resource constraints the survey was only executed in one of the regions of the Eastern Cape province. For various reasons the survey was only conducted in two of the five regions of Gauteng and in three of the five regions of the Northern Cape. No 4- to 5-year-old children were included in the Northern Cape survey (Department of Health, 2003b).

Analysis of the data was conducted by STATOMET by combining the datasets from all province. When access to the 1999-2002 NCOHS dataset was requested for the purpose of this study, the datasets for Gauteng and Limpopo could not be retrieved. Treatment need data for these two provinces was therefore limited to those reported in the publications of the NCOHS (Department of Health, 2003b).

For the purpose of this study a new mean weighted national value was calculated from the data for those provinces for which this information was available. This new mean weighted national value was then used for those provinces where data could not be retrieved or was not available. An example of how this weighted national value was calculated is presented in Table 30.

Table 30: Example of calculation of mean weighted national values

This example is for the percentage of 4- to 5-year-old children in need of care

		A	B	C
	Province	**Population size**	**% needing care**	**Weighted value**
1	Western Cape	155,005.60	73.2	11,346,409.92
2	Northern Cape		48.1	
3	Eastern Cape	78,536.87	54.4	4,272,405.73
4	Free State	131,102.90	59.7	7,826,843.13
5	KwaZulu-Natal	406,712.90	43.7	17,773,353.73
6	Gauteng		43.0	
7	North West	153,986.60	33.6	5,173,949.76
8	Mpumalanga	170,585.60	36.9	6,294,608.64
9	Limpopo		30.1	
10	**National**	1,095,930.47	**48.1**	52,687,570.91

Notes:

- Values in Column A are the population sizes which were used by STATOMET to calculate the original mean national weighted values
- Values in Column B for provinces were obtained from either NCOHS reports or the STATOMET database (except those in the cells shaded grey – see later). For this example no data was available for Northern Cape as 4- to 5-year-olds were not included in the survey for this province
- Values in Cells C1 to C9 for each province are calculated by applying the formula:
  Population size (Column A) x Treatment need value (Column B)
- The value in Cell C10 represents the sum of the weighted values for all provinces (Cells C1 to C9)
- Value in Cell B10 is the mean national weighted value and is calculated by applying the formula:
  Sum of weighted values (Cell C10) / National population size (Cell A10)
- This new mean national weighted value is used for those provinces where this information was not available, in this example Northern Cape (indicated in shaded grey)

Table 31 presents data of the percentage of children in need of treatment and Table 32 data of the mean number of teeth in need of treatment. The national value was calculated as explained in Table 30. Where the mean national value was used for provinces where this data was not available from the STATOMET database or reports, it is indicated in shaded grey.

Table 31: Percentage treatment need for 4- to 5-, 6-, 12- and 15-year-olds for all provinces

Province	Population size (STATOMET)	% needing care	Preven-tive care	Fissure sealants	1 surface restoration	2 or more surface restoration	Extrac-tion
4- to 5-year-olds							
Western Cape	155,005.6	73.2	8.8	21.9	29.5	35.3	31.4
Northern Cape		48.1	10.2	7.3	22.7	16.7	19.8
Eastern Cape	78,536.9	54.4	23.7	0	33.1	13.8	22.4
Free State	131,102.9	59.7	4.6	7.0	34.2	15.0	28.7
KwaZulu-Natal	406,712.9	43.7	12.6	7.7	15.7	12.6	21.6
Gauteng		43.0	10.2	7.3	22.7	16.7	19.8
North West	153,986.6	33.6	6.7	3.2	23.3	10.4	4.5
Mpumalanga	170,585.6	36.9	6.7	0.5	18.8	18.0	10.8
Limpopo		30.1	10.2	7.3	22.7	16.7	19.8
National	**1,095,930.5**	**48.1**	**10.2**	**7.3**	**22.7**	**16.7**	**19.8**
6-year-olds							
Western Cape	78,268.6	86.3	5.1	52.2	27.8	34.7	47.3
Northern Cape	9,110.4	85.1	3.0	17.7	47.4	53.7	52.3
Eastern Cape	39,349.4	66.6	23.7	5.9	32.9	18.1	32.6
Free State	70,288.4	65.9	8.0	22.0	32.7	15.7	30.6
KwaZulu-Natal	201,350.4	62.3	11.5	34.9	17.1	15.4	28.2
Gauteng		62.5	9.8	25.0	24.5	20.1	28.0
North West	77,224.1	39.6	7.5	10.4	21.9	15.4	10.2
Mpumalanga	84,327.3	51.3	8.1	1.6	28.1	22.8	18.9
Limpopo		35.5	9.8	25.0	24.5	20.1	28.0
National	**559,918.5**	**62.0**	**9.8**	**25.0**	**24.5**	**20.1**	**28.0**
12-year-olds							
Western Cape	78,834.5	80.5	3.9	47.9	37.9	20.2	19.6
Northern Cape	9,297.2	57.4	2.0	5.1	30.3	22.2	18.3
Eastern Cape	28,105.7	38.5	0.9	3.4	22.5	11.5	16.9
Free State	62,643.6	58.2	14.3	27.9	28.7	8.1	14.2
KwaZulu-Natal	148,347.1	52.3	8.6	31.6	18.2	11.3	12.1
Gauteng		61.6	8.1	23.8	23.4	11.1	12.4
North West	75,559.6	29.8	9.7	9.1	16.7	5.0	4.1
Mpumalanga	70,972.5	39.2	7.9	3.3	20.2	8.3	9.9
Limpopo		14.1	8.1	23.8	23.4	11.1	12.4
National	**473,760.2**	**51.5**	**8.1**	**23.8**	**23.4**	**11.1**	**12.4**

Table 31: (continued)

Province	Population size (STATOMET)	% needing care	Preven-tive care	Fissure sealants	1 surface restoration	2 or more surface restoration	Extrac-tion
15-year-olds							
Western Cape	73,851.9	85.2	3.3	42.2	56.6	26.6	26.2
Northern Cape	6,702.3	62.2	2.0	4.6	39.6	31.5	23.5
Eastern Cape	27,872.0	49.7	7.2	1.7	34.0	9.1	16.0
Free State	58,373.1	66.6	3.8	26.0	43.0	12.3	11.7
KwaZulu-Natal	265,310.4	59.0	10.8	22.7	25.0	13.2	12.2
Gauteng		47.1	9.2	20.4	31.7	13.8	12.6
North West	71,518.1	31.3	12.3	8.3	20.8	6.9	3.7
Mpumalanga	64,747.6	44.9	12.4	4.0	30.8	11.1	7.1
Limpopo		24.1	9.2	20.4	31.7	13.8	12.6
National	**568,375.3**	**57.7**	**9.2**	**20.4**	**31.7**	**13.8**	**12.6**

Table 32: Treatment need per tooth for 4- to 5-, 6-, 12- and 15-year-olds for all provinces

Province	Population size (STATOMET)	Mean no. of teeth needing care	Preven-tive care	Fissure sealants	1 surface restoration	2 or more surface restoration	Extrac-tion
4-to 5-year-olds							
Western Cape	155,005.6	3.9	0.3	0.9	0.6	0.9	1.2
Northern Cape		2.5	0.4	0.2	0.6	0.5	0.8
Eastern Cape	78,536.9	2.5	0.6	0	0.7	0.3	0.9
Free State	131,102.9	2.7	0.1	0.2	0.8	0.3	1.2
KwaZulu-Natal	406,712.9	2.1	0.4	0.2	0.4	0.4	0.7
Gauteng		1.4	0.3	0.2	0.6	0.5	0.1
North West	153,986.6	2.0	0.7	0.1	0.6	0.2	0.1
Mpumalanga	170,585.6	2.2	0.2	0.0	0.6	0.6	0.7
Limpopo		0.8	0.0	0.2	0.6	0.5	0.3
National	**1,095,930.5**	**2.5**	**0.4**	**0.2**	**0.6**	**0.5**	**0.8**

Table 32: (continued)

Province	Population size (STATOMET)	Mean no. of teeth needing care	Preven-tive care	Fissure sealants	1 surface restoration	2 or more surface restoration	Extrac-tion
6-year-olds							
Western Cape	78,268.6	5.2	0.1	2.0	0.5	0.9	1.7
Northern Cape	9,110.4	4.7	0.1	0.6	0.9	1.3	1.5
Eastern Cape	39,349.4	3.2	0.7	0.2	0.6	0.4	1.3
Free State	70,288.4	3.1	0.2	0.7	0.8	0.3	0.9
KwaZulu-Natal	201,350.4	3.2	0.3	1.2	0.4	0.4	0.9
Gauteng		2.8	0.9	0.9	0.6	0.5	0.3
North West	77,224.1	2.4	0.6	0.4	0.5	0.4	0.2
Mpumalanga	84,327.3	3.0	0.2	0.0	1.0	0.6	1.0
Limpopo		1.5	0.1	0.9	0.6	0.5	0.8
National	**559,918.5**	**3.3**	**0.3**	**0.9**	**0.6**	**0.5**	**1.0**
12-year-olds							
Western Cape	78,834.5	5.3	0.1	3.7	0.7	0.4	0.3
Northern Cape	9,297.2	1.8	0.0	0.2	0.7	0.4	0.3
Eastern Cape	28,105.7	0.9	0.0	0.1	0.3	0.2	0.2
Free State	62,643.6	5.9	1.5	3.0	0.7	0.1	0.2
KwaZulu-Natal	148,347.1	3.2	0.3	2.1	0.4	0.2	0.2
Gauteng		4.0	3.3	1.8	0.5	0.2	0.2
North West	75,559.6	2.1	1.0	0.6	0.3	0.1	0.1
Mpumalanga	70,972.5	1.8	0.2	0.1	0.7	0.3	0.4
Limpopo		0.4	0.1	1.8	0.5	0.2	0.1
National	**473,760.2**	**3.4**	**0.5**	**1.8**	**0.5**	**0.2**	**0.2**
15-year-olds							
Western Cape	73,851.9	6.2	0.1	3.4	1.6	0.5	0.5
Northern Cape	6,702.3	2.8	0.0	0.1	1.3	0.7	0.4
Eastern Cape	27,872.0	2.2	1.1	0.0	0.6	0.1	0.3
Free State	58,373.1	4.6	0.4	2.2	1.3	0.3	0.2
KwaZulu-Natal	265,310.4	3.7	0.4	1.5	0.6	0.3	0.2
Gauteng		2.7	1.6	1.5	0.8	0.3	0.1
North West	71,518.1	2.6	1.4	0.5	0.4	0.1	0.1
Mpumalanga	64,747.6	1.9	0.3	0.1	0.9	0.3	0.1
Limpopo		0.8	0.1	1.5	0.8	0.3	0.3
National	**568,375.3**	**3.7**	**0.5**	**1.5**	**0.8**	**0.3**	**0.2**

Periodontal disease for 15-year-old children in South Africa was determined in the 1999-2002 NCOHS with the Community Periodontal Index (CPI) and was reported as the percentage of sextants (prevalence) and the mean number of sextants (severity) with the highest score being either healthy, bleeding, calculus, shallow pockets or deep pockets (Department of Health, 2003b).

A study conducted in Kenya extrapolated findings from a survey of children during which the Community Periodontal Index of Treatment Need (CPITN) was used to the population to calculate human resources required to treat the child population in Kenya (Manji and Sheiham, 1986). This study concluded that the uses of CPITN data for human resources planning leads to excessive and unrealistic requirements.

Fifteen years after the creation of the CPITN, a workshop was convened in Manila, Philippines, to consider the strengths and weaknesses of this index. It was recognised that the use of CPITN to determine treatment need led to unrealistic requirements which cannot be met (Page and Morrison, 1994). The conclusions of the workshop state that bleeding and calculus should be reported separately from pocketing. When used for public health planning, data must be expressed clearly and in such a way to enable the outcomes to be evaluated.

This study recognises the limitations of the use of CPI data in health systems planning. Results as found in this study should therefore be read in this light.

For the purpose of this study it was assumed that no periodontal care would be required for the 4- to 5-year-old cohort. Since no data was available for periodontal treatment need of 6- and 12-year-old children, the data for the 15-year-olds was used for these two age cohorts as well.

Periodontal treatment need data as used in this study is presented in Table 33. The mean national value was used for Gauteng as periodontal disease was not included in the survey for 15-year-olds for this province.

Table 33: Prevalence and severity of periodontal disease (bleeding and calculus only) for 15-year-old South African children (Department of Health, 2003b)

Province	Prevalence: percentage of sextants			Severity: mean number of sextants		
	Bleeding	Calculus	Total	Bleeding	Calculus	Total
Weighted national mean	15.3	59.9	75.2	1.14	2.17	3.31
Western Cape	20.1	63.6	83.7	1.43	1.84	3.27
Northern Cape	30.7	34.2	64.9	1.45	0.85	2.3
Eastern Cape	3.9	80.3	84.2	0.26	2.62	2.88
Free State	6.1	56.3	62.4	0.99	2.96	3.95
KwaZulu-Natal	17.3	55.1	72.4	1.34	2.23	3.57
Gauteng	15.3	59.9	75.2	1.14	2.17	3.31
North West	19.3	47.7	67.0	1.1	1.47	2.57
Mpumalanga	17.3	50.9	68.2	0.75	1.22	1.97
Limpopo	22.0	56.0	78.0	1.98	2.43	4.41

Table 34 indicates whether the percentage of the population or the mean number of teeth/sextants data were used in this study to convert the treatment need to a per capita monetary value.

Table 34: Treatment need values used in this study

Oral health procedure	Treatment need value used in calculations
Oral examination	Total population
Two bitewing radiographs	Total population
Prophylaxis	Mean number of sextants with bleeding and calculus
Consultation	% of population needing care
Preventive care	% of population in need
Dental sealants	Mean number of teeth in need
One surface restoration	Mean number of teeth in need
Two or more surface restoration	Mean number of teeth in need
Extraction	Mean number of teeth in need

4.2.3 Treatment fees (Variable [3])

a) The National Reference Price List (NRPL)

The NRPL is published annually by the Council for Medical Schemes and is intended to serve as a baseline against which medical schemes and health service providers can determine benefit levels or fees charged to patients (Council for Medical Schemes, 2006).

The respective 2006 NRPL procedure descriptions, codes and fees used in this study are presented in Table 36.

b) The Uniform Patient Fee Schedule (UPFS)

The UPFS was developed by the Department of Health to provide a simpler charging mechanism for publicly funded facilities and replaced the itemised billing approach with a grouped fee approach with the intention to reduce the amount of items that appear on bills but to still reflect the value of the service being provided. It was adopted as policy by the Department of Health in November 2000 and is updated on an annual basis (Department of Health, 2006b).

UPFS tariffs are determined by the procedure category, the type of facility where the service is provided, the type of health professional delivering the procedure and the patient classification which is based on income.

- **Procedure classification**

  All procedures linked to the provision of the minimum package of oral care are classified as either category A or B procedures. The UPFS category for the various oral health procedures used in this study related to the corresponding NRPL code are presented in Table 36.

- **Facility classification**

  The UPFS classifies public facilities are either Level 1 (District Health or Primary Health Centres), Level 2 (Regional or Community Health Centres) or Level 3 (Special hospitals or Tertiary Health Centres).

  For the purpose of this study it was assumed that the oral health services provided as part of the minimum package of oral care would be delivered from a Level 1 and Level 2 facility. There is no difference in UPFS fees between Level 1 and Level 2 facilities.

- **Health professional classification**

  UPFS categories of health care professionals for the delivery of oral health service include General Dental Practitioners, Specialist Dental Practitioners and Allied Health Practitioners which includes Oral Hygienists and Dental Therapists.

  For the purpose of this study it was assumed that the oral health services provided as part of the minimum package of oral care would be delivered by either a dentist, oral hygienist or dental therapist.

- **Patient classification**

  Patients are classified according to income and fees are charged according to these categories:

  HG en H0: Includes social pensioners and the formally unemployed. All services are provided free with no facility or professional fees charged.

  H1: Low income (<R36,000 per individual or <R50,000 per household per year). Only a consultation fee is charged.

  H2: Middle income (<R72,000 per individual or <R100,000 per household per year). A consultation and procedure fee is charged.

  HG: High income: (>R72,000 per individual or >R100,000 per household per year). A consultation and procedure fee is charged.

  For the purpose of this study results are only presented for the middle (H2) and high income (HG) groups.

All tariffs (with the exception of anaesthesia) are divided into:

- A **facility fee** which reflects the overhead costs of providing the environment in which the health care service is delivered;
- A **professional fee** which is structured to reflect the costs of health care professionals delivering the service. These fees are charged whenever the health care professional employed by the applicable provincial health department provides the service; and

- A **consultation fee** depending on the category of health care professional providing the service.

The UPFS fees according to the procedure category (see Table 36), the oral health professional delivering the service and the patient income category are presented in Table 35 (Gauteng Provincial Government, 2005).

Table 35: UPFS oral health procedure and consultation fees for middle (H2) and high (HG) income patients (Gauteng Provincial Government, 2005)

UPFS Code	Procedure Category (see Table 36)	Oral Health Professional	Fee Type	Fee (H2 / HG)	Combined facility/professional fee for a Level 1 or 2 facility (H2 / HG)
Oral health procedure fees					
0910	A		Facility	R5.00 / R14.00	
0911		Dentist	Professional	R10.00 / R24.00	R15.00 / R38.00
0914		Oral Hygienist/ Dental Therapist		R10.00 / R19.00	R15.00 / R33.00
0920	B		Facility	R20.00 / R43.00	
0921		Dentist	Professional	R25.00 / R47.00	R45.00 / R90.00
0924		Oral Hygienist/ Dental Therapist		R20.00 / R38.00	R40.00 / R81.00
Consultation fees					
1010			Facility	R30.00 / R46.00	
1011		Dentist	Professional	R35.00 / R51.00	R65.00 / R97.00
1014		Oral Hygienist/ Dental Therapist		R20.00 / R31.00	R50.00 / R77.00

The UPFS category for the various oral health procedures used in this study related to the corresponding NRPL code as well as the fee and the appropriate oral health professional responsible for delivering the procedure are presented in Table 36.

For the purpose of this study an average NRPL fee calculated from the codes for a one surface restoration of R138.60 and for a two or more surface restoration of R202.99 were used in this model.

Similarly for the UPFS an average consultation fee of R57.50 for H2 and R87.00 for HG income categories was calculated from the consultation fees for an oral hygienist/dental therapist and a dentist.

Table 36: NRPL and UPFS fees used in this study

	NRPL		UPFS				
Procedure description	**Code**	**Fee**	**Code (see Table 35)**	**Category**	**Oral health professional**	**Fee (see Table 35)**	
						Middle income (H2)	**High income (HG)**
Consultation			1014		Oral hygienist/ Dental Therapist	R50.00	R77.00
Consultation			1011		Dentist	R65.00	R97.00
Average consultation fee (1014, 1011)						R57.50	R87.00
Oral examination - GDP	8101	R103.50	0924	B	Oral hygienist/ Dental Therapist	R40.00	R81.00
Intra-oral radiograph - bitewing	8112	R41.90	0914	A	Oral hygienist/ Dental Therapist	R15.00	R33.00
Prophylaxis - complete dentition	8159	R124.90	0924	B	Oral hygienist/ Dental Therapist	R40.00	R81.00
Topical application of fluoride - child	8161	R63.60	0924	B	Oral hygienist/ Dental Therapist	R40.00	R81.00
Dental sealant	8163	R41.90	0914	A	Oral hygienist/ Dental Therapist	R15.00	R33.00
Amalgam - one surface	8341	R126.50		B			
Resin - one surface, anterior	8351	R138.80		B			
Resin - one surface, posterior	8367	R150.50		B			
Average one surface restoration fee (Codes 8341, 8351, 8367)		R138.60	0921	B	Dentist	R45.00	R90.00
Amalgam - two surfaces	8342	R155.90		B			
Amalgam - three surfaces	8343	R190.00		B			
Amalgam - four or more surfaces	8344	R211.80		B			
Resin - two surfaces, anterior	8352	R174.60		B			
Resin - three surfaces, anterior	8353	R208.70		B			
Resin - four or more surfaces, anterior	8354	R232.70		B			
Resin - two surfaces, posterior	8368	R186.20		B			
Resin - three surfaces, posterior	8369	R225.00		B			
Resin - four or more surfaces, posterior	8370	R242.00		B			
Average two or more surface restoration fee (Codes 8342-8344, 8351-8354, 8368-8370)		R202.99	0921	B			
Extraction - tooth or exposed tooth roots (first per quadrant)	8201	R63.60	0921	B			

A summary of the treatment need variable (percentage or mean number of teeth/sextants) and the respective NRPL and UPFS code and fees used in this study to determine per capita cost of delivering the minimum package of oral care are presented in Table 37.

Table 37: Summary of treatment need variables and NRPL/UPFS codes and fees used in this study

Oral health procedure	Treatment need value used in calculations (See Table 34)	NRPL code (See Table 36)	UPFS code (H2/HG) (See Table 36)
Oral examination	Total population	8101: R103.50	0924: R40.00/R81.00
Two bitewing radiographs	Total population	8112: R41.90	0914: R15.00/R33.00
Prophylaxis	Mean no. of sextants	8159: R124.90	0924: R40.00/R81.00
Consultation	% of population in need of care		Average UPFS consultation fee: R57.50/ R87.00
Preventive care	% of population	8161: R63.60	0924: R40.00/R81.00
Dental sealants	Mean no. of teeth	8163: R41.90	0914: R15.00/R33.00
One surface restoration	Mean no. of teeth	Average 1 surface restoration fee: R138.60	0921: R45.00/R90.00
Two or more surface restoration	Mean no. of teeth	Average 2 or more surface restoration fee: R202.99	0921: R45.00/R90.00
Extraction	Mean no. of teeth	8201: R63.60	0921: R45.00/R90.00

Since UPFS fees are identical for an oral hygienist/dental therapist, it was assumed that both will be responsible for the oral examination, bitewing radiographs, prophylaxis, fluoride treatment and placement of fissure sealants while a dentist will be responsible for the restorative procedures and extractions.

A prophylaxis was not included in the calculations for the 4- to 5-year-old cohort as it was assumed that this age cohort would not be in need of this treatment.

4.2.4 Monetary value for each treatment need type (Variable [4])

The formula applied to convert each of the treatment need types to a monetary value was:

Population size x Treatment need x Treatment fee

4.2.5 Total expense to address treatment need (Variable [5])

This was calculated by adding all the monetary values for each treatment need type.

4.2.6 Total per capita cost to address treatment need (Variable [6])

This was calculated by applying the formula:

Total expense to address treatment need / Population size

4.2.7 Percentage of total cost for each treatment need type (Variable [7])

The monetary value for each treatment need type was expressed as a percentage of the total expense to address treatment need by applying the formula:

Monetary value for each treatment need type / Total expense to address treatment need x 100

4.2.8 Per capita cost of each treatment need type (Variable [8])

The monetary value for each treatment need type was converted to a per capita cost by applying the formula:

Total per capita cost to address treatment need x % of total cost for each treatment need type

4.3 Results

Per capita cost of delivering the minimum package of oral care per province and on a national level, based on treatment need and the NRPL and UPFS fees for middle and high income earners as explained in the previous section, were calculated for 4- to 5-, 6-, 12- and 15-year olds.

Assuming caries reductions of 10%, 30% and 50% as a result of the implementation of water fluoridation, treatment need expressed as a percentage of the population or the mean number of teeth in need of treatment (see Table 31, p 110 and Table 32, p 111) were adjusted

accordingly. Per capita cost of delivering the minimum package of oral care was calculated based on these reduced treatment needs to determine the impact of the introduction of water fluoridation.

For all calculations the cost of an oral examination and two bitewing radiographs was calculated for the total population and therefore remains unchanged as this would not be affected by a reduction in dental caries as a result of the implementation of water fluoridation. The mean number of sextants in need of a scaling (bleeding and calculus) also remain unchanged as this is not affected by the implementation of water fluoridation either.

Treatment need types were grouped as follows and the contribution of each group in terms of cost and the percentage of the total per capita cost was expressed accordingly:

- Examination and bitewing radiographs;
- Prophylaxis;
- Topical fluoride application and fissure sealants; and
- One surface restorations, two or more surface restorations and extractions.

Table 38 presents the per capita cost on a national level to deliver the minimum package of oral care to each of the age cohorts included in this study. The average per capita cost was calculated from the NRPL, UPFS (H2) and UPFS (HG) calculations in equal weightings.

It is clear from Table 38 that the cost of providing each child with an oral examination and two bitewing radiographs accounts for between 30 to 40% of the total cost of providing the minimum package of oral care to all age cohorts, irrespective whether the NRPL, UPFS (H2) or UPFS (HG) fee schedule is used for the calculations.

