A COMPARATIVE ANALYSIS OF DELIVERING DIFFERENT MODES OF DENTAL CARE AT DISTRICT LEVEL

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INDEX

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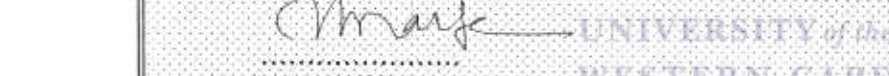
Declaration

I, A D Khalfe declare that "**A comparative analysis of delivering different modes of dental care at district level**" is my own work and that all the sources I have quoted have been indicated and acknowledged by means of references.



A.D.Khalfe

Dedication

This thesis is dedicated to:

My family for their spiritual and moral support and to those members of my family and friends who were taken away from us prematurely.

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List of Abbreviations

ANC	African National Congress
CCC	Cape Town City Council
CPA	Cape Provincial Administration
CSS	Central Statistical Services
DHS	District Health Systems
DMFT	Decayed, Missing and Filled Teeth
DNHPD	Department of National Health and Population Development
FDI	Federation Dentaire Internationale
FT	Filled component of DMFT
FTE	Full Time Equivalents
HOR	House of Representatives
JWG	Joint Working Group
MP	Mitchells Plain
MT	Missing component of DMFT
NaF	Sodium Fluoride
NFS	New filled surfaces
NFT	New filled teeth
NOHS	National Oral Health Survey
OHC	Oral Health Centre
RAMS	Representative Association of Medical Schemes
RFS	Replacement of previously filled surfaces
RFT	Replacement of previously filled teeth
S/T	Surface to tooth ratio
XLA	Extraction
PHC	Primary Health Care
POHCC	Primary Oral Health Care Centre
UNISA	University of South Africa
UWC	University of the Western Cape
WHO	World Health Organisation

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SUMMARY

The aim of this study is to analyse and compare the delivery of oral health care services based on the prevailing curative paradigm and WHO-treatment norms for the school-going community of Mitchells Plain district in relation to selected alternative methods of dental care delivery. The optimal use of auxiliary personnel, purchasing care from private dental practitioners and introducing community water fluoridation was examined. The WHO normative planning process was used to determine the resources necessary to overcome the oral disease burden using the current mode of dental care delivery and to determine the resources necessary to reduce the oral disease burden five years after hypothetical exposure to community water fluoridation. The results indicate that the dental services provided to this population by the public health sector are curative orientated, using expensive technology and varying categories of highly qualified personnel, particularly dentists, but also oral hygienists. The dental services rendered are very basic in nature (viz. simple fillings, extractions, sealants, scalings and to some extent dentures). The results show that the dentists and oral hygienists are working four hours per day performing basic clinical duties which could be performed by dental therapists. Vast resources are required to remunerate these categories of personnel. This curative form of dental delivery appears to have limited impact on oral health in general and Mitchells Plain in particular. The introduction of community water fluoridation as a public health measure will not only improve oral health but will also help to reduce the inequity in oral health resource allocation or distribution and reduce existing inequities in oral health. The annual cost of fluoridating a mouth is R1.18 per capita. The amount spent on curative care per child in the public sector is R47.00 using dentists and R23.00 using dental therapists. By employing dental therapists the current cost of curative care per patient can be reduced by 32-68% (R14-19) depending on whether the water is fluoridated or not. Purchasing care from the private practitioners will only be cost effective if the services are purchased below 55% of the RAMS Tariff (Scale of Benefits). If the current oral disease burden is to be overcome, redefinition of acceptable levels of oral health and the training and employment of more auxiliary personnel should be considered. As a medium term plan no more dentists or oral hygienists should be employed in the public health sector. The deficits should be replaced with other auxiliary staff (dental therapists) to deliver the basic care needed. The State can employ three dental therapists for every one dentist remunerated. It is recommended that the planners of oral health care concentrate their efforts and resources on rendering preventive and promotive care to target groups, supported by the use of auxiliary personnel to obtain a good return for their investment. This study shows that the opportunity cost of continuing to render curative care using dentists is R2 871 929 and can be reduced to R437 059 if the same services were rendered by dental therapists. This analysis of different modes of dental delivery at district level clearly demonstrates that no matter what combination of personnel one chooses to render community dental care, the least cost alternative is community water fluoridation with dental therapists providing the care needed. This option should, therefore, receive the higher priority. Utilisation of alternate personnel such as dental therapists, is strongly recommended to curtail costs of dental service provision in the public sector.

Die doel van hierdie studie was om die verskaffing van openbare tandheelkundige dienste gebaseer op die huidige kuratiewe benadering en WGO-kriteria vir die skoolgaande gemeenskap van Mitchells Plain te ondersoek. Alternatiewe metodes van mondgesondheidsversorging soos die gebruik van hulppersoneel, aankoop van tandheelkundige dienste asook die instel van 'n program waardeur drinkwater gefluorideer word, was ontlei. Die Wereldgesondheidsorganisasie se beplanningsproses was gebruik om die bronne te identifiseer wat nodig sal wees om siekteprofiel te verminder na 'n blootstelling periode van vyf jaar afhangend of die watertoevoer van die distriksgemeenskap gefluorideer is. Dit word bevestig dat die huidige openbare tandheelkundige dienste kuratief georiënteerd is. Daar word gebruik gemaak van hoogs gekwalifiseerde personeel (meestal tandartse), as ook mondhigiëniste. Die tandheelkundige dienste wat verskaf word is baie basies. Die behandelingsprofiel sluit in die stop en trek van tande, verseëlings, verwydering van plaak en tot 'n mate die verskaffing van kunsgebitte. Die vergoeding van hierdie personeel vereis die beskikbaarheid van ontsaglike finansiële hulpbronne. Hierdie benadering tot mondgesondheidsdiennste blyk 'n beperkte impak te hê oor die algemeen en in die besonder op mondgesondheid van die skoolgaande gemeenskap van Mitchell Plein. Die resultate dui verder daarop dat tandartse en mondhigiëniste vier ure per dag werk, waartydens hulle basiese kliniese werksaamhede verrig wat deur tandterapeute verrig kon word.

Die daarstelling van watertoevoer fluoriedering sal nie net mondhigiëne verbeter nie, maar sal ook die onreelmatighede met betrekking tot finansiële uitleg vir personeelvoorsiening sowel as die fasilitering van ongelykhede met betrekking tot bestaande tandheekundige dienste. Die totale koste verbonde aan mondfluoridasie (R1.18, wat ongeveer die bedrag is vir 'n halwe brood) is baie minder as die totale koste verbonde aan kuratiewe versorging in die openbare sektor. Aanstelling van tandterapeute in die Staatsdiens kan die huidige koste met betrekking tot kuratiewe versorging per pasiënt verminder met 32-68%, afhangende daarvan of die drinkwater gefluorideer is of nie. Indien die owerheid die agterstand met betrekking tot tandheelkundige siektetoename wil uitwis, sal daar ernstig besin moet word oor 'n herdefiniëring van aanvaarbare vlakke van mondgesondheid. Die opleiding en aanstelling van tandheelkundige hulppersoneel word sterk aanbeveel. As 'n interim maatreël behoort geen tandartse of mondhigiëniste meer deur die openbare gesondheidssektor in diens geneem te word nie. Die leemtes wat deur so 'n maatreël mag ontstaan, kan deur ander hulppersoneel (tandterapeute) aangevul word, wat die basiese versorgingsdienste sal verskaf. Huidiglik is dit moontlik om drie tandterapeute in diens te neem teen die vergoedingspakket van een tandarts. Dit word sterk aanbeveel dat die beplanners van mondversorgingsdienste eerder op voorkomende versorg aan teikengroepe konsentreer. Fluoriedering van watertoevoer is die enigste manier waarop aan hierdie behoeftes voorsien kan word.

Injongo zezizifundo yayikukujonga ixabiso lethuba lokunika uhayo kwimpilo yomlomo kubafundi base Mitchells Plain. Ngosekwa ngemthetho yo WHO (Kusetyenziswe abancedisi kwaye kuthengwe. Kogqira bamazinyo abazimeleyo okanye kufakwe ifluoride emanzini). Eli cebo lomthetho we WHO lisentyenziswe ekufikeleni kwimfuneko ezibalulekileyo zokuphelisa izifo zasemlonyeni ngoku sebenzisa indlela entsha yokunakekela amazinyo ukuphelisa ukungahoyakali kwe mpilo yomlomo emva kwe minyaka emihlanu emveni abahlalik besebenzise amanzi-ane fluoride. Iziphumo kulendawo zazalisekisa ukuba icandelo lwezempilo bayanyanga, basebenzisa izixhobo zexabiso eliphezulu, nabo nogqira bamazinyo ne oral hygienists, ba kupha nje amazinyo, benze ifilling ezilula, isealants bawa coce. Abagqira bahlawzilwa iimali izinkulu. Lendlela yonyango kwimpilo yomlomo zinzinto eziyimfuneko kuphela ngakumbi e Mitchells Plain. Eziziphumo zibonakalisa ukuba oogqira bamazinyo ne oral hygienists basebenza iyure eziwe ngemini imisebenzana enge yenziwe zi dental therapists.

Xa isebe lezempilo belinoku fakela ifluoride emanzini waba hlali ukwenzela ukuncedana nempilo yomlomo ingacuta izifo zomlomo kwaye yenze ingeniso yoku hlawula abantu balomisebenzi noku cuta iinxaki zomlomo. Ixabiso lefluoride nge nyanga yi X (R1.18 imali yesonka esincici) ingaphantsi kwe mali yomntu ogulayo kwi sebe lezemphilo Xa kuqeshwe iDental therapist yabiso lingehla nge 32-68% isigulani sihlawula i (R14-19), amanzi ene fluoride na xa engenayo. Xa iziphatamandla zinokuzama ukuphelisa ingxaki ebeziko kwimpilo yomlomo bafuneke baqiniseke ngomgangath yoku gcina impilo yomlomo baye baqeqeshe abantu ngokuba ngaba ncedisi.

Okwe thutyana kufanele isebe lezempilo linga qeshi ogqira bamazinyo ne oral hygienist kufanele kuqeshwe idental therapist ezinthathu endawe kagqira wamazinyo omnye. Ibilicebiso kubaphathi bezempilo yomlomo ukuba ba qiniseke ukuba ukunonophela noku phucukisa impilo yomlomo ibe yinto ephambili ngoku ncediswa ngabantu aba ncedisana nge mpilo yomlomo baze bafumane imbyikezo yemali ngoko sebenzisa abancedisi. Njengokuba Umzantsi Afrika ukweli xesha lokuzi guqula nangolihlenga hlengisa noku phucuka naba phati. Kwisebe lempilo yomlomo belimele ukuba lenza ibe yinto epumbili kubo ukwenzela uluntu amaXabiso aphantsi ngaphandle koku keta bala na moyomutu Ugamanzi ane fluoride kuphela anokusinceda kulombandela.

INTRODUCTION

The problems facing the South African health authorities in providing adequate dental services are vast and complex. It has been complicated in the past by Apartheid political ideology which has contributed to vast wastage of resources, producing an inefficient, fragmented health care delivery system inaccessible to the majority in need (De Beer, 1984, 1987; Jinabhai et al., 1986; Price, 1986; De Beer and Broomberg, 1990). This had a significant and detrimental effect on the health of the majority of disadvantaged South Africans (Anderson and Marks, 1988; Van Rensburg and Fourie, 1994).

Having entered an era of universal franchise and proactive health policy development, South Africa is now, committed to a health policy based on the Primary Health Care Approach (PHCA), the goal of which is "Health for all by the year 2000" (WHO/UNICEF, 1978; ANC 1994a; ANC 1994b). There is now a unique opportunity to implement a rational community health plan which can ensure as comprehensive a range as possible of promotive, preventive, curative and rehabilitative health activities within the domain of the PHCA. Public health dental services must be addressed in the process of reform.

With health care reform at the forefront of our nation's policy agenda, it is also imperative to investigate whether dental service delivery in the public sector is appropriate or adequate to cater for community needs in general. For the Mitchells Plain area, there is limited data available for planning effective comprehensive health services and almost none in relation to dental services.

The purpose of this dissertation is to assist health planners in the difficult choices they are facing at the level of policy at district level (especially with regards to the appropriateness of personnel in the light of the dental services they are rendering).

The aim of this dissertation is to compare the mode of delivering oral health care based on the prevailing curative paradigm and WHO-treatment norms for the school-going community of Mitchells Plain district in relation to selected alternative methods of dental care delivery.

The different modes of dental care to be analysed include the optimal use of auxiliary personnel, purchasing care from private dental practitioners and the hypothetical exposure of the community to water fluoridation.

