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

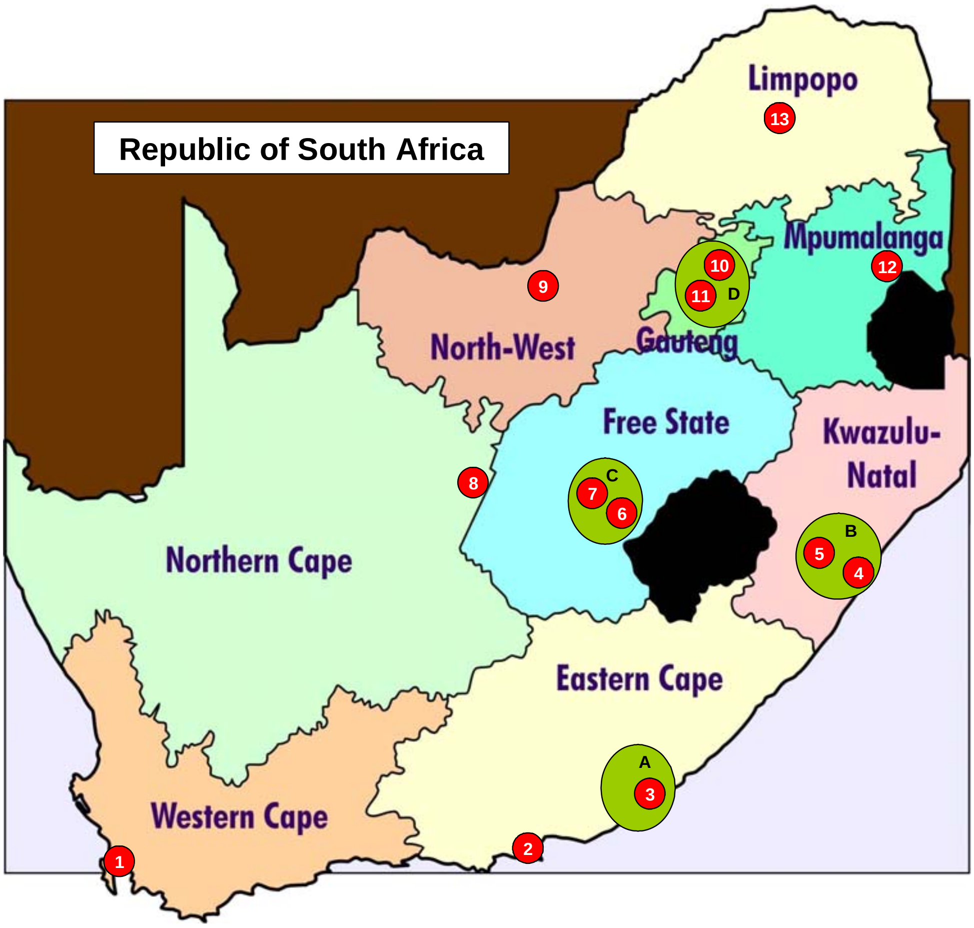
3.1 Introduction

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 x 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