Table 38: National per capita cost of delivering the minimum package of oral care by age cohort

Treatment need group	NHRPL		UPFS (H2)		UPFS (HG)		Average	
	%	Cost	%	Cost	%	Cost	%	Cost
4-5-year-olds								
UPFS consultation			14.9	R27.64	11.4	R41.83	8.8	R23.16
Examination/bitewings	44.2	R187.30	37.6	R70.00	40.1	R147.00	40.7	R134.77
Prophylaxis	-	-	-	-	-	-	-	-
Topical fluoride/Fissure sealant	3.9	R16.61	4.1	R7.70	4.4	R16.22	4.2	R13.51
Restorative/Extraction	51.9	R220.03	43.4	R80.63	44.0	R161.25	46.4	R153.97
Total		**R423.94**		**R185.97**		**R366.30**		**R325.40**
6-year-olds								
UPFS consultation			14.5	R35.65	11.1	R53.93	8.5	R29.86
Examination/bitewings	33.0	R187.30	28.5	R70.00	30.3	R147.00	30.6	R134.77
Prophylaxis	16.5	R93.92	12.2	R30.08	12.6	R60.91	13.8	R61.64
Topical fluoride/Fissure sealant	7.6	R42.96	6.9	R17.07	7.6	R36.87	7.4	R32.30
Restorative/Extraction	42.9	R243.95	37.8	R92.90	38.3	R185.80	39.7	R174.22
Total		**R568.13**		**R245.70**		**R484.52**		**R432.78**
12-year-olds								
UPFS consultation			14.5	R29.61	11.0	R44.81	8.5	R24.81
Examination/bitewings	38.1	R187.30	34.4	R70.00	36.2	R147.00	36.2	R134.77
Prophylaxis	19.1	R93.92	14.8	R30.08	15.0	R60.91	16.3	R61.64
Topical fluoride/Fissure sealant	16.0	R78.92	14.6	R29.64	15.9	R64.64	15.5	R57.73
Restorative/Extraction	26.8	R131.87	21.7	R44.21	21.8	R88.42	23.4	R88.17
Total		**R492.01**		**R203.54**		**R405.78**		**R367.11**
15-year-olds								
UPFS consultation			15.1	R33.16	11.5	R50.18	8.9	R27.78
Examination/bitewings	34.8	R187.30	31.9	R70.00	33.8	R147.00	33.5	R134.77
Prophylaxis	17.4	R93.92	13.7	R30.08	14.0	R60.91	15.1	R61.64
Topical fluoride/Fissure sealant	12.6	R67.69	11.8	R25.82	12.9	R56.15	12.4	R49.88
Restorative/Extraction	35.2	R189.35	27.5	R60.37	27.8	R120.74	30.1	R123.49
Total		**R538.27**		**R219.43**		**R434.98**		**R397.56**

Table 39 presents the average per capita cost for the NRPL, UPFS (H2) and UPFS (HG) fee schedules combined without the impact of water fluoridation and assuming an estimated caries reduction of 10%, 30% and 50% after its introduction.

As would be expected the average per capita cost for delivering the minimum package of oral care reduces as the anticipated caries reduction expected with water fluoridation increases. Since water fluoridation does not influence the cost of an oral examination, two bitewing radiographs and a prophylaxis, the reduction in per capita cost is less than would be expected as these

procedures (including the UPFS consultation) contribute almost 60% to the total per capita cost.

Table 39: Impact of water fluoridation on the average national per capita cost of delivering the minimum package of oral care (including examination and bitewing radiographs)

Treatment need group	No water fluoridation		Estimated caries reduction with water fluoridation					
			10%		30%		50%	
	%	Cost	%	Cost	%	Cost	%	Cost
4-5-year-olds								
UPFS consultation	8.8	R23.16	8.4	R20.84	7.5	R16.21	6.3	R11.58
Examination/bitewings	40.7	R134.77	43.2	R134.77	49.4	R134.77	57.8	R134.77
Prophylaxis	-	-	-	-	-	-	-	-
Topical fluoride/Fissure sealant	4.2	R13.51	4.0	R12.16	3.5	R9.46	3.0	R6.76
Restorative/Extraction	46.4	R153.97	44.4	R138.57	39.5	R107.78	33.0	R76.98
Total		**R325.40**		**R306.34**		**R268.21**		**R230.09**
6-year-olds								
UPFS consultation	8.5	R29.86	8.2	R26.87	7.3	R20.90	6.0	R14.93
Examination/bitewings	30.6	R134.77	32.4	R134.77	36.7	R134.77	42.4	R134.77
Prophylaxis	13.8	R61.64	14.6	R61.64	16.5	R61.64	19.0	R61.64
Topical fluoride/Fissure sealant	7.4	R32.30	7.0	R29.07	6.2	R22.61	5.1	R16.15
Restorative/Extraction	39.7	R174.22	37.8	R156.80	33.3	R121.95	27.5	R87.11
Total		**R432.78**		**R409.14**		**R361.87**		**R314.59**
12-year-olds								
UPFS consultation	8.5	R24.81	8.1	R22.33	7.0	R17.37	5.7	R12.40
Examination/bitewings	36.2	R134.77	38.0	R134.77	42.2	R134.77	47.5	R134.77
Prophylaxis	16.3	R61.64	17.1	R61.64	19.0	R61.64	21.3	R61.64
Topical fluoride/Fissure sealant	15.5	R57.73	14.7	R51.96	12.7	R40.41	10.2	R28.87
Restorative/Extraction	23.4	R88.17	22.1	R79.35	19.1	R61.72	15.3	R44.08
Total		**R367.11**		**R350.04**		**R315.90**		**R281.76**
15-year-olds								
UPFS consultation	8.9	R27.78	8.4	R25.00	7.4	R19.45	6.1	R13.89
Examination/bitewings	33.5	R134.77	35.3	R134.77	39.6	R134.77	45.1	R134.77
Prophylaxis	15.1	R61.64	15.9	R61.64	17.8	R61.64	20.2	R61.64
Topical fluoride/Fissure sealant	12.4	R49.88	11.8	R44.90	10.3	R34.92	8.4	R24.94
Restorative/Extraction	30.1	R123.49	28.6	R111.14	24.9	R86.44	20.3	R61.74
Total		**R397.56**		**R377.44**		**R337.21**		**R296.98**

Table 40 presents the national average per capita cost without water fluoridation and assuming a 10%, 30% and 50% caries reduction after the introduction of water fluoridation, but excluding an oral examination and two bitewing radiographs as part of the calculations.

Table 40: Impact of water fluoridation on the average national per capita cost of delivering the minimum package of oral care (excluding examination and bitewing radiographs)

Treatment need group	No water fluoridation		Estimated caries reduction with water fluoridation					
			10%		30%		50%	
	%	Cost	%	Cost	%	Cost	%	Cost
4-5-year-olds								
UPFS consultation	14.3	R23.16	14.3	R20.84	14.3	R16.21	14.3	R11.58
Prophylaxis								
Topical fluoride/Fissure sealant	7.0	R13.51	7.0	R12.16	7.0	R9.46	7.0	R6.76
Restorative/Extraction	78.7	R153.97	78.7	R138.57	78.7	R107.78	78.7	R76.98
Total		**R190.64**		**R171.57**		**R133.45**		**R95.32**
6-year-olds								
UPFS consultation	12.1	R29.86	11.9	R26.87	11.2	R20.90	10.3	R14.93
Prophylaxis	19.9	R61.64	21.7	R61.64	26.2	R61.64	33.1	R61.64
Topical fluoride/Fissure sealant	10.6	R32.30	10.4	R29.07	9.8	R22.61	8.9	R16.15
Restorative/Extraction	57.3	R174.22	56.1	R156.80	52.8	R121.95	47.7	R87.11
Total		**R298.01**		**R274.38**		**R227.10**		**R179.83**
12-year-olds								
UPFS consultation	13.2	R24.81	12.8	R22.33	12.0	R17.37	10.7	R12.40
Prophylaxis	25.6	R61.64	27.7	R61.64	32.9	R61.64	40.7	R61.64
Topical fluoride/Fissure sealant	24.4	R57.73	23.7	R51.96	21.9	R40.41	19.4	R28.87
Restorative/Extraction	36.9	R88.17	35.8	R79.35	33.2	R61.72	29.3	R44.08
Total		**R232.35**		**R215.28**		**R181.13**		**R146.99**
15-year-olds								
UPFS consultation	13.2	R27.78	12.9	R25.00	12.1	R19.45	11.0	R13.89
Prophylaxis	22.7	R61.64	24.6	R61.64	29.5	R61.64	36.9	R61.64
Topical fluoride/Fissure sealant	18.7	R49.88	18.2	R44.90	17.0	R34.92	15.2	R24.94
Restorative/Extraction	45.4	R123.49	44.3	R111.14	41.3	R86.44	36.9	R61.74
Total		**R262.79**		**R242.68**		**R202.45**		**R162.21**

When the cost of an oral examination and two bitewing radiographs are not taken into consideration, reductions in per capita cost for delivering the minimum package of oral care are much greater as the anticipated caries reduction due to water fluoridation increases.

To illustrate this better, Table 41 summarises the average per capita cost from Table 39 and Table 40 for all age cohorts, with and without an oral examination and two bitewing radiographs and with and without the anticipated effect of water fluoridation.

Table 41: Impact of an oral examination and bitewing radiographs on the average national per capita cost of delivering the minimum package of oral care

	4-5-year-olds	6-year-olds	12-year-olds	15-year-olds
No water fluoridation				
Examination/2 x bitewings included	R325.40	R432.78	R367.11	R397.56
Examination/2 x bitewings excluded	R190.64	R298.01	R232.35	R262.79
% difference	41.4	31.1	36.7	33.9
Anticipated 10% caries reduction due to water fluoridation				
Examination/2 x bitewings included	R306.34	R409.14	R350.04	R377.44
Examination/2 x bitewings excluded	R171.57	R274.38	R215.28	R242.68
% difference	44.0	32.9	38.5	35.7
Anticipated 30% caries reduction due to water fluoridation				
Examination/2 x bitewings included	R268.21	R361.87	R315.90	R337.21
Examination/2 x bitewings excluded	R133.45	R227.10	R181.13	R202.45
% difference	50.2	37.2	42.7	40.0
Anticipated 50% caries reduction due to water fluoridation				
Examination/2 x bitewings included	R230.09	R314.59	R281.76	R296.98
Examination/2 x bitewings excluded	R95.32	R179.83	R146.99	R162.21
% difference	58.6	42.8	47.8	45.4

When the average per capita cost for an oral examination and two bitewing radiographs are deducted from the average per capita cost for the delivery of the minimum package of oral care where this was included for every child, the percentage difference ranges from 31.1% to 58.6%. As would be expected this difference increases for all age cohorts as the anticipated caries reduction as a results of water fluoridation increases.

Table 42 presents the average per capita cost of delivering the minimum package of oral care per province as calculated from the average per capita cost for all age cohorts in equal weightings, with and without the estimated caries reduction as a result of the implementation of water fluoridation and with and without an oral examination and two bitewing radiographs.

Table 42: Mean per capita cost of delivering the minimum package of oral care per province

Province	No water fluoridation		Estimated caries reduction with water fluoridation					
			10%		30%		50%	
	Ex / BW included	Ex / BW excluded	Ex / BW included	Ex / BW excluded	Ex / BW included	Ex / BW excluded	Ex / BW included	Ex / BW excluded
National	R380.71	R245.95	R360.74	R225.98	R320.80	R186.03	R280.85	R146.09
Western Cape	R520.25	R385.49	R486.85	R352.08	R420.04	R285.28	R353.24	R218.47
Northern Cape	R425.61	R290.84	R400.52	R265.75	R350.33	R215.56	R300.14	R165.37
Eastern Cape	R345.39	R210.62	R329.50	R194.74	R297.73	R162.97	R265.96	R131.19
Free State	R406.43	R271.67	R383.10	R248.34	R336.44	R201.68	R289.78	R155.01
KwaZulu-Natal	R359.02	R224.25	R341.05	R206.28	R305.10	R170.33	R269.15	R134.38
Gauteng	R348.94	R214.17	R332.14	R197.38	R298.56	R163.79	R264.97	R130.20
North West	R282.83	R148.06	R272.14	R137.38	R250.77	R116.00	R229.39	R94.63
Mpumalanga	R368.43	R233.67	R349.26	R214.49	R310.91	R176.14	R272.56	R137.80
Limpopo	R356.43	R221.66	R339.06	R204.29	R304.32	R169.55	R269.57	R134.81

Note: Ex = Examination; BW = Bitewings

Irrespective of whether an examination and bitewings are included or excluded from the calculations and irrespective of the anticipated impact of the introduction of water fluoridation, the minimum package of oral care expressed as a per capita cost is the lowest for North West, Gauteng and the Eastern Cape and the highest for the Free State, Northern Cape and Western Cape.

On a national level, when an oral examination and bitewings are included, the per capita cost ranges from R280.85 at an anticipated 50% caries reduction due to water fluoridation to R380.71 with no water fluoridation. When the examination and bitewings are excluded, per capita cost ranges from R146.09 (50% caries reduction due to water fluoridation) to R245.95 (no water fluoridation).

4.4 Discussion

4.4.1 Introduction

In line with the adoption of the principles of PHC at Alma Ata in 1978 (World Health Organization, 1978), followed by the formulation of the action areas of health promotion as part of the Ottawa Charter (World Health Organization,

1986), the White Paper for the Transformation of Health Services in South Africa was formulated to meet the basic needs of the population. Adoption of the PHC approach and reducing the incidence of common oral diseases through a minimum package of care, water fluoridation, and reduction of the consumption of refined sugar have been identified as the two main principles to address oral health (Republic of South Africa, 1997b).

A package of PHC services was agreed upon in 2000 (Pick et al., 2001) and has been published in separate documents (Department of Health, 2001a; Department of Health, 2001b). For oral health it consists of an oral examination and charting of dental status, intra-oral radiographs, scaling and polishing of teeth, promotive and preventive oral health services, basic curative services, emergency relief of pain and sepsis (including dental extractions), simple one to three surface restorations, treatment of traumatic injuries to teeth and treatment of post-extraction bleeding.

The South African National Oral Health Strategy (Department of Health, 2005) listed the provision of appropriate disease prevention and health promotion measures based on the minimum package of oral care on a district level.

For this study a model was developed to express the delivery of the minimum package of oral health care to 4- to 5-, 6-, 12- and 15-year-olds based on treatment need data from the 1999-2002 NCOHS (Department of Health, 2003b; Van Wyk et al., 2004) as a per capita cost by applying the 2006 NRPL (Council for Medical Schemes, 2006) and UPFS (Gauteng Provincial Government, 2005) treatment fees on a national level as well as for all nine South African provinces.

To illustrate the possible impact of the implementation of water fluoridation on the cost of delivering the minimum package or oral care, treatment need, expressed as a percentage of the population or the mean number of teeth in need of treatment (see Table 31, p 110 and Table 32, p 111), was adjusted accordingly based on assumed caries reductions of 10%, 30% and 50%.

4.4.2 Per capita cost of delivering the minimum package or oral care to South African children

Per capita cost was calculated based on a high income (NRPL and UPFS (HG) tariffs) and a middle income (UPFS (H2) tariffs) scenario. Treatment need types were grouped as follows:

- Examination and bitewing radiographs;
- Prophylaxis;
- Topical fluoride application and fissure sealants; and
- One surface restorations, two or more surface restorations and extractions.

The contribution of each group in terms of cost and the percentage of the total per capita cost were calculated.

The cost of an oral examination and two bitewing radiographs was calculated for the total population and therefore would not be affected by a reduction in dental caries as a result of the implementation of water fluoridation. The cost of providing each child with an oral examination and two bitewing radiographs accounts for between 30 to 40% of the total cost of providing the minimum package of oral care to all age cohorts, irrespective of whether the NRPL, UPFS (H2) or UPFS (HG) fee schedule are used for the calculations (see Table 38, p 122).

For this reason this section will only deal with the per capita cost of a prophylaxis and those treatment needs affected by a 30% reduction in caries as a result of the introduction of water fluoridation. An average cost was calculated for the NRPL, UPFS (H2) and UPFS (HG) tariffs in equal weightings.

On an national level per capita cost of delivering the minimum package of oral care (excluding the oral examination and bitewing radiographs), without the impact of water fluoridation, varies from R190.64 (4- to 5-year-olds) to R298.01 for 6-year-olds, R232.35 for 12-year-olds and R262.79 for 15-year-olds (see Table 40, p 124).

At an anticipated caries reduction of 30% as a results of the introduction of water fluoridation, per capita cost decreases to R133.45 for 4- to 5-year-olds, R227.10 for 6-year-olds, R181.13 for 12-year-olds and R202.45 for 15-year-olds (see Table 40, p 124). This represents a respective percentage cost reduction of 30%, 23.8%, 22% and 23% for the four age cohorts included in this study.

An explanation why a 30% caries reduction is not seen across all age groups is that the per capita cost of a prophylaxis remains unaffected by a caries reduction as a result of water fluoridation, yet it is still included in the per capita cost as this procedure is considered to be part of the minimum package of oral care. Prophylaxis was not considered as a treatment option for the 4- to 5-year-old age cohort.

On a provincial level the per capita cost for delivering the minimum package of oral care (without fluoridation versus 30% caries reduction due to water fluoridation) for all age groups combined (oral examination and bitewing radiographs excluded) was the lowest for North West (R148.06 versus R116.00), Eastern Cape (R210.62 versus R162.97) and Gauteng (R214.17 versus R163.79) and the highest for the Free State (R271.67 versus R201.68), Northern Cape (R290.84 versus R215.56) and Western Cape (R385.49 versus R285.28) (see Table 42, p 126).

The variation in per capita cost between provinces is mainly due to the large variation in treatment needs (see Table 31, p 110 and Table 32, p 111). Reports on the 1999-2002 NCOHS highlight the higher caries prevalence in provinces such as the Western and Northern Cape with North West province recording some of the lowest caries prevalence rates (Department of Health, 2003b; Van Wyk et al., 2004). This is reflected in higher treatment needs for the Western and Northern Cape as well.

The greatest treatment need was recorded for the Western Cape where almost 80% of children need care. For all provinces preventive care and

restorations were the most common forms of treatment required with the need for restorations higher than the need for extractions for all age cohorts.

4.5 Summary

This chapter described a model, results and discussion to determine the per capita cost of delivering the minimum package of oral care to 4- to 5-, 6-, 12- and 15-year-old South African children based on treatment need from the 1999-2002 NCOHS (Department of Health, 2003b; Van Wyk et al., 2004) by using the 2006 NRPL (Council for Medical Schemes, 2006) and UPFS (Gauteng Provincial Government, 2005) treatment fees.

The inclusion of an oral examination and two bitewing radiographs for every child accounts for between 30 to 40% of the total cost of providing the minimum package or oral care. Without the possible effect of water fluoridation taken into consideration, the average national per capita cost for 4- to 5-, 6-, 12- and 15-year-olds (NRPL, UPFS (H2) and UPFS (HG)) is R380.71 when the oral examination and bitewing radiographs are included compared to R245.95 when the examination and bitewings are excluded from the calculations.

Chapter 5 will describe two models, results and discussion of the oral health human resources required for the implementation of the minimum package of oral care to 4- to 15-year-old children, taking into account different scenarios for caries reduction achieved through water fluoridation.

CHAPTER 5: ORAL HEALTH HUMAN RESOURCES NEEDS FOR SOUTH AFRICAN CHILDREN

5.1 Introduction

The four approaches to human resources planning (human resources to population ratios, health needs, health demands and service targets) (Hall, 1978) and the WHO/FDI human resources planning model (World Health Organization/Fédération Dentaire Internationale, 1989) were reviewed in Chapter 2.

This chapter describes two models to calculate oral health human resources required for the delivery of the minimum package of oral care to 4- to 15-year-old children. These models are:

- The WHO/FDI human resources planning model (World Health Organization/Fédération Dentaire Internationale, 1989); and
- A "Service Targets Method" model.

For the purpose of this study both approaches assume that the public oral health services would not be responsible for delivering the minimum package of oral care to children older than fifteen.

5.2 World Health Organization/Fédération Dentaire Internationale human resources planning model

This model is based on the needs and demands of a population. It places a much bigger emphasis on the prevention and control of disease, maintenance of health and high quality restorative care and also provides for modifying factors. The WHO/FDI model translates need into FTE of oral health human resources required to provide a calculated level of care.

The WHO/FDI model was used in two previous South African studies to determine human resources needed for delivering primary preventive services (Booyens, 1994) and to develop a human resources plan for oral health care for the province of KwaZulu-Natal (Kissoon-Singh, 2001). The results of both these studies were reviewed in Chapter 2.

The WHO/FDI model calculates human resources for the 0- to 14-, 15- to 29-, 30- to 64- and 65- to 79-year-old age cohorts. Based on the assumption that the public oral health services would not be responsible for delivering the minimum package of oral care to children older than fifteen, the WHO/FDI model was adapted to calculate oral health human resources requirements for the 4- to 15-year-old age cohort only.

The input variables to calculate human resources required with the WHO/FDI model to deliver the minimum package or oral care to the 4- to 5- (primary dentition) and 6- to 15-year-old (mixed/permanent dentition) age cohorts are presented in Table 43. Each variable has been allocated a unique number (in a square bracket) which indicates where it is used in the different formulas. Variables have been grouped as follows:

(A) Restorative Care, arresting care and extractions
(B) Treatment time requirements
(C) Human resources requirements

All predetermined values used in this model are based on those for a country with stable caries levels (World Health Organization/Fédération Dentaire Internationale, 1989).

Microsoft Excel software was used to computerise the WHO/FDI model. An example of the model applied on a national level is presented in Annexure 4.

Table 43: The WHO/FDI model to calculate human resources required to deliver the minimum package of oral care (World Health Organization/Fédération Dentaire Internationale, 1989)

Variable	Formula
(A) RESTORATIVE CARE, ARRESTING CARE AND EXTRACTIONS	
[1] Number of age intervals	
[2] Predicted dmft or DMFT	
[3] Predicted dt or DT	
[4] Predicted mt or MT	
[5] Predicted ft or FT	
[6] Restoration fraction	
[7] New fillings : Teeth (NFT)	[6] x [2]
[8] Mean replacement period in years for a restoration	
[9] Replacement fillings : Teeth (RFT)	([1] x [7]) / (2 x [8])
[10] Ratio Surfaces / Teeth	
[11] Sealants, arresting care and remineralisation	(1 - [6]) x [2]
[12] New fillings : Surfaces (NFS)	[7] x [10]
[13] Replacement fillings : Surfaces (RFS)	[9] x [10]
[14] Extraction	[4]
(B) TREATMENT TIME REQUIREMENTS	
[15] Number of Group Preventive Care sessions	
[16] Time per Group Preventive Care session	
[17] Group Preventive Care (minutes)	[15] x [16]
[18] Number of Individual Preventive Care sessions	
[19] Time per Individual Preventive Care session	
[20] Individual Preventive Care (minutes)	[18] x [19]
[21] Time per fissure sealant	
[22] Arresting Care (minutes)	[11] x [21]
[23] Mean number of sextants in need of scaling	
[24] Time per scaling per sextant	
[25] Number of scaling sessions	
[26] Periodontal Care (prophylaxis only) (minutes)	[23] x [24] x [25]
[27] % in need of Surgical Care	
[28] Time for Surgical Care	
[29] Surgical Care (minutes)	[27] / 100 x [28]
[30] Time per restoration (new or replacement)	
[31] Restorative Care for new fillings (NFS) (minutes)	[12] x [30]
[32] Restorative Care for replacement fillings (RFS) (minutes)	[13] x [30]
[33] Time per extraction	
[34] Extraction (minutes)	[14] x [33]
[35] Total minutes of need per cohort	[17]+[20]+[22]+[26]+[29]+[31]+[32]+[34]
Total minutes of need per year:	
[36] For total human resources	[35] / [1]
[37] For Oral Hygienists	([17]+[20]+[22]+[26]) / [1]
[38] For Dental Therapists/Dentists	([29]+[31]+[32]+[34]) / [1]
[39] % Demand (utilization)	
Minutes of demand per year:	
[40] For total human resources	[36] x [39] /100
[41] For Oral Hygienists	[37] x [39] /100
[42] For Dental Therapists/Dentists	[38] x [39] /100

Table 43: (continued)

Variable	Formula
(C) HUMAN RESOURCES CALCULATIONS	
[43] Working year (hours)	
[44] Working year (minutes)	[43] x 60
Human resources : population ratio:	
[45] For total human resources	[44] / [40]
[46] For Oral Hygienists	[44] / [41]
[47] For Dental Therapists/Dentists	[44] / [42]
[48] Population size	
Number of human resources required:	
[49] Total human resources	[48] / [45]
[50] Oral Hygienists	[48] / [46]
[51] Dental Therapists/Dentists	[48] / [47]
[52] Dentists	[51] / 6
(Ratio 1 Dentist : 5 Dental Therapists)	
[53] Dental Therapists	[51] / 6 x 5
(Ratio 1 Dentist : 5 Dental Therapists)	
[54] Dental Assistants	[51] x 1.5
(Ratio 1 Dental Therapist/Dentist : 1.5 Dental Assistants)	

5.2.1 Restorative care, arresting care and extractions (Variable Group (A))

a) Number of age intervals (Variable [1])

Calculations were done for the 4- to 5- and the 6- to 15-year-old age cohorts. The number of age intervals for each cohort are:

- **Age 4 to 5:** Two (4-5 and 5-5.99)
- **Age 6 to 15:** Ten (6-7, 7-8, 8-9, 9-10, 10-11, 11-12, 12-13, 13-14, 14-15 and 15-15.99)

b) Predicted caries prevalence values (Variables [2] to [5])

The WHO/FDI model requires DMFT caries index data as treatment need information. Caries prevalence data for 4- to 5- (dmft) and 15-year-old children (DMFT) from the 1999-2002 NCOHS (Department of Health, 2003b) were used in the calculations. These are summarised in Table 44. The mean national values were used for 4- to 5-year-olds in the Northern Cape as this age cohort was not included in the survey for that province.