The objectives of this study are to: provide a situation analysis of the school-going population of Mitchells Plain in terms of age, gender, oral epidemiology and the availability of oral health care services; use the WHO normative planning model to estimate the appropriate numbers and type of oral health personnel required to meet the oral health needs of the school-going population in Mitchells Plain before and after the hypothetical introduction of community water fluoridation and; describe to what extent the utilisation of auxiliary personnel or the purchasing of care from private practitioners would change the opportunity (alternative) cost[1] of delivery of dental care at a district level, using Mitchells Plain as a case study.

[1] *The term 'opportunity cost', or 'alternative cost' expresses the cost of a commodity not in terms of money, but in terms of the alternative forgone (Brown, 1970; Whitehead 1982).*

LITERATURE REVIEW

The literature review will commence with an overview of the dental public health sector in South Africa. Key issues such as the curative approach to dental treatment, approaches to health planning in general, the role of auxiliary personnel and the WHO approach to oral health care planning in particular will be explored. In addition an overview of dental caries epidemiology and it's implications for dental service rendering will be presented. The impact of fluorides and community water fluoridation on oral health will be reviewed. In the final section of the literature review, the concept of district health systems, efficiency and opportunity cost will be outlined.

The South African Public Health Sector

The health care system in South Africa initiated under Dutch influence as early as 1652, developed gradually reflecting a transition towards modern scientific medicine with physicians ("doctoren") and surgeons ("chirurgins"), the former being products of university training and the latter products of apprenticeships in an extensive system of guilds. Besides these main categories of health care providers there were also many other practitioners who provided traditional forms of indigenous health care (Burrows, 1958).

The Western culture of the colonists and the diverse African cultures laid the foundation for the parallel existence of at least two divergent systems of medical or health care, characterised respectively by a professional-scientific orientation in respect of health care on one hand, and a magico-religious orientation on the other. This split structure is still in existence today, although the most traditional and alternative forms of health care delivery are being marginalised by the powerful processes of westernisation and professionalisation imparting characteristics to the South African health care system.

Today, the health care system in South Africa is predominantly run by highly trained health professionals. The system is characterised by it's curative bias, inequality, maldistribution, preferential treatment of those previously classified as Whites, discrimination and at times exclusion of those who are most in need of the services, especially in the rural areas (De Beer, 1984; Price, 1986; Chimere-Dan, 1992).

It has been deeply permeated by the structures of Apartheid which has caused disempowerment and exploitation of the community. This political ideology has also contributed to widespread poverty, malnutrition and ill-health which are contrary to the needs of healthy community (Anderson and Marks, 1988).

Most vitally, Apartheid meant that the majority of the people were not consulted or were excluded from any real decisions shaping the design and delivery of health care services in South Africa. Very few Blacks in the homelands could help decide about the frame work of medicine in certain geographic areas (Savage 1979).

In the field of oral health, the mode of curative health care delivery has a dubious or limited impact on the promotion of oral health (Cutress et al., 1979; Woolfolk et al., 1985; Locker, 1988; Sheiham, 1989; 1994). In the Western Cape, 77 % of the budget (Khalfe,1994) is spent on the remuneration of highly trained personnel (mainly dentists and to a lesser extent dental therapists and oral hygienists) who render basic[2] dental services.

With health care reform in the forefront of our nation's policy agenda, these issues present major challenges for the planners of public health care delivery. The reform must deal with reducing the inequities in the health care system taking into account issues of cost, quality and access in relation to general and oral health care.

One way of approaching this problem is to question whether the current dental care workforce will appropriately meet the oral health care needs and demands of the community in the district.

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[2] *Basic dental care includes procedures such as simple fillings, extractions, fissure sealants, scalings,oral health education and to some extent dentures.*

Impact of the curative approach to oral health care.

The conventional restorative, rehabilitative oral health care delivery systems, served by sophisticated technology, are based on the engineering and curative approach to the body. This system of delivering oral health care, is staffed by highly qualified personnel and has been unsuccessful in halting the deterioration of oral health in developing countries (Ibikunle, 1985; Songpaisan, 1985; Saparamadu, 1986; Kamilot et al., 1992, Sheiham, 1994) and have often failed to provide the basic oral health care needed. Their effectiveness has been challenged (Louw, 1982; Dowel et al., 1983; Elderton, 1990; Khalfe et al., 1994; Sheiham, 1994).

The failure to achieve improvement in community oral health care services has been attributed to inadequate and inappropriate training of oral health care personnel, continuance of the curative approach to dental care and a lack of political will to provide basic services to those members of the society most in need of treatment.

Louw and Moola (1979) and Louw (1982) demonstrated that the type of personnel rendering dental services in the Western Cape is inappropriate for the type of caries experienced in the community.

The results of the 1988/1989 National Oral Health Survey (NOHS) (du Plessis et al., 1994; Khalfe et al., 1994) confirmed that the dental caries experience prevalent amongst the Coloured and Black population groups[3] is still very high in the primary dentition, despite public dental health services being in operation for the last 25 years. One can argue that the type of service rendered has had limited impact in improving the oral health of the nation.

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[3] *The terms "White", "Coloured", "Indian" and "Black" are politically inspired categorisations found in South Africa's former Population Registration Act of 1950 and carry no meaning beyond this definition. They were used in the 1988/1989 National Oral Health Survey.*

International studies have reported similar experiences amongst first world populations despite organised dental care (Cutress et al., 1979; Cohen, 1980; Valentine, 1981).

On the other hand studies have reported lower caries experiences and indicated dramatic improvements in the oral health of people resident in areas with natural and artificial fluoridation (Anderson, 1981a, 1981b; Helöe and Haugejorden, 1981; Anderson et al., 1982; Kunzel, 1982; Hunt et al., 1989).

These studies provide the motivation for assessing the implications of continuing the curative mode of dental service delivery in relation to alternatives such as (i) the use of auxiliary personnel (dental therapists or a combination of dental therapists and oral hygienist) for rendering curative and preventive care, or (ii) the introduction of a public health measure such as community water fluoridation.

The following section will address the role of using auxiliary personnel in the delivery of oral health care to a community.

The Role of Auxiliary Personnel

It is reported that using appropriately trained auxiliaries is a cost effective way to contain health care costs, as salaries normally absorb 60-80% of the budget (Jeboda, 1984, 1989; Warnakulasuriya, 1985; Razak and Lind, 1994). A dentist is paid approximately three times more than a dental therapist or an oral hygienist, according to the current scale of remuneration in the public health sector in South Africa (CPA, 1994).

Appropriately trained auxiliaries could perform duties which include the provision of routine preventive, curative and restorative services, monitoring primary health care activities, and refer patients needing complex care to "oral specialists" (dentists). This approach complies with the strategy of the universal three level model of Tala which operates by a referral system based on full community involvement at the primary health care level (WHO, 1982).

A joint working group (JWG5) of the Federation Dentaire Internationale and the World Health Organisation concluded that oral health problems in developing countries are now at a stage when reasonable resources devoted to prevention would obviate the need for a huge expenditure for restorative and rehabilitative dentistry using highly trained personnel to carry out these procedures (Renson et al., 1985).

In South Africa, the dental profession has yet to find a way to meet the ever increasing demand for dental services for developing communities, though attempts to investigate this problem have been made (van der Sandt de Villiers, 1970; Louw, 1979, 1982; Dreyer,1988; Report of Committee of Dental Deans, 1991; du Plessis et al., 1994) and are currently under scrutiny.

South Africa has been training dental therapists and oral hygienists since 1974. Approximately 150 oral hygienists and 50 dental therapists are being trained around the country annually (DNHPD, 1992). Currently there are 195 dental therapists registered, but only 90 are employed in the public service (DNHPD, 1992). There are posts available in the services to employ a greater percentage of these dental therapists, but the attrition and turnover of dental therapists is considerably high. This may be due to poor salaries, lack of promotion and work incentives. It is also argued that because dental therapists are Black, their service conditions in the public sector were poor as compared to the oral hygienists who were predominantly White. This has been largely due to the past Apartheid legacy. Furthermore, this cadre of auxiliary (the dental therapists) are not being utilised effectively in accordance with the demands and disease profile of the community (Dreyer et al., 1986).

Global studies (Enwonwu, 1981; Barmes, 1983; Songpaisan, 1985; Songpaisan and Davies, 1989; Kamilot et al., 1992) and the recent National Oral Survey in South Africa (Khalfe et al., 1994) have shown that oral health in the developing communities is deteriorating.

Despite the rising consumption of sugar in the developing countries (Enwonwu, 1981), the disease pattern of caries in developing communities can be considered low in severity (Eg. a mean DMFT of 2 for 12 year olds is considered low compared with the WHO global goal of 3 DMFT: Barmes, 1983).

In South Africa the oral disease burden is high, especially amongst the six year old and younger Black and Coloured children (du Plessis et al., 1994). 24% of the six-year, 40% of 12 year and 20% of 15 year olds are caries free (Khalfe et al., 1994).

The results of the National Oral Health Survey (du Plessis et al., 1994; Khalfe et al., 1994) demonstrated that the decayed component makes up the major proportion of the dmft of the primary dentition. The majority (71%) of the children require simple restorative and exodontic treatment (44% requiring one surface fillings whilst 23% require two surface fillings; Annexure 1-3).

One may argue that this type of caries (treatment) profile is most appropriately treated by auxiliaries such as dental therapists and expanded duty oral hygienists. Hence appropriately trained auxiliaries can be an asset to the health care delivery system especially in areas where the human and financial resources are scarce (Louw 1979, du Plessis et al,1989, 1994).

Clinical experience indicates that dental caries cannot be controlled by means of a restorative approach unless it is supplemented by preventive measures, supported by appropriate use of auxiliary personnel.

One of the objectives of this study is to estimate the numbers and types of personnel for dental service delivery. The following section will briefly deal with various methods that are available for estimating the human resources required to deliver dental care.

Planning Dental Resources

There are various approaches for estimating future requirements for dental personnel. Hall and Mejia (1978) describe four methods of estimating demand for human resources viz health needs, service targets, health demand (or economic) and manpower/population ratio methods. In Slack (1981), Sheiham mentions two additional models namely the Supply and Demand Model and the Functional Analysis Model (See Annexure 4).

The first three methods of Hall and Mejia (the health-needs, service-targets and health demand (or economic) method) first convert people into the health services they require and then into the human resources required to deliver the services. The last method, popularly known as the "manpower/population ratio method" converts people directly into "human resources" needed. The health-needs and service-targets methods are based on normative judgements (depending on the current need, mostly without inputs from the consumer of care). The health demand method is used to make predictions of the human resources for future use. The ratio method lends itself to either approach although most authors feel that dentist to population ratios are not good indicators for calculating human resources (See Annexure 4).

The rationale for estimating the need for oral health personnel is to assist us in using limited resources more appropriately and effectively. This depends to a large extent on the subjective values of purchasers of oral care, policy makers and the consumers (De Fries and Barker, 1982). The decision on which method to use will depend very much on how the planners assess the situation in their own country or what questions they intend to answer. The optimal solution should be to utilise human resources whose qualifications reflect the population's needs and demand, at a cost that is compatible with the financial resources of the country (Hall and Mejia, 1978). In general, these methods enable the prediction of envisaged personnel requirements for the services with widely varying degrees of accuracy.

The WHO/FDI Model (WHO,1989)

In order to provide decision-makers with a methodological tool that can be used for planning services, the World Health Organisation and the Federation Dentaire Internationale set up a joint working group (JWG6) to provide such a tool. This method provides for quantifying the need for dental care in communities. This method is a combination of several methods previously described. The programme allows for conversion of the current and predicted needs of a given population to full time equivalent (FTE's) personnel required to provide the dental care. This is a needs-based, demand weighted normative model. It assumes that a 100% of the identified need for dental services will have to be provided to achieve good oral health (WHO, 1989).

The WHO/FDI Planning Method is a versatile programme, it combines several of the features of the various planning methods (Annexure 4). It also takes into account the epidemiological, social, demographic and technological developments in prevention and treatment procedures (WHO,1989). It has been applied mostly in industrialised countries such as France and Australia (Bourgeois et al., 1993; Morgan et al., 1994) and to a limited extent in developing countries such as Zimbabwe (Khan and Sithole, 1991) and South Africa (Chikte, 1994). The literature reports conflicting opinions about it's usefulness.

Morgan et al. (1994) found it to be a useful tool for planning and monitoring of the workforce. Morgan et al. (1994) concluded that rational planning of workforce requirements is essential for nations in order to minimise under- and over-supply of personnel and services. Bourgeois et al. (1993) applied the WHO/FDI planning to estimate oral health personnel in Australia and found it useful to forecast requirements, by age cohort and by type of care allowing for flexibility of use. On the other hand, Bronkhorst et al. (1991) found that there were major deficiencies with this model. They reported that it neglects cohort and period effects in its estimates of oral care needs, that it overlooks aspects of demand, and is retrospective in its calculations thereby providing overly simplistic answers. They also found the model to have little added value for estimating the future need for periodontal and orthodontic care.