<table>
<tr><th rowspan="2"></th><th colspan="2">Category A</th><th rowspan="2">Category B</th><th>Category C</th></tr>
<tr><th>Rand Water (2002)</th><th>Gauteng (1998)</th><th>Nelspruit (2003)</th></tr>
<tr><td>Capital cost</td><td>R18,850,000.00</td><td>R14,000,000.00</td><td></td><td>R274,130.00</td></tr>
<tr><td>Daily water purification rate (Ml)</td><td>3,400</td><td>2,800</td><td></td><td>44</td></tr>
<tr><td>Capital cost per Mega litre water</td><td>R5,544.12</td><td>R5,000.00</td><td></td><td>R6,230.23</td></tr>
<tr><td>Buildings and Storage</td><td></td><td>R2,897,338.00 (21% of capital cost)</td><td>29%</td><td>R100,000.00 (36% of capital cost)</td></tr>
<tr><td>Mechanical and Electrical</td><td></td><td>R11,102,662.00 (79% of capital cost)</td><td>71%</td><td>R174,130.00 (64% of capital cost)</td></tr>
<tr><td colspan="5">Adjustment of 2002 Rand Water capital costs for 2005</td></tr>
<tr><td colspan="3">BER-BCI 2003: 12%</td><td colspan="2">R21,112,000.00</td></tr>
<tr><td colspan="3">BER-BCI 2004: 10%</td><td colspan="2">R23,223,200.00</td></tr>
<tr><td colspan="3">BER-BCI 2005: 19%</td><td colspan="2">R27,635,608.00</td></tr>
<tr><td colspan="3">2005 daily water purification rate (Ml)</td><td colspan="2">3,558</td></tr>
<tr><td colspan="3">2005 Capital Cost per Mega litre water</td><td colspan="2">R7,767.17</td></tr>
<tr><td colspan="5">Adjustment of 2005 Rand Water capital cost per Mega litre water for 2006
(Projected BER-BCI 2006: 13%)</td></tr>
<tr><td colspan="3">2006 Capital Cost per Mega litre water</td><td colspan="2">≃ R8,750.00</td></tr>
</table>

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

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

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

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

  The factor of 1×10^6 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.

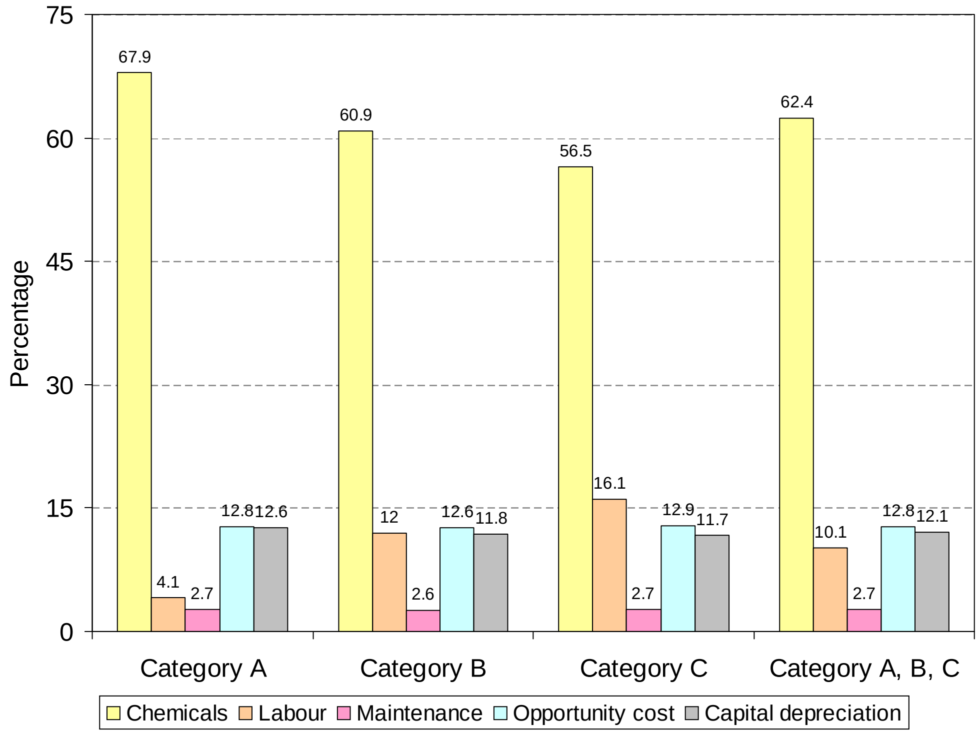


Figure 5: Cost of the introduction of water fluoridation for Category A, B and C municipalities and water boards as a percentage of the total cost

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.