Table 44: Caries prevalence of 4- to 5- and 15-year-old South African children: 1999-2002 NCOHS (Department of Health, 2003b)

Province	4- to 5-year-olds				15-year-olds			
	dmft (Var. [2])	dt (Var. [3])	mt (Var. [4])	ft (Var. [5])	DMFT (Var. [2])	DT (Var. [3])	MT (Var. [4])	FT (Var. [5])
National	2.44	1.95	0.35	0.16	1.86	1.34	0.29	0.23
Western Cape	4.81	3.66	1.04	0.10	3.99	2.65	0.92	0.42
Northern Cape	2.44	1.95	0.35	0.16	2.88	2.48	0.32	0.07
Eastern Cape	3.36	2.55	0.73	0.07	2.01	1.08	0.64	0.28
Free State	2.96	2.60	0.31	0.05	1.92	1.73	0.09	0.09
KwaZulu-Natal	2.52	2.30	0.19	0.03	1.87	1.57	0.22	0.08
Gauteng	1.96	1.06	0.20	0.66	1.81	1.04	0.11	0.65
North West	1.52	1.39	0.09	0.04	1.20	1.00	0.08	0.11
Mpumalanga	2.05	1.58	0.24	0.23	1.66	1.31	0.10	0.24
Limpopo	0.84	0.82	0.10	0.01	0.86	0.78	0.05	0.03

c) Restoration fraction (Variable [6])

This variable was predetermined and represents the fraction of the dmft/DMFT which can be saved through preventive procedures. The values used in this model are:

- **Age 4 to 5:** 0.5
- **Age 6 to 15:** 0.6

d) New fillings : Teeth (NFT) (Variable [7])

The NFT ratio was calculated by applying the formula:
Restoration fraction x Predicted dmft or DMFT

e) Mean replacement period in years for a restoration (Variable [8])

This variable was predetermined and a value of fifteen years was used in this model.

f) Replacement fillings : Teeth (RFT) (Variable [9])

The RFT ratio was calculated by applying the formula:
(Age intervals x NFT) / (2 x Mean replacement period in years for a restoration)

g) Ratio of surfaces / Teeth (Variable [10])

This variable was predetermined and a value of 1.5 was used in this model.

h) Sealants, arresting care and remineralisation (Variable [11])

This variable was calculated by applying the formula:
(1 – Restoration fraction) x Predicted dmft or DMFT

i) New fillings : Surfaces (NFS) (Variable [12])

The NFS ratio was calculated by applying the formula:
NFT x Ratio of surfaces / Teeth

j) Replacement fillings : Surfaces (RFS) (Variable [13])

The RFS ratio was calculated by applying the formula:
RFT x Ratio of surfaces / Teeth

k) Extraction (Variable [14])

This variable is represented by the predicted mt or MT (Variable [4]).

5.2.2 Treatment time requirements (Variable Group (B))

a) Group Preventive Care (Variables [15] to [17])

The number of group preventive care sessions as well as the time per session was predetermined. A single group preventive session in each of the 4- to 5- and 6- to 15-year-old cohorts (Variable [15]) of fifteen minutes duration (Variable [16]) was used in this model.

The time required for group preventive care (Variable [17]) was calculated by applying the formula:
Number of Group Preventive Care sessions x Time per Group Preventive Care session

b) Individual Preventive Care (Variables [18] to [20])

The number of individual preventive care sessions as well as the time per session was predetermined. For this study no individual preventive care was included for the 4- to 5-year-old cohort. Four sessions (Variable [18]) of fifteen minutes each (Variable [19]) over the duration of the 6- to 15-year-old cohort (10 years) were used in this model.

The time required for individual preventive care (Variable [20]) was calculated by applying the formula:
Number of Individual Preventive Care sessions x Time per Individual Preventive Care session

c) Arresting care (Variables [21] and [22])

Variable [21] was predetermined and a value of 5 minutes required per fissure sealant was used in this model.

Arresting care (Variable [22]) was calculated by applying the formula:
Sealants, arresting care and remineralisation variable x Time per fissure sealant

d) Periodontal care (Variables [23] to [26])

Severity of periodontal disease for 15-year-old children in South Africa as determined in the 1999-2002 NCOHS (Department of Health, 2003b) was used in the calculations for periodontal care for the 6- to 15-year-old cohort only as it was assumed that no periodontal care would be required for the 4- to 5-year-old cohort. The mean number of sextants with bleeding and calculus are presented in Table 45. The mean national values were used for Gauteng as periodontal disease was not included in the survey for this province.

In this model the sum of the mean number of sextants with bleeding and calculus were regarded as being in need of a prophylaxis treatment (Variable [23]).

This study does recognise the limitations of the use of CPI data in human resources planning as reported in the literature (Manji and Sheiham, 1986; Page and Morrison, 1994).

Table 45: Mean number of sextants with bleeding and calculus in 15-year-old South African children (Department of Health, 2003b)

Province	Mean number of sextants		
	Bleeding	Calculus	Total sextants in need of scaling
Weighted national mean	1.14	2.17	3.31
Western Cape	1.43	1.84	3.27
Northern Cape	1.45	0.85	2.3
Eastern Cape	0.26	2.62	2.88
Free State	0.99	2.96	3.95
KwaZulu-Natal	1.34	2.23	3.57
Gauteng	1.14	2.17	3.31
North West	1.1	1.47	2.57
Mpumalanga	0.75	1.22	1.97
Limpopo	1.98	2.43	4.41

Variables [24] and [25] were predetermined and values of two sessions of periodontal care over the duration of the 6- tot 15-year-old cohort and five minutes required for each sextant in need of scaling were used in this model.

Periodontal care (prophylaxis only) (Variable [26]) was calculated by applying the formula:
Mean number of sextants in need of scaling x Time per scaling per sextant x Number of scaling sessions

e) Surgical care (Variables [27] to [29])

It was assumed that 60 minutes would be required to cover surgical care for trauma, impaction and other oral surgery (Variable [28]) over the duration of

each of the 4- to 5- and 6- to 15-year-old age cohorts (World Health Organization/Fédération Dentaire Internationale, 1989).

The following values were assumed for the percentage of children in need of surgical care (Variable [27]):

- **Age 4 to 5:** 1%
- **Age 6 to 15:** 10%

Surgical care (Variable [29]) was calculated by applying the formula:
% in need of Surgical Care x Time for Surgical Care

f) Restorative care for new and replacement fillings (Variables [30] to [32])

The WHO/FDI model assumes that fifteen minutes are required for either a new or a replacement restoration (Variable [30]). The following formulas were applied:

- **Restorative care for new fillings (NFS) (Variable [31]):**
  NFS x Time per restoration

- **Restorative care for replacement fillings (RFS) (Variable [32]):**
  RFS x Time per restoration

g) Extractions (Variables [33] and [34])

The WHO/FDI model assumes that 7.5 minutes are required per extraction (Variable [33]). Time for extractions was calculated by applying the formula:
Extraction variable x Time per extraction

h) Total minutes of need per cohort (Variable [35])

This variable was calculated by adding the time required for preventive (group and individual), arresting, periodontal, surgical and restorative care as well as extractions.

i) Total minutes of need per year (Variables [36] to [38])

This variable was calculated by applying the formula:

Total minutes of need per cohort / Age intervals

By assuming that the oral hygienist would be responsible for delivering the preventive, arresting and periodontal care and the dental therapist/dentist the surgical care, restorative care and extractions, total minutes of need per year were calculated separately for each of the total human resources (Variable [36]), oral hygienists (Variable [37]) and dental therapists/dentists (Variable [38]) by applying the formula above for those procedures for which the oral hygienist and dental therapist/dentist are responsible.

j) Minutes of demand per year (Variables [39] and [40])

Table 46 provides information on the utilization of oral health services by South African adults aged 20 to 64 as determined in the 1988/89 NOHS (Department of Health, 1994). A weighted national mean value was calculated from this data using the 2006 South African mid-year population estimates (Statistics South Africa, 2006). A weighted mean service utilization value of 25.7% for those having visited a dentist/dental clinic within the last 12 months was used for both the 4- to 5- and 6- to 15-year-old cohorts (Variable [39]).

Table 46: Utilization of services based on time elapsed since previous visit to a dentist or dental clinic for the South African adult population (Department of Health, 1994)

Time elapsed since last visit	Percentage utilization of services by population group (% of population)				
	Asian (2.46%)	Black (79.47%)	Coloured (8.86%)	White (9.21%)	Weighted national mean
Within 12 months	31.5	21.5	26.7	59.9	**25.7**
> 1 year ago	49.7	48.9	64.9	37.4	49.3
Do not know	5.3	2.7	4.5	2.2	2.9
Never	13.5	26.9	3.9	0.5	22.1

Minutes of demand per year were calculated for the each of the total human resources (Variable [40]), oral hygienists (Variable [41]) and dental therapists/dentists (Variable [42]) by applying the formula:
Total minutes of need per year x % Demand

5.2.3 Human resources calculations (Variable Group (C))

a) Working year (Variables [43] and [44])

For the purpose of this model a working year (Variable [43]) was considered as 40 hours per week for 44 weeks (1,760 hours).

In this model this value was converted to minutes (Variable [44]) for calculating the human resources required.

b) Human resources to population ratio (Variables [45] to [47])

This variable was calculated for the each of the total human resources (Variable [45]), oral hygienists (Variable [46]) and dental therapists/dentists (Variable [47]) by applying the formula:
Working year in minutes / Minutes of demand per year

c) Population size (Variable [48])

This variable was calculated from the 2006 South African mid-year population estimates (Statistics South Africa, 2006). Table 47 presents the values used in this model.

d) Number of human resources required (Variables [49] to [54])

The number of human resources required was calculated for the each of the total human resources (Variable [49]), oral hygienists (Variable [50]) and dental therapists/dentists (Variable [51]) by applying the formula:
Population size / Human resources : population ratio

The ratio of dental therapists to dentists of 5:1 and dental therapists/dentists to dental assistants of 1:1.5 as described in Table 12 (p 63) (Department of Health, 1999) were applied to the results to separately calculate the number of dentists (Variable [52]), dental therapists (Variable [53]), and dental assistants (Variable [54]) required.

Table 47: 2006 South African mid-year population estimates for the 4- to 5- and 6- to 15-year-old age cohorts (Statistics South Africa, 2006)

Province	Total population	4- to 5-year-olds		6- to 15-year-olds		4- to 15-year-olds	
		n	%	n	%	n	%
National	47,390,800	2,035,320	4.29	10,087,080	21.28	12,122,400	25.57
Western Cape	4,745,500	182,980	3.86	869,340	18.32	1,052,320	22.18
Northern Cape	910,500	38,600	4.24	186,540	20.49	225,140	24.73
Eastern Cape	7,051,500	312,260	4.43	1,700,100	24.11	2,012,360	28.54
Free State	2,958,800	119,940	4.05	607,120	20.52	727,060	24.57
KwaZulu-Natal	9,731,800	440,360	4.52	2,235,140	22.97	2,675,500	27.49
Gauteng	9,211,200	348,300	3.78	1,472,640	15.99	1,820,940	19.77
North West	3,858,200	167,900	4.35	798,240	20.69	966,140	25.04
Mpumalanga	3,252,500	151,180	4.65	751,980	23.12	903,160	27.77
Limpopo	5,670,800	273,800	4.83	1,465,980	25.85	1,739,780	30.68

5.2.4 Impact of the implementation of water fluoridation

Estimated caries reductions as a result of the implementation of water fluoridation of 10%, 30% and 50%, were applied to the dmft/DMFT values (Variables [2] to [5]) to indicate the impact that this would have on the required human resources.

Results of the human resources required to deliver the minimum package of oral care to the 4- to 5- and 6- to 15-year-old cohorts with and without the impact of water fluoridation as calculated with the WHO/FDI model are presented in Section 5.4 (p 149).

5.3 A “Service Targets Method” model to calculate human resources

This approach involves the setting of targets for the production and delivery of specific health services followed by converting these into human resources

requirements by means of staffing and productivity standards. This method attempts to strike a balance between needs and wants of the population, available technology and what can be delivered (Hall, 1978).

Based on need and demand the service target for the model described in this section is to deliver the minimum package of oral care to 4- to 15-year-old children with appropriate oral health human resources where the oral hygienist would be responsible for delivering the group prevention, periodontal care (prophylaxis only), topical fluoride application and fissure sealants and the dental therapist/dentist the restorative care and extractions.

Similar to the approach used for the WHO/FDI model, for the purpose of this study, this model also assumes that the public oral health services would not be held responsible for delivering the minimum package of oral care to children older than fifteen.

The calculation of oral health human resources requirements with this model consisted of three steps:

1. Convert treatment need to time required to complete treatment;
2. Convert time required to complete treatment need to demand time to complete treatment; and
3. Convert demand time to complete treatment to human resources required.

Table 48 presents the input variables to calculate the human resources required to deliver the minimum package of oral care to the 4- to 15-year-old cohort with a “Service Target Method” model. Each variable has been allocated a unique number (in a square bracket) which indicates where it is used in the different formulas.

Microsoft Excel software was used to computerise this model. An example of the model applied to the 4- to 15-year-old age cohort is presented in Annexure 5.

Table 48: A "Service Targets Method" model to calculate human resources needed to deliver the minimum package of oral care

Variable	Formula
(A) Minutes of need	
[1] Population size	
[2] Treatment need	
[3] Treatment time per procedure	
[4] Time to complete each treatment need type	[1] x [2] x [3]
[5] Total time to complete treatment need	
[6] Per capita time to complete treatment need	[5] / [1]
[7] % of total time for each treatment need type	[4] / [5] x 100
[8] Per capita time of each treatment need type	[6] x [7] / 100
(B) Minutes of demand	
[9] % Demand (utilization)	
[10] Minutes of demand per person per year	[6] x [9] / 100
(C) Human resources calculations	
[11] Working year (hours)	
[12] Working year (minutes)	[11] x 60 minutes
[13] Human resource : population ratio	[12] / [10]
[14] Number of human resources required	[1] / [13]

5.3.1 Minutes of need (Variable Group (A))

a) Population size (Variable [1])

The 2006 South African mid-year population estimates by age and sex (national and per province) were used in this model (Statistics South Africa, 2006). Since these population estimates are presented in five year age intervals, the mean values for each interval were used to calculate the population estimates for the 4- to 15-year-old cohort. A population estimate for the 6- to 15-year-old age cohort was used to calculate the human resources for prophylaxis since this procedure was not included in this model for the 4- to 5-year-olds. Population size values used in this model are presented in Table 47 (p 142).

b) Treatment need (Variable [2])

Percentage treatment need and mean number of teeth in need of treatment as reported in Chapter 4 (Table 31, p 110 and Table 32, p 111) for 4- to 5-, 6-, 12- and 15-year-olds were used to calculate a mean weighted value for the 4- to 15-year-old cohort on a national as well as a provincial level for each of the

nine South African provinces. The mean national value was used for Gauteng and Limpopo as survey data for these two provinces were not available.

Similar to the model described in Chapter 4 to calculate the per capita cost to deliver the minimum package or oral care as well as the WHO/FDI human resources model described in a previous section of this chapter, it was assumed that no periodontal care would be required for the 4- to 5-year-old cohort. Data for 15-year-old children in South Africa as determined in the 1999-2002 NCOHS (Department of Health, 2003b) and reported as the percentage of sextants (prevalence) and the mean number of sextants (severity) with the highest score being either healthy or bleeding was used in this model for the 6- to 15-year-old age cohort (See Table 33, p 114). The mean national values were used for Gauteng as periodontal disease was not included in the survey for 15-year-olds for this province.

An oral examination and bitewing radiographs were excluded from the calculations in this model as these procedures were not included in the WHO/FDI model either. The mean weighted treatment need values used in this model are presented in Table 49.

Table 49: Treatment need as a percentage of the population or mean number of teeth/sextants for the 4- to 15-year-old age cohort

Province	Prophylaxis	Topical fluoride application	Fissure sealant	1 surface restoration	>1 surface restoration	Extraction
	Mean no. of sextants	% of population	Mean no. of teeth	Mean no. of teeth	Mean no. of teeth	Mean no. of teeth
National	3.31	5.39	0.80	0.39	0.20	0.29
Western Cape	3.27	2.46	1.80	0.56	0.36	0.50
Northern Cape	2.3	2.36	0.31	0.93	0.81	0.77
Eastern Cape	2.88	6.66	0.07	0.29	0.14	0.37
Free State	3.95	5.21	1.13	0.54	0.13	0.28
KwaZulu-Natal	3.57	6.32	0.94	0.29	0.18	0.26
Gauteng	3.31	5.39	0.80	0.39	0.20	0.29
North West	2.57	5.79	0.29	0.25	0.11	0.07
Mpumalanga	1.97	5.24	0.05	0.48	0.24	0.33
Limpopo	4.41	5.39	0.80	0.39	0.20	0.29

c) Treatment time per procedure (Variable [3])

Treatment times used for this model were based on those of the WHO/FDI human resources model, except for topical fluoride application. These are:

- **Group prevention:** Four sessions of fifteen minutes each over twelve age intervals between the ages of 4 to 15
- **Prophylaxis:** Two prophylaxis treatment sessions for the 6- to 15-year-old cohort based on five minutes per sextant in need of a scaling over ten age intervals
- **Topical fluoride application:** Three fluoride applications of ten minutes each at ages 6, 12 and 15 over twelve age intervals. These ages were chosen to coincide with the eruption of the first and second permanent molars at a stage when mineralisation of the enamel has not been fully completed. A final topical fluoride application is provided at age fifteen, the last age for which it is assumed the minimum package of oral care would be provided.
- **Fissure sealants:** Five minutes per sealant
- **Restorations (one or more than one surface):** Fifteen minutes per restoration
- **Extractions:** 7.5 minutes per extraction

The treatment times used in this model are summarised in Table 50.

Table 50: Treatment times used in the "Service Targets Method" model

Procedure	Estimated time per year (minutes)
Group prevention	4 sessions x 15 minutes each / 12 age intervals = 5 minutes per year
Prophylaxis	2 sessions x 5 minutes per sextant / 10 age intervals = 1 minute per year
Topical fluoride application	3 applications x 10 minutes each / 12 age intervals = 2.5 minutes per year
Fissure sealant	5 minutes per sealant
1 surface restoration	15 minutes per restoration
More than 1 surface restoration	15 minutes per restoration
Extraction	7.5 minutes per extraction

d) Time to complete each treatment need type (Variable [4])

For each of the treatment need types the time to complete treatment for the specific procedure was calculated by applying the formula:

Population size x Treatment need x Treatment time per procedure

e) Total time to complete treatment need (Variable [5])

Total time to complete treatment need was calculated by adding all times required to complete each of the treatment need types which are part of the minimum package or oral care.

f) Per capita time to complete treatment need (Variable [6])

This variable was calculated by applying the formula:

Total time to complete treatment need / Population size

g) Percentage of total time for each treatment need type (Variable [7])

The time to complete each treatment need type was expressed as a percentage of the total time to address treatment need by applying the formula:

Time to complete each treatment need type / Total time to complete treatment need x 100

h) Per capita time of each treatment need type (Variable [8])

The time for each treatment need type was converted to a per capita time by applying the formula:

Per capita time to complete treatment need x % of total time for each treatment need type

5.3.2 Minutes of demand (Variable Group (B))

Similar to the WHO/FDI model a mean weighted service utilization value of 25.7% (Variable [9]) for those having visited a dentist or dental clinic within the last 12 months (see Table 46, p 140) was used in this model.

Minutes of demand per person per year (Variable [10]) was calculated by applying the formula:
Per capita time to complete treatment need x % Demand

5.3.3 Human resources calculations (Variable Group (C))

a) Working year (Variables [11] and [12])

For the purpose of this study a working year (Variable [11]) was considered as 40 hours per week for 44 weeks (1,760 hours).

This value was converted to minutes (Variable [12]) for calculating the human resources required with this model.

b) Human resources to population ratio (Variable [13])

This variable was calculated by applying the formula:
Working year in minutes / Minutes of demand per person per year

c) Number of human resources required (Variable [12])

This variable was calculated by applying the formula:
Population size / Human resources : population ratio

The number of required oral hygienists was calculated based on the minutes of demand per person per year to deliver prevention, prophylaxis, fissure sealants and fluoride applications. The number of required dental therapists/dentists was calculated based on the minutes of demand per person per year to deliver restorations and extractions.

Similar to the WHO/FDI model the ratios of dental therapists to dentists (5:1) and dental therapists/dentists to dental assistants (1:1.5) as described in

Table 12 (p 63) (Department of Health, 1999) were applied to the results to separately determine the number of dental therapists, dentists and dental assistants required.

5.3.4 Impact of the implementation of water fluoridation

Estimated caries reductions as a result of the implementation of water fluoridation of 10%, 30% and 50%, were applied to the treatment need values to indicate the impact that this would have on the required human resources to deliver the minimum package of oral care.

Results of the human resources required for the 4- to 15-year-old cohort with and without the impact of water fluoridation as calculated with the "Service Targets Method" model are presented in the next section.

5.4 Results

5.4.1 Background information

For both the WHO/FDI and "Service Targets Method" models results are presented for the 4- to 15-year-old age cohort using oral health status and treatment need data for dental caries and periodontal disease (bleeding and calculus only) from the 1999-2002 NCOHS (Department of Health, 2003b) combined with a mean weighted demand/utilization of services of 25.7% (See Table 46, p 140).

Based on anticipated caries reductions as a result of the implementation of water fluoridation of 10%, 30% and 50%, caries prevalence values for the WHO/FDI model and treatment need for dental caries values for the "Service Targets Method" model were adjusted accordingly to indicate the impact that this would have on the required human resources to deliver the minimum package of care.

For both models the total number of human resources required is indicated on a national as well as a provincial level. It was assumed that the oral hygienist would be responsible for delivering the group prevention, prophylaxis, topical fluoride application and fissure sealants and the dental therapist/dentist for the restorative care and extractions.

5.4.2 Total human resources

Table 51 presents the human resources required as calculated with the two models without the introduction of water fluoridation as well as assuming a 10%, 30% or 50% reduction in caries prevalence after its introduction. Please note that dental assistants are not included in the total human resources required column.

In general on both the national and all provincial levels the number of human resources required as calculated with the WHO/FDI model was less than calculated with the “Service Targets Method” model.

Table 52 presents the difference between the calculations for the two models for the total human resources requirements to deliver the minimum package of care.

Figure 11 and Figure 12 present the required human resources on a national level without water fluoridation and with an estimated caries reduction of 10%, 30% and 50% after its introduction as calculated with the WHO/FDI and “Service Targets Method” models.

Table 51: Summary of human resources requirements for 4- to 15-year-old South African children calculated with the WHO/FDI and "Service Targets Method" models

Estimated caries reduction	Total human resources (excl. Dental Assistants)		Oral Hygienists		Dental Therapists/ Dentists		Dentists		Dental Therapists		Dental Assistants	
	WHO/ FDI	STM	WHO/ FDI	STM	WHO/ FDI	STM	WHO/ FDI	STM	WHO/ FDI	STM	WHO/ FDI	STM
National												
No water fluoridation	510	679	327	352	183	327	31	54	153	272	275	490
10%	491	634	325	339	166	294	28	49	139	245	250	441
30%	453	544	320	315	133	229	22	38	111	191	200	343
50%	415	454	315	290	100	163	17	27	83	136	149	245
Western Cape												
No water fluoridation	63	88	31	43	33	45	5	8	27	38	49	68
10%	60	81	30	41	30	41	5	7	25	34	44	61
30%	53	68	29	36	23	32	4	5	19	26	35	48
50%	45	54	28	31	17	23	3	4	14	19	26	34
Northern Cape												
No water fluoridation	10	22	6	5	4	17	1	3	4	15	6	26
10%	10	20	6	5	4	16	1	3	3	13	6	24
30%	9	17	6	4	3	12	1	2	3	10	5	18
50%	8	13	5	4	2	9	0	1	2	7	3	13
Eastern Cape												
No water fluoridation	91	84	54	39	37	45	6	7	31	37	56	67
10%	87	79	53	39	34	40	6	7	28	34	51	60
30%	79	70	52	38	27	31	4	5	22	26	40	47
50%	71	60	51	38	20	22	3	4	17	19	30	34
Free State												
No water fluoridation	33	47	21	25	12	22	2	4	10	18	18	33
10%	31	44	21	24	11	20	2	3	9	16	16	29
30%	29	37	20	22	8	15	1	3	7	13	13	23
50%	26	31	20	20	6	11	1	2	5	9	10	16
KwaZulu-Natal												
No water fluoridation	114	142	74	84	40	59	7	10	33	49	60	88
10%	109	133	73	80	36	53	6	9	30	44	54	79
30%	101	115	72	74	29	41	5	7	24	34	43	62
50%	93	97	71	68	22	29	4	5	18	24	33	44

Note: STM = "Service Targets Method" model

Table 51: (continued)

Estimated caries reduction	Total human resources (excl. Dental Assistants)		Oral Hygienists		Dental Therapists/ Dentists		Dentists		Dental Therapists		Dental Assistants	
	WHO/ FDI	STM	WHO/ FDI	STM	WHO/ FDI	STM		WHO/ FDI	STM	WHO/ FDI	STM	WHO/ FDI
Gauteng												
No water fluoridation	74	102	49	52	25	49	4	8	21	41	38	74
10%	71	95	48	51	23	44	4	7	19	37	34	66
30%	66	81	48	47	18	34	3	6	15	29	27	52
50%	61	68	47	43	14	25	2	4	11	20	21	37
North West												
No water fluoridation	33	35	24	21	9	14	2	2	8	12	14	21
10%	32	33	24	20	9	13	1	2	7	11	13	19
30%	31	29	24	19	7	10	1	2	6	8	11	15
50%	29	26	23	19	5	7	1	1	4	6	8	11
Mpumalanga												
No water fluoridation	33	45	22	15	12	29	2	5	10	24	18	44
10%	32	42	22	15	11	26	2	4	9	22	16	40
30%	30	36	21	15	9	21	1	3	7	17	13	31
50%	27	30	21	15	6	15	1	2	5	12	10	22
Limpopo												
No water fluoridation	60	101	49	55	11	47	2	8	9	39	17	70
10%	59	95	49	53	10	42	2	7	9	35	16	63
30%	57	82	48	49	9	33	1	5	7	27	13	49
50%	55	69	48	46	7	23	1	4	6	20	10	35

Note: STM = “Service Targets Method” model

It is clear from Table 51 and both Figure 11 and Figure 12, irrespective of whether the WHO/FDI or the “Service Targets Method” model were used for the calculations, that oral hygienists represent the majority of oral health human resources required to deliver the minimum package of oral care to 4- to 15-year-old children.