The Zimbabwean experience showed that, oral health personnel projections using this approach together with two other approaches, were all different, and even the lowest projection was beyond the resources of the country (Khan and Sithole, 1991). Khan and Sithole (1991) advise that in making the personnel projections, the facilities available to accommodate the personnel should also be taken into consideration. The South African study cautions that it should only be employed for provisional forecasting of human resource requirements (Chikte, 1994).

The WHO/FDI Planning Method, though, essentially meant for planning on a national basis, can be utilised for planning at district and local levels, facilitating the calculation and prediction of future human resource and service needs. The application of this programme for predicting the supply of personnel at district level will be tested using Mitchells Plain as a case for study.

The District Health System (DHS)

In South Africa, the DHS will soon provide the structure in which rational planning based on need takes place at grassroots level.

The DHS constitutes the building block of the new national health system. It helps to ensure community accountability and has representation by members of both the community and local health authorities in the geographic area under it's jurisdiction (Tarimo, 1991).

The district is a geographically compact unit with a clearly delineated area and a fairly well defined population. It may be the most appropriate level at which community participation can be developed and enhanced (Tarimo,1991).

The population of a district could vary from less than 50 000 to over 300 000, depending on its geographic location (urban or rural). A number of small district authorities could be grouped within a regional health structure (Tarimo, 1991; Zwarenstein and Barron, 1992).

Mitchells Plain has most of the attributes of a district and may in future provide the base for rational planning according to local needs, encouraging community inputs in the planning, implementation and evaluating the services provided (Zwarenstein et al. 1993). Community based public health measures such as water fluoridation could easily be introduced in such a district. For this reason, Mitchells Plain has been chosen as a case for study, for comparing different methods of dental delivery at district level.

Concept of efficiency and opportunity cost

In many parts of the world, health sectors are busy restructuring services within a macro-economic policy environment emphasising the limitations of the public health sector to provide health services due to scarce resources, escalating costs, use of high technology and highly qualified personnel and a bias towards expensive curative care. In the process the health authorities are trying to shift the financial burden or responsibility to the consumer (Gift, 1984; Creese, 1991; Green, 1995).

In order to rationalise allocation of resources and improve efficiency in the health delivery systems, health professionals and economists are looking at various ways of evaluating and comparing the costs of service delivery within the health care sector.

According to Drummond and Stoddart (1985), economists view the cost of health care programmes not merely as money expenditures, but as potential benefits that are being forgone. For example, in developing countries a commitment to an urban hospital development may imply a cost in forgone rural health services which may be more urgently needed.

The notion of costs as forgone opportunities (or sacrifices) provides the logic for comparing health service options in terms of their benefits and costs. Economic evaluation seeks to do just that and takes various forms depending on the problem at hand and the extent to which the benefits of programmes can be quantified and valued (Drummond and Stoddart, 1985),

The literature on economic evaluations is very confusing due to the wrestling with semantics and the economic jargon used. Studies that deal with economic evaluations must compare competing alternatives which achieve the same objective at the lowest cost.

Costs are not the same as prices, which reflect a market rate of exchange. Some actions may have costs which have no price or market value while others have market prices that do not reflect the real resource implications to society of an action.

Since one of the objectives this study is to compare the cost implications of delivering different methods of dental care at district level, an assessment of the alternatives in resource use is required. This assessment is based on the notion of opportunity cost.

Brooks (1995) defines the opportunity cost of an action as the value of the next best alternative use of the resource or resources used in that action. For example, the opportunity costs to the supervisors, in examining this dissertation, certainly include the value of sacrificing some of their leisure time.

According to Brown the term 'opportunity cost', or 'alternative cost' expresses the cost of a commodity not in terms of money but in terms of the alternative that is forgone (Brown, 1970; Whitehead, 1982). By this they mean the alternative actions that could have occurred if one had gone ahead with the chosen action. For example, the opportunity cost of training one doctor might be the alternative of training two nurses.

If we exercise choices we must have alternatives from which to choose. The housewife who decides to give a party on an anniversary or birthday will tend to reduce expenditure on ordinary meals so that she can accumulate reserves for the party. The true cost of the party is the reduced enjoyment at other meals.

Similarly, a decision by a district authority to render comprehensive oral services may divert resources from clinic accommodation and professional staff towards this type of service. It may never be known whether these resources would have given greater satisfaction if they had been used in other ways.

According to Mooney and Drummond (1982), "aiming to keep costs down (that is reducing opportunity costs) means maximising the benefits of health care (it means that the benefits to be derived from using resources in their best alternative use)".

Minimising opportunity costs is derived from the notion that resources are finite and scarce, deploying them in one way implies that a benefit is foregone in not choosing the other alternative. Thus cost becomes a measure of sacrifice. The gains foregone are called opportunity costs. On the other hand to utilise resources inefficiently would mean that these resources could be reallocated and better utilised to increase output and thereby social welfare (Donaldson and Gerard, 1994).

Achieving efficiency is therefore about comparing costs and benefits of competing health care interventions. The ultimate objective of achieving efficiency in the public health sector is to ensure that resources are allocated in such a way that consumer satisfaction is maximised at least cost to society (Warner, 1989; Antzack-Bouckoms, 1989).

There are two levels of efficiency, operational efficiency and allocative efficiency, each of which is based on effectiveness.

Operational efficiency involves choosing between two alternatives which can achieve the same end result ensuring that the best use is made of scarce resources to meet the programme's objective. It may be interpreted as the means to minimum cost for given level of output (Donaldson and Gerard, 1994).

For example, if one had to choose between a antibiotic therapy and a surgical procedure to treat a given condition. If the antibiotic therapy is both cheaper and more effective then it should receive preference. The problem arises when one treatment modality is both less costly and less effective, then the cost effective ratios of the alternative determines which is most effective; the lower ratio indicating greater operational efficiency.

On the other hand allocative efficiency judges whether an activity is worth doing. It also addresses the question of scale or marginal analysis. In the case of allocative efficiency the benefits of a programme far exceed costs (Donaldson and Gerard, 1994).

Donaldson and Gerard (1994) advise that the following rules of achieving efficiency should be followed. Firstly, if a given option is less costly and brings about the same end result (or produces more output) this option should receive preference over the alternative option. Secondly, if the given option is less costly and produces less output, then the cost-effective ratios should be computed, the lower ratio indicating greater efficiency.

Green (1995) recommends a variety of techniques and policies for improving the efficiency of a given service. These include economic appraisal of existing services by way of a cost effective analysis, purchasing care from outside sources, development of cost-centred budgeting systems involvement of clinicians in management decisions and providing productivity related incentives to staff. However, Green (1995) warns that, while some of these tactics may prove beneficial, they may prove counter-productive if a manager's attention is focused narrowly on efficiency-orientated tactics.

In carrying out an appraisal of alternatives in the public health service which has the welfare of society as it's aim, one should as far as possible, consider all costs. A private health care service, concerned to maximise profits is, in contrast, likely to consider costs falling on itself, rather than on society.

A public health measure such as community water fluoridation is an excellent example of a minimal opportunity cost intervention and its benefits also include substantial and positive outcomes for the oral health status of the population. The concept of opportunity costs as defined by Brooks (1995) will be applied in this study.

The following section will present an overview of dental caries epidemiology with specific emphasis on the caries experience of children in the Western Cape. Issues related to the prevention of dental caries on a community basis will also be addressed.

Dental Caries

Dental caries constitutes a major public health problem in developing communities, despite reports of it's decline in affluent communities (Sardo-Infirri and Barmes, 1979; Enwonwu, 1981; Konig, 1982; Barmes, 1983; Steyn et al., 1987; Cleaton-Jones and Hargreaves, 1988).

It is thought that the increase in caries prevalence is associated with changing life styles and increasing sugar consumption with different patterns of caries prevalence and severity amongst various countries in Africa (Akpata, 1978; Enwonwu, 1981; Sheiham, 1984; Gordon and Reddy, 1985). The prevalence of dental caries in most developing countries can still be regarded as low to moderate (Sardo infirri and Barmes, 1979; WHO, 1980, 1994).

According to Sithole (1994) there seems to be equal evidence to support both a lack of increase and a rise in the prevalence of dental caries in Zimbabwe and in East Africa especially amongst the 12 year olds.

Sithole (1994) urges that perhaps the 12-year old group may not be as appropriate an age to use as an indicator to study caries trends in East African countries. The severity and prevalence of caries is higher in children over the age of 15.

Chironga and Manji (1989) are also of the opinion that older children in Zimbabwe and other East African countries should be targeted for future comparative studies in dental care.

In South Africa numerous epidemiologic surveys have been conducted since 1910. Because of racial segregation most of these studies have described the caries prevalence in terms of racial categories making it extremely difficult to classify the caries profile of the South African population as a whole. Almost all of these studies have been cross-sectional surveys restricted to populations in specific areas, resulting in an inability to determine caries trends. They may provide some idea of the changing patterns in oral health status.

In comparing results, it should always be borne in mind that different criteria and methods may have been used by different examiners. The age groups being compared may not always be the same (eg. 6 year olds being compared with 6-7 year olds or different cut off dates may have been utilised to asses the age).

For easier reference the studies will be summarised according to race as has been the practice up to now (Annexure 1-3).

In the Western Cape, children previously classified as Coloured appear to have high levels of caries. A mean dmft of 4.3 has been reported for children under five years of age (Yasin-Harneker, 1987), while for six to seven year old children a mean dmft ranging from 7 to 7.8 has been reported by Mohamood and Moola (1985) and Moola and Vergotine (1988). The results of the NOHS 1988/89 showed that the caries experience at age six is very high, especially in the primary dentition (Mean dmft=4.1), with only 24% of the cohort being caries free (Annexure 1-3).

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In a national study, Williams (1984) reported a mean DMFT of 3,7 for 11 to 12 year old Coloured school children. In the Cape, Louw and Moola (1979) reported a DMFT of 6 for the 12 year olds.

The DMFT of 2,1 for the 12 year olds (Khalfe et al., 1994; Annexure 1-3) is within the WHO global goals of three for the year 2000. These findings are similar to that of Moola and Vergotine (1988) (Moola and Vergotine reported a DMFT of 2,2 for 12 year old rural schoolchildren in the Western Cape).

Myburgh and Moola (1984) examined Coloured industrial workers in the Boland and found that the mean DMFT was 21.8 for 16-35 year olds with more than a third of the sample being edentulous. For the 15 year olds a mean DMFT of 3.7 was reported in the National Oral Health Survey 1988/89 (Khalfe et al., 1994).

The common factor in all these studies, is that the decayed component is predominant in the age cohorts below 20 years. These results reflect a major oral health problem in the school population that needs urgent attention.

This caries prevalence is probably an under estimate because of the absence of radiological assessments in many of these surveys. The NOHS study confirmed that a high proportion of oral disease remains untreated (Khalfe et al., 1994). The following section will highlight some of the limitations of the NOHS 1988/89.

The National Oral Health Survey 1988/89 used a cluster sampling technique which has major limitations. The results of this survey are not truly representative of the major communities of South Africa as it was a cross-sectional survey limited to the major metropolitan areas of South Africa.

In the district of Mitchells Plain for example only 75 children each were examined in the age group 6 and 12 years. Under six year olds were not examined in any region.

15 year olds did not feature any where in the epidemiological survey in the district. Besides, the results of this national survey were only published in 1994, nearly five to six years after the survey.

Nevertheless, the studies reviewed do provide a base for comparing the current caries experience in the district of Mitchells Plain. The nature of the caries profile can provide a guideline for the provision of dental services and human resources to help identifying appropriately trained oral health personnel based on the specific oral health care needs of the pre-and school-going children in the district.

Prevention of Dental Caries

Dental caries is amenable to prevention. Numerous reports testify to this fact. Stamm (1984) and Murray (1986) stress the inherent inability of the curative approach to deal with dental caries and place greater emphasis on the value of preventive strategies (Barmes 1994). Burt (1984) highlights the need for community-based efforts. He argues that the prevention strategy should be compatible with the community disease profile, the level of education, demography and the availability of resources.

Communities and institutions are an ideal setting in which the determinants of individual behaviour can be altered and preventive services can be rendered (Silversin and Kornicki, 1984). It is in this context that public health measures such as community fluoridation and brushing programmes using fluoridated toothpaste are appropriate.

The FDI working group (1984) supports the principle of community based programmes, that oral health is an integral part of general health and that "the quality of human life is enhanced considerably when dental caries and periodontal disease is prevented".

The FDI group (1984) recommends nine priorities for the prevention of caries including community and school water fluoridation; salt and milk fluoridation; promotion of healthy diet; fluoride mouth rinses and gels; fluoride tablets and tooth pastes; educational targets for individuals and the community policy control on cariogenic foods; fissure sealants; prophylaxis and removal of plaque.