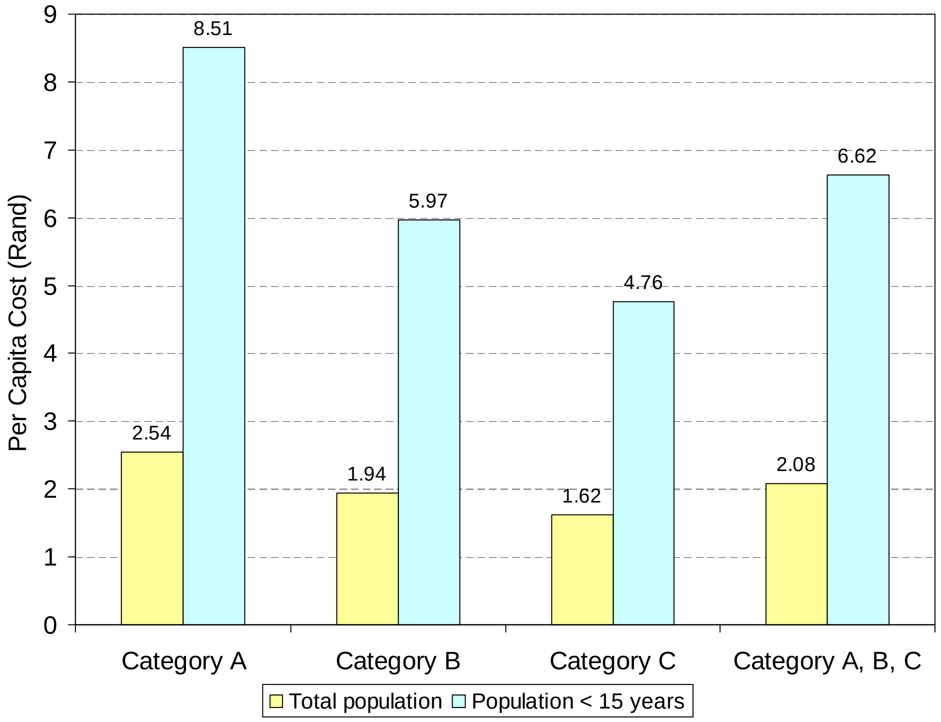


Figure 6: Per capita cost for the total population and those younger than fifteen years for Category A, B and C municipalities and water boards

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**

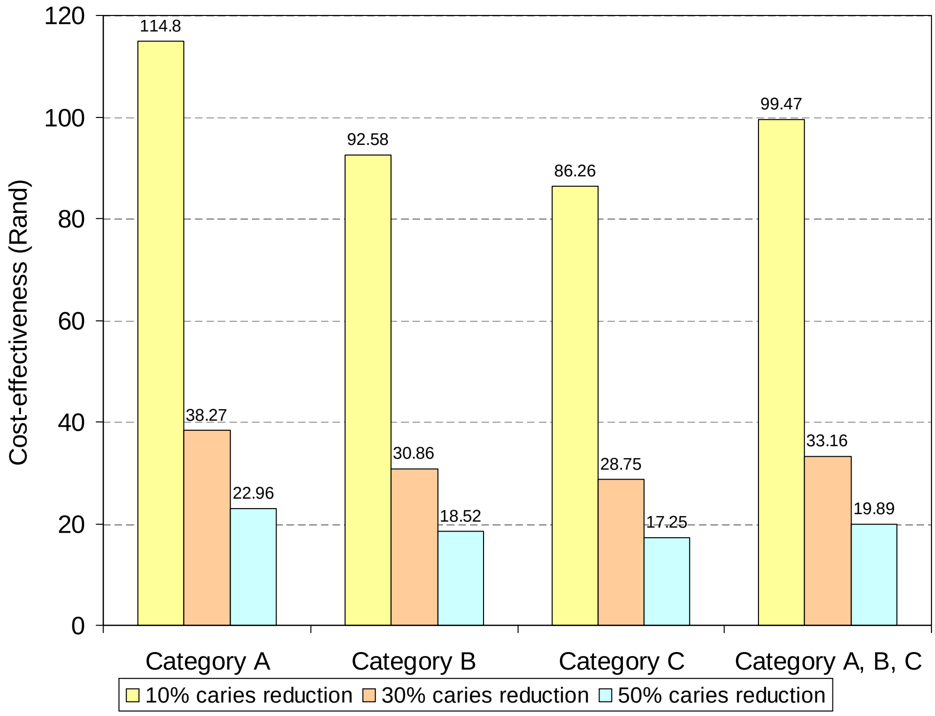


Figure 7: Cost-effectiveness of water fluoridation for the total population for Category A, B and C municipalities and water boards at three anticipated levels of caries reduction