Table 52: Difference between human resources requirements for 4- to 15-year-old South African children calculated with the WHO/FDI and "Service Targets Method" models

Estimated caries reduction	Total (excl. Dental Assistants)		Difference
	WHO/FDI	STM	
National			
No water fluoridation	510	679	169
10%	491	634	143
30%	453	544	91
50%	415	454	39
Western Cape			
No water fluoridation	63	88	25
10%	60	81	21
30%	53	68	15
50%	45	54	9
Northern Cape			
No water fluoridation	10	22	12
10%	10	20	10
30%	9	17	8
50%	8	13	5
Eastern Cape			
No water fluoridation	91	84	7
10%	87	79	8
30%	79	70	9
50%	71	60	11
Free State			
No water fluoridation	33	47	14
10%	31	44	13
30%	29	37	8
50%	26	31	5
KwaZulu-Natal			
No water fluoridation	114	142	28
10%	109	133	24
30%	101	115	14
50%	93	97	4
Gauteng			
No water fluoridation	74	102	28
10%	71	95	24
30%	66	81	15
50%	61	68	7
North West			
No water fluoridation	33	35	2
10%	32	33	1
30%	31	29	2
50%	29	26	3
Mpumalanga			
No water fluoridation	33	45	12
10%	32	42	10
30%	30	36	6
50%	27	30	3
Limpopo			
No water fluoridation	60	101	41
10%	59	95	36
30%	57	82	25
50%	55	69	14

Note: STM = "Service Targets Method" model

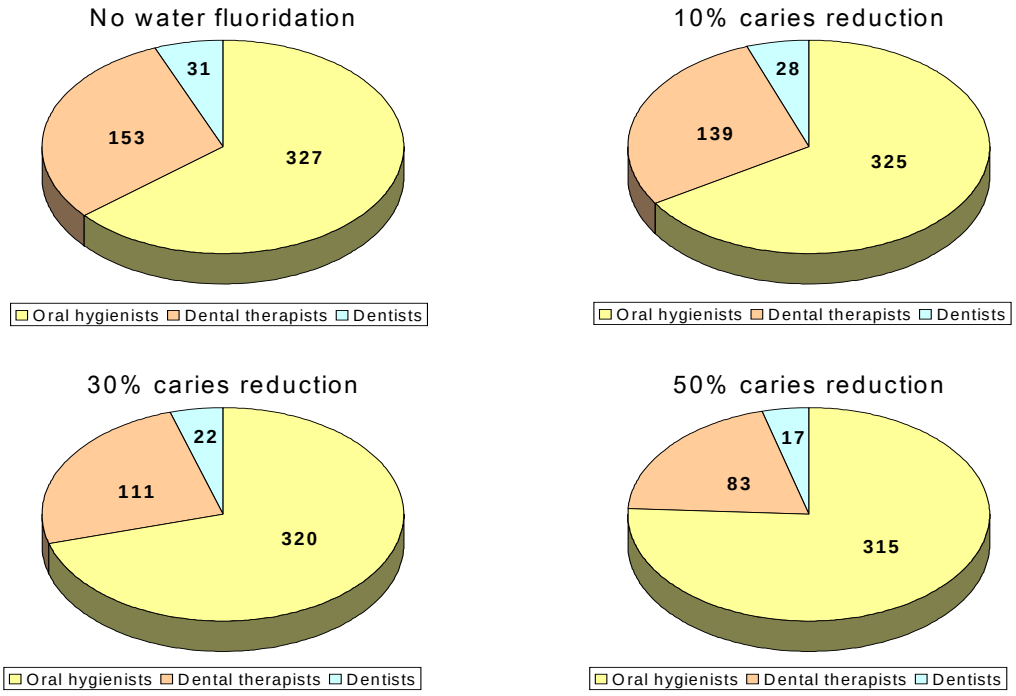


Figure 11: National human resources requirements calculated with the WHO/FDI model for delivering the minimum package of oral care to 4- to 15-year-old South African children

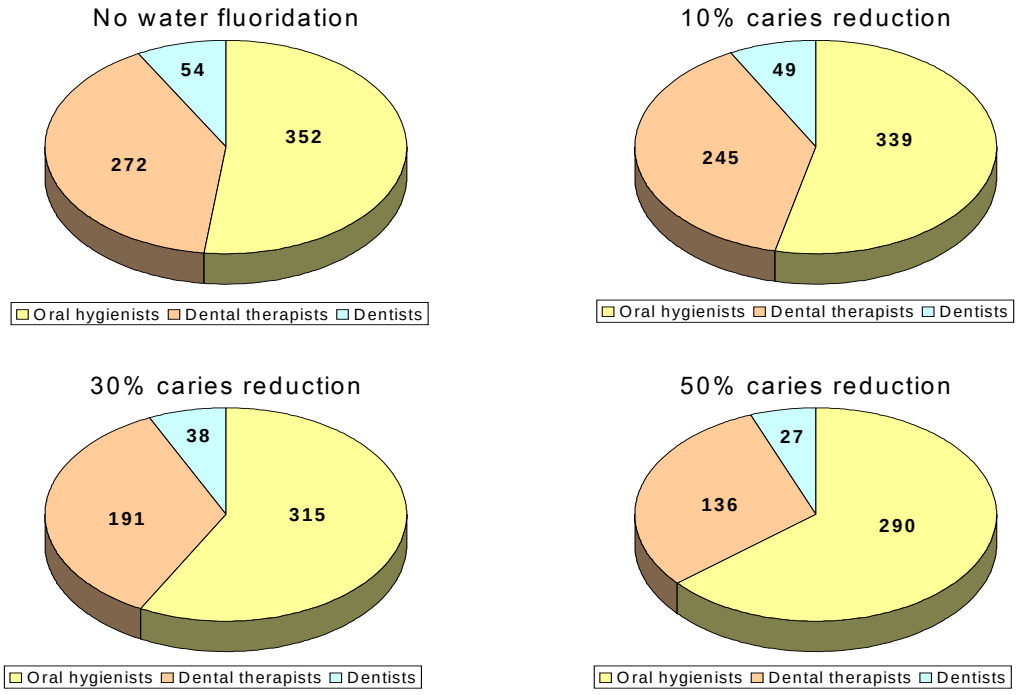


Figure 12: National human resources requirements calculated with the "Service Targets Method" model for delivering the minimum package of oral care to 4- to 15-year-old South African children

5.4.3 Oral hygienists

Table 53 presents the requirements for oral hygienists to deliver the minimum package of care as calculated with the WHO/FDI and "Service Targets Method" models. Requirements on a national and provincial level are also expressed as a percentage of the total number of human resources required.

For the WHO/FDI model, oral hygienists represent more than 50% of the total human resources required to deliver the minimum package of oral care to 4- to 15-year-olds. Although less oral hygienists are required when the "Service Targets Method" model was used, for the majority of provinces it still represents more than 50% of the total human resources required.

With both models, as the anticipated caries reduction due to the implementation of water fluoridation increases, the proportion of oral hygienists in relation to the need for dentists and dental therapists increases (see Table 54).

5.4.4 Dental therapists and dentists

Table 54 presents the requirements for dental therapists and dentists to deliver the minimum package of care as calculated with the WHO/FDI and "Service Targets Method" models. Requirements on a national and provincial level are also expressed as a percentage of the total number of human resources required.

Dental therapists represent approximately 30 to 40% and dentists less than 10% of the total human resources required to deliver the restorative care and extraction components of the minimum package of oral care to 4- to 15-year-old children.

Table 54 clearly illustrates the reduced need for both dental therapists and dentists as the anticipated level of caries reduction increases due to the introduction of water fluoridation.

Table 53: Requirements for oral hygienists for 4- to 15-year-old South African children using the WHO/FDI and "Service Targets Method" models

Estimated caries reduction	Total (excl Dental Assistants)		Oral Hygienists			
	WHO/FDI	STM	WHO/FDI		STM	
			n	% of total	n	% of total
National						
No water fluoridation	510	679	327	64.1	352	51.8
10%	491	634	325	66.2	339	53.5
30%	453	544	320	70.6	315	57.9
50%	415	454	315	75.9	290	63.9
Western Cape						
No water fluoridation	63	88	31	49.2	43	48.9
10%	60	81	30	50.0	41	50.6
30%	53	68	29	54.7	36	52.9
50%	45	54	28	62.2	31	57.4
Northern Cape						
No water fluoridation	10	22	6	60.0	5	22.7
10%	10	20	6	60.0	5	25.0
30%	9	17	6	66.7	4	23.5
50%	8	13	5	62.5	4	30.8
Eastern Cape						
No water fluoridation	91	84	54	59.3	39	46.4
10%	87	79	53	60.9	39	49.4
30%	79	70	52	65.8	38	54.3
50%	71	60	51	71.8	38	63.3
Free State						
No water fluoridation	33	47	21	63.6	25	53.2
10%	31	44	21	67.7	24	54.5
30%	29	37	20	69.0	22	59.5
50%	26	31	20	76.9	20	64.5
KwaZulu-Natal						
No water fluoridation	114	142	74	64.9	84	59.2
10%	109	133	73	67.0	80	60.2
30%	101	115	72	71.3	74	64.3
50%	93	97	71	76.3	68	70.1
Gauteng						
No water fluoridation	74	102	49	66.2	52	51.0
10%	71	95	48	67.6	51	53.7
30%	66	81	48	72.7	47	58.0
50%	61	68	47	77.0	43	63.2
North West						
No water fluoridation	33	35	24	72.7	21	60.0
10%	32	33	24	75.0	20	60.6
30%	31	29	24	77.4	19	65.5
50%	29	26	23	79.3	19	73.1
Mpumalanga						
No water fluoridation	33	45	22	66.7	15	33.3
10%	32	42	22	68.8	15	35.7
30%	30	36	21	70.0	15	41.7
50%	27	30	21	77.8	15	50.0
Limpopo						
No water fluoridation	60	101	49	81.7	55	54.5
10%	59	95	49	83.1	53	55.8
30%	57	82	48	84.2	49	59.8
50%	55	69	48	87.3	46	66.7

Note: STM = "Service Targets Method" model

Table 54: Requirements for dental therapists and dentists for 4- to 15-year-old South African children using the WHO/FDI and "Service Targets Method" models

Estimated caries reduction	Total (excl Dental Assistants)		Dental Therapists				Dentists			
			WHO/FDI		STM		WHO/FDI		STM	
	WHO/FDI	STM	n	% of total	n	% of total	n	% of total	n	% of total
National										
No water fluoridation	510	679	153	30.0	272	40.1	31	6.1	54	8.0
10%	491	634	139	28.3	245	38.6	28	5.7	49	7.7
30%	453	544	111	24.5	191	35.1	22	4.9	38	7.0
50%	415	454	83	20.0	136	30.0	17	4.1	27	5.9
Western Cape										
No water fluoridation	63	88	27	42.9	38	43.2	5	7.9	8	9.1
10%	60	81	25	41.7	34	42.0	5	8.3	7	8.6
30%	53	68	19	35.8	26	38.2	4	7.5	5	7.4
50%	45	54	14	31.1	19	35.2	3	6.7	4	7.4
Northern Cape										
No water fluoridation	10	22	4	40.0	15	68.2	1	10.0	3	13.6
10%	10	20	3	30.0	13	65.0	1	10.0	3	15.0
30%	9	17	3	33.3	10	58.8	1	11.1	2	11.8
50%	8	13	2	25.0	7	53.8	0	0.0	1	7.7
Eastern Cape										
No water fluoridation	91	84	31	34.1	37	44.0	6	6.6	7	8.3
10%	87	79	28	32.2	34	43.0	6	6.9	7	8.9
30%	79	70	22	27.8	26	37.1	4	5.1	5	7.1
50%	71	60	17	23.9	19	31.7	3	4.2	4	6.7
Free State										
No water fluoridation	33	47	10	30.3	18	38.3	2	6.1	4	8.5
10%	31	44	9	29.0	16	36.4	2	6.5	3	6.8
30%	29	37	7	24.1	13	35.1	1	3.4	3	8.1
50%	26	31	5	19.2	9	29.0	1	3.8	2	6.5
KwaZulu-Natal										
No water fluoridation	114	142	33	28.9	49	34.5	7	6.1	10	7.0
10%	109	133	30	27.5	44	33.1	6	5.5	9	6.8
30%	101	115	24	23.8	34	29.6	5	5.0	7	6.1
50%	93	97	18	19.4	24	24.7	4	4.3	5	5.2
Gauteng										
No water fluoridation	74	102	21	28.4	41	40.2	4	5.4	8	7.8
10%	71	95	19	26.8	37	38.9	4	5.6	7	7.4
30%	66	81	15	22.7	29	35.8	3	4.5	6	7.4
50%	61	68	11	18.0	20	29.4	2	3.3	4	5.9
North West										
No water fluoridation	33	35	8	24.2	12	34.3	2	6.1	2	5.7
10%	32	33	7	21.9	11	33.3	1	3.1	2	6.1
30%	31	29	6	19.4	8	27.6	1	3.2	2	6.9
50%	29	26	4	13.8	6	23.1	1	3.4	1	3.8
Mpumalanga										
No water fluoridation	33	45	10	30.3	24	53.3	2	6.1	5	11.1
10%	32	42	9	28.1	22	52.4	2	6.3	4	9.5
30%	30	36	7	23.3	17	47.2	1	3.3	3	8.3
50%	27	30	5	18.5	12	40.0	1	3.7	2	6.7
Limpopo										
No water fluoridation	60	101	9	15.0	39	38.6	2	3.3	8	7.9
10%	59	95	9	15.3	35	36.8	2	3.4	7	7.4
30%	57	82	7	12.3	27	32.9	1	1.8	5	6.1
50%	55	69	6	10.9	20	29.0	1	1.8	4	5.8

5.5 Discussion

5.5.1 Introduction

An appropriate workforce to address the oral health needs and demands of the South African population has been described in a number of publications, research reports, policy documents and position papers. An overview of major decisions and recommendation in this regard was presented in Chapter 2 (see Section 2.2.4, p 39).

The majority of reports on human resources in South Africa have highlighted the inequitable distribution between urban and rural on the one side and the private and public sectors on the other. Recent reports and publication suggested more appropriately trained human resources, for example the NHRP proposed annual productions for the various members of the oral health team (Department of Health, 2006a). In doing so it recognised that consideration had to be given to mobility of health professionals to and from the private sector, migration overseas and other attrition factors.

Three studies have been conducted in South Africa over the past number of years investigating human resources required for oral health. Booyens (1994) applied the WHO/FDI needs model (World Health Organization/Fédération Dentaire Internationale, 1989) to the 1988/89 NOHS data (Department of Health, 1994). This study concluded that more oral hygienists should be trained to address the need for more primary preventive dental services.

Van Wyk (1996) developed a model to determine the future human resource needs for optimal health care for the total population of South Africa where the actual demand for services was used as a point of departure. This study concluded that the levels of human resources required for 2011 would be difficult to attain and a programme of optimal fluoridation was suggested as an absolute necessity to address oral health to the population of South Africa.

Kissoon-Singh (2001) also used the WHO/FDI needs based model (World Health Organization/Fédération Dentaire Internationale, 1989) and the basic

oral health care package (Department of Health, 2001a) to plan human resources for oral health care for KwaZulu-Natal. This study concluded that there was a gross shortage of oral health personnel to meet the oral health needs of this province.

For this study the WHO/FDI human resources planning model (World Health Organization/Fédération Dentaire Internationale, 1989) and a "Service Targets Method" model were used to calculate the oral health human resources required for the delivery of the minimum package of oral care to 4- to 15-year-old children. In both models total human resources and the number of oral hygienists and dentists/dental therapists were calculated separately. Both approaches assumed that the public oral health services would not be responsible for delivering the minimum package of oral care to children older than fifteen and that the oral hygienist would be responsible for delivering the preventive care (group and individual), topical fluoride application, fissure sealants and periodontal care and the dental therapist/dentist the restorative care and extractions.

To illustrate the possible impact of the implementation of water fluoridation on the number of oral health human resources required, treatment need expressed as a percentage of the population or the mean number of teeth in need of treatment (see Table 31, p 110 and Table 32, p 111) were adjusted accordingly based on assumed caries reductions of 10%, 30% and 50% which were applied to both the water fluoridation model and calculating the cost of delivering the minimum package or oral care as well.

Considering the low caries prevalence observed from the 1999-2002 NCOHS (Department of Health, 2003b), only results for an anticipated 30% caries reduction due to the implementation of water fluoridation compared to no water fluoridation will be discussed.

5.5.2 Oral health human resources required on a national level

In general on both the national and all provincial levels the number of human resources required as calculated with the WHO/FDI model is less than the numbers calculated with the "Service Targets Method" model (see Table 51, p 151). The WHO/FDI model calculates that without the impact of water fluoridation 510 oral health workers would be required to deliver the minimum package of care to 4- to 15-year-olds compared to 679 with the "Service Targets Method" model. Similarly at a 30% anticipated caries reduction the number required would be 453 with the WHO/FDI model and 544 with the "Service Targets Method" model.

A possible explanation for this is that the WHO/FDI model places a big emphasis on prevention and control of disease, maintenance of health and high quality restorative care whereas the "Service Targets Method" model converts treatment need based on demand to FTE with all types of treatment need considered as equal. For both models similar treatment times were used for the calculations. The WHO/FDI model also requires DMFT data, whereas the "Service Targets Method" model requires treatment need. Both these datasets used in this study are from the 1999-2002 NCOHS (Department of Health, 2003b). It can be argued that treatment need in this survey might have been overestimated leading to more oral health workers required as calculated with the "Service Targets Method" model.

It is clear from Table 51 (p 151) and both Figure 11 and Figure 12 (p 154), irrespective of whether the WHO/FDI or the "Service Targets Method" models were used for the calculations, that oral hygienists represent the majority of oral health human resources required to deliver the minimum package of oral care to 4- to 15-year-old children. This is not surprising as the minimum package or oral care adopts a much more preventative approach, yet still takes into consideration that active disease needs to be addressed as well through restorative procedures and extractions.

When the impact of the introduction of water fluoridation is taken into consideration at an anticipated caries reduction of 30%, the impact is much larger on the number of dentists and dental therapists required compared to oral hygienists. With the WHO/FDI model (see Figure 11, p 154), compared to when no water fluoridation has been introduced, the number of dentists decrease from 31 to 22 (29%) and the number of dental therapists from 153 to 111 (27.5%), whereas the number of oral hygienists only decrease from 327 to 320 (2.1%). Similarly, with the "Service Targets Method" (see Figure 12, p 154), the number of dentists decrease from 54 to 38 (29.6%) and the number of dental therapists from 272 to 191 (29.8%), whereas the number of oral hygienists decrease from 352 to 315 (10.5%). This can be explained by water fluoridation impacting on the number of restorations and extractions required, whereas it has little impact on the required number of fissure sealants and topical fluoride applications and no impact on group prevention and prophylaxis. These procedures are all provided by oral hygienists.

When results are studied by the type of oral health worker, due to the emphasis op prevention in both models used in this study, oral hygienists represent more than 50% of oral health human resources required to deliver the minimum package of oral care to 4- to 15-year-old children (see Table 53, p 156). Dental therapists represent approximately 30 to 40% and dentists less than 10% of the total human resources required to deliver the restorative care and extraction components of the minimum package of oral care (see Table 54, p 157).

The decreased need for oral health human resources as a result of the implementation of water fluoridation, based on an anticipated 30% reduction in dental caries, can be expressed as a monetary value by using the remuneration paid to a senior oral hygienist, senior dental therapist and a community service dentist employed in the public service as on 1 July 2006 (Department of Public Service and Administration, 2006). The average annual basic salary for both a senior oral hygienist and senior dental therapist appointed on Level 7 in the public service is R106,700. If 30% is added to the basic salary for benefits such as pension, medical insurance and bonuses,

this amounts to R138,700 per annum. The average salary for a community service dentist, including scarce skills allowance, overtime payment, pension, medical insurance and bonuses is R259,000 per annum.

If the mean value of the reduction in the required human resources between those calculated with the WHO/FDI and "Service Targets Method" models is used, 12.5 less dentists (9 with the WHO/FDI and 16 with the "Service Targets Method" model), 61.5 less dental therapists (42 with the WHO/FDI and 81 with the "Service Targets Method" model) and 22 less oral hygienists (7 with the WHO/FDI and 37 with the "Service Targets Method" model) would be required to deliver the minimum package of oral care to 4- to 15-year-olds at an anticipated 30% caries reduction due to the implementation of water fluoridation. This converts to an annual saving in salary of R3,237,500 for dentists, R8,530,050 for dental therapists and R3,051,400 for oral hygienists. The total annual saving in salaries alone for all oral health human resources combined would be R14,818,950 per year.

5.5.3 Oral health human resources required on a provincial level

Population size and treatment need are the two determining variables in calculating human resources in both models. The great variation between provinces for the total number of human resources required as well as the different types of oral health workers can therefore be explained based on these. The 2006 South African mid-year population estimates indicate the largest 4- to 15-year-old population to be in KwaZulu-Natal (2.7 million), followed by the Eastern Cape (2 million), Gauteng (1.8 million) and Limpopo (1.7 million) (Statistics South Africa, 2006). Reports on the 1999-2002 NCOHS highlight the higher caries prevalence in provinces such as the Western and Northern Cape with North West province recording some of the lowest caries prevalence rates (Department of Health, 2003b; Van Wyk et al., 2004). This is reflected in higher treatment needs for the Western and Northern Cape as well.

According to both the WHO/FDI and "Service Targets Method" models, without the impact of water fluoridation, KwaZulu-Natal would require the highest number of human resources (114 and 142 respectively), followed by the Eastern Cape (91 and 84) and Gauteng (74 and 102) (see Table 52, p 153). The lowest number of human resources to implement the minimum package of oral care without the impact of water fluoridation are the Northern Cape (10 and 22), North West (33 and 35), Mpumalanga (33 and 45) and the Free State (33 and 47). Similar results are found for the number of oral hygienists required (see Table 54, p 157).

For dentists and dental therapists combined the largest number are required for KwaZulu-Natal (40 and 59), Eastern Cape (37 and 45), Western Cape (33 and 45) and Gauteng (25 and 49). The lowest number of dentists and dental therapist are needed in the Northern Cape (4 and 17), North West (9 and 14), Limpopo (11 and 47) and Free State (12 and 22) (see Table 51, p 151). This can be explained mainly by the difference in caries prevalence for these provinces.

5.6 Summary

This chapter presented the WHO/FDI and "Service Targets Method" models, results and discussion to calculate the oral health human resources required for the implementation of the minimum package of oral care to 4- to 15-year-old children, taking into account different scenarios for caries reduction achieved through water fluoridation.

In general on both the national and all provincial levels the number of human resources required as calculated with the WHO/FDI model is less than calculated with the "Service Targets Method" model.

For both models oral hygienists represent more than 50% of the total oral health human resources required to deliver the minimum package of oral care to 4- to 15-year-old children.

Dental therapists represent approximately 30 to 40% and dentists less than 10% of the total human resources required to deliver the restorative care and extraction components of the minimum package of oral care.

The conclusions and recommendations from this study linked to water fluoridation and delivering the basic package of oral care as well as the impact on the required number of oral health human resources will be discussed in Chapter 6.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

6.1.1 Cost evaluation of the implementation of water fluoridation in South Africa

Decision makers in dental public health should continuously decide on which community-based preventive procedures utilise limited resources optimally. Due to its ease of implementation and equity associated with the artificial fluoridation of public water supplies, it remains the first choice to expose the public to the protective effect of fluoride.

Worldwide declines in dental caries and low caries prevalence in both developed and developing countries, including South Africa, has led to the cost-effectiveness of water fluoridation being questioned, especially in smaller communities and towns.

White et al. (1989) identified ten variables related to the cost of water fluoridation. These include political costs (referenda and campaigning), number of employees (labour cost), choice of chemicals (chemical cost), cost of equipment and instrumentation, annual operational cost (electricity, rent, insurance, shared space), maintenance (annual cost of testing equipment, length of usefulness and replacement cost), natural fluoride content of drinking water, the optimal level of fluoride in drinking water suggested for a country, number of injection sites and cost of installation and consulting engineers' fees.