The district of Mitchells Plain provides an ideal base for testing to what extent the implementation of a public health prevention programme such as the fluoridation of the community water supply would influence the reduction in service provision thereby reducing the human resources required for curative care. It is important to find out how far a rand spent on prevention instead of restorative care can be stretched if this option is followed to bring about a meaningful change in the community's oral health status.

Fluoridation: it's impact on oral health

The World Health Organisation has identified water fluoridation as the strategy of choice for caries prevention in both developed and developing countries (WHO,1986; WHO,1994). The health and cost benefits of water fluoridation are well established (O'Mullane et al., 1988; Stamm, 1990; Horowitz, 1991; Murray et al., 1991; Stookey, 1993).

According to Newbrun (1989), community water fluoridation, reduces dental caries in the deciduous dentition by 30-60%, in the mixed dentition group by 20-40%, and mildly in adolescents (15 to 35%) in the United States, Canada, Britain, Ireland and New Zealand.

Brunelle and Carlos (1990) showed that other factors like increased concentrations of fluoride in drinks, food and dental products (processed in fluoridated areas and transported to other areas where community water supply is not fluoridated) may also be responsible for caries reduction.

Other studies have demonstrated that continuous exposure to fluoridated water is beneficial (O'Mullane et al., 1988; Stamm, 1990; Horowitz, 1991; Murray et al., 1991, Stookey, 1993) even when the exposure to fluoridated water only begins in adulthood (Hunt et al., 1989; O'Mullane, 1994).

Throughout the world it is estimated that 210 million people drink artificially fluoridated water and that a further 103 million drink water whose natural fluoride level is high enough to provide a significant degree of protection against tooth decay (Murray et al., 1991). Countries with fluoridation schemes include the United States, the United Kingdom, Canada, Argentina, New Zealand, Ireland, Australia, Hong Kong and Singapore.

The United States is the most extensively fluoridated country in the world (Murray et al.,1991). The implementation of water fluoridation, however, is limited in other parts of the world. The major reasons for the limited implementation have been the constraints of regulations, finance, policy and politics of water fluoridation. It may be argued that political support is a critical factor on which any plan of action to fluoridate community water supplies will stand or fall.

The costs involved in fluoridating community water supplies

A review of the cost of fluoridation across 44 communities showed that the cost per person is highly dependent on the population served, the number of fluoride-injection points (from where the fluoride is introduced in the water) and the method of chemical purchases and delivery, with economy of scale favouring the larger communities (Ringelberg et al., 1992). Studies which did not take into account the annualised costs of labour and maintenance, have reported lower costs per person.

Ringelberg et al. (1992) found that the total mean cost per person varied between $0.41 and $0.45 (equivalent to R1.46 and R1.60) for all installations. The mean cost for communities of fewer than 10,000 was $2.12 (= R7.53); for communities between 10,000 and 50,000 it was $0.68 (= R2.42); and for communities over 50,000 it was $0.31 (=R1.31).

The United States experience shows that Department of Health and Human Services Report (1992) states that for every one dollar spent on water fluoridation, a saving of 80 dollars in dental treatment costs is achieved.

According to this report the estimated non-discounted per capita expenditure for water fluoridation during a lifetime (40 dollars for 75 years) is approximately equal to the average non-discounted cost of a filling (the mean cost per restoration in the United States being $40).

Garcia (1989) reported that the direct costs of fluoridation in the United States in 1988 ranged from $0.12 to $1.16 per person with a mean cost of $0.49 (equivalent to R1.74) per person per year.

Analysing the economics of water fluoridation, White et al. (1989) concluded that water fluoridation is one of the most cost effective preventive dental programmes in health care.

However, one should be very cautious when interpreting the afore-mentioned figures from the US experience as the nature of the economy and society differ in important respects and may not be applicable to the South African context. The underlying principles of savings and economy of scale may apply. Nevertheless, there is much to learn from the UK and US experience.

In South Africa, a few studies relating to the costing of water fluoridation have been undertaken (Hadfield and Cleaton-Jones, 1983; Barrie, 1992; Subcommittee on fluoridation, 1994).

An unpublished report by Barrie (1992) showed that it would cost 70 cents per person per year in the Western Cape.

In Port Elizabeth the cost would be R1.28 (Subcommittee on fluoridation, 1994). It has been reported that the cost of fluoridating Port Elizabeth's water is less than a loaf of bread per person per year. It is far cheaper than purchasing either toothpaste which would cost more than R6.00 per person per year or fluoride tablets which would cost R122 per child per year (Owen, 1994). The Port Elizabeth estimates show that at a cost equivalent to that of a one surface filling per person per year, one can provide each person with optimally fluoridated water for 22 years.

The Rand Water Board (1994) estimated the cost between 65 cents per capita per annum for low socio-economic groups and R1.20 per capita for affluent households. It is not clear what criteria were employed to categorise socio-economic status. This estimate is fairly similar to the estimate of Hadfield and Cleaton-Jones (1983) (69-100 cents per person per year for fluoridating the water in Johannesburg). They also reported that it would cost R21 per child per year using Zymafluor tablets (equivalent to R130 per child per year from birth to age 14, given that the retail price is R43.80 per 400 tablets in 1995).

According to Hadfield and Cleaton-Jones, (1983) the topical application of fluoride would cost R11 per person per annum, (equivalent to R27.00 in 1995) and that R4.00 per child per year could be spent on fluoridated tooth paste (equivalent to R 12.00, for 4 tubes of 100 ml each in 1995)

It is clear from the voluminous literature that community water fluoridation is the most economical intervention available to prevent dental caries. Despite the abundance of data supporting the benefits and cost effectiveness of community water fluoridation, until recently there has been little development and no caries benefit for South Africans.

The rationale for introducing fluoridation in South Africa

There are several advantages for the government of the day in introducing this important public health measure.

South Africa meets most of the prerequisites of Murray (WHO,1986) for water fluoridation, (especially in the major metropolitan areas). In South Africa dental caries seems set to rise in most disadvantaged communities-especially amongst the under six year olds. The results of several studies undertaken over the last ten years (Annexure 1) confirm that dental decay is rife.

The situation in Mitchells Plain is compounded because 49% of the population is below the age of 20 years. Of these, nearly a third are less than six years old. This young demographic profile presents a major service provision problem for the school going population in the district.

As dental diseases are expensive to treat, the financial cost to individuals and society is considerable. Reliance on the restorative strategy alone cannot control dental caries unless this is accompanied by preventive measures (Helöe and Haugejorden, 1981). The reduction in this profile of caries experience, which is to a large extent interproximal in the primary dentition, is amenable to prevention by way of community water fluoridation (Newbrun, 1993). The protective effects of fluoride are more pronounced in the smooth surfaces of the teeth than they are in pit and fissure surfaces (Burt in Slack 1981, Newbrun, 1989; Burt,1993).

At present all children under the age of six years are entitled to free treatment (ANC,1994). It is this age group that must be targeted under the mother and child care programme to reap the greatest benefits of fluoridation programme.

Another issue is the question of equity and social justice in oral health (Locker, 1988). This has been denied to the disadvantaged groups in South Africa because of the system of Apartheid. Water fluoridation is the only politically viable public oral health measure which can equitably benefit all people within reach of a potable reticulated water supply. The measure would give equal access, equal per capita expenditure, equal resource allocation and equal utilisation at least to people in the metropolitan areas (Myburgh and Solanki 1990). And since the poorest people have the wost caries even, they stand to benefit the most from this public health measure. The White Paper of the Ministry of Water Affairs (1995) supports this principle and advocates improving the access and development of potable piped water supply to all communities. The CSIR Report (Staz,1962) and the Commission of Enquiry into Fluoridation (1966), both strongly support community water fluoridation.

The SALDRU Report (1993) states that while 18 million people in the country do not have access to piped municipal water supplies, a substantial number of homes in the major metropolitan areas of South Africa are provided with water. Therefore, it is logistically viable, especially for areas such as Mitchells Plain.

AIM AND OBJECTIVES

The aim of this study is to analyse and compare the delivery of oral health care based on the prevailing curative paradigm to the school-going community of Mitchells Plain district in relation to selected alternative methods of dental care delivery, including the use of auxiliary personnel, purchasing care from private dental practitioners and introducing community water fluoridation.

The objectives of this study are to :

1. describe the school-going population of Mitchells Plain in terms of age, gender, oral epidemiology and the availability of oral health care services

2. use the WHO normative planning process to determine the appropriate numbers and types of oral health personnel required to meet the oral health needs of the school going population in Mitchells Plain

3. determine the human resources necessary to reduce the oral disease burden after hypothetical exposure to community water fluoridation

4. assess the utilisation of auxiliary personnel and the purchasing of care from private dental practitioners in the delivery of oral care in the district.

Constructing the scenarios to be tested using the WHO/FDI Model

In order to compare the provision of public oral health care services based on the current system of service provision using dentists and oral hygienists to the pre and school-going children, aged 0-19 years, in Mitchells Plain District, selected alternative methods of dental care delivery were examined.

The scenarios to be tested included the current mode of dental delivery using dentists and oral hygienists, the exclusive use of auxiliary personnel, purchasing care from private dental practitioners and introducing community water fluoridation at a district level, using Mitchells Plain as a case for study.

The information needed for ascertaining the human and financial resources to provide the dental service to the 0-19 year olds in the district of Mitchells Plain was broadly classified into four broad categories. These included describing the demography of the study population, determining their oral health epidemiological profile, examining the resources for dental service in terms of the patient profile, types of treatment and the cost of delivery thereof. The costs of fluoridating the water supplies was also analysed.

Two time periods were chosen, one at the beginning of the plan, and the other at the end of 5 years (ie before and after fluoridation). For each of these scenarios the curative mode of dental delivery was used as the point of departure for the purposes of comparing the resources and the cost entailed of each option before and after the hypothetical exposure to community water fluoridation. The scenarios to be tested therefore were constructed as follows:

Table 1 Scenarios to be compared and tested

Beginning of plan: 1995	End of Plan: 2000	
Before fluoridation	**Without fluoridation**	**With fluoridation**
1. Total Care using Dentists and Oral Hygienists	2. Total Care using Dentists and Oral Hygienists	3. Total Care using Dentists and Oral Hygienists
4. Total Care using Dental Therapists	5. Total Care using Dental Therapists	6. Total Care using Dental Therapists
7. Purchasing Total Care from the Private Practitioners	8. Purchasing Total Care from the Private Practitioners	9. Purchasing Total Care from the Private Practitioners

Defining the boundaries of the District of Mitchells Plain

The boundaries of the proposed district were determined prior to the commencement of the study, using convenient landmarks, freeways or railway lines to denote the proposed district. Advice and necessary maps were obtained from the Regional Services Council and the Urban Planning Department of the Cape Town City Council (Eichorn, 1994; See Annexures 5 and 6 for brief history of Mitchells Plain and Map of the area).

As a District Health Care System operates within a defined geographical area, the boundaries chosen for the "District of Mitchells Plain" were identified (as Vanguard Drive, Swartklip Road, The R300 Freeway and the coast line) (Annexure 6). The Strategic Management Team for the Western Cape suggested that Strandfontein, Mandalay and Mitchells Plain itself should be considered as the areas constituting the district in the new health service dispensation (SMT, 1994). The rationale for choosing Mitchells Plain area as a case study was that it has many of the geographic and demographic characteristics of a future health district.

Determining the Resources for rendering Public Dental Services in the District of Mitchells Plain

The JWG6 Programme (WHO 1989) was utilised to determine the resources needed to deliver oral health services to the school-going population of Mitchells Plain. The method provided for assessing the quantity of restorative and periodontal services required to satisfy the needs of the current and predicted school-going population in the district (now and after five years: before and after fluoridation).

Two sets of estimates, now and after five years, ie. at the beginning (1995) and end of the plan (2000), were done to determine the human resource requirements for rendering dental services to the 0-19 year olds in the district.

The full time equivalents for each period (in 1995 and after five years) were calculated using the 100% (full coverage, the ideal) and actual service utilisation levels (to be measured) (explained later under section on level of utilisation). An additional estimate of human resource needs for the year 2000 was made assuming that the caries level had dropped by 50%.

The results for the two periods will be presented separately for ease of reference. The first estimate will indicate the relativity between what exists and what is needed while the second estimate, at the end of five years (the end of plan) provides an idea of what will happen given certain conditions such as level of caries experience and population growth. For each of the periods certain basic input data was required for the calculation of the human resource requirements.

The process of estimating the human resource requirements (full time equivalents) involved a series of calculations. The various variables and steps that go along with them are summarised below (from Health Through Oral Health: Guidelines for Planning and Monitoring for Oral Health, WHO,1989).