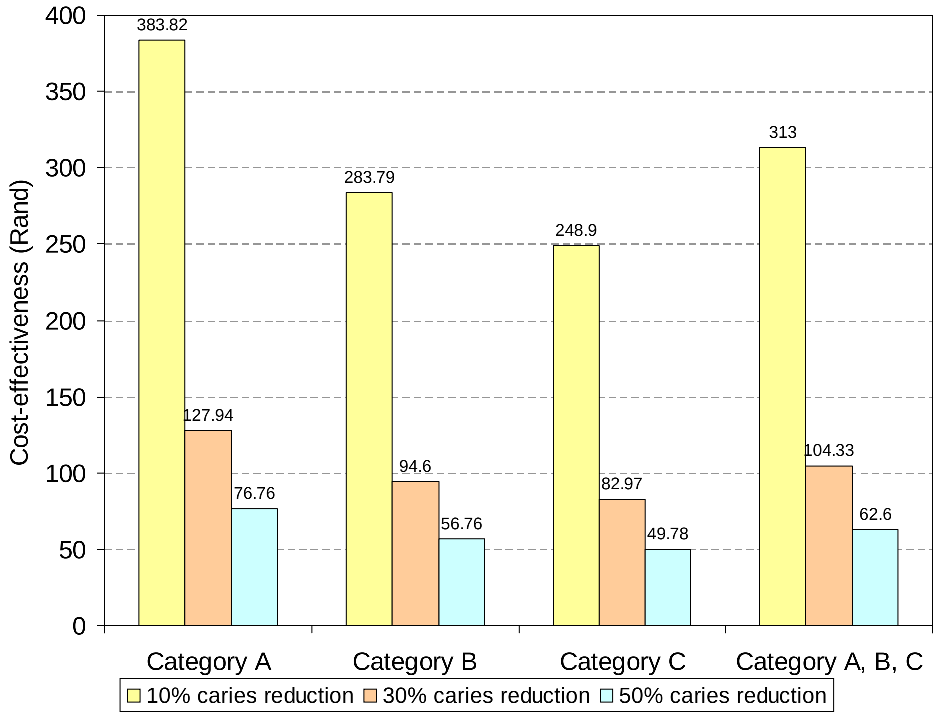


Figure 8: Cost-effectiveness of water fluoridation for those younger than fifteen years for Category A, B and C municipalities and water boards at three anticipated levels of caries reduction

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.