A model to determine the per capita cost, cost-effectiveness and cost-benefit of the implementation of water fluoridation for seventeen major metropolitan cities, towns and water boards from all nine South African provinces was presented in Chapter 3. This model addressed eight of the ten variables suggested by White et al. (1989). Regulations for the implementation of water

fluoridation for South Africa make provision for consultation with and informing the public (Republic of South Africa, 2000). It is therefore fair to assume that political costs for South Africa will be limited to public communication without referenda. A National Fluoridation Survey conducted in 1998 indicated that the majority of respondents (61.9%) agreed that fluoride should be added to water, 9% disagreed with the remaining 29.1% unsure. (Chikte and Brand, 1999; Chikte and Brand, 2000; Chikte et al., 2000).

Operational costs such as electricity, rent, insurance and shared space was not included in the model, but it can be assumed that this would have represented only a small portion of the total operational cost.

When this model was applied to seventeen major metropolitan cities, towns and water boards from all nine South African provinces, results clearly show that despite a low prevalence of dental caries in South African children, artificial fluoridation of drinking water remains the community-based preventive measure of choice for South Africa. The average per capita cost for all municipalities and water providers is R2.08 per annum, which is extremely low compared to the cost other fluoride vehicles. Other additional benefits of artificially fluoridated water include that it is equitable and passive without direct interaction with a dental provider required.

Results of this study also clearly show that cost-effectiveness and cost-benefit at an anticipated 30% reduction in caries levels as a result of the introduction of water fluoridation is highly favourable. Even at an anticipated 10% caries reduction level, cost-benefit only approached or slightly exceeded a ratio of 0.8 for three municipalities.

Two previous South African studies described the economics of water fluoridation for Gauteng. Smalberger (1998) calculated the per capita cost for Gauteng (based on information supplied by Rand Water in 1995) as R0.11 for poor households and R2.40 for affluent households. At an estimated caries reduction of 25%, saving per person per year varied from R11.70 to R26.60. Based on information supplied between 1998 and 2000, Van Wyk et

al. (2001) calculated the per capita cost for Gauteng as R0.73 and cost-effectiveness and cost-benefit at an anticipated caries reduction of 30% as R6.58 and 0.07 respectively, compared to this study where the per capita cost for Gauteng (Rand Water) was calculated as R2.06 and cost-effectiveness and cost-benefit at an anticipated caries reduction of 30% as R34.18 and 0.2 respectively. Reasons for the difference between the Van Wyk et al. (2001) and this study is a decline in caries prevalence (DMFT for 15-year-olds of 3.3 used by Van Wyk et al. (2001) compared to 1.81 for the current study) and the impact of inflation.

The model presented in this study does not take into account the impact of water fluoridation on physical, social and emotional well-being or changes in quality of life as a result of its introduction. An increase in the number of caries free teeth and declines in caries incidence will without doubt have a positive outcome on these indicators. These include cosmetic advantages of caries free unrestored teeth, reduced discomfort associated with dental treatment, reduction in the number of dental visits and the associated loss of employment time and absenteeism from school or work to have the treatment performed.

The WHO in collaboration with the FDI and the IADR hosted a global consultation on “Oral Health through Fluoride” from 17-19 November 2006. A declaration from this consultation reaffirmed the efficiency, cost-effectiveness and safety of the daily use of optimal fluoride and that access to fluoride for dental health formed part of the basic human right to health (Fédération Dentaire Internationale, 2006).

6.1.2 Cost evaluation of delivering the minimum package of oral care to South African children

Adoption of the PHC approach and reducing the incidence of common oral diseases through a minimum package of care, water fluoridation, and reduction of the consumption of refined sugar were identified as the main principles to address oral health (Republic of South Africa, 1997b). The South

African National Oral Health Strategy (Department of Health, 2005) listed the provision of appropriate disease prevention and health promotion measures based on the minimum package of care on a district level.

According to the 1999-2002 NCOHS (Department of Health, 2003b; Van Wyk et al., 2004) dental caries is more severe in the primary dentition compared to the permanent dentition. Although caries levels for 12-year-olds range between very low and low according to the WHO classification (Barmes, 1977), high levels of untreated caries in all provinces is of major concern. The population under fifteen years of age in South Africa is around 14.3 million which is approximately 32% of the total population (Statistics South Africa, 2003).

The introduction of water fluoridation to major metropolitan areas and larger towns will impact on the number of caries lesions. Restorative dentistry should be simpler as lesions will develop slower and be smaller. In the majority of cases these will be limited to occlusal surfaces as regular exposure to fluoride protects mainly the smooth surfaces of the tooth. This will impact on the human resources required to address especially dental caries.

A model to express the delivery of the minimum package of oral health care as a per capita cost was presented in Chapter 4. This model was applied to 4- to 5-, 6-, 12- and 15-year-olds based on treatment need data from the 1999-2002 NCOHS (Department of Health, 2003b; Van Wyk et al., 2004) which was converted to a cost by applying the 2006 NRPL (Council for Medical Schemes, 2006) and UPFS (Gauteng Provincial Government, 2005) treatment fees on a national level as well as for all nine South African provinces.

To illustrate the possible impact of the implementation of water fluoridation on the cost of delivering the minimum package or oral care, treatment need was adjusted accordingly based on assumed caries reductions of 10%, 30% and 50% as a result of the introduction of water fluoridation.

At an anticipated caries reduction of 30% where the cost of an oral examination and bitewing radiographs were excluded, per capita cost for delivering the minimum package of oral care ranges from R133.45 for 4- to 5-year-olds to R227.10 for 6-year-olds with the cost of restorations and extractions as the major contributor.

Results varied greatly between provinces with those provinces where the highest treatment need exists (Western and Northern Cape) presenting with the highest per capita cost of delivering the minimum package of care. At an anticipated 30% caries reduction due to water fluoridation these were calculated as R215.56 for the Northern Cape and R285.28 for the Western Cape.

6.1.3 Oral health human resources needs for South African children

The four approaches to human resources planning are the human resources to population ratio, health needs, health demands approach and the service targets approach (Hall, 1978). The WHO/FDI model translates need into FTE of oral health personnel required to provide a calculated level of care based on time estimates for each treatment type (World Health Organization/Fédération Dentaire Internationale, 1989). This model makes provision for modifying factors such as demand.

Human resources planning for oral health in South Africa has received a lot of attention. This was reviewed in Chapter 2 (see Section 2.2.4, p 39). Despite several committees and commissions reporting on oral health, very few have been taken seriously and only a limited number of recommendations have been implemented.

Since 1994 three postgraduate studies and reports into human resources for the new South Africa have been published. Booyens (1994) reported on human resources needed to deliver primary preventive services. A modified version of the WHO/FDI human resources model was used in this study. Van Wyk (1996) reported on human resources needed based on the principles of

supply and demand taking into consideration modifying factors, treatment needs and trends. Kissoon-Singh (2001) reported on a human resources plan for oral health care for the province of KwaZulu-Natal. The WHO/FDI human resources model was used for the calculations.

A new debate on human resources planning for oral health was triggered with the publication of the NHRP for South Africa (Department of Health, 2006a) building on recommendations from the Pick report (Pick et al., 2001).

The Pick report used computer simulation models developed by the WHO and historical information from registers of the statutory councils to project supply of a number of health workers, including oral health, over a thirty year period to 2029 using different demographic assumptions (Pick et al., 2001). The report suggested the creation of a single dental auxiliary to replace the oral hygienist and dental therapist, a downward revision of the annual intake of dental students, dental assistants in underserved areas should receive a one year training by dentists to perform simple procedures such as the ART and the scope of the dental therapist should be expanded to include placement and removal of sutures and removable orthodontic appliances and care of wounds and finally a projected requirement for 2029 of 6,413 dentists and 435 oral hygienists.

The NHRP for Health for South Africa provided a framework to guide all stakeholders to ensure an adequate workforce in partnership with government (Department of Health, 2006a). The NHRP proposed an annual production of 120 dental practitioners by 2008, 600 dental therapists by 2009, maintaining current levels of dental technicians, 150 oral hygienists by 2009 and 300 dental assistants by 2008. In a response to the NHRP the editor of the SADJ on behalf of the SADA (Campbell, 2006) criticised the recommendation made for dentists, but welcomed the suggested increase in the production of oral hygienists. It furthermore expressed concern on the suggested number of dental therapists to be trained, especially since current facilities are only equipped to train 300 dentists/dental therapists per year.

In this study the WHO/FDI human resources planning model (World Health Organization/Fédération Dentaire Internationale, 1989) and a "Service Targets Method" model were used to calculate oral health human resources required for the delivery of the minimum package of oral care to 4- to 15-year-old. In both models total human resources and the number of oral hygienists and dentists/dental therapists were calculated separately. Both approaches assumed that the public oral health services would not be responsible for delivering the minimum package of oral care to children older than fifteen and that the oral hygienist would be responsible for delivering the preventive (group and individual), topical fluoride application, fissure sealants and periodontal care and the dental therapist/dentist the restorative care and extractions.

Without the impact of water fluoridation taken into consideration, the number of human resources required to deliver the minimum package of oral care was calculated as 510 with the WHO/FDI model (327 oral hygienists, 31 dentists and 153 dental therapists) and 679 with the "Service Targets Method" (352 oral hygienists, 54 dentists and 272 dental therapists).

When an anticipated caries reduction of 30% is taken into consideration with the introduction of water fluoridation, the impact is much larger on the number of dentists and dental therapists required compared to oral hygienists. With the WHO/FDI model, compared to when no water fluoridation has been introduced, the number of dentists decrease from 31 to 22 (29%) and the number of dental therapists from 153 to 111 (27.5%), whereas the number of oral hygienists decrease from 327 to 320 (2.1%). Similarly, with the "Service Targets Method", the number of dentists decrease from 54 to 38 (29.6%) and the number of dental therapists from 272 to 191 (29.8%), whereas the number of oral hygienists decrease from 352 to 315 (10.5%). This can be explained by water fluoridation impacting on the number of restorations and extractions required, whereas it has little impact on the required number of fissure sealants and topical fluoride applications and no impact on group prevention and prophylaxis. These procedures are all provided by oral hygienists.

When this decreased need for oral health human resources is expressed as a monetary value by using the remuneration paid to a senior oral hygienist, senior dental therapist and a community service dentist employed in the public service as on 1 July 2006 (Department of Public Service and Administration, 2006), it converts to an annual saving of R3,237,500 for dentists, R8,530,050 for dental therapists and R3,051,400 for oral hygienists. The total annual saving in salaries alone for all oral health human resources to deliver the minimum package of oral care to 4- to 15-year-olds at an anticipated 30% caries reduction due to the implementation of water fluoridation would be R14,818,950.

Although this study was limited to calculating the number of human resources required to deliver the minimum package of oral care to 4- to 15-year-olds only, the results would support an increase in the training of oral hygienists to be employed in mainly the public sector. The majority of restorative procedures and extractions required as part of the minimum package of oral care can be provided by a dental therapist.

As of 30 March 2007, 961 oral hygienists, 456 dental therapists and 4,792 dentists were registered with the HPCSA (Health Professions Council of South Africa, 2007). It would require 35% or oral hygienists and between 34% and 60% of dental therapists currently registered with the HPCSA to deliver the minimum package of oral care to 4- to 15-year-old children.

In terms of the Medical, Dental and Supplementary Health Service Professions Amendment Act, 1997 (Act 89 of 1997) (Republic of South Africa, 1997a), one year of CCS in the public sector was introduced for dentists in July 2000. These numbers should be sufficient to address that component of the minimum package of oral care where a dentist is required.

6.2 Recommendations

Despite declines in caries incidence worldwide, artificial fluoridation of drinking water is still regarded as a viable public health measure. Public health professionals at a national, provincial and local level need to enhance their promotion of fluoride and commit the necessary resources for equipment, personnel and training.

Currently no artificially fluoridated water scheme exists in South Africa, despite a Commission of Inquiry into water fluoridation recommending the fluoridation of public water supplies to the optimal fluoride concentration (Republic of South Africa, 1966) and regulations for the introduction of water fluoridation in South Africa which were promulgated on 8 September 2000 (Republic of South Africa, 2000) which compel water providers to fluoridate public water supplies. These regulations were repealed with the repealing of the Health Act of 1977 and have been amended and will follow the normal legal process for approval (Smit, 2007).

This study confirms that in view of a low per capita cost, favourable cost-effectiveness and cost-benefit ratios, which will result in huge savings in the cost of treatment, artificial fluoridation of drinking water remains a feasible community-based preventive option for South Africa, even if only a 10% caries reduction as a result of its introduction is achieved. Evidence exists that fluoridation has the effect of reducing the dental caries disparities between different socio-economic status groups (Burt, 2002), which on its own is a major reason, especially for South Africa, to seriously consider its introduction.

It is strongly recommended that the NFC should use this model and the results from this investigation to convince water providers and local authorities about the benefits of this measure, provided that the national and provincial Departments of Health, who will be the main beneficiaries of improved oral health, make available resources to municipalities and water providers to subsidise its introduction. The national Department of Health should also

launch an information campaign to inform the public of all aspects of the artificial fluoridation of drinking water.

Water fluoridation does not only lead to improved oral health, but will also result in a change in need and demand for oral health services which will translate to a decrease in human resource requirements.

Although the introduction of water fluoridation will impact on caries incidence, caries will still develop. It is strongly recommended that all provinces should actively pursue the introduction of the suggested minimum package of oral care to all children aged younger than fifteen to address especially the large untreated caries component. Appropriate modes of delivery, such as mobile oral health units and equipment, must be investigated to deliver the service to as wide a community as possible in the most cost-effective way. Per capita cost of delivering the minimum package of care will be reduced as a result of the impact of water fluoridation.

To deliver the minimum package of oral care according to the White Paper for the Transformation of Health Services in South Africa (Republic of South Africa, 1997b), will require the creation of a number of posts as well as incentives to attract especially oral hygienists to the public service. The recommendations from the NHRP to increase the number of oral hygienists (Department of Health, 2006a) is supported by this study. This study does not recommend an increase in the training of the number of dental therapists, or the suggested creation of a single dental auxiliary to replace the oral hygienist and dental therapist. The minimum package of oral care places great emphasis on preventive services for which an oral health worker dedicated to prevention, such as an oral hygienist, already exists.

A change in regulations in 1993 to allow dental therapists to enter the private sector and open their own practices, combined with poor salaries and limited career opportunities were listed as the main reasons for dental therapists resigning in large numbers from the public service (Prinsloo, 1994). This

decision and its impact remains controversial and especially the SADA has made its view on this clear on a number of occasions.

A position paper on dental therapists (South African Dental Association, 2000) recommended an immediate moratorium on the training of dental therapist until all key stakeholders have debated this issue. It also urged the HPCSA to rescind the decision to allow dental therapists to practice independently as this was seen as not to be in the best interest of the public sector, especially since the intention was that dental therapists be employed in this sector. In response to the NHRP, the SADA once again called for meaningful negotiations with all stakeholders to address the future of the dental therapy profession (Campbell, 2006).

Results from this study clearly illustrate an urgent need for dental therapists in the public service. Until adequate numbers of oral hygienists have been trained and the future of dental therapists investigated, it is recommended that CCS be expanded to include both oral hygienists and dental therapists with the primary objective of focusing on the delivery of the minimum package of care to children younger than fifteen. When training institutions, in collaboration with the Department of Health and professional bodies, decide on the appropriate numbers to be trained, the envisaged introduction of water fluoridation and its subsequent impact on caries levels should always be taken into account.

A summary of the recommendations from this study are presented in Table 55.

Table 55: Summary of recommendations from this study

Cost evaluation of the implementation of water fluoridation in South Africa: • In view of a low per capita cost, favourable cost-effectiveness and cost-benefit ratios as well as the effect of reducing the dental caries disparities between different socio-economic status groups, water fluoridation remains a viable option for South Africa, even if only a 10% caries reduction as a result of its introduction is achieved; • The NFC should use this model and the results from this investigation to convince water providers and local authorities about the benefits of this measure; • The national and provincial Departments of Health, who will be the main beneficiaries of improved oral health, should make available resources to municipalities and water providers to subsidise its introduction; and • The national Department of Health should launch an information campaign to inform the public of all aspects of the artificial fluoridation of drinking water.
Cost evaluation of delivering the minimum package of oral care to South African children: • All provinces should actively pursue the introduction of the minimum package of oral care to all children aged younger than fifteen to address especially the large untreated caries component; and • Appropriate modes of delivery such as mobile oral health units and equipment must be investigated to deliver the service to as wide a community as possible in the most cost-effective way.
Oral health human resources needs for South African children: • The creation of a number of posts as well as incentives to attract especially oral hygienists to the public service will be required to deliver the minimum package of oral care; • An increase in the number of oral hygienists trained; • To ensure a focus on preventive services the creation of a single dental auxiliary to replace the oral hygienist and dental therapist is not supported; • Meaningful negotiations with all stakeholders to address the future of the dental therapy profession and attracting this profession back to the public sector is urgently required; • CCS be expanded to include both oral hygienists and dental therapists with the primary objective of focusing on the delivery of the minimum package of care to children younger than fifteen; and • The possible impact of the introduction of water fluoridation on human resources should always be considered in planning the number of oral health professionals to be trained.

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ANNEXURES

ANNEXURE 1: PER CAPITA COST, COST-EFFECTIVENESS AND COST-BENEFIT OF THE IMPLEMENTATION OF WATER FLUORIDATION FOR THE CITY OF TSHWANE METROPOLITAN MUNICIPALITY (PRETORIA)

Category A: >700 Ml/day	Note: Data is needed for all shaded fields	
Category B: <700; >100 Ml/day	City	Category
Category C: <100 Ml/day	Tshwane (Pretoria)	Category A
Chemical name		Fluorosilicic acid
Chemical formula		H_2SiF_6
Molecular mass		144.08
[a] Available fluoride		79.1%
[b] Purity		40.0%

Variable	Formula	Value
(A) CHEMICAL COST:		
[1] Daily water purification rate (litre per day)		722,000,000
[2] Natural fluoride content of water (mg F/litre)		0.20
[3] Adjustment of fluoride level to (mg F/litre)		0.7
[4] Fluoride needed per day (metric tonne)	[1]x([3]-[2])/(1 x 10^9)	0.36
[5] Fluoride needed per year (metric tonne)	[4]x365	131.77
[6] Chemical needed per year (metric tonne)	[5]/([a]*[b])	416.45
[7] Cost of chemical (Rand per metric tonne)		R7,044.00
[8] Percentage handling fee by agent		12.5
[9] Delivery cost (metric tonne)		R180.00
[10] Total delivery cost of chemical	[7]+([7]x[8]/100)+[9]	R8,104.50
(A) Cost of chemical per year	[6]*[10]	**R3,375,124.66**
(B) LABOUR COST:		
[11] Average operator salary		R255,162.87
[12] Number of operators needed		6
[13] Annual operator salary for number of operators needed	[11]x[12]	R1,561,596.77
[14] Number of hours needed per operator per day		1
(B) Annual labour cost for number of hours needed per day	[13]/8x[14]	**R195,199.60**
(C) MAINTENANCE COST:		
[15] Capital cost per Mega litre of water processed		R8,750.00
[16] Percentage cost of buildings and storage		21
[17] Cost of buildings and storage	[1]/1,000,000*[15]*[16]/100	R1,326,675.00
[18] Percentage cost of mechanical and electrical plant		79
[19] Cost of mechanical and electrical plant	[1]/1,000,000*[15]*[18]/100	R4,990,825.00
[20] Total capital cost	[17]+[19]	**R6,317,500.00**
[21] Percentage		2.4
(C) Maintenance cost: % of total capital cost	[20]x[21]/100	**R151,620.00**

Variable	Formula	Value
(D) OPPORTUNITY COST:		
[22] Prime Overdraft Rate of Banks		11.5
(D) Opportunity cost: % of total capital cost	[20]x[22]/100	**R726,512.50**
(E) CAPITAL DEPRECIATION:		
[23] Years for building and storage		15
[24] Capital depreciation of buildings and storage	[17]/[23]	R88,445.00
[25] Years for mechanical and electrical plant		8
[26] Capital depreciation of mechanical and electrical plant	[19]/[25]	R623,853.13
(E) Total capital depreciation per annum	[24]+[26]	**R712,298.13**
(F) OPERATING COST:		
Chemical cost + Labour cost + Maintenance cost	(A)+(B)+(C)	**R3,721,944.26**
(G) TOTAL COST:		
Opportunity cost + Capital depreciation + Operating cost	(D)+(E)+(F)	**R5,160,754.88**
(H) PER CAPITA COST:		
[27] Population served by water provider		2,100,000
[28] Per capita cost for total population	(G)/[27]	**R2.46**
[29] Percentage of population younger than 15 years		26.46
[30] Population served by water scheme younger than 15 years	[27]x[29]/100	555,660
[31] Per capita cost younger than 15 years	(G)/[30]	**R9.29**
(I) CARIES DATA		
[32] DMFT		1.81
[33] Age for DMFT score		15
[34] DMFT increment per year	[32]/([33]-6)	0.20

Variable	Formula	Value		
(J) COST-EFFECTIVENESS (the cost per person per year to save 1 DMFT)				
[35] Decrease in caries incidence (%)		10	30	50
[36] Decrease in DMFT per child per year	[35]/100x[34]	0.02	0.06	0.10
(J) Cost-effectiveness for total population	[28]/[36]	**R122.20**	**R40.73**	**R24.44**
(J) Cost-effectiveness for population younger than 15 years	[31]/[36]	**R461.81**	**R153.94**	**R92.36**
(K) COST-BENEFIT RATIO (the cost of implementation of water fluoridation divided by savings in cost of treatment)				
[37] Cost of a 2 surface amalgam restoration		R155.90		
[38] Cost of a 2 surface anterior resin restoration		R174.60		
[39] Cost of a 2 surface posterior resin restoration		R186.20		
[40] Average cost of a 2 surface restoration	([37]+[38]+[39])/3	R172.23		
(K) Cost-benefit ratio for total population	[28]/([36]x[40])	**0.71**	**0.24**	**0.14**
(K) Cost-benefit ratio for population younger than 15 years	[31]/([36]x[40])	**2.68**	**0.89**	**0.54**

ANNEXURE 2: DETAILED INFORMATION ON WATER PROVIDERS

Classification of water providers:

- **Category A:** Water purification rate of more than 700 Mega litre per day
- **Category B:** Water purification rate of less than 700 and more than 100 Mega litres per day
- **Category C:** Water purification rate of less than 100 Mega litres per day

Number of plant superintendents required:

- **Water purification rate of more than 250 Mega litre per day:** 4 plant superintendents
- **Water purification rate between 100 and 249 Mega litre per day:** 3 plant superintendents
- **Water purification rate between 50 and 99 Mega litre per day:** 2 plant superintendents
- **Water purification rate less than 50 Mega litre per day:** 1 plant superintendent
- **Water purification rate less than 1 Mega litre per day:** Assumed that superintendents from other plants service this plant

Salary adjustments:

Information on salaries of plant superintendents was supplied in 2004. Adjustments for 2005 and 2006 were based on the annual salary adjustments recommended by the Department of Public Service and Administration for post levels 1 to 12 (Department of Public Service and Administration, 2005; Department of Public Service and Administration, 2006):

- **2005:** 4.6% adjustment of 2004 salary rates
- **2006:** 5.3% adjustment of 2005 salary rates

Category A water providers:

- **Cape Town**

Plant	Current production (Ml/day)	Population served	Plant superintendents	Salary (2006)
Faure	188.3		3	R558,237.42
Blackheath	190		3	R558,237.42
Wemmershoek	195.3		3	R558,237.42
Voëlvlei	154		3	R558,237.42
Steenbras	86.2		2	R372,158.28
Witzands	17.1		1	R186,079.14
Kloof Nek	12.4		1	R186,079.14
Somerset West	2.1		Same team as Faure	
Brooklands	2.7		1	R186,079.14
Albion Spring	1.1		Unmanned	
Constantia Nek	1.1		1	R186,079.14
Total	**850.3**	**3,350,000**	**18**	**R3,349,424.49**

- **Umgeni Water**

Plant	Current production (Ml/day)	Population served	Plant superintendents	Salary (2006)
Midmar	250	800,000	4	R1,101,438.00
D.V. Harris	45	150,000	1	R275,359.50
Durban Heights	613	1,750,000	4	R1,101,438.00
Wiggins	120	500,000	3	R826,078.50
Hazelmere	30	40,000	1	R220,287.60
Amanzimtoti	25	75,000	1	R220,287.60
Mtwalumi	4	15,000	1	R220,287.60
Craigie Burn	4	15,000	1	R220,287.60
Umzinto	12	60,000	1	R220,287.60
Umbumbulu	2.5	10,000	1	R220,287.60
Ixopo	2	7,000	1	R220,287.60
Total	**1,107.5**	**3,422,000**	**19**	**R4,846,327.20**

- **Durban/Pietermaritzburg combined**

Plant	Current production (Ml/day)	Population served	Plant superintendent	Salary (2006)
Midmar	250	800,000	4	R1,101,438.00
D.V. Harris	45	150,000	1	R275,359.50
Durban Heights	613	1,750,000	4	R1,101,438.00
Wiggins	120	500,000	3	R826,078.50
Hazelmere	30	40,000	1	R220,287.60
Amanzimtoti	25	75,000	1	R220,287.60
Total	**1,083**	**3,315,000**	**14**	**R3,744,889.20**

- **Durban**

Plant	Current production (Ml/day)	Population served	Plant superintendent	Salary (2006)
Midmar (60%)	150		2.4	R660,862.80
D.V. Harris (60%)	27		0.6	R165,215.70
Durban Heights	613		4	R1,101,438.00
Wiggins	120		3	R826,078.50
Hazelmere	30		1	R220,287.60
Amanzimtoti	25		1	R220,287.60
Craigie Burn	4		1	R200,000.00
Umbumbulu	2.5		1	R200,000.00
Total	**971.5**	**3,064,624**	**14**	**R3,594,170.20**