(i) The Demography of the Mitchells Plain Population

For the purpose of this study two age cohorts were used (0-14 years and 15-19 year olds). The population census of 1991 had to be modified using the median method suggested by du Plessis (1994) to conform to these cohorts for the programme (Details of population estimates in Annexure 7).

The demographic details of the Mitchells Plain school-going community (pre-primary, primary and secondary schoolchildren), were obtained from the 1991 population census, including population size, gender, age, education level and occupation (Table 2). An estimation of the school-going population by age was made using the median age in a cohort and weighting the mean by 3% (the assumed growth rate) on either side of the median to calculate the number of people in each age category (du Plessis, 1994; See Annexure 7). The estimated totals were very close to the actual totals obtained from the schools and those that were recorded from the population census. They may be subject to a degree of undercount. However, the population figures were adjusted for the estimated undercount.

A senior official from the Department of Social and Welfare Services, Administration House of Representatives in Mitchells Plain provided the list of schools and preschools in the area (Salie, 1994). The data for the preschools was not reliable as there are only a few registered and many unregistered creches in Mitchells Plain. The attendance registers at these creches are constantly in a state of flux which made it difficult to estimate the exact population of these creches.

The population denominator for all calculations was assumed to include 100 percent of the pre and primary school population in the Mitchells Plain area. This denominator, projected from the 1991 population census (Annexure 7: The figure for 0-19 year olds for was 131 736 for 1995 and 152 718 for 2000), was applied throughout the study unless otherwise stated. When there is mention of 20% utilisation, it should be interpreted as 20% of the school-going population, aged 0-19 years, who are effectively using the services.

(ii) Establishing the Oral Health Epidemiological Profile in the MP District

Data on the caries and periodontal profile of the school going population was obtained from the 1988/1989 NOHS (Khalfe et al., 1994). For validation, a pilot study was undertaken to confirm whether there was any difference between the oral health status observed in the NOHS and other local studies.

The sample for verification included 200 preschool children (2-5 years), primary (6 and 12 years) and secondary school-children (15-19 years). The sample was found to reflect adequately the dental status of the Mitchells Plain school going population found in the NOHS report.

All dental examinations were carried out by the author, calibrated according to the WHO 1987 criteria for caries and periodontal disease. Duplicate examinations were done on 10 % of the sample to check for intra-examiner variability. The DMFT and CPITN indices were employed to indicate the prevalence and severity of caries and periodontal disease respectively. The presence or absence of fluorosis was also recorded.

No major differences between the mean recordings of this pilot study and those of the National Oral Health Survey of 1989 were found, except for the primary dentition. The observed differences were the increases within the decayed components of each dmft (DMFT) index (Details in Annexures 2 and 3).

In view of these results one might want to know whether the difference within the cohort was due to increase in incidence of the disease or a cumulative effect. This decay could be attributed to the lack of utilisation of the dental services in the area. A similar pattern of decay has also been observed in a control group of pupils in a longitudinal study which has been conducted over the last 10 years in the Western Cape (Moola et al., 1995). A full-scale epidemiological investigation using the dmfs index (which is essential for base-line data especially to monitor caries reduction after fluoridation) may provide further insight.

Based on evidence from the caries research conducted over the years it could be broadly stated that dental caries is on the rise in the primary dentition. The intention of the pilot study was to observe if there were any radical changes in the caries prevalence over the last five to seven years. Hence the NOHS data for the Western Cape Coloured population was used in conjunction with the results of the pilot study conducted by the author to calculate the resources needed to provide the dental care needed.

Since there was a lack of information about age-specific comprehensive oral health data for both the preschool and school-going children in Mitchells Plain, several assumptions in this connection were made (Only 150, six and twelve year old children were surveyed in Mitchells Plain during the NOHS; no children under six years were examined).

This input data, which was necessary for restorative care items (to calculate the human resources required) was obtained as follows. The caries experience of the primary and permanent dentition for the 0-14 year cohort (tabulated as dmft and DMFT in Annexure 2), was based on the overall results of several studies previously undertaken in the Western Cape (Louw and Moola,1979; Yasin-Harneker, 1987; Louw, 1982; Mohamood and Moola, 1984; Khalfe and Moola, 1994).

The baseline caries data used for the primary dentition (0-14 cohort) was that of six-year olds from the National Oral Health Survey of 1988/89 (Annexures 1-3). It was assumed that the caries at age six is at it's peak and there would not be much variation in the caries experience in the primary dentition in this cohort between the ages of seven and nine years. It was also felt that the NOHS data for the Western Cape provided a reasonable indication of the caries experience in the district which could be broadly classified as stable (with the exception of the primary dentition) for purposes of using the WHO/FDI model.

For the permanent dentition of the 0-14 year olds, the caries experience of the 12 year olds was chosen as the basis for all calculations.

For the 15-19 year cohort, the caries experience of 15 year olds was used as the basis for DMFT calculations. There was not much variability within the age cohorts.

For all the cohorts (12 years and older) at least two sextants per child needed scaling. Every one needed oral health education. This periodontal profile reflects the results of the NOHS (Khalfe et al., 1994). It was assumed that this estimate for preventive services for a particular cohort would remain constant in future projections (the periodontal status is not affected by fluoride) except in relation to increased demand due to population growth.

For all the five year projections it was assumed that the caries levels would remain stable as inferred from the results of the NOHS and the verification study carried out in the district by the author. For the preventive scenario it was assumed that the caries would decrease by 50% after the 'introduction' of community water fluoridation.

(iii) Level of utilisation (or effective demand)

Two levels of service utilisation were assumed for the two periods of the plan, one based on 100% utilisation (the ideal) for services and the other, the actual service utilisation rate (to be measured). The preventive situation was based upon the premise that community water fluoridation would have been in place for at least 5 years, and that the need for curative services related to the dental caries prevalence would then be reduced by 50%.

The basis for calculating effective utilisation was that annually 22,431 schoolchildren attend the dental clinics for restorative care and 3,868 attend the clinics for clinical preventive care services. According to the clinic attendance only 20% of the study population is being treated (Annexure 8). What this implies is that 20% of the school children, aged 0-19 years (26,347) from a possible a total of 131,736 children (in 1995) are assumed to visit the dental clinic at least once a year (Annexure 7). In practice it means that 20% of all preschool and school-going population covered by the current service, attend dental clinics for dental care, 85% of which is curative in nature.

(iv) Worksheet Y and X for calculating the restorative[4] and preventive[5] care calculation items

A special form called Worksheet Y, was used in conjunction with the programme to record certain information which included the components of dmft (or DMFT), the number of fillings (surfaces) needed to be replaced and the fraction of dmft (or DMFT) that does not require restorative care (Annexure 9). Likewise, Worksheet X was used to calculate the time needed to carry out preventive work (Annexure 10).

These worksheets X and Y, had to be reduced to a reasonable size to standardise and facilitate the outlay of the preliminary information needed for the various calculations as proposed by the WHO (WHO,1989). The abbreviations are tabulated under the List of Abbreviations on page 7.

An assumption based on evidence from the literature was that a fillings will be replaced once in every ten years (Mjör, 1990) (a constant of 10, indicating beginning of plan and a constant of 15 will be applied if the filling had to be replaced at the end of the plan five years later, indicating the end of plan.

The operator was allowed 7.5 minutes per extraction expressed as T(XLA) (WHO,1989). A time allocation of 15 minutes each was allowed for filling new tooth surfaces expressed as T(NFS) or replacing defective filled tooth surfaces expressed as (RFS). It was assumed that each operator (a full time equivalent) spends at least 1750 hours working annually (WHO, 1989).

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[4] *The term restorative or curative care will henceforth collectively include procedures like fillings, extractions and root-canal therapy.*

[5] *The term preventive care will henceforth collectively include procedures oral prophylaxis (scaling and polishing), fluoride treatment and oral hygiene instruction.*

The basis for determining the time needed for preventive work, expressed as "T(S&P)" (which includes oral prophylaxis, fluoride treatment and oral hygiene instruction is that it would take 30 minutes on average for a thorough examination, charting and oral hygiene instructions session). Another 30 minutes is needed for the oral prophylaxis (WHO,1980, 1989).

The preliminary formulae and information needed for calculating the restorative (curative) and preventive care times (to assess the resources needed to render such care) based on the WHO/FDI System of Planning are summarised in Annexures 9 and 10.

(v) Form Y and X for calculating the time estimates for preventive and restorative care in 0-14 and 15-19 year olds

Based on the information in Worksheets Y and X (in which the preliminary restorative and preventive care calculation items are recorded respectively), the time estimates for the services (eg restorative and preventive services) needed per procedure, expressed in minutes, were transferred to a form X (for the 0-14 year olds) and a form Y for the 15-19 year olds. These estimates were then divided by the number of years in a cohort to arrive at the mean time in minutes per person per year.

All the foregoing information (level of caries, level of need and utilisation, percentage of cohort in the population) was used in conjunction with various formulae to ascertain the human resource requirement for preventive and curative care for the 0-19 year olds for the two periods of planning ("*before and after fluoridation*").

The current curative model using dentists and oral hygienists (with and without fluoridation) was used as the baseline for all comparisons during the two periods (also called *before fluoridation and after fluoridation*).

The predictions suggested by the model were carefully reviewed for their appropriateness using the actual service delivery statistics (Annexure 8) and the projected human resource situation in the district.

Determining the Resources for Fluoridating the Water Supplies

The Cape Town City Engineer's Department was consulted for advice to estimate the cost of fluoridating the water supplies of the Western Cape (Annexures 11-13).

The information gathered included the various sources of water supply, their output capacities, and the total number of people who consume the water. The suppliers of relevant equipment and chemicals (necessary for the fluoridation procedure) were contacted for some of the estimates (Bi-Water, 1995).

For the purpose of standardisation, the cost of equipment required for fluoridation was amortised (over a period of ten years) along similar lines to the cost of dental equipment. It was assumed that all new equipment will be replaced every 10 years.

It was assumed that the natural concentration of fluoride present in the water in South Western Cape averages around 0.05 parts per million (ppm) (Dreyer and Grobler, 1984). Therefore, to raise the concentration to 0.65 or 0.75 ppm (allowing for diurnal, seasonal and environmental variation in source of fluoride), 0.6-0.7 ppm (parts per million) of fluoride had to be added.

The interviews with the City Engineer's Department of Cape Town City Council revealed that estimation of the cost of fluoridation of the South Western Cape's drinking water is complicated by the fact that there are seven water treatment plants, each with a different water capacity. It was not feasible to fluoridate only the water supply of Mitchells Plain. Technical reasons prevent the isolation of water supply to this area. Hence, all the water had to be fluoridated at each source of the treatment plant.

The recommended chemical for use was sodium fluoride (NaF) as it is stable and cheap (Murray,1986) and can be produced locally. The amount of sodium fluoride required to deliver the fluoride ion was derived by multiplying the water capacity of each treatment plant by the atomic weight of sodium fluoride at concentrations of 0.6 and 0.7 parts per million respectively.

Determining the oral health facilities and cost of dental care delivery in the district for each selected scenario.

For each envisaged method of delivering dental care, a cost comparison was made at two intervals in time, at the beginning of the plan and after five years.

The final comparison includes an analysis of the cost of preventive and curative care using the option of community water fluoridation. At the end of five years, the cost implications of each of the scenarios (with and without fluoridation were compared with the current mode of delivery using dentists and oral hygienists (with and without fluoridation).

The rationale for this estimate was to ascertain how the reduction in dental caries would influence the projected supply of operators for curative care after fluoridation and without fluoridation. These estimates would ultimately allow one to compare the opportunity costs (the alternate costs) of the current mode of delivery with that of community water fluoridation. These comparisons were then used to analyse how much cheaper it would be to use the selected alternatives and what resources would be saved if the one scenario is selected over the other.

Details of the dental clinics, particulars pertaining to hours of operation, patient statistics (Annexure 8), personnel, capital and operating expenses (Annexure 14) were obtained from CPA Dental Services for the Western Cape Region and the Oral Health Centre, University of the Western Cape.

The cost of equipment (Annexure 14), was calculated at original purchase prices and discounted by the number of years used. If a piece of equipment was ten years old then the original purchase price was spread over ten years to arrive at a price in the tenth year. It was assumed that all new equipment will be replaced every ten years.

A summary of the common medical aid tariffs (Annexure 15) using the scale of benefits of the RAMS (1994-5) was compiled for the sole purpose of assessing and estimating the feasibility of purchasing dental services from the private dental practitioners in Mitchells Plain (Annexure 16). These tariffs were originally based on a relative value system and are not compatible with data in this study. Therefore no meaningful analysis can be done. Nevertheless, they were used as a guideline and any inferences drawn should therefore be viewed with caution.

The cost estimates of the selected dental delivery options used in this study were based on true expenditures relating to capital expenses, remuneration of staff and consumables (expendable items like local anaesthetic and filling materials).