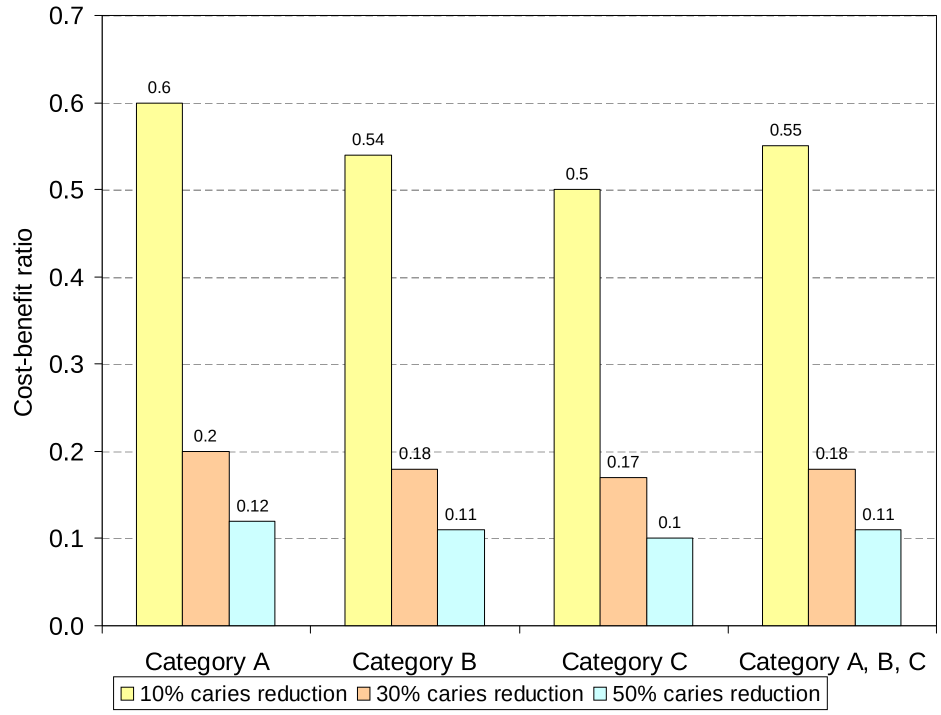


Figure 9: Cost-benefit of water fluoridation for the total population for Category A, B and C municipalities and water boards at three anticipated levels of caries reduction

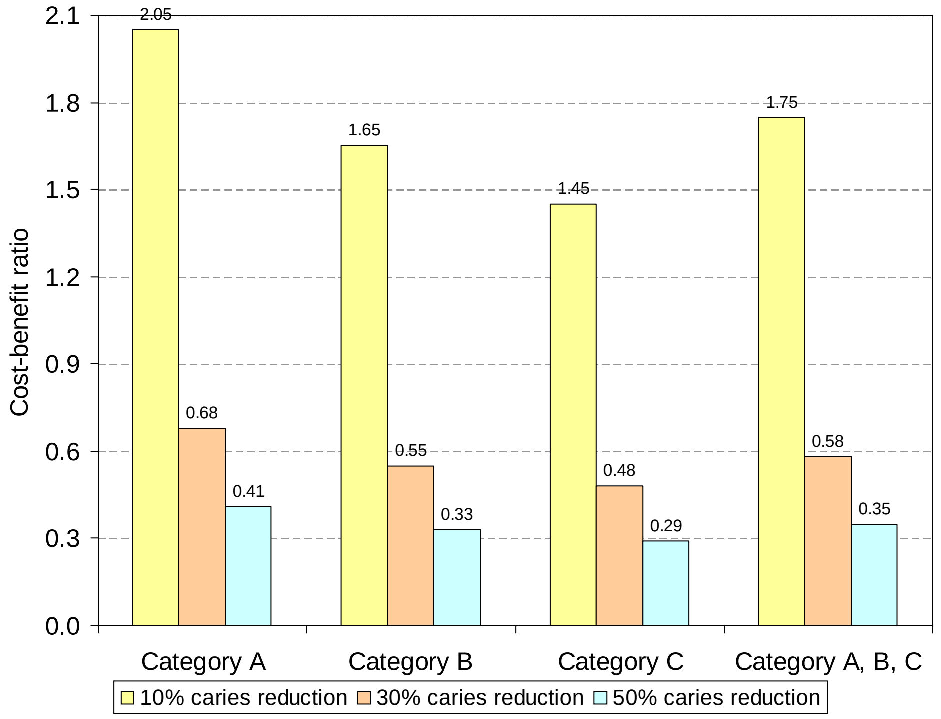


Figure 10: Cost-benefit of water fluoridation for those younger than fifteen years for Category A, B and C municipalities and water boards at three anticipated levels of caries reduction

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	[redacted]	48.1	[redacted]
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	[redacted]	43.0	[redacted]
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	[redacted]	30.1	[redacted]
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	[redacted]	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	[redacted]	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	[redacted]	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	[redacted]	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	[redacted]	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	[redacted]	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	[redacted]	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	[redacted]	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	[redacted]	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	[redacted]	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	[redacted]	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	[redacted]	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	[redacted]	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	[redacted]	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	[redacted]	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	[redacted]	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	[redacted]	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	[redacted]	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	[redacted]	Facility	R5.00 / R14.00	[redacted]
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	[redacted]	Facility	R20.00 / R43.00	[redacted]
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	[redacted]	[redacted]	Facility	R30.00 / R46.00	[redacted]
1011	[redacted]	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				
						Fee (see Table 35)	
Procedure description	**Code**	**Fee**	**Code (see Table 35)**	**Category**	**Oral health professional**	**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.