Note: 60% of water processed by the Midmar and D.V. Harris plants (Umgeni Water) is supplied to Durban, therefore Durban is responsible for 60% of the cost of superintendents for these plants

- **Rand Water**

Plant	Current production (Ml/day)	Population served	Plant superintendent	Salary (2006)
Vereeniging			4	R1,101,438.00
Zuikerbosch			4	R1,101,438.00
Total	**3,558**	**12,000,000**	**8**	**R2,202,876.00**

- **Johannesburg**

Plant	Current production (Ml/day)	Population served	Plant superintendent	Salary (2006)
Vereeniging (36%)			1.44	R396,517.68
Zuikerbosch (36%)			1.44	R396,517.68
Total	**1,280**	**3,225,608**	**2.88**	**R793,035.36**

Note: 36% of water processed by the Vereeniging and Zuikerbosch plants (Rand Water) is supplied to Johannesburg, therefore Johannesburg is responsible for 36% of the cost of superintendents for these plants

- **Tshwane (Pretoria)**

Plant	Current production (Ml/day)	Population served	Plant superintendent	Salary (2006)
Rietvlei	40		1	R250,638.83
Temba	60		2	R501,277.65
Roodeplaat	60		2	R501,277.65
Fonteine, Grootfontein, Sterkfontein	65		Unmanned	
Rand Water (14%)	497		1.12	R308,402.64
Total	**722**	**2,100,000**	**6.12**	**R1,561,596.77**

Note: 14% of water processed by Rand Water is supplied to Tshwane, therefore Tshwane is responsible for 14% of the cost of superintendents for these plants

Category B water providers:

- **Port Elizabeth**

Plant	Current production (Ml/day)	Population served	Plant superintendent	Salary (2006)
Linton	11		1	R201,563.15
Loerie	65		2	R403,126.31
Churchill	70		2	R403,126.31
Elandsjagt	65		2	R403,126.31
Groendal	15		1	R201,563.15
Springs	6		Unmanned	
Nooitgedacht	50		2	R403,126.31
Total	**282**	**1,200,000**	**10**	**R2,015,631.54**

- **Amatola Water**

Plant	Current production (Ml/day)	Population served	Plant superintendent	Salary (2006)
Sandile	18		1	R132,172.56
Laing	27.3		1	R132,172.56
Nahoon	33.7		1	R132,172.56
Peddie	6.56		1	R132,172.56
Binfield Park	4.8		1	R132,172.56
Wesley Coastal	4.3		1	R132,172.56
Mascincedane	2.2		1	R132,172.56
Debe Nek	1.5		1	R132,172.56
Rooikrantz	1.2		1	R132,172.56
Pleasant View	0.75			
Dabi	0.72			
Upper Mnyameni	0.56			
Glenmore	0.5			
Upper Gxulu	0.11			
Total	**102.2**	**1,210,286**	**9**	**R1,189,553.04**

- **Pietermaritzburg**

Plant	Current production (Ml/day)	Population served	Plant superintendents	Salary (2006)
Midmar (40%)	100		1.6	R440,575.20
D.V. Harris (40%)	18		0.4	R110,143.80
Total	**118**	**500,000**	**2**	**R550,719.00**

Note: 40% of water processed by the Midmar and D.V. Harris plants (Umgeni Water) is supplied to Pietermaritzburg, therefore Pietermaritzburg is responsible for 40% of the cost of superintendents for these plants

- **Bloem Water**

Plant	Current production (Ml/day)	Population served	Plant superintendents	Salary (2006)
Welbedacht	120	600,000	3	R712,178.80
Rustfontein	30	330,000	1	R237,392.93
Groothoek	5	25,000	1	R237,392.93
Bethulie	4	24,000	1	R237,392.93
Gariep	2.2	4,000	1	R237,392.93
Philippolis	1	4,000	1	R237,392.93
Sterkspruit	3.5	40,000	1	R237,392.93
Total	**165.7**	**1,027,000**	**9**	**R2,136,536.39**

- **Bloemfontein**

Plant	Current production (Ml/day)	Population served	Plant superintendents	Salary (2006)
Welbedacht (88%)	105.6	528,000	2.64	R626,717.34
Rustfontein (4%)	1.2	13,200	0.04	R9,495.72
Total	**106.8**	**541,200**	**2.68**	**R636,213.06**

Note: 88% of water processed by the Welbedacht and 4% of the Rustfontein plants (Bloem Water) is supplied to Bloemfontein, therefore Bloemfontein is responsible for 88% and 4% of the cost of superintendents for these plants

- **Kimberley**

Plant	Current production (Ml/day)	Population served	Plant superintendents	Salary (2006)
Riverton	128		3	R454,607.52
Ritchie	1.7		1	R151,535.84
Total	**129.7**	**223,000**	**4**	**R606,143.36**

Category C water providers:

- **Buffalo City (East London)**

Plant	Current production (Ml/day)	Population served	Plant superintendents	Salary (2006)
Sandile	18		1	R132,172.56
Laing	27.3		1	R132,172.56
Nahoon	33.7		1	R132,172.56
Total	**79**	**677,379**	**3**	**R396,517.68**

- **Botshabelo**

Plant	Current production (Ml/day)	Population served	Plant superintendents	Salary (2006)
Rustfontein (93%)	27.9	306,900	0.93	R200,442.90

Note: 93% of water processed by the Rustfontein plant (Bloem Water) is supplied to Botshabelo, therefore Botshabelo is responsible for 93% of the cost of superintendents for these plants

- **Mafikeng**

Plant	Current production (Ml/day)	Population served	Plant superintendents	Salary (2006)
Mmabatho	10		1	R137,679.75
Mafikeng	27		1	R137,679.75
Total	**37**	**170,000**	**2**	**R275,359.50**

- **Nelspruit**

Plant	Current production (Ml/day)	Population served	Plant superintendents	Salary (2006)
Nelspruit	28	35,000	1	R132,172.56
Matsulu	14	60,000	1	R132,172.56
Total	**42**	**95,000**	**2**	**R264,345.12**

- **Polokwane**

Plant	Current production (Ml/day)	Population served	Plant superintendents	Salary (2006)
Polokwane	16	47,565	1	R109,477.43
Seshego	2	70,991	1	R109,477.43
Houtrivierdam	3	53,600	1	R109,477.43
Molepodam	2	28,400	1	R109,477.43
Chuenespoortdam	1		1	R109,477.43
Total	**24**	**200,556**	**5**	**R547,387.15**

ANNEXURE 3: PER CAPITA COST OF DELIVERING THE MINIMUM PACKAGE OF ORAL CARE TO THE 15-YEAR-OLD AGE COHORT

Anticipated % caries reduction due to water fluoridation	0

NRPL 2006								
			Examination/bitewings included			Examination/bitewings excluded		
Variable:	[1]	[2]	[3]; [4]	[7]	[8]	[3]; [4]	[7]	[8]
Examination								
% of population	Pop est 2006	Treatment need	Fee code: 8101 Fee: R103.50	% of total	Per capita cost			
National	987,600	100	R102,216,600.00	19.23	R103.50			
Western Cape	84,980	100	R8,795,430.00	12.98	R103.50			
Northern Cape	17,140	100	R1,773,990.00	16.40	R103.50			
Eastern Cape	174,720	100	R18,083,520.00	23.87	R103.50			
Free State	62,040	100	R6,421,140.00	17.04	R103.50			
KwaZulu-Natal	215,760	100	R22,331,160.00	20.51	R103.50			
Gauteng	139,400	100	R14,427,900.00	19.60	R103.50			
North West	76,980	100	R7,967,430.00	26.60	R103.50			
Mpumalanga	71,600	100	R7,410,600.00	21.31	R103.50			
Limpopo	144,980	100	R15,005,430.00	18.98	R103.50			
Bitewings								
% of population	Pop est 2006	Treatment need	Fee code: 8112 Fee: R41.90	% of total	Per capita cost			
National	987,600	100	R82,760,880.00	15.57	R83.80			
Western Cape	84,980	100	R7,121,324.00	10.51	R83.80			
Northern Cape	17,140	100	R1,436,332.00	13.27	R83.80			
Eastern Cape	174,720	100	R14,641,536.00	19.32	R83.80			
Free State	62,040	100	R5,198,952.00	13.80	R83.80			
KwaZulu-Natal	215,760	100	R18,080,688.00	16.61	R83.80			
Gauteng	139,400	100	R11,681,720.00	15.87	R83.80			
North West	76,980	100	R6,450,924.00	21.53	R83.80			
Mpumalanga	71,600	100	R6,000,080.00	17.25	R83.80			
Limpopo	144,980	100	R12,149,324.00	15.36	R83.80			
Prophylaxis								
Mean no of sextants	Pop est 2006	Treatment need	Fee code: 8159 Fee: R124.90	% of total	Per capita cost	Fee code: 8159 Fee: R124.90	% of total	Per capita cost
National	987,600	3.31	R92,760,132.48	17.45	R93.92	R92,760,132.48	26.76	R93.92
Western Cape	84,980	3.27	R8,883,919.67	13.12	R104.54	R8,883,919.67	17.14	R104.54
Northern Cape	17,140	2.30	R1,389,370.11	12.84	R81.06	R1,389,370.11	18.26	R81.06
Eastern Cape	174,720	2.88	R18,374,568.58	24.25	R105.17	R18,374,568.58	42.69	R105.17
Free State	62,040	3.95	R4,835,248.70	12.83	R77.94	R4,835,248.70	18.55	R77.94
KwaZulu-Natal	215,760	3.57	R19,510,658.98	17.92	R90.43	R19,510,658.98	28.50	R90.43
Gauteng	139,400	3.31	R13,093,117.12	17.79	R93.92	R13,093,117.12	27.57	R93.92
North West	76,980	2.57	R6,441,917.34	21.50	R83.68	R6,441,917.34	41.46	R83.68
Mpumalanga	71,600	1.97	R6,099,016.88	17.53	R85.18	R6,099,016.88	28.54	R85.18
Limpopo	144,980	4.41	R14,124,241.56	17.86	R97.42	R14,124,241.56	27.20	R97.42
Consultation								
% needing care	Pop est 2006	Treatment need						
National	987,600	57.67						
Western Cape	84,980	85.20						
Northern Cape	17,140	62.20						
Eastern Cape	174,720	49.70						
Free State	62,040	66.60						
KwaZulu-Natal	215,760	59.00						
Gauteng	139,400	47.10						
North West	76,980	31.30						
Mpumalanga	71,600	44.90						
Limpopo	144,980	24.10						

Topical fluoride application								
% of population	**Pop est 2006**	**Treatment need**	**Fee code: 8161 Fee: R63.60**	**% of total**	**Per capita cost**	**Fee code: 8161 Fee: R63.60**	**% of total**	**Per capita cost**
National	987,600	**9.20**	R5,776,935.88	1.09	R5.85	R5,776,935.88	1.67	R5.85
Western Cape	84,980	3.30	R178,356.02	0.26	R2.10	R178,356.02	0.34	R2.10
Northern Cape	17,140	2.00	R21,802.08	0.20	R1.27	R21,802.08	0.29	R1.27
Eastern Cape	174,720	7.20	R800,077.82	1.06	R4.58	R800,077.82	1.86	R4.58
Free State	62,040	3.80	R149,938.27	0.40	R2.42	R149,938.27	0.58	R2.42
KwaZulu-Natal	215,760	10.80	R1,482,012.29	1.36	R6.87	R1,482,012.29	2.16	R6.87
Gauteng	139,400	9.20	R815,416.02	1.11	R5.85	R815,416.02	1.72	R5.85
North West	76,980	12.30	R602,199.14	2.01	R7.82	R602,199.14	3.88	R7.82
Mpumalanga	71,600	12.40	R564,666.24	1.62	R7.89	R564,666.24	2.64	R7.89
Limpopo	144,980	9.20	R848,056.06	1.07	R5.85	R848,056.06	1.63	R5.85
Fissure sealant								
Mean no of teeth	**Pop est 2006**	**Treatment need**	**Fee code: 8163 Fee: R41.90**	**% of total**	**Per capita cost**	**Fee code: 8163 Fee: R41.90**	**% of total**	**Per capita cost**
National	987,600	**1.48**	R61,069,345.81	11.49	R61.84	R61,069,345.81	17.62	R61.84
Western Cape	84,980	3.38	R12,018,597.63	17.74	R141.43	R12,018,597.63	23.19	R141.43
Northern Cape	17,140	0.13	R95,748.05	0.88	R5.59	R95,748.05	1.26	R5.59
Eastern Cape	174,720	0.03	R207,686.53	0.27	R1.19	R207,686.53	0.48	R1.19
Free State	62,040	2.23	R5,807,895.63	15.41	R93.62	R5,807,895.63	22.29	R93.62
KwaZulu-Natal	215,760	1.55	R14,008,984.86	12.87	R64.93	R14,008,984.86	20.47	R64.93
Gauteng	139,400	1.48	R8,619,954.24	11.71	R61.84	R8,619,954.24	18.15	R61.84
North West	76,980	0.52	R1,687,710.73	5.63	R21.92	R1,687,710.73	10.86	R21.92
Mpumalanga	71,600	0.14	R411,350.78	1.18	R5.75	R411,350.78	1.92	R5.75
Limpopo	144,980	1.48	R8,964,999.75	11.34	R61.84	R8,964,999.75	17.27	R61.84
One surface restoration								
Mean no of teeth	**Pop est 2006**	**Treatment need**	**Average fee: R138.60**	**% of total**	**Per capita cost**	**Average fee: R138.60**	**% of total**	**Per capita cost**
National	987,600	**0.83**	R113,474,632.01	21.35	R114.90	R113,474,632.01	32.74	R114.90
Western Cape	84,980	1.60	R18,867,774.29	27.85	R222.03	R18,867,774.29	36.41	R222.03
Northern Cape	17,140	1.31	R3,106,788.30	28.71	R181.26	R3,106,788.30	40.83	R181.26
Eastern Cape	174,720	0.63	R15,311,062.74	20.21	R87.63	R15,311,062.74	35.57	R87.63
Free State	62,040	1.30	R11,212,125.87	29.76	R180.72	R11,212,125.87	43.03	R180.72
KwaZulu-Natal	215,760	0.60	R17,947,652.44	16.49	R83.18	R17,947,652.44	26.22	R83.18
Gauteng	139,400	0.83	R16,016,974.18	21.76	R114.90	R16,016,974.18	33.73	R114.90
North West	76,980	0.44	R4,692,539.27	15.66	R60.96	R4,692,539.27	30.20	R60.96
Mpumalanga	71,600	0.92	R9,148,725.26	26.30	R127.78	R9,148,725.26	42.81	R127.78
Limpopo	144,980	0.83	R16,658,112.75	21.07	R114.90	R16,658,112.75	32.08	R114.90
Two or more surface restoration								
Mean no of teeth	**Pop est 2006**	**Treatment need**	**Average fee: R202.99**	**% of total**	**Per capita cost**	**Average fee: R202.99**	**% of total**	**Per capita cost**
National	987,600	**0.30**	R60,201,310.27	11.32	R60.96	R60,201,310.27	17.37	R60.96
Western Cape	84,980	0.54	R9,289,359.05	13.71	R109.31	R9,289,359.05	17.93	R109.31
Northern Cape	17,140	0.73	R2,548,482.42	23.55	R148.69	R2,548,482.42	33.49	R148.69
Eastern Cape	174,720	0.14	R5,141,229.16	6.79	R29.43	R5,141,229.16	11.94	R29.43
Free State	62,040	0.27	R3,393,542.95	9.01	R54.70	R3,393,542.95	13.02	R54.70
KwaZulu-Natal	215,760	0.29	R12,844,263.60	11.80	R59.53	R12,844,263.60	18.76	R59.53
Gauteng	139,400	0.30	R8,497,430.79	11.55	R60.96	R8,497,430.79	17.89	R60.96
North West	76,980	0.12	R1,857,557.07	6.20	R24.13	R1,857,557.07	11.95	R24.13
Mpumalanga	71,600	0.31	R4,472,217.81	12.86	R62.46	R4,472,217.81	20.93	R62.46
Limpopo	144,980	0.30	R8,837,571.85	11.18	R60.96	R8,837,571.85	17.02	R60.96
Extraction								
Mean no of teeth	**Pop est 2006**	**Treatment need**	**Fee code: 8201 Fee: R63.60**	**% of total**	**Per capita cost**	**Fee code: 8201 Fee: R63.60**	**% of total**	**Per capita cost**
National	987,600	**0.21**	R13,331,004.56	2.51	R13.50	R13,331,004.56	3.85	R13.50
Western Cape	84,980	0.48	R2,581,287.82	3.81	R30.38	R2,581,287.82	4.98	R30.38
Northern Cape	17,140	0.41	R447,496.09	4.14	R26.11	R447,496.09	5.88	R26.11
Eastern Cape	174,720	0.29	R3,211,447.93	4.24	R18.38	R3,211,447.93	7.46	R18.38
Free State	62,040	0.17	R660,545.95	1.75	R10.65	R660,545.95	2.53	R10.65
KwaZulu-Natal	215,760	0.19	R2,659,704.33	2.44	R12.33	R2,659,704.33	3.89	R12.33
Gauteng	139,400	0.05	R443,292.00	0.60	R3.18	R443,292.00	0.93	R3.18
North West	76,980	0.05	R256,729.73	0.86	R3.34	R256,729.73	1.65	R3.34
Mpumalanga	71,600	0.15	R675,724.25	1.94	R9.44	R675,724.25	3.16	R9.44
Limpopo	144,980	0.27	R2,489,596.56	3.15	R17.17	R2,489,596.56	4.79	R17.17

Variable:	[1]		[5]		[6]	[5]		[6]
All procedures								
	Pop est 2006		Total expense		Total per capita cost	Total expense		Total per capita cost
National	987,600		R531,590,841.02		**R538.27**	R346,613,361.02		**R350.97**
Western Cape	84,980		R67,736,048.49		**R797.08**	R51,819,294.49		**R609.78**
Northern Cape	17,140		R10,820,009.05		**R631.27**	R7,609,687.05		**R443.97**
Eastern Cape	174,720		R75,771,128.77		**R433.67**	R43,046,072.77		**R246.37**
Free State	62,040		R37,679,389.38		**R607.34**	R26,059,297.38		**R420.04**
KwaZulu-Natal	215,760		R108,865,124.50		**R504.57**	R68,453,276.50		**R317.27**
Gauteng	139,400		R73,595,804.35		**R527.95**	R47,486,184.35		**R340.65**
North West	76,980		R29,957,007.29		**R389.15**	R15,538,653.29		**R201.85**
Mpumalanga	71,600		R34,782,381.23		**R485.79**	R21,371,701.23		**R298.49**
Limpopo	144,980		R79,077,332.53		**R545.44**	R51,922,578.53		**R358.14**

Treatment need group	%	Rand		%	Rand
National					
UPFS consultation					
Examination/bitewings	34.80	R187.30			
Prophylaxis	17.45	R93.92		26.76	R93.92
Topical F app/Dental sealant	12.57	R67.69		19.29	R67.69
Curative/Extraction	35.18	R189.35		53.95	R189.35
	100.0	**R538.27**		**100.0**	**R350.97**
Western Cape					
UPFS consultation					
Examination/bitewings	23.50	R187.30			
Prophylaxis	13.12	R104.54		17.14	R104.54
Topical F app/Dental sealant	18.01	R143.53		23.54	R143.53
Curative/Extraction	45.38	R361.71		59.32	R361.71
	100.0	**R797.08**		**100.0**	**R609.78**
Northern Cape					
UPFS consultation					
Examination/bitewings	29.67	R187.30			
Prophylaxis	12.84	R81.06		18.26	R81.06
Topical F app/Dental sealant	1.09	R6.86		1.54	R6.86
Curative/Extraction	56.40	R356.05		80.20	R356.05
	100.0	**R631.27**		**100.0**	**R443.97**
Eastern Cape					
UPFS consultation					
Examination/bitewings	43.19	R187.30			
Prophylaxis	24.25	R105.17		42.69	R105.17
Topical F app/Dental sealant	1.33	R5.77		2.34	R5.77
Curative/Extraction	31.23	R135.44		54.97	R135.44
	100.0	**R433.67**		**100.0**	**R246.37**
Free State					
UPFS consultation					
Examination/bitewings	30.84	R187.30			
Prophylaxis	12.83	R77.94		18.55	R77.94
Topical F app/Dental sealant	15.81	R96.03		22.86	R96.03
Curative/Extraction	40.52	R246.07		58.58	R246.07
	100.0	**R607.34**		**100.0**	**R420.04**
KwaZulu-Natal					
UPFS consultation					
Examination/bitewings	37.12	R187.30			
Prophylaxis	17.92	R90.43		28.50	R90.43
Topical F app/Dental sealant	14.23	R71.80		22.63	R71.80
Curative/Extraction	30.73	R155.04		48.87	R155.04
	100.0	**R504.57**		**100.0**	**R317.27**
Gauteng					
UPFS consultation					
Examination/bitewings	35.48	R187.30			
Prophylaxis	17.79	R93.92		27.57	R93.92
Topical F app/Dental sealant	12.82	R67.69		19.87	R67.69
Curative/Extraction	33.91	R179.04		52.56	R179.04
	100.0	**R527.95**		**100.0**	**R340.65**

North West					
UPFS consultation					
Examination/bitewings	48.13	R187.30			
Prophylaxis	21.50	R83.68		41.46	R83.68
Topical F app/Dental sealant	7.64	R29.75		14.74	R29.75
Curative/Extraction	22.72	R88.42		43.81	R88.42
	100.0	**R389.15**		**100.0**	**R201.85**
Mpumalanga					
UPFS consultation					
Examination/bitewings	38.56	R187.30			
Prophylaxis	17.53	R85.18		28.54	R85.18
Topical F app/Dental sealant	2.81	R13.63		4.57	R13.63
Curative/Extraction	41.10	R199.67		66.90	R199.67
	100.0	**R485.79**		**100.0**	**R298.49**
Limpopo					
UPFS consultation					
Examination/bitewings	34.34	R187.30			
Prophylaxis	17.86	R97.42		27.20	R97.42
Topical F app/Dental sealant	12.41	R67.69		18.90	R67.69
Curative/Extraction	35.39	R193.03		53.90	R193.03
	100.0	**R545.44**		**100.0**	**R358.14**

UPFS 2006 (H2)								
			Examination/bitewings included			Examination/bitewings excluded		
Variable:	**[1]**	**[2]**	**[3]; [4]**	**[7]**	**[8]**	**[3]; [4]**	**[7]**	**[8]**
Examination								
% of population	**Pop est 2006**	**Treatment need**	**Fee code: 0924 Fee: R40.00**	**% of total**	**Per capita cost**			
National	987,600	100	R39,504,000.00	18.23	R40.00			
Western Cape	84,980	100	R3,399,200.00	12.41	R40.00			
Northern Cape	17,140	100	R685,600.00	16.34	R40.00			
Eastern Cape	174,720	100	R6,988,800.00	21.79	R40.00			
Free State	62,040	100	R2,481,600.00	16.22	R40.00			
KwaZulu-Natal	215,760	100	R8,630,400.00	19.10	R40.00			
Gauteng	139,400	100	R5,576,000.00	19.41	R40.00			
North West	76,980	100	R3,079,200.00	25.80	R40.00			
Mpumalanga	71,600	100	R2,864,000.00	20.82	R40.00			
Limpopo	144,980	100	R5,799,200.00	19.62	R40.00			
Bitewings								
% of population	**Pop est 2006**	**Treatment need**	**Fee code: 0914 Fee: R15.00**	**% of total**	**Per capita cost**			
National	987,600	100	R29,628,000.00	13.67	R30.00			
Western Cape	84,980	100	R2,549,400.00	9.31	R30.00			
Northern Cape	17,140	100	R514,200.00	12.25	R30.00			
Eastern Cape	174,720	100	R5,241,600.00	16.34	R30.00			
Free State	62,040	100	R1,861,200.00	12.16	R30.00			
KwaZulu-Natal	215,760	100	R6,472,800.00	14.33	R30.00			
Gauteng	139,400	100	R4,182,000.00	14.56	R30.00			
North West	76,980	100	R2,309,400.00	19.35	R30.00			
Mpumalanga	71,600	100	R2,148,000.00	15.61	R30.00			
Limpopo	144,980	100	R4,349,400.00	14.72	R30.00			
Prophylaxis								
Mean no of sextants	**Pop est 2006**	**Treatment need**	**Fee code: 0924 Fee: R40.00**	**% of total**	**Per capita cost**	**Fee code: 0924 Fee: R40.00**	**% of total**	**Per capita cost**
National	987,600	3.31	R29,707,008.00	13.71	R30.08	R29,707,008.00	20.13	R30.08
Western Cape	84,980	3.27	R2,845,130.40	10.39	R33.48	R2,845,130.40	13.27	R33.48
Northern Cape	17,140	2.30	R444,954.40	10.60	R25.96	R444,954.40	14.85	R25.96
Eastern Cape	174,720	2.88	R5,884,569.60	18.35	R33.68	R5,884,569.60	29.66	R33.68
Free State	62,040	3.95	R1,548,518.40	10.12	R24.96	R1,548,518.40	14.13	R24.96
KwaZulu-Natal	215,760	3.57	R6,248,409.60	13.83	R28.96	R6,248,409.60	20.78	R28.96
Gauteng	139,400	3.31	R4,193,152.00	14.60	R30.08	R4,193,152.00	22.11	R30.08
North West	76,980	2.57	R2,063,064.00	17.28	R26.80	R2,063,064.00	31.50	R26.80
Mpumalanga	71,600	1.97	R1,953,248.00	14.20	R27.28	R1,953,248.00	22.34	R27.28
Limpopo	144,980	4.41	R4,523,376.00	15.31	R31.20	R4,523,376.00	23.31	R31.20