The dentist and oral hygienist-to-population ratios for Mitchells Plain were arrived at by dividing the total population by numbers of personnel as determined from the data collected (Annexure 17) and compared with national and regional ratios according to a report by the Department of National Health and Population Development (1992). They were used in conjunction with the planning programme of WHO (1989).

Data Collection and Analysis

The demographic information and dental survey data collected, was collated and captured using the D Base IV software package. The statistical analyses was carried out using the Epi Info 5 statistical package.

Resources

All resources such as instrumentation, stationery, transport, computer facilities and the recorders were obtained from the Dental Faculty and the Department of Community Dentistry, University of the Western Cape (UWC).

Ethical Considerations

The protocol was approved by the research committee of the Faculty of Dentistry before the study was undertaken.

All the participating individuals and care givers were informed about the rationale of the study and ensured of the anonymity and confidentiality of interviews. Consent was obtained from the parents of the school-going children and those attending the creches in the area where the pilot survey was carried out.

RESULTS

Demography of the District

Analysis of the population of Mitchells Plain, after adjustments for undercounts, showed that 38% of the population were below the age of 15 years. Only 2.4% of the total population is above the age of 60 years (CSS, 1991). This age distribution is typical of a developing community with many young people and fewer older people (Table 2 below). This young demographic profile implies that the bulk of the patients are young, consequently more emphasis should be placed on prevention and health promotion targeted towards mother and child care.

The gender distribution showed similar numbers of males and females. The area distribution of the population showed that the Tafelsig and Lentegeur residential suburbs had the largest numbers of people and Woodlands and Westridge the fewest.

A situational analysis of the dental facilities and profile of services available in the district is outlined in Annexure 17.

Table 2. Population of Mitchell's Plain after adjustment for undercount (UNISA, 1993).

Age cohort	Male	Female	Total	%[6]
0 - 4 years	15 511	15 264	30 775	13
5 -14 years	29 697	29 565	59 262	25
15-19 years	25 466	25 498	50 964	11
Total population 0-19 years	70 674	70 327	141 001	49
Total population of district	117 946	121 715	239 661	100.00

[6] *Figures in the last column denote percentage of total population in the district*

Oral health epidemiological profile of the school going population

The results of the pilot survey showed that only 22% of the 2 to 6 six-year olds were caries-free (Annexures 2-3).

The mean dmft for the six year olds was 4.2 which was very similar to the national average, but higher than that reported for the Western Cape during the National Oral Health Survey of 1988/89. There were no significant differences between the missing, decayed and filled components of the respective DMFT between the genders and for the various age cohorts (Annexures 2-3). However, the ratio of decayed, missing and filled teeth of the combined DMFT and dmft scores showed that the decayed component was the largest. Analysis of the frequency distribution of the mean number of teeth present showed that nearly 70% of the subjects had all their teeth.

The treatment profile was very similar when compared with the national averages of the NOHS 1988/89 (Annexure 3). Nearly half (44 %) of the children required one surface restoration whilst 23% needed a 2-3 surface restoration (Annexure 3). The number of teeth indicated for extraction were slightly more than those reported in the national survey (Annexure 3).

All the children examined needed oral health education. Children 12 years and older needed oral prophylaxis in at least two sextants of their dentition.

The cost implications of rendering the services using the selected modes of dental delivery (outlined in Table 1) will now be explored further.

The first stage will involve determining the full-time equivalents that will be needed to render the services at the beginning and after five years. In the second stage the cost of the various scenarios will be analysed.

Human resources (dentists and oral hygienists) needed with 100% utilisation of dental services at the beginning of the plan (Before fluoridation).

The time required by the dentist to render restorative care was calculated as 18.5 minutes per child per year, for the 0-14 year cohort (Annexure 19, Form X). Only half this time is being spent on preventive work (9.2 minutes) compared with the senior group (Annexure 20, Form X). (Baseline data needed to calculate the restorative care times, is summarised in Annexures 18 and 21 for beginning and end of plan respectively).

To provide dental services for the pre and school going population of Mitchells Plain, the model projected that 37 full time equivalents (20 dentists or dental therapists and 17.4 oral hygienists) will be needed to render restorative and preventive care for all members of the group in the 0-19 year cohort (Table 3). This estimation implies that one full time equivalent was needed for every 2 994.

Table 3. **Estimate of Human Resources for the 0-19 year olds in the MP District for 1995, based on 100% need and demand for services.**

Restorative Care	% Utilisation	Minutes of Need	Minutes of Demand x by % of cohort in the population	Minutes per person per year
0-14 years	100	18.5	18.5 x 38 = a	a+b ÷ 49 =
15-19 years	100	28.7	28.7 x 11 = b	21 minutes
Full time equivalents (dentists) needed for restorative care based on 1750 hour working year = (131 736 x 21 min) =(46 108 hrs ÷ 1750) = **23 FTe's**				
Fte's needed **for periodontal care (hygienists):** (9.2 x 38) + (30 x 11) ÷ 49 = (13.87 mins x 131 736) = (30 453 hrs ÷ 1750) = **17.4 FTe's**				

Estimating human resources based on actual utilisation of services (at beginning of the plan)

When the estimates for human resources needed, were based on the actual utilisation rates of services (equated as effective demand = 20%) for restorative and preventive dental care at the State dental clinics, the model suggested that only 8.8 full time equivalents (5.3 dentists and 3.5 oral hygienists) will be needed to overcome the oral disease burden of the 0-19 year olds.

Projection of Human Resources after five years of the plan with no fluoridation.

The model suggested that a total of 40 full time equivalents (23 for curative care, 20 for preventive care) would be required to manage State dental services for the children of the district at the end of the plan (caries being stable; utilisation of services 100%) The baseline information for restorative care items is summarised in Annexure 21.

This estimate was similar to the human resource requirement of 1995 (at the beginning of the plan). The only difference being that one full time equivalent is needed for every 3 320 pupils compared with one full time equivalent for every 2,994 pupils in 1995 (taking into account the 3% growth rate).

Assuming the actual utilisation of services is 20%, and that caries levels remained stable, the model suggested that the foregoing estimates of human resources, based upon 100%, would reduce proportionally by one fifth.

If the above calculations were to be repeated given the condition that dental caries in the primary dentition is on the rise (Annexure 21 : Condition 2, caries rising), the estimate obtained above changes by one additional full time equivalent for curative care. This is attributed to the rise in caries experience of the primary dentition observed in the pilot study.

Projection of Human Resources at the end of the plan, five years after the hypothetical introduction of Community Water Fluoridation.

The rationale for this estimate was to ascertain how the reduction in dental caries would influence the projected supply of operators for curative care. These estimates would ultimately allow one to compare the opportunity costs of the current mode of delivery with that of community water fluoridation.

Assuming 50% caries reduction occurred after the introduction of community water fluoridation and there was 100% utilisation of the services, the model suggested that 30 full time equivalents (10 dentists and 20 oral hygienists) would be needed by the public sector to render a total dental service to the preschoolers and scholars (Table 4) after fluoridation. This projected estimate of 30 FTe's is one third less than that projected for a five year period assuming that there was 100% utilisation and no fluoridation (Table 4). It is important to note that the full-time equivalents for curative care have been reduced by slightly more than a half to 10 FTE's after the hypothetical exposure to community water fluoridation. The preliminary data and calculations are shown in Annexures 22-24.

Table 4. Summary of Time Estimates for the Study Population in MP District after 5 years assuming an actual reduction of caries by 50%

Restorative Care	% Utilisation	Mins of Need	Mins of Demand x by % of cohort in the population	Mins per person
0-14 years	100	7.0	7 x 38 = a	a+b ÷ 49 =
15-19 years	100	7.0	7 x 11 = b	7 minutes
Full time equivalents (dentists) needed for restorative care : (7 mins x 152 918) = (17 840 hrs ÷ 1750) = **10.2 fte's**				
Total **time** needed per person for periodontal care : [(9.2 x 38) + (30 x 11)] ÷ 49 = (561.8 ÷ 49) = 13.87 minutes				14 minutes
Full time equivalents needed for periodontal care (hygienists): (13.86 min x 152918) = (35 324 hrs ÷ 1750) = **20.2 fte's**				

Summary of Human Resources Estimation for dental services

All the foregoing estimates for human resources can be consolidated and used to estimate the number of operators that will be needed for the different scenarios to be costed later (Table 5). The model has been consistent in it's predictions. It is clear from these results that the human resource requirements for curative care is more at the beginning of the plan (40 full time equivalents in the form of 23 dentists and 17 oral hygienists) and reduces by a third after 5 years (of community water fluoridation) as the need for curative care is reduced by 50% (Table 5).

Table 5. Summary Comparison of Human Resource Requirements for Dental Services Based on various percentages of utilisation

Year of Plan	% Need	% Demand	Full-time equivalents:* [Dentists+ Oral Hygienist)]
With no community water fluoridation in place			
1995: at beginning of plan	100	100	40 = (23 + 17)[7]*
2000: after five years of plan	100	100	46 = (26 + 20) *
1995: at beginning of plan	100	20	8 = (05 + 03) *
2000: after five years of plan	100	20	9 = (06 + 03) *
With community water fluoridation in place			
2000: after five years of plan	100	50	30 = (10 + 20)[8]*

[7] *Estimates vary slightly due to rounding off (*). Caries levels assumed to be stable*

[8] *Estimate based on the assumption that there will be 50% caries reduction. Consequently less operators will be required*

Human Resource requirements based on actual clinical work performed by dentists and oral hygienists in the public sector

The human resource requirements for curative and preventive care currently being carried out at the public health dental clinics (based on actual clinical statistics, using WHO-time estimates for various procedures performed by public sector operators), showed that dentists are productive as clinicians for only four hours a day (Annexure 25). Similarly, three oral hygienists are doing the work of 1.6 full-time equivalents (Annexure 26).

Determining the opportunity cost of rendering the public dental services in M.Plain

The financial implications of rendering the dental services for the 0-19 year olds using the human resources projected by the WJG6 programme for the selected options of dental delivery (outlined in Table 1) will be presented in three stages (summarised in Table 6). These include the period before fluoridation (that is at the beginning of the plan), the period at the end of the plan (after five years) without fluoridation and with fluoridation (in the year 2000).

Cost of services at beginning of the plan (1995): No Fluoridation

Before dealing with the opportunity costs of selected modes of dental provision, it is necessary to provide the reader with a brief financial overview of the current State dental services in the district of Mitchells Plain.

The combined outlay for rendering school dental services (using five dentists and three oral hygienists) in the public health sector at the moment (which excludes the academic component of service care) is R 1,006,295 (Annexure 14).

Personnel expenses constitute 77% of the total budget (further details in Annexure 14). The overall cost of employing one full-time dentist per clinic, taking into consideration costs of infrastructure, salaries and benefits of professional allowance, pension and employer contribution to medical aid and housing subsidy, was calculated at R171,070 (Annexure 14) ranging from a minimum of R165,000 per annum to a maximum of R210,000 per dentist per annum.

Similarly the total cost to the State for employing a full-time oral hygienist is in the vicinity of R50,315 per annum (Annexure 14) which figure is the same for a dental therapist according to the current remuneration scales in the public sector. These figures seem to suggest that roughly three oral hygienists or dental therapists can be employed in the place of one dentist. The average running cost of a one-unit surgery (all expenses, inclusive of capital and running expenses) was calculated as R70,000 per annum.

If we continue providing this mode of dental service using dentists and oral hygienists as the operators, for 100% coverage of children (aged 0-19 years) the services would cost in the vicinity of R6 420 787 per annum after five years in the absence of community fluoridation (Table 6). With community fluoridation in place, the opportunity cost can be reduced by 55.3% (Table 6).

If these services been provided by dental therapists, the costs could be reduced by 51% compared with the dentist-hygienist option. If the dental services for the school children were to be purchased from the private dental practitioners against the RAMS Scale of Benefits tariffs (Summary of common medical aid tariffs in Annexure 15), the current services would cost in the vicinity of R777 000 to R3 820 344 per annum (at 20% and 100% utilisation rate respectively: Annexure 16, and Table 6).

The average cost per patient[9] using dental therapists (R23) is cheaper than that of using dentists from both the public and private sectors (in which case the cost would be R47 and R29.00 per child respectively) (Table 6).

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[9] *The average cost per patient treatment irrespective of the procedures carried out was obtained by dividing the total cost of the service by the population denominator for the 0-19 year olds in 1995.*

Table 6. Opportunity cost of Dental Services in MP District (in rands p/a)#.

Beginning of plan				
Before Fluoridation	**Human Resources#**	**Capital Cost#**	**Consumables#**	**Total Cost#**
Care using Dentists & OH	5 716 444	164 695	312 195	6 193 334
Care using Dental Therapists	2 547 148	164 695	312 195	3 024 038
Private Practitioner Care	For 0-19 year olds (131 736) at beginning of plan			3 820 344
End of plan (2000): Without Fluoridation				
Care using Dentist & OH	5 894 152	164 695	361 940	6 420 787
Future Care using Therapists	2 724 856	164 695	361 940	3 251 491
Practitioner care				4 428 822
End of Plan: With Fluoridation				
Future care: Dentist & OH[10]	3 026 040	166 222	356 596	3 548 858
Future Care using Therapists	1 509 450	166 222	356 596	2 032 268
Practitioner care	Only 50% of care to be purchased. Cost of fluoridation included.			2 421 564
Cost of fluoridation[11]	30 000	1 527	175 626	207 153

Note: *Cost of fluoridation has been incorporated in the scenarios "with fluoridation". Projections for 2000 do take into account increased patient load and consumables, subject to inflation and salary increases.*

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[10] *Human resource costs of fluoridation is (R30 000)is included in the estimate*

[11] *The cost of maintenance = R30,000 per annum; cost of equipment was amortised over a ten year period (therefore = one cent per child per year x 0-19 year old cohort in 2000; Cost of chemical (NaF) @ 0.7 ppm = R1.15 per child per annum.*

Cost of services at the end of the plan (2000): With no community water fluoridation

Using 5 dentists and 3 oral hygienists to deliver the dental care needed, the total cost of care was calculated as R6 420 787 per annum. This cost is nearly twice the therapist option which was calculated as R3 251 491 (Tables 7).

The total cost of purchasing care from the private sector against the Scale of benefits is R4 428 822 suggesting a saving of 49 % compared with the care delivered by public sector dentists in the district.

Cost of services at the end of the plan (2000): With community water fluoridation

To ascertain the costs of dental service provision after the water supplies had been fluoridated, it was first necessary to find out what the costs of fluoridating the water supply to MP district would be (details in Annexures 11-13).

Cost of fluoridating community water supply

The interviews with the City Engineer's Department of Cape Town City Council revealed that estimation of the cost of fluoridation of the South Western Cape's drinking water is complicated by the fact that there are seven water treatment plants, each with a different water capacity (Annexure 11).

Preliminary calculations show that 833-972 kilograms of fluoride ions daily will be needed at 0.6 and 0.7 ppm respectively (Annexure 12). In order to deliver these quantities of fluoride ions a total of 1833-2139 kilograms of Sodium Fluoride (NaF) would be needed daily (Annexure 12). The cost of NaF could vary between R 8-10,000 per day (Annexure 12). This means that the cost of consuming fluoridated water would vary between R 1.05 and R 1.15 per person per annum (excluding capital costs of equipment and building etc; at 0.6 and 0.7 ppm respectively; Annexure 12).

The costs of equipment and installation (according to a local supplier, Bi-Water (1994), would be in the vicinity of R 508,085 subject to the finer details on the planning and location of feeders (Annexure 13).

If the equipment is amortised over a 10 year period then the cost of equipment per person per year would be just under one cent per person per year (Based on the calculation that three million people consume piped water in the Western Cape according to Cape Town City Council (CCC, 1994). If we were to add the cost of maintenance and monitoring (at R 30,000 per year), by inference it would also amount to one cent per person per year.

The total cost of fluoridating the water would thus vary between R 1.08 and R 1.18, depending on which concentration is chosen (0.6 ppm or 0.7 ppm). Using the foregoing information, the total cost of school dental care using the current oral health personnel (dentists and oral hygienists) all costs of fluoridation included would amount to R3 548 858 which is nearly one and a half times more than the therapist option (as suggested by the model) (Tables 6-7).

If one were to determine the cost of care per patient after fluoridation, one finds that it would cost the Authorities (State) R21 per patient for the care rendered by the State dentist and this cost could be reduced by a third had the care been rendered by a dental therapist. The cost of private care per patient after fluoridation can be reduced from R29.00 to R16.00 (a saving of nearly 45%, inferred from Annexure 16 and Table 6).

Table 7. Summary Table comparing the Opportunity Costs of the different methods of Dental Service Delivery (in rands per annum)

Beginning of Plan		End of Plan: 2000	
	Before fluoridation	**Without fluoridation**	**With fluoridation**
Total Care using Dentists and Oral Hygienists	6 193 334	6 420787	3 548 858
Total Care using Dental Therapists only	3 024 038	3 251 491	2 032 268
Purchasing Total Care from the Private Practitioners	3 820 344	4 428 822	2 421 564

DISCUSSION

The discussion will commence by reviewing the main findings of the demographic and oral health epidemiological profile of the district and the implications these have for providing dental care in the district of Mitchells Plain.

The implications of estimating human resources for dental service provision will be highlighted followed by a closer scrutiny of each of the selected scenarios of dental care delivery. Issues related to the costing of a public health measure such as community water fluoridation will be discussed.

Some of the limitations which were encountered during the study period will be pointed out. This chapter will conclude by putting forward some suggestions that emerge from this study.

Demographic and Oral Epidemiological Profile

Analysis of the population of Mitchells Plain, after adjustments for undercounts, showed that 49 % of the population were below the age of 20 years. Nearly a third of this cohort is below the age of 6 years (Table 2). The overall results of the pilot study indicate that dental caries is a serious problem amongst the preschoolers and six year old primary scholars.

The proportion of caries-free children in a population is an important parameter in the measurement of dental caries. The WHO proposed that 50% of the five to six year olds should be caries-free by the year 2000 (Barmes, 1983).

However, amongst the Mitchells Plain preschoolers only 22% of this cohort are caries-free which is nearly half the WHO goal for the year 2000. It is highly unlikely that this goal will be achieved with the current mode of curative care delivery in the public sector. Reliance on a restorative strategy alone will not necessarily contribute to improved oral health unless this complemented by a public health measure such as community fluoridation (Sheiham, 1994).

The results of the pilot study confirmed that the caries experience at age five (dmft= 4.9, sd ± 4.2 and median dmft= 5) and six years (mean dmft=4.2. sd ± 3.6, median dmft= 4) is high. The decayed component of dmft scores makes up 70% of the caries score (Annexures 2) and this should be considered in a serious light. This caries prevalence maybe an under estimate because of the absence of radiological assessments in these surveys.

In the 12 year olds, the mean DMFT of 2,8 (sd ± 3.2, median DMFT=3, mode=3, decay component of DMFT constitutes over 90 % of the caries score) is within the WHO global goals of 3 for the year 2000 (Annexure 3),. Only 42% of this cohort are caries-free. The DMFT score for this group is similar to the average reported for Western Cape during the NOHS 1988/89 (du Plessis et al., 1994).

The results of the pilot survey confirm the finding that a high proportion of oral disease remains untreated (Enwonwu, 1981; Helöe and Haugejorden, 1981; Moola and Vergotine, 1988; du Plessis et al.,1989; Khalfe et al.,1994). The pattern of high decay within the DMFT of 12 year olds has also been observed in a control group of pupils in a longitudinal study which has been conducted over the last 10 years in the Western Cape (Moola et al., 1995) and reflects the general picture of caries prevalence in the Western Cape. This pattern of decay could be attributed to the lack of utilisation of the dental services in the area as only 20 % of the study population utilise the dental services in the district of Mitchells Plain (Annexure 8).

In the 15 year olds, the decayed component (of the DMFT) constituted 50% of the caries experience for this group (mean DMFT=5.3, median DMFT=6, mode=6) whilst the missing component was a third. This profile is similar to that reported by du Plessis et al., (1994) for this group in the Western Cape (Annexure 2).

It is not evident whether the missing component is due to caries, periodontal disease, patient (and dentists!) demand for extractions or the extraction practices of dentists. This finding is similar to that reported by Louw (1982). It could also be argued that this high missing component is due to lack of comprehensive dental services, hence the demand for extraction services.

In view of these results one might want to know whether the difference within the cohort was due to an increase in incidence of the disease or a cumulative effect. All the studies conducted in the Western Cape have been cross-sectional which only indicate whether the caries in certain cohorts is higher or lower than others. Evidence from other studies done in Mitchells Plain suggest that dental caries has not increased.

The WHO proposed that the periodontal health goal for the year 2000 should be at least 3 healthy sextants for the 12-18 year olds (Gjermo, 1983, 1984). Only 15% the 12 and 15 year meet these criteria. Calculus was predominant in the 12 and 15 year olds. Only two sextants in their dentition needed oral prophylaxis. This could be due to lack of poor oral hygiene and poor periodontal health which are dependant on cultural and socio-economic determinants such as income and educational level and the value the consumers place on oral health (Enwonwu, 1981; Helöe and Haugejorden, 1981; Louw 1982). Moreover the service in the community dental clinics is predominantly for relief of pain and sepsis available during office hours (Van Wyk et al., 1977; Louw and Moola, 1979; Ferreira and Rip, 1989).

A periodontal programme for this community will have to be aimed at health promotion and education leading to improved oral hygiene and culminating in self-care activity. Treatment resources should be restricted for patients with severe periodontal problems. If the current back log of oral disease burden is to be met by the authorities, they should seriously redefine what are acceptable levels of periodontal health and consider the training and employment of auxiliary personnel.

Research has shown that the epidemiological profiles of communities can guide health planners in decisions as to the type of workforce that would be necessary to meet the oral health needs and demands of the consumers of dental care (WHO, 1971; Sheiham, 1981; Louw, 1982; WHO, 1983; Songpaisan, 1985; du Plessis, 1994).

The treatment profile for caries (44% of the children needing 1-2 surface fillings, 23% two and three surface fillings, and 27% of children needing at least one extraction periodontal disease (which reflects a general need for oral health education and two sextants of the mouth requiring oral prophylaxis) shows that basic treatment is needed to upgrade the oral health of both the preschoolers and scholars in the district. It has been argued that not all calculus has to be scaled (Manji and Sheiham, 1986; Khalfe et al., 1994).

This treatment can be provided by auxiliary personnel such as dental therapists and expanded duty oral hygienists (WHO, 1982; Jeboda, 1985; Saparamadu, 1986; WHO, 1987; Kamilot et al., 1992; Davies et al., 1993; Razak and Lind, 1994).

Auxiliary personnel in the form of health educators who are already working in the community can be retrained to give oral health education as part of general health. This will allow increased delivery of health education and promotional programmes among the younger age groups who will be accessible for longer periods of time while they are in school.

Dental therapists can perform most of the work currently rendered by State dentists (viz. doing routine examinations, oral prophylaxis, applying fissure sealants, taking x-rays and doing extractions and fillings). The more advanced work (such as root canal fillings, fractures and denture work) can be referred to the Oral Health Centre of the University of Western Cape. At the same time one need not employ any oral hygienists as their work can also be accomplished by the dental therapist.

In this way the dental therapists would be able to perform the duties of both dentists and oral hygienists at lower cost. The State could then employ at least three dental therapists for every one dentist as the salaries of dental therapists and oral hygienists are identical (CPA, 1994). For example, if the two dentists at Westridge and Lentegeur for example, are replaced by six dental therapists there would be no additional costs involved. The advantage of doing this is that the coverage is increased three-fold.

Likewise, if the three oral hygienists are replaced with three dental therapists (who can also do the work of oral hygienists), more patients would be treated for both curative and preventive work.

The draw back of such a model (ie. replacing all the oral hygienists and dentists with therapists) is, that if there is complete replacement with a therapist, they may not be motivated to carry out the prevention work and may do only curative work.

To overcome this problem, a balanced combination of dentist, dental therapists and oral hygienists or dental therapists and oral hygienists can be considered to reduce the opportunity costs of dental care in the district. The work which the therapists are not allowed to do (root canal therapies and dentures) can then be purchased from the private sector at a negotiated fee if there is complete replacement of dentists. One can then say that if most of the care can be provided by a therapist, then the State services would be more cost effective.

For example, a combination of two dental therapists and an oral hygienist can save the total salary of one oral hygienist and yet reduce the opportunity cost of a one dentist and one oral hygienist combination.

Estimation of Human Resources for the delivery of Dental Services

The WHO/FDI Programme confirmed that the human resource requirements for delivering dental care to the majority of pre and school-going children for the district of Mitchells Plain is excessively high in the absence of a public health preventive measure such as community water fluoridation (summarised in Table 5).

The estimations clearly show that the human resource requirements for curative care is more at the beginning of the plan (40 full time equivalents in the form of 23 dentists and 17 oral hygienists)[12] and reduces by half (30 full time equivalents: 10 dentists and 20 oral hygienists)[13] after five years of hypothetical exposure to community water fluoridation as the need for curative care is reduced by 50%. These projections have important implications in terms of reducing the costs of services and the need for human resources in the public sector in general, and Mitchells Plain in particular and will be discussed a little later under the section dealing with opportunity costs.