Consultation								
% needing care	**Pop est 2006**	**Treatment need**	**Average fee: R57.50**	**% of total**	**Per capita cost**	**Average fee: R57.50**	**% of total**	**Per capita cost**
National	987,600	**57.67**	R32,751,801.19	15.11	R33.16	R32,751,801.19	22.19	R33.16
Western Cape	84,980	85.20	R4,163,170.20	15.20	R48.99	R4,163,170.20	19.42	R48.99
Northern Cape	17,140	62.20	R613,012.10	14.61	R35.77	R613,012.10	20.46	R35.77
Eastern Cape	174,720	49.70	R4,993,060.80	15.57	R28.58	R4,993,060.80	25.17	R28.58
Free State	62,040	66.60	R2,375,821.80	15.53	R38.30	R2,375,821.80	21.68	R38.30
KwaZulu-Natal	215,760	59.00	R7,319,658.00	16.20	R33.93	R7,319,658.00	24.34	R33.93
Gauteng	139,400	47.10	R3,775,300.50	13.14	R27.08	R3,775,300.50	19.91	R27.08
North West	76,980	31.30	R1,385,447.55	11.61	R18.00	R1,385,447.55	21.16	R18.00
Mpumalanga	71,600	44.90	R1,848,533.00	13.44	R25.82	R1,848,533.00	21.14	R25.82
Limpopo	144,980	24.10	R2,009,060.35	6.80	R13.86	R2,009,060.35	10.35	R13.86
Topical fluoride application								
% of population	**Pop est 2006**	**Treatment need**	**Fee code: 0924 Fee: R40.00**	**% of total**	**Per capita cost**	**Fee code: 0924 Fee: R40.00**	**% of total**	**Per capita cost**
National	987,600	**9.20**	R3,633,293.01	1.68	R3.68	R3,633,293.01	2.46	R3.68
Western Cape	84,980	3.30	R112,173.60	0.41	R1.32	R112,173.60	0.52	R1.32
Northern Cape	17,140	2.00	R13,712.00	0.33	R0.80	R13,712.00	0.46	R0.80
Eastern Cape	174,720	7.20	R503,193.60	1.57	R2.88	R503,193.60	2.54	R2.88
Free State	62,040	3.80	R94,300.80	0.62	R1.52	R94,300.80	0.86	R1.52
KwaZulu-Natal	215,760	10.80	R932,083.20	2.06	R4.32	R932,083.20	3.10	R4.32
Gauteng	139,400	9.20	R512,840.26	1.79	R3.68	R512,840.26	2.70	R3.68
North West	76,980	12.30	R378,741.60	3.17	R4.92	R378,741.60	5.78	R4.92
Mpumalanga	71,600	12.40	R355,136.00	2.58	R4.96	R355,136.00	4.06	R4.96
Limpopo	144,980	9.20	R533,368.59	1.80	R3.68	R533,368.59	2.75	R3.68
Fissure sealant								
Mean no of teeth	**Pop est 2006**	**Treatment need**	**Fee code: 0914 Fee: R15.00**	**% of total**	**Per capita cost**	**Fee code: 0914 Fee: R15.00**	**% of total**	**Per capita cost**
National	987,600	**1.48**	R21,862,534.30	10.09	R22.14	R21,862,534.30	14.81	R22.14
Western Cape	84,980	3.38	R4,302,600.58	15.71	R50.63	R4,302,600.58	20.07	R50.63
Northern Cape	17,140	0.13	R34,277.34	0.82	R2.00	R34,277.34	1.14	R2.00
Eastern Cape	174,720	0.03	R74,350.79	0.23	R0.43	R74,350.79	0.37	R0.43
Free State	62,040	2.23	R2,079,198.91	13.59	R33.51	R2,079,198.91	18.97	R33.51
KwaZulu-Natal	215,760	1.55	R5,015,149.71	11.10	R23.24	R5,015,149.71	16.68	R23.24
Gauteng	139,400	1.48	R3,085,902.47	10.74	R22.14	R3,085,902.47	16.27	R22.14
North West	76,980	0.52	R604,192.39	5.06	R7.85	R604,192.39	9.23	R7.85
Mpumalanga	71,600	0.14	R147,261.62	1.07	R2.06	R147,261.62	1.68	R2.06
Limpopo	144,980	1.48	R3,209,427.12	10.86	R22.14	R3,209,427.12	16.54	R22.14
One surface restoration								
Mean no of teeth	**Pop est 2006**	**Treatment need**	**Fee code: 0921 Fee: R45.00**	**% of total**	**Per capita cost**	**Fee code: 0921 Fee: R45.00**	**% of total**	**Per capita cost**
National	987,600	**0.83**	R36,842,412.99	17.00	R37.30	R36,842,412.99	24.97	R37.30
Western Cape	84,980	1.60	R6,125,900.74	22.37	R72.09	R6,125,900.74	28.58	R72.09
Northern Cape	17,140	1.31	R1,008,697.50	24.04	R58.85	R1,008,697.50	33.67	R58.85
Eastern Cape	174,720	0.63	R4,971,124.27	15.50	R28.45	R4,971,124.27	25.06	R28.45
Free State	62,040	1.30	R3,640,300.61	23.79	R58.68	R3,640,300.61	33.22	R58.68
KwaZulu-Natal	215,760	0.60	R5,827,159.88	12.90	R27.01	R5,827,159.88	19.38	R27.01
Gauteng	139,400	0.83	R5,200,316.29	18.11	R37.30	R5,200,316.29	27.42	R37.30
North West	76,980	0.44	R1,523,551.71	12.76	R19.79	R1,523,551.71	23.27	R19.79
Mpumalanga	71,600	0.92	R2,970,365.34	21.59	R41.49	R2,970,365.34	33.97	R41.49
Limpopo	144,980	0.83	R5,408,478.16	18.30	R37.30	R5,408,478.16	27.87	R37.30
Two or more surface restoration								
Mean no of teeth	**Pop est 2006**	**Treatment need**	**Fee code: 0921 Fee: R45.00**	**% of total**	**Per capita cost**	**Fee code: 0921 Fee: R45.00**	**% of total**	**Per capita cost**
National	987,600	**0.30**	R13,345,848.52	6.16	R13.51	R13,345,848.52	9.04	R13.51
Western Cape	84,980	0.54	R2,059,330.24	7.52	R24.23	R2,059,330.24	9.61	R24.23
Northern Cape	17,140	0.73	R564,965.45	13.46	R32.96	R564,965.45	18.86	R32.96
Eastern Cape	174,720	0.14	R1,139,743.73	3.55	R6.52	R1,139,743.73	5.75	R6.52
Free State	62,040	0.27	R752,304.39	4.92	R12.13	R752,304.39	6.87	R12.13
KwaZulu-Natal	215,760	0.29	R2,847,406.40	6.30	R13.20	R2,847,406.40	9.47	R13.20
Gauteng	139,400	0.30	R1,883,770.03	6.56	R13.51	R1,883,770.03	9.93	R13.51
North West	76,980	0.12	R411,796.27	3.45	R5.35	R411,796.27	6.29	R5.35
Mpumalanga	71,600	0.31	R991,432.60	7.21	R13.85	R991,432.60	11.34	R13.85
Limpopo	144,980	0.30	R1,959,174.89	6.63	R13.51	R1,959,174.89	10.10	R13.51

Extraction								
Mean no of teeth	**Pop est 2006**	**Treatment need**	**Fee code: 0921 Fee: R45.00**	**% of total**	**Per capita cost**	**Fee code: 0921 Fee: R45.00**	**% of total**	**Per capita cost**
National	987,600	**0.21**	R9,432,314.55	4.35	R9.55	R9,432,314.55	6.39	R9.55
Western Cape	84,980	0.48	R1,826,382.89	6.67	R21.49	R1,826,382.89	8.52	R21.49
Northern Cape	17,140	0.41	R316,624.59	7.55	R18.47	R316,624.59	10.57	R18.47
Eastern Cape	174,720	0.29	R2,272,250.90	7.09	R13.01	R2,272,250.90	11.45	R13.01
Free State	62,040	0.17	R467,367.42	3.05	R7.53	R467,367.42	4.27	R7.53
KwaZulu-Natal	215,760	0.19	R1,881,866.27	4.17	R8.72	R1,881,866.27	6.26	R8.72
Gauteng	139,400	0.05	R313,650.00	1.09	R2.25	R313,650.00	1.65	R2.25
North West	76,980	0.05	R181,648.40	1.52	R2.36	R181,648.40	2.77	R2.36
Mpumalanga	71,600	0.15	R478,106.78	3.48	R6.68	R478,106.78	5.47	R6.68
Limpopo	144,980	0.27	R1,761,507.00	5.96	R12.15	R1,761,507.00	9.08	R12.15
Variable:	**[1]**		**[5]**		**[6]**	**[5]**		**[6]**
All procedures								
	Pop est 2006		**Total expense**		**Total per capita cost**	**Total expense**		**Total per capita cost**
National	987,600		R216,707,212.56		**R219.43**	R147,575,212.56		**R149.43**
Western Cape	84,980		R27,383,288.66		**R322.23**	R21,434,688.66		**R252.23**
Northern Cape	17,140		R4,196,043.38		**R244.81**	R2,996,243.38		**R174.81**
Eastern Cape	174,720		R32,068,693.68		**R183.54**	R19,838,293.68		**R113.54**
Free State	62,040		R15,300,612.33		**R246.62**	R10,957,812.33		**R176.62**
KwaZulu-Natal	215,760		R45,174,933.07		**R209.38**	R30,071,733.07		**R139.38**
Gauteng	139,400		R28,722,931.56		**R206.05**	R18,964,931.56		**R136.05**
North West	76,980		R11,937,041.92		**R155.07**	R6,548,441.92		**R85.07**
Mpumalanga	71,600		R13,756,083.34		**R192.12**	R8,744,083.34		**R122.12**
Limpopo	144,980		R29,552,992.11		**R203.84**	R19,404,392.11		**R133.84**

Treatment need group	**%**	**Rand**		**%**	**Rand**
National					
UPFS consultation	15.11	R33.16		22.19	R33.16
Examination/bitewings	31.90	R70.00			
Prophylaxis	13.71	R30.08		20.13	R30.08
Topical F app/Dental sealant	11.77	R25.82		17.28	R25.82
Curative/Extraction	27.51	R60.37		40.40	R60.37
	100.0	**R219.43**		**100.0**	**R149.43**
Western Cape					
UPFS consultation	15.20	R48.99		19.42	R48.99
Examination/bitewings	21.72	R70.00			
Prophylaxis	10.39	R33.48		13.27	R33.48
Topical F app/Dental sealant	16.12	R51.95		20.60	R51.95
Curative/Extraction	36.56	R117.81		46.71	R117.81
	100.0	**R322.23**		**100.0**	**R252.23**
Northern Cape					
UPFS consultation	14.61	R35.77		20.46	R35.77
Examination/bitewings	28.59	R70.00			
Prophylaxis	10.60	R25.96		14.85	R25.96
Topical F app/Dental sealant	1.14	R2.80		1.60	R2.80
Curative/Extraction	45.05	R110.29		63.09	R110.29
	100.0	**R244.81**		**100.0**	**R174.81**
Eastern Cape					
UPFS consultation	15.57	R28.58		25.17	R28.58
Examination/bitewings	38.14	R70.00			
Prophylaxis	18.35	R33.68		29.66	R33.68
Topical F app/Dental sealant	1.80	R3.31		2.91	R3.31
Curative/Extraction	26.14	R47.98		42.26	R47.98
	100.0	**R183.54**		**100.0**	**R113.54**
Free State					
UPFS consultation	15.53	R38.30		21.68	R38.30
Examination/bitewings	28.38	R70.00			
Prophylaxis	10.12	R24.96		14.13	R24.96
Topical F app/Dental sealant	14.21	R35.03		19.84	R35.03
Curative/Extraction	31.76	R78.34		44.35	R78.34
	100.0	**R246.62**		**100.0**	**R176.62**
KwaZulu-Natal					
UPFS consultation	16.20	R33.93		24.34	R33.93
Examination/bitewings	33.43	R70.00			
Prophylaxis	13.83	R28.96		20.78	R28.96
Topical F app/Dental sealant	13.16	R27.56		19.78	R27.56
Curative/Extraction	23.37	R48.93		35.10	R48.93
	100.0	**R209.38**		**100.0**	**R139.38**

Gauteng					
UPFS consultation	13.14	R27.08		19.91	R27.08
Examination/bitewings	33.97	R70.00			
Prophylaxis	14.60	R30.08		22.11	R30.08
Topical F app/Dental sealant	12.53	R25.82		18.98	R25.82
Curative/Extraction	25.76	R53.07		39.01	R53.07
	100.0	**R206.05**		**100.0**	**R136.05**
North West					
UPFS consultation	11.61	R18.00		21.16	R18.00
Examination/bitewings	45.14	R70.00			
Prophylaxis	17.28	R26.80		31.50	R26.80
Topical F app/Dental sealant	8.23	R12.77		15.01	R12.77
Curative/Extraction	17.73	R27.50		32.33	R27.50
	100.0	**R155.07**		**100.0**	**R85.07**
Mpumalanga					
UPFS consultation	13.44	R25.82		21.14	R25.82
Examination/bitewings	36.43	R70.00			
Prophylaxis	14.20	R27.28		22.34	R27.28
Topical F app/Dental sealant	3.65	R7.02		5.75	R7.02
Curative/Extraction	32.28	R62.01		50.78	R62.01
	100.0	**R192.12**		**100.0**	**R122.12**
Limpopo					
UPFS consultation	6.80	R13.86		10.35	R13.86
Examination/bitewings	34.34	R70.00			
Prophylaxis	15.31	R31.20		23.31	R31.20
Topical F app/Dental sealant	12.66	R25.82		19.29	R25.82
Curative/Extraction	30.89	R62.97		47.05	R62.97
	100.0	**R203.84**		**100.0**	**R133.84**

UPFS 2006 (HG)								
			Examination/bitewings included			**Examination/bitewings excluded**		
Variable:	**[1]**	**[2]**	**[3]; [4]**	**[7]**	**[8]**	**[3]; [4]**	**[7]**	**[8]**
Examination								
% of population	**Pop est 2006**	**Treatment need**	**Fee code: 0924 Fee: R81.00**	**% of total**	**Per capita cost**			
National	987,600	100	R79,995,600.00	18.62	R81.00			
Western Cape	84,980	100	R6,883,380.00	12.68	R81.00			
Northern Cape	17,140	100	R1,388,340.00	16.87	R81.00			
Eastern Cape	174,720	100	R14,152,320.00	22.43	R81.00			
Free State	62,040	100	R5,025,240.00	16.57	R81.00			
KwaZulu-Natal	215,760	100	R17,476,560.00	19.53	R81.00			
Gauteng	139,400	100	R11,291,400.00	19.92	R81.00			
North West	76,980	100	R6,235,380.00	26.07	R81.00			
Mpumalanga	71,600	100	R5,799,600.00	21.32	R81.00			
Limpopo	144,980	100	R11,743,380.00	19.60	R81.00			
Bitewings								
% of population	**Pop est 2006**	**Treatment need**	**Fee code: 0914 Fee: R33.00**	**% of total**	**Per capita cost**			
National	987,600	100	R65,181,600.00	15.17	R66.00			
Western Cape	84,980	100	R5,608,680.00	10.34	R66.00			
Northern Cape	17,140	100	R1,131,240.00	13.74	R66.00			
Eastern Cape	174,720	100	R11,531,520.00	18.27	R66.00			
Free State	62,040	100	R4,094,640.00	13.50	R66.00			
KwaZulu-Natal	215,760	100	R14,240,160.00	15.91	R66.00			
Gauteng	139,400	100	R9,200,400.00	16.23	R66.00			
North West	76,980	100	R5,080,680.00	21.24	R66.00			
Mpumalanga	71,600	100	R4,725,600.00	17.37	R66.00			
Limpopo	144,980	100	R9,568,680.00	15.97	R66.00			
Prophylaxis								
Mean no of sextants	**Pop est 2006**	**Treatment need**	**Fee code: 0924 Fee: R81.00**	**% of total**	**Per capita cost**	**Fee code: 0924 Fee: R81.00**	**% of total**	**Per capita cost**
National	987,600	3.31	R60,156,691.20	14.00	R60.91	R60,156,691.20	21.15	R60.91
Western Cape	84,980	3.27	R5,761,389.06	10.62	R67.80	R5,761,389.06	13.79	R67.80
Northern Cape	17,140	2.30	R901,032.66	10.95	R52.57	R901,032.66	15.77	R52.57
Eastern Cape	174,720	2.88	R11,916,253.44	18.88	R68.20	R11,916,253.44	31.84	R68.20
Free State	62,040	3.95	R3,135,749.76	10.34	R50.54	R3,135,749.76	14.78	R50.54
KwaZulu-Natal	215,760	3.57	R12,653,029.44	14.14	R58.64	R12,653,029.44	21.91	R58.64
Gauteng	139,400	3.31	R8,491,132.80	14.98	R60.91	R8,491,132.80	23.46	R60.91
North West	76,980	2.57	R4,177,704.60	17.47	R54.27	R4,177,704.60	33.15	R54.27
Mpumalanga	71,600	1.97	R3,955,327.20	14.54	R55.24	R3,955,327.20	23.72	R55.24
Limpopo	144,980	4.41	R9,159,836.40	15.29	R63.18	R9,159,836.40	23.73	R63.18

Consultation								
% needing care	**Pop est 2006**	**Treatment need**	**Average fee: R87.00**	**% of total**	**Per capita cost**	**Average fee: R87.00**	**% of total**	**Per capita cost**
National	987,600	**57.67**	R49,554,899.20	11.54	R50.18	R49,554,899.20	17.42	R50.18
Western Cape	84,980	85.20	R6,299,057.52	11.61	R74.12	R6,299,057.52	15.08	R74.12
Northern Cape	17,140	62.20	R927,513.96	11.27	R54.11	R927,513.96	16.24	R54.11
Eastern Cape	174,720	49.70	R7,554,718.08	11.97	R43.24	R7,554,718.08	20.19	R43.24
Free State	62,040	66.60	R3,594,721.68	11.85	R57.94	R3,594,721.68	16.94	R57.94
KwaZulu-Natal	215,760	59.00	R11,074,960.80	12.38	R51.33	R11,074,960.80	19.17	R51.33
Gauteng	139,400	47.10	R5,712,193.80	10.08	R40.98	R5,712,193.80	15.78	R40.98
North West	76,980	31.30	R2,096,242.38	8.76	R27.23	R2,096,242.38	16.63	R27.23
Mpumalanga	71,600	44.90	R2,796,910.80	10.28	R39.06	R2,796,910.80	16.77	R39.06
Limpopo	144,980	24.10	R3,039,795.66	5.07	R20.97	R3,039,795.66	7.88	R20.97
Topical fluoride application								
% of population	**Pop est 2006**	**Treatment need**	**Fee code: 0924 Fee: R81.00**	**% of total**	**Per capita cost**	**Fee code: 0924 Fee: R81.00**	**% of total**	**Per capita cost**
National	987,600	**9.20**	R7,357,418.34	1.71	R7.45	R7,357,418.34	2.59	R7.45
Western Cape	84,980	3.30	R227,151.54	0.42	R2.67	R227,151.54	0.54	R2.67
Northern Cape	17,140	2.00	R27,766.80	0.34	R1.62	R27,766.80	0.49	R1.62
Eastern Cape	174,720	7.20	R1,018,967.04	1.61	R5.83	R1,018,967.04	2.72	R5.83
Free State	62,040	3.80	R190,959.12	0.63	R3.08	R190,959.12	0.90	R3.08
KwaZulu-Natal	215,760	10.80	R1,887,468.48	2.11	R8.75	R1,887,468.48	3.27	R8.75
Gauteng	139,400	9.20	R1,038,501.54	1.83	R7.45	R1,038,501.54	2.87	R7.45
North West	76,980	12.30	R766,951.74	3.21	R9.96	R766,951.74	6.08	R9.96
Mpumalanga	71,600	12.40	R719,150.40	2.64	R10.04	R719,150.40	4.31	R10.04
Limpopo	144,980	9.20	R1,080,071.40	1.80	R7.45	R1,080,071.40	2.80	R7.45
Fissure sealant								
Mean no of teeth	**Pop est 2006**	**Treatment need**	**Fee code: 0914 Fee: R33.00**	**% of total**	**Per capita cost**	**Fee code: 0914 Fee: R33.00**	**% of total**	**Per capita cost**
National	987,600	**1.48**	R48,097,575.46	11.20	R48.70	R48,097,575.46	16.91	R48.70
Western Cape	84,980	3.38	R9,465,721.28	17.44	R111.39	R9,465,721.28	22.66	R111.39
Northern Cape	17,140	0.13	R75,410.16	0.92	R4.40	R75,410.16	1.32	R4.40
Eastern Cape	174,720	0.03	R163,571.73	0.26	R0.94	R163,571.73	0.44	R0.94
Free State	62,040	2.23	R4,574,237.61	15.08	R73.73	R4,574,237.61	21.56	R73.73
KwaZulu-Natal	215,760	1.55	R11,033,329.37	12.33	R51.14	R11,033,329.37	19.10	R51.14
Gauteng	139,400	1.48	R6,788,985.44	11.98	R48.70	R6,788,985.44	18.75	R48.70
North West	76,980	0.52	R1,329,223.25	5.56	R17.27	R1,329,223.25	10.55	R17.27
Mpumalanga	71,600	0.14	R323,975.56	1.19	R4.52	R323,975.56	1.94	R4.52
Limpopo	144,980	1.48	R7,060,739.66	11.79	R48.70	R7,060,739.66	18.29	R48.70
One surface restoration								
Mean no of teeth	**Pop est 2006**	**Treatment need**	**Fee code: 0921 Fee: R90.00**	**% of total**	**Per capita cost**	**Fee code: 0921 Fee: R90.00**	**% of total**	**Per capita cost**
National	987,600	**0.83**	R73,684,825.98	17.15	R74.61	R73,684,825.98	25.91	R74.61
Western Cape	84,980	1.60	R12,251,801.48	22.58	R144.17	R12,251,801.48	29.33	R144.17
Northern Cape	17,140	1.31	R2,017,395.00	24.51	R117.70	R2,017,395.00	35.32	R117.70
Eastern Cape	174,720	0.63	R9,942,248.53	15.76	R56.90	R9,942,248.53	26.57	R56.90
Free State	62,040	1.30	R7,280,601.21	24.00	R117.35	R7,280,601.21	34.32	R117.35
KwaZulu-Natal	215,760	0.60	R11,654,319.77	13.02	R54.02	R11,654,319.77	20.18	R54.02
Gauteng	139,400	0.83	R10,400,632.59	18.35	R74.61	R10,400,632.59	28.73	R74.61
North West	76,980	0.44	R3,047,103.42	12.74	R39.58	R3,047,103.42	24.18	R39.58
Mpumalanga	71,600	0.92	R5,940,730.69	21.84	R82.97	R5,940,730.69	35.63	R82.97
Limpopo	144,980	0.83	R10,816,956.33	18.06	R74.61	R10,816,956.33	28.02	R74.61
Two or more surface restoration								
Mean no of teeth	**Pop est 2006**	**Treatment need**	**Fee code: 0921 Fee: R90.00**	**% of total**	**Per capita cost**	**Fee code: 0921 Fee: R90.00**	**% of total**	**Per capita cost**
National	987,600	**0.30**	R26,691,697.04	6.21	R27.03	R26,691,697.04	9.39	R27.03
Western Cape	84,980	0.54	R4,118,660.48	7.59	R48.47	R4,118,660.48	9.86	R48.47
Northern Cape	17,140	0.73	R1,129,930.90	13.73	R65.92	R1,129,930.90	19.78	R65.92
Eastern Cape	174,720	0.14	R2,279,487.45	3.61	R13.05	R2,279,487.45	6.09	R13.05
Free State	62,040	0.27	R1,504,608.78	4.96	R24.25	R1,504,608.78	7.09	R24.25
KwaZulu-Natal	215,760	0.29	R5,694,812.81	6.36	R26.39	R5,694,812.81	9.86	R26.39
Gauteng	139,400	0.30	R3,767,540.06	6.65	R27.03	R3,767,540.06	10.41	R27.03
North West	76,980	0.12	R823,592.55	3.44	R10.70	R823,592.55	6.53	R10.70
Mpumalanga	71,600	0.31	R1,982,865.20	7.29	R27.69	R1,982,865.20	11.89	R27.69
Limpopo	144,980	0.30	R3,918,349.77	6.54	R27.03	R3,918,349.77	10.15	R27.03

Extraction								
Mean no of teeth	**Pop est 2006**	**Treatment need**	**Fee code: 0921 Fee: R90.00**	**% of total**	**Per capita cost**	**Fee code: 0921 Fee: R90.00**	**% of total**	**Per capita cost**
National	987,600	**0.21**	R18,864,629.10	4.39	R19.10	R18,864,629.10	6.63	R19.10
Western Cape	84,980	0.48	R3,652,765.79	6.73	R42.98	R3,652,765.79	8.74	R42.98
Northern Cape	17,140	0.41	R633,249.18	7.69	R36.95	R633,249.18	11.09	R36.95
Eastern Cape	174,720	0.29	R4,544,501.79	7.20	R26.01	R4,544,501.79	12.14	R26.01
Free State	62,040	0.17	R934,734.84	3.08	R15.07	R934,734.84	4.41	R15.07
KwaZulu-Natal	215,760	0.19	R3,763,732.54	4.21	R17.44	R3,763,732.54	6.52	R17.44
Gauteng	139,400	0.05	R0.00	0.00	R0.00	R0.00	0.00	R0.00
North West	76,980	0.05	R363,296.79	1.52	R4.72	R363,296.79	2.88	R4.72
Mpumalanga	71,600	0.15	R956,213.56	3.52	R13.35	R956,213.56	5.73	R13.35
Limpopo	144,980	0.27	R3,523,014.00	5.88	R24.30	R3,523,014.00	9.13	R24.30
Variable:	**[1]**		**[5]**		**[6]**	**[5]**		**[6]**
All procedures								
	Pop est 2006		**Total expense**		**Total per capita cost**	**Total expense**		**Total per capita cost**
National	987,600		R429,584,936.31		**R434.98**	R284,407,736.31		**R287.98**
Western Cape	84,980		R54,268,607.16		**R638.60**	R41,776,547.16		**R491.60**
Northern Cape	17,140		R8,231,878.65		**R480.27**	R5,712,298.65		**R333.27**
Eastern Cape	174,720		R63,103,588.07		**R361.17**	R37,419,748.07		**R214.17**
Free State	62,040		R30,335,493.01		**R488.97**	R21,215,613.01		**R341.97**
KwaZulu-Natal	215,760		R89,478,373.21		**R414.71**	R57,761,653.21		**R267.71**
Gauteng	139,400		R56,690,786.22		**R406.68**	R36,198,986.22		**R259.68**
North West	76,980		R23,920,174.73		**R310.73**	R12,604,114.73		**R163.73**
Mpumalanga	71,600		R27,200,373.40		**R379.89**	R16,675,173.40		**R232.89**
Limpopo	144,980		R59,910,823.22		**R413.24**	R38,598,763.22		**R266.24**

Treatment need group	%	Rand		%	Rand
National					
UPFS consultation	11.54	R50.18		17.42	R50.18
Examination/bitewings	33.79	R147.00			
Prophylaxis	14.00	R60.91		21.15	R60.91
Topical F app/Dental sealant	12.91	R56.15		19.50	R56.15
Curative/Extraction	27.76	R120.74		41.93	R120.74
	100.0	**R434.98**		**100.0**	**R287.98**
Western Cape					
UPFS consultation	11.61	R74.12		15.08	R74.12
Examination/bitewings	23.02	R147.00			
Prophylaxis	10.62	R67.80		13.79	R67.80
Topical F app/Dental sealant	17.86	R114.06		23.20	R114.06
Curative/Extraction	36.90	R235.62		47.93	R235.62
	100.0	**R638.60**		**100.0**	**R491.60**
Northern Cape					
UPFS consultation	11.27	R54.11		16.24	R54.11
Examination/bitewings	30.61	R147.00			
Prophylaxis	10.95	R52.57		15.77	R52.57
Topical F app/Dental sealant	1.25	R6.02		1.81	R6.02
Curative/Extraction	45.93	R220.57		66.18	R220.57
	100.0	**R480.27**		**100.0**	**R333.27**
Eastern Cape					
UPFS consultation	11.97	R43.24		20.19	R43.24
Examination/bitewings	40.70	R147.00			
Prophylaxis	18.88	R68.20		31.84	R68.20
Topical F app/Dental sealant	1.87	R6.77		3.16	R6.77
Curative/Extraction	26.57	R95.96		44.81	R95.96
	100.0	**R361.17**		**100.0**	**R214.17**
Free State					
UPFS consultation	11.85	R57.94		16.94	R57.94
Examination/bitewings	30.06	R147.00			
Prophylaxis	10.34	R50.54		14.78	R50.54
Topical F app/Dental sealant	15.71	R76.81		22.46	R76.81
Curative/Extraction	32.04	R156.67		45.82	R156.67
	100.0	**R488.97**		**100.0**	**R341.97**

KwaZulu-Natal					
UPFS consultation	12.38	R51.33		19.17	R51.33
Examination/bitewings	35.45	R147.00			
Prophylaxis	14.14	R58.64		21.91	R58.64
Topical F app/Dental sealant	14.44	R59.89		22.37	R59.89
Curative/Extraction	23.60	R97.85		36.55	R97.85
	100.0	**R414.71**		**100.0**	**R267.71**
Gauteng					
UPFS consultation	10.08	R40.98		15.78	R40.98
Examination/bitewings	36.15	R147.00			
Prophylaxis	14.98	R60.91		23.46	R60.91
Topical F app/Dental sealant	13.81	R56.15		21.62	R56.15
Curative/Extraction	24.99	R101.64		39.14	R101.64
	100.0	**R406.68**		**100.0**	**R259.68**
North West					
UPFS consultation	8.76	R27.23		16.63	R27.23
Examination/bitewings	47.31	R147.00			
Prophylaxis	17.47	R54.27		33.15	R54.27
Topical F app/Dental sealant	8.76	R27.23		16.63	R27.23
Curative/Extraction	17.70	R55.00		33.59	R55.00
	100.0	**R310.73**		**100.0**	**R163.73**
Mpumalanga					
UPFS consultation	10.28	R39.06		16.77	R39.06
Examination/bitewings	38.70	R147.00			
Prophylaxis	14.54	R55.24		23.72	R55.24
Topical F app/Dental sealant	3.83	R14.57		6.26	R14.57
Curative/Extraction	32.65	R124.02		53.25	R124.02
	100.0	**R379.89**		**100.0**	**R232.89**
Limpopo					
UPFS consultation	5.07	R20.97		7.88	R20.97
Examination/bitewings	35.57	R147.00			
Prophylaxis	15.29	R63.18		23.73	R63.18
Topical F app/Dental sealant	13.59	R56.15		21.09	R56.15
Curative/Extraction	30.48	R125.94		47.30	R125.94
	100.0	**R413.24**		**100.0**	**R266.24**

ANNEXURE 4: THE WORLD HEALTH ORGANIZATION/FéDéRATION DENTAIRE INTERNATIONAL HUMAN RESOURCES PLANNING MODEL: NATIONAL REQUIREMENTS TO DELIVER THE MINIMUM PACKAGE OF ORAL CARE TO 4- TO 15-YEAR-OLD SOUTH AFRICAN CHILDREN

		Note: Data is needed for all shaded fields		
Anticipated % caries reduction due to water fluoridation		0	National	
Variable		Formula	Value	
			4- to 5-year-olds	6- to 15-year-olds
(A) RESTORATIVE CARE, ARRESTING CARE AND EXTRACTIONS				
[1]	Number of age intervals		2	10
[2]	Predicted dmft or DMFT		2.44	1.86
[3]	Predicted dt or DT		1.95	1.34
[4]	Predicted mt or MT		0.35	0.29
[5]	Predicted ft or FT		0.16	0.23
[6]	Restoration fraction		0.50	0.60
[7]	New fillings : Teeth (NFT)	[6] x [2]	1.22	1.12
[8]	Mean replacement period in years for a restoration		15	15
[9]	Replacement fillings : Teeth (RFT)	([1] x [7]) / (2 x [8])	0.08	0.37
[10]	Ratio Surfaces / Teeth		1.50	1.50
[11]	Sealants, arresting care and remineralisation	(1 - [6]) x [2]	1.22	0.74
[12]	New fillings : Surfaces (NFS)	[7] x [10]	1.83	1.67
[13]	Replacement fillings : Surfaces (RFS)	[9] x [10]	0.12	0.56
[14]	Extraction	[4]	0.35	0.29
(B) TREATMENT TIME REQUIREMENTS				
[15]	Number of Group Preventive Care sessions		1	1
[16]	Time per Group Preventive Care session		15	15
[17]	**Group Preventive Care (minutes)**	[15] x [16]	**15**	**15**
[18]	Number of Individual Preventive Care sessions		0	4
[19]	Time per Individual Preventive Care session		15	15
[20]	**Individual Preventive Care (minutes)**	[18] x [19]	**0**	**60**
[21]	Time per fissure sealant		5	5
[22]	**Arresting Care (minutes)**	[11] x [21]	**6.10**	**3.72**
[23]	Mean number of sextants in need of scaling		0	3.31
[24]	Time per scaling per sextant		5	5
[25]	Number of scaling sessions		0	2
[26]	**Periodontal Care (prophylaxis only) (minutes)**	[23] x [24] x [25]	**0.00**	**33.10**
[27]	% in need of Surgical Care		1	10
[28]	Time for Surgical Care		60	60
[29]	**Surgical Care (minutes)**	[27] / 100 x [28]	**0.60**	**6.00**
[30]	Time per restoration (new or replacement)		15	15
[31]	**Restorative Care for new fillings (NFS) (minutes)**	[12] x [30]	**27.45**	**25.11**

[32]	**Restorative Care for replacement fillings (RFS) (minutes)**	[13] x [30]	**1.83**	**8.37**
[33]	Time per extraction		7.5	7.5
[34]	**Extraction (minutes)**	[14] x [33]	**2.63**	**2.18**
[35]	**Total minutes of need per cohort**	[17]+[20]+[22]+[26]+[29]+[31]+[32]+[34]	**53.61**	**153.48**
	Total minutes of need per year:			
[36]	**For total human resources**	[35] / [1]	**26.80**	**15.35**
[37]	**For Oral Hygienists**	([17]+[20]+[22]+[26])/[1]	**10.55**	**11.18**
[38]	**For Dental Therapists/Dentists**	([29]+[31]+[32]+[34])/[1]	**16.25**	**4.17**
[39]	% Demand (utilization)		25.7	25.7
	Minutes of demand per year:			
[40]	**For total human resources**	[36] x [39] /100	**6.90**	**3.95**
[41]	**For Oral Hygienists**	[37] x [39] /100	**2.72**	**2.88**
[42]	**For Dental Therapists/Dentists**	[38] x [39] /100	**4.18**	**1.07**
(C)	**HUMAN RESOURCES CALCULATIONS**			
[43]	Working year (hours)		1760	1760
[44]	Working year (minutes)	[43] x 60	105,600	105,600
	Human resources : population ratio:			
[45]	For total human resources	[44] / [40]	15,307	26,731
[46]	For Oral Hygienists	[44] / [41]	38,887	36,689
[47]	For Dental Therapists/Dentists	[44] / [42]	25,243	98,489
[48]	Population size		2,035,320	10,087,080
	Number of human resources required:			
[49]	**Total human resources**	[48] / [45]	**133**	**377**
[50]	**Oral Hygienist**	[48] / [46]	**52**	**275**
[51]	**Dental Therapist/Dentist**	[48] / [47]	**81**	**102**
[52]	**Dentists (Ratio 1 Dentist : 5 Dental Therapists)**	[51] / 6	**13**	**17**
[53]	**Dental Therapists (Ratio 1 Dentist : 5 Dental Therapists)**	[51] / 6 x 5	**67**	**85**
[54]	**Dental Assistants (Ratio 1 Dental Therapist/Dentist : 1.5 Dental Assistants)**	[51] x 1.5	**121**	**154**

Summary for 4-15-year-olds	
Total human resources	**510**
Oral Hygienist	**327**
Dental Therapist/Dentist	**183**
Dentists (Ratio 1 Dentist : 5 Dental Therapists)	**31**
Dental Therapists (Ratio 1 Dentist : 5 Dental Therapists)	**153**
Dental Assistants (Ratio 1 Dentist/Dental Therapist : 1.5 Dental Assistants)	**275**

ANNEXURE 5: A "SERVICE TARGETS METHOD" MODEL FOR HUMAN RESOURCES PLANNING: REQUIREMENTS TO DELIVER THE MINIMUM PACKAGE OF ORAL CARE TO 4- TO 15-YEAR-OLD SOUTH AFRICAN CHILDREN

Treatment times		
Procedure	**Unit**	**Time/year (minutes)**
Group prevention	15 min/session	**5**
Prophylaxis	5 min/sextant	**1**
Topical fluoride	10 min/application	**2.5**
Fissure sealant	5 min/sealant	**5**
1 surface restoration	15 min/restoration	**15**
> 1 surface restoration	15 min/restoration	**15**
Extraction	7.5 min/extraction	**7.5**

Anticipated % caries reduction due to water fluoridation	0

Variable:	**[1]**	**[2]**	**[3]; [4]**	**[7]**	**[8]**
Group prevention					
	Pop est 2006	**Treatment need**	**Time (minutes): 5**	**% of total**	**Per capita time**
National	12,122,400	100	60,612,000	21.78	5.00
Western Cape	1,052,320	100	5,261,600	14.52	5.00
Northern Cape	225,140	100	1,125,700	12.37	5.00
Eastern Cape	2,012,360	100	10,061,800	29.26	5.00
Free State	727,060	100	3,635,300	18.97	5.00
KwaZulu-Natal	2,675,500	100	13,377,500	22.92	5.00
Gauteng	1,820,940	100	9,104,700	21.85	5.00
North West	966,140	100	4,830,700	33.86	5.00
Mpumalanga	903,160	100	4,515,800	24.61	5.00
Limpopo	1,739,780	100	8,698,900	20.90	5.00
Prophylaxis (6- to 15-year-olds only)					
Mean no of sextants	**Pop est 2006**	**Treatment need**	**Time (minutes): 1**	**% of total**	**Per capita time**
National	10,087,080	3.31	33,388,235	11.99	2.75
Western Cape	869,340	3.27	2,842,742	7.85	2.70
Northern Cape	186,540	2.30	429,042	4.72	1.91
Eastern Cape	1,700,100	2.88	4,896,288	14.24	2.43
Free State	607,120	3.95	2,398,124	12.51	3.30
KwaZulu-Natal	2,235,140	3.57	7,979,450	13.67	2.98
Gauteng	1,472,640	3.31	4,874,438	11.70	2.68
North West	798,240	2.57	2,051,477	14.38	2.12
Mpumalanga	751,980	1.97	1,481,401	8.07	1.64
Limpopo	1,465,980	4.41	6,464,972	15.53	3.72

Topical fluoride application					
% of population	Pop est 2006	Treatment need	Time (minutes): 2.5	% of total	Per capita time
National	12,122,400	5.39	1,633,613	0.59	0.13
Western Cape	1,052,320	2.46	64,777	0.18	0.06
Northern Cape	225,140	2.36	13,299	0.15	0.06
Eastern Cape	2,012,360	6.66	335,237	0.97	0.17
Free State	727,060	5.21	94,710	0.49	0.13
KwaZulu-Natal	2,675,500	6.32	422,689	0.72	0.16
Gauteng	1,820,940	5.39	245,390	0.59	0.13
North West	966,140	5.79	139,944	0.98	0.14
Mpumalanga	903,160	5.24	118,296	0.64	0.13
Limpopo	1,739,780	5.39	234,452	0.56	0.13
Fissure sealant					
Mean no of teeth	Pop est 2006	Treatment need	Time (minutes): 5	% of total	Per capita time
National	12,122,400	0.80	48,610,096	17.46	4.01
Western Cape	1,052,320	1.80	9,475,528	26.15	9.00
Northern Cape	225,140	0.31	353,615	3.89	1.57
Eastern Cape	2,012,360	0.07	738,925	2.15	0.37
Free State	727,060	1.13	4,092,552	21.35	5.63
KwaZulu-Natal	2,675,500	0.94	12,511,220	21.43	4.68
Gauteng	1,820,940	0.80	7,301,860	17.52	4.01
North West	966,140	0.29	1,417,279	9.94	1.47
Mpumalanga	903,160	0.05	214,101	1.17	0.24
Limpopo	1,739,780	0.80	6,976,413	16.76	4.01
One surface restoration					
Mean no of teeth	Pop est 2006	Treatment need	Time (minutes): 15	% of total	Per capita time
National	12,122,400	0.39	70,509,367	25.33	5.82
Western Cape	1,052,320	0.56	8,897,698	24.56	8.46
Northern Cape	225,140	0.93	3,153,394	34.66	14.01
Eastern Cape	2,012,360	0.29	8,631,649	25.10	4.29
Free State	727,060	0.54	5,937,590	30.98	8.17
KwaZulu-Natal	2,675,500	0.29	11,627,754	19.92	4.35
Gauteng	1,820,940	0.39	10,591,412	25.42	5.82
North West	966,140	0.25	3,670,124	25.73	3.80
Mpumalanga	903,160	0.48	6,523,249	35.54	7.22
Limpopo	1,739,780	0.39	10,119,348	24.31	5.82
Two or more surface restoration					
Mean no of teeth	Pop est 2006	Treatment need	Time (minutes): 15	% of total	Per capita time
National	12,122,400	0.20	37,042,650	13.31	3.06
Western Cape	1,052,320	0.36	5,761,429	15.90	5.47
Northern Cape	225,140	0.81	2,723,977	29.94	12.10
Eastern Cape	2,012,360	0.14	4,131,874	12.01	2.05
Free State	727,060	0.13	1,468,714	7.66	2.02
KwaZulu-Natal	2,675,500	0.18	7,199,957	12.33	2.69
Gauteng	1,820,940	0.20	5,564,281	13.35	3.06
North West	966,140	0.11	1,650,123	11.57	1.71
Mpumalanga	903,160	0.24	3,291,093	17.93	3.64
Limpopo	1,739,780	0.20	5,316,279	12.77	3.06

Extraction					
Mean no of teeth	Pop est 2006	Treatment need	Time (minutes): 7.5	% of total	Per capita time
National	12,122,400	0.29	26,557,573	9.54	2.19
Western Cape	1,052,320	0.50	3,925,098	10.83	3.73
Northern Cape	225,140	0.77	1,298,181	14.27	5.77
Eastern Cape	2,012,360	0.37	5,597,501	16.27	2.78
Free State	727,060	0.28	1,537,717	8.02	2.11
KwaZulu-Natal	2,675,500	0.26	5,257,246	9.01	1.96
Gauteng	1,820,940	0.29	3,989,288	9.57	2.19
North West	966,140	0.07	505,536	3.54	0.52
Mpumalanga	903,160	0.33	2,208,525	12.03	2.45
Limpopo	1,739,780	0.29	3,811,484	9.16	2.19
Variable:	[1]		[5]		[6]
All procedures					
	Pop est 2006		Total time (minutes)		Per capita time (minutes)
National	12,122,400		278,353,534		22.96
Western Cape	1,052,320		36,228,872		34.43
Northern Cape	225,140		9,097,208		40.41
Eastern Cape	2,012,360		34,393,273		17.09
Free State	727,060		19,164,708		26.36
KwaZulu-Natal	2,675,500		58,375,816		21.82
Gauteng	1,820,940		41,671,369		22.88
North West	966,140		14,265,182		14.77
Mpumalanga	903,160		18,352,464		20.32
Limpopo	1,739,780		41,621,849		23.92

Variable:	[1]	[5]	[6]	[9]	[10]
All procedures					
		Need		Demand	
	Pop est 2006	Total time (minutes)	Per capita time (minutes)	% demand (utilization)	Per capita time (minutes)
National	12,122,400	278,353,534	22.96	25.74	5.91
Western Cape	1,052,320	36,228,872	34.43	25.74	8.86
Northern Cape	225,140	9,097,208	40.41	25.74	10.40
Eastern Cape	2,012,360	34,393,273	17.09	25.74	4.40
Free State	727,060	19,164,708	26.36	25.74	6.78
KwaZulu-Natal	2,675,500	58,375,816	21.82	25.74	5.62
Gauteng	1,820,940	41,671,369	22.88	25.74	5.89
North West	966,140	14,265,182	14.77	25.74	3.80
Mpumalanga	903,160	18,352,464	20.32	25.74	5.23
Limpopo	1,739,780	41,621,849	23.92	25.74	6.16

[11] Working year (hours)	1,760
[12] Working year (minutes)	105,600

	Variable:	[6]	[10]	[13]	[14]	
	% of total	Need: Per capita time (Minutes)	Demand: Per capita time (Minutes)	HR: population ratio	HR Required	
National						
Group prevention	21.78	5.00	1.29	82040.33	148	Oral hygienist
Prophylaxis	11.99	2.75	0.71	148933.55	81	Oral hygienist
Topical F app/ Dental sealant	18.05	4.14	1.07	98970.17	122	Oral hygienist
Curative/Extraction	48.18	11.06	2.85	37078.84	327	Dental therapist/ Dentist
	100.00	**22.96**	**5.91**	**17864.43**	**679**	Total
Western Cape						
Group prevention	14.52	5.00	1.29	82040.33	13	Oral hygienist
Prophylaxis	7.85	2.70	0.70	151847.56	7	Oral hygienist
Topical F app/ Dental sealant	26.33	9.07	2.33	45246.29	23	Oral hygienist
Curative/Extraction	51.30	17.66	4.55	23227.41	45	Dental therapist/ Dentist
	100.00	**34.43**	**8.86**	**11914.90**	**88**	Total
Northern Cape						
Group prevention	12.37	5.00	1.29	82040.33	3	Oral hygienist
Prophylaxis	4.72	1.91	0.49	215253.51	1	Oral hygienist
Topical F app/ Dental sealant	4.03	1.63	0.42	251701.40	1	Oral hygienist
Curative/Extraction	78.88	31.87	8.20	12870.48	17	Dental therapist/ Dentist
	100.00	**40.41**	**10.40**	**10151.77**	**22**	Total
Eastern Cape						
Group prevention	29.26	5.00	1.29	82040.33	25	Oral hygienist
Prophylaxis	14.24	2.43	0.63	168591.67	12	Oral hygienist
Topical F app/ Dental sealant	3.12	0.53	0.14	768480.97	3	Oral hygienist
Curative/Extraction	53.39	9.12	2.35	44957.92	45	Dental therapist/ Dentist
	100.00	**17.09**	**4.40**	**24001.01**	**84**	Total
Free State						
Group prevention	18.97	5.00	1.29	82040.33	9	Oral hygienist
Prophylaxis	12.51	3.30	0.85	124364.38	6	Oral hygienist
Topical F app/ Dental sealant	21.85	5.76	1.48	71225.82	10	Oral hygienist
Curative/Extraction	46.67	12.30	3.17	33345.31	22	Dental therapist/ Dentist
	100.00	**26.36**	**6.79**	**15562.00**	**47**	Total
KwaZulu-Natal						
Group prevention	22.92	5.00	1.29	82040.33	33	Oral hygienist
Prophylaxis	13.67	2.98	0.77	137540.12	19	Oral hygienist
Topical F app/ Dental sealant	22.16	4.83	1.24	84854.04	32	Oral hygienist
Curative/Extraction	41.26	9.00	2.32	45567.63	59	Dental therapist/ Dentist
	100.00	**21.82**	**5.62**	**18800.50**	**142**	Total

Gauteng						
Group prevention	21.85	5.00	1.29	82040.33	22	Oral hygienist
Prophylaxis	11.70	2.68	0.69	153238.70	12	Oral hygienist
Topical F app/ Dental sealant	18.11	4.14	1.07	98970.17	18	Oral hygienist
Curative/Extraction	48.34	11.06	2.85	37078.84	49	Dental therapist/ Dentist
	100.00	**22.88**	**5.89**	**17924.84**	**102**	Total
North West						
Group prevention	33.86	5.00	1.29	82040.33	12	Oral hygienist
Prophylaxis	14.38	2.12	0.55	193183.86	5	Oral hygienist
Topical F app/ Dental sealant	10.92	1.61	0.41	254499.30	4	Oral hygienist
Curative/Extraction	40.84	6.03	1.55	68027.30	14	Dental therapist/ Dentist
	100.00	**14.77**	**3.80**	**27781.78**	**35**	Total
Mpumalanga						
Group prevention	24.61	5.00	1.29	82040.33	11	Oral hygienist
Prophylaxis	8.07	1.64	0.42	250086.11	4	Oral hygienist
Topical F app/ Dental sealant	1.81	0.37	0.09	1114565.36	1	Oral hygienist
Curative/Extraction	65.51	13.31	3.43	30814.42	29	Dental therapist/ Dentist
	100.00	**20.32**	**5.23**	**20186.81**	**45**	Total
Limpopo						
Group prevention	20.90	5.00	1.29	82040.33	21	Oral hygienist
Prophylaxis	15.53	3.72	0.96	110388.82	16	Oral hygienist
Topical F app/ Dental sealant	17.32	4.14	1.07	98970.17	18	Oral hygienist
Curative/Extraction	46.24	11.06	2.85	37078.84	47	Dental therapist/ Dentist
	100.00	**23.92**	**6.16**	**17146.30**	**101**	Total

Summary of human resources	Total	Oral hygienists	Dental Therapists/ Dentists	Dentists	Dental Therapists	Dental Assistants
National	679	352	327	54	272	490
Western Cape	88	43	45	8	38	68
Northern Cape	22	5	17	3	15	26
Eastern Cape	84	39	45	7	37	67
Free State	47	25	22	4	18	33
KwaZulu-Natal	142	84	59	10	49	88
Gauteng	102	52	49	8	41	74
North West	35	21	14	2	12	21
Mpumalanga	45	15	29	5	24	44
Limpopo	101	55	47	8	39	70