Theoretically, the model has been consistent in it's predictions. However, in reality there is a big discrepancy between the projected person power requirement and the actual situation in the District of Mitchells Plain. This could be justified by analysing the personpower situation in the area. The ratio of public dentist to population served is currently 1:50 000 for the entire Mitchells Plain population (based on the fact that there are 5 dentists serving the area at the moment). This compares favourably with the national average of 1:86 000 but unfavourably with that of Western Cape Development region A (1:36 321). If one were to follow the norm which was set out by Mathews (1990) at a workshop on Dental Health Policy for South Africa (1:20,000), then 6.6 dentists would be needed to cover the study population which is nearly half (131 736= 49%) that of the total population).

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[12] *Estimates vary slightly due to rounding off.*

[13] *Estimates vary slightly due to rounding off.*

As far as the oral hygienists are concerned, the model projects that 17 oral hygienists are required to manage the preventive care (Table 13). This seems to be gross overestimate as clinical records and statistics for the area indicate that the oral hygienists at the present moment are underutilised. In practice, the output of three oral hygienists is equivalent to that of 1.6 oral hygienists (Annexure 28). The high projection of oral hygienists is due to the fact that community periodontal index of treatment needs (CPITN)[14] creates an impression that unrealistically high numbers and consequently a substantial amount of person hours would be required to carry out the oral prophylaxis (Manji and Sheiham, 1986; Khalfe et al., 1994). This would imply that unrealistic allocation of resources would be required if a public health programme was to be implemented, a cost South Africa can certainly not afford. It could also be argued that it is not only unrealistic, but also based on invalid assumptions that all calculus has to be removed (Manji and Sheiham, 1986; Khalfe et al., 1994).

In reality the average public sector hygienist to population ratio for Mitchell Plain, at present, is 1:80,000 which is very favourable when compared against the National and provincial average of 1:190 000 and 1:112 000 respectively (DNHPD 19922). One can conclude, therefore, that no additional oral hygienists would be required for service provision in the area if the norm of Mathews (1:50,000) is adopted at least for 1995.

Furthermore, the dental statistics (annexure 8) show (and this has been confirmed by the WHO/FDI model as well) that the work done by the 5 dentists in the public sector, based on actual utilisation of the services (which is 20%) is equivalent to that of 2.5 full-time equivalents (Annexure 27). In view of this, it would be reasonable to accept that there is no need for additional dentists if all the people are to be covered in Mitchells Plain area (as the short fall would then entail only 1.6 dentists if the study population is to be covered) also if the dentists are replaced by dental therapists.

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[14] *It should be noted that the CPITN was merely employed to obtain an estimate of the sextants needing oral prophylaxis for the purposes of this study and this argument will not be pursued further.*

Calculations based on the WHO-estimates for various procedures performed in the public sector dental clinics (Annexures 27 and 28) suggest that the operators (dentists and oral hygienists) are only productive as clinicians for four hours a day, catering to only 20% of the population. This finding suggests that the current work force is under-utilised.

These estimates may be explained by the fact that at present the service rendering dental clinics cater for only 20% of the entire school-going population and that the busyness of the dental clinics is dictated by the school calender (approximately 32-34 working weeks). 80% of the operator's time is devoted to school children whilst the rest is devoted to treatment of adults and administration.

A recent survey amongst the workforce in the Western Cape confirms that this low productivity (or under utilisation of the present staff component) could be due to low morale, lack of incentives and clear directives from the management (supervisors) (SMT,1994).

The low productivity could also be due to insufficient and inadequate use of auxiliary oral health workers and complete absence of productivity related incentives and peer review systems in the public dental health sector. The implementation of productivity related incentives may induce more productivity. Alternatively the authorities can replace one dentist with three dental therapists and in this way produce more output per rand.

Khalfe and Lalloo have (1995) also reported that in today's competitive health-care market, both the conceptualisation and measurement of satisfaction of providers (including the work force) is pivotal to improving the efficiency in an organisation. A negative relationship between work satisfaction and work environment can affect productivity adversely. Perhaps a time and motion study (a time management study) could show that there is poor administration, management and audit of clinic and clinical work and provide further insight.

Comparing the opportunity cost of selected options of dental delivery in the district with fluoridation and dentist-based dental delivery.

If we take all the foregoing results and discussion into consideration, we can compile a summary table (Table 8) which consolidates all the relevant information needed (from Table 7 and Annexure 11) for comparing the various scenarios based upon 100 % utilisation.

Using the dental therapist model as the baseline, the opportunity (alternative) costs of each selected option of dental delivery (Table 1) will be discussed in relation to three stages in time ie., at the beginning of the plan, five years thereafter with and without fluoridation (Table 8).

Table 8. **Summary comparison of the Opportunity Cost (in rands per annum) and (Opportunity Cost Ratios)[15] of the different methods of Dental Service Delivery**

	Beginning of Plan: 1995	End of Plan: 2000	
Dental Team offering the care	**Before fluoridation**	**Without fluoridation**	**With fluoridation**
Total Care using Dentists and Oral Hygienists	6 193 334 (3.0)	6 420 787 (3.2)	3 548 858 (1.8)
Total Care using Dental Therapists	3 024 038 (1.5)	3 251 491 (1.6)	2 032 268 (1)
Purchasing Total Care from the Private Practitioners	3 820 344 (1.3)	4 428 822 (2.2)	2 421 564 (1.2)

[15] *The opportunity cost ratio (denoted by the figure in brackets of each cell) was arrived by dividing all the cells by cost of lowest scenario to compare with the other scenarios.*

Comparing the opportunity cost of dentist and therapist driven services

If we continue providing the curative mode of dental service using dentists and oral hygienists as the operators, for 100% coverage of children aged 0-19 years, the services would cost in the vicinity of R6 193 334 to R 6420 787 per annum at the beginning and end of the plan in the absence of community water fluoridation (Table 8).

The opportunity cost of continuing to render this mode of dental services in the absence of community water fluoridation, is R2 871 929 (Inferred from Table 8). What this implies is that R2 871 929 are foregone using the dentist oral hygiene combination and the water is not fluoridated. If the water is fluoridated then there will be a saving of 45% using dentists.

The opportunity cost of services using dentists (R2 871 929) can be further reduced to R437 059 if eight dental therapists are to replace the present combination of five dentists and three oral hygienists with a net saving of 68% if the water is fluoridated. It can be concluded that using dentists to deliver dental care to a young population in the Mitchells Plain District is a costly way of gaining a modest return in oral health investment.

Purchase of care from the private practitioner

If the dental services for the school children were to be purchased from the private dental practitioners against the RAMS (1994) Scale of Benefits tariffs, the current services would cost in the vicinity of R 777,000 to R3 820 344 per annum, at a 100% and 20% utilisation rates respectively (Compare Annexure 15, and Tables 7 and 8).

The average cost per patient[16] *before fluoridation* is R23.00 using dental therapists is far cheaper than that using dentists from either the public or private sectors, the cost of which is R47.00 and R29.00 per child respectively (Tables 7 and 8).

However, the total cost of purchasing dental care from the private practitioners *after fluoridation* is very competitive at R16.00 per visit compared to R13.00 for dental therapists (Tables 7 and 8).

Therefore one can argue that contracting out services to the private practitioners will only be cost effective if they are purchased from the private sector at a negotiated fee below 55% of the current RAMS Tariffs against the Scale of Benefits as the services can be provided by the dental therapists in the public sector cost effectively (R23.00 *before fluoridation* and R13.00 *after fluoridation*, with a saving of 45%).

One must bear in mind that the RAMS Tariffs are based on a relative value unit system and are not fully compatible with the data in this study which was derived empirically from real costs incurred. Direct comparisons cannot be made and any inferences drawn should be viewed with circumspection. The cost estimates of the selected dental delivery options used in the study were based on true expenditures for capital expenses, remuneration of staff and consumable (expendable) items.

Comparing the opportunity costs of employing sessional dentists

Analysis of the dental statistics gathered (see Annexure 8), indicates that the service rendering dentists appointed on a sessional basis at UWC Dental Faculty seem to produce nearly double the overall output when compared to full time salaried State dentists at CPA Clinics (Annexure 8).

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[16] *The average cost per patient treatment irrespective of the procedures carried out was obtained by dividing the total cost of the service by the population denominator for the 0-19 year olds in 1995.*

To support this finding, an additional calculation comparing the output of State dental clinics with the service rendering clinics of OHC (at UWC Dental Faculty) against the RAMS tariffs (in Scale of Benefits), showed that the total output for OHC Service Rendering Clinics was in the vicinity of R 444 320 per annum which was twice the output of R 227 069 per annum of both the CPA (State) dental clinics. It could be inferred that the opportunity cost (based on the RAMS evaluation alone) can be reduced by 50% by employing sessional dentists only.

This finding seems to suggest that perhaps it would be expedient for the authorities to consider employing more sessional dentists. The advantage of doing this is that more patients can be seen in the mornings as the bulk of the patient load is usually in the mornings. Secondly, there will be the additional advantage of spreading this employment among more people.

This strategy of employing more sessional dentists can reduce the opportunity costs by more than 50% if the above benefits are taken into consideration and there can be further savings if dental therapists are hired to do the basic work which they are legally allowed to do. The management should investigate this possibility as it could provide the answer to improving efficiency in the public sector.

The opportunity cost analysis shows that dentist driven dental services are costly, even if there is a 50% reduction in dental caries after community water fluoridation. The comparison of the opportunity costs of different modes of dental delivery at district level clearly demonstrates that no matter what combination of personnel you choose to render community dental care, the cost effective alternative is community water fluoridation with dental therapists to provide the care needed (Tables 7 and 8).

The World Health Organisation has identified community water fluoridation as the strategy of choice for the prevention of caries in both the developing and developed countries (WHO, 1986 1994).

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The World Health Organisation has identified community water fluoridation as the strategy of choice for the prevention of caries in both the developing and developed countries (WHO, 1986 1994).

South Africa meets most of the prerequisites of Murray (WHO, 1986). Dental caries is high especially the disadvantaged communities and is no different in Mitchells Plain, especially amongst the under six year olds. The situation in Mitchells Plain is compounded because 49% of the population is below the age of 20 years. Of these, nearly a third are less than six years old. This young demographic profile presents a major service provision problem for the school going population in the district.

At present all children under the age of six years are entitled to free treatment (ANC,1994). Anderson (1981) maintains that the proportion of untreated decay can be reduced by 51 % after exposure of the teeth to fluoridated water supplies. The caries in the pit and fissures (44%) and in the smooth surfaces (23%) can be reduced by 30-60 % according to Newbrun (1989). It is this age group that must be targeted under the mother and child care programme to reap the greatest benefits of the fluoridation programme.

The other issue is the question of equity and social justice in oral health (Locker, 1988) which has been denied to the disadvantaged groups in South Africa because of the system of Apartheid. Water fluoridation is the only politically viable public oral health measure which transcends all barriers of race and class to equitably benefit all people within reach of a potable reticulated water supply.

The measure would give equal access, equal per capita expenditure, equal resource allocation and equal utilisation at least to people in the metropolitan areas (Myburgh and Solanki 1990). The CSIR Report (Staz,1962) and the Commission of Enquiry into Fluoridation (1966), both strongly support community water fluoridation.

This study has shown that the advantage of fluoridating the community water supplies of the Western Cape is two-fold. It can reduce the opportunity costs of dental service provision and at the same time bring about a meaningful improvement in the oral health of the people in the Western Cape in general, and Mitchells Plain in particular.

As dental diseases are expensive to treat, the financial cost to individuals and society is considerable. Reliance on increased dental manpower and the restorative strategy alone, cannot significantly contribute to improved oral health, unless this accompanied by preventive measure such as community water fluoridation (Helöe and Haugejorden, 1981; Sheiham, 1994).

One can therefore conclude that community water fluoridation is the most economical and cost effective means of dental care delivery especially when this is combined with optimal use of auxiliary personnel such as dental therapists.

In view of the results and epidemiological evidence, the implementation of community water fluoridation seems to be the most logical conclusion if one is to curtail costs in the public sector.

In the Government's plan for reconstruction and development, fluoridation of community water supplies can play a vital role in the mother and child programme as it is here where the benefits can be reaped.

With the commitment of the State to provide primary health care free to all inhabitants of South Africa, funds from the Primary Health Care Budget can be allocated for this programme initially. It is felt that political support for this notion should be regarded as a vital cornerstone on which any plan of action to fluoridate community water supplies can be based.

The following section will address some of the difficulties experienced during the course of the study.

Difficulty of isolating Mitchells Plain District for fluoridation

The interviews with the City Engineer's Department of Cape Town City Council revealed that estimation of the cost of fluoridation of the South Western Cape's drinking water is complicated by the fact that there are seven water treatment plants, each with a different water capacity. It was not feasible to fluoridate only the water supply of Mitchells Plain. Technical reasons prevent the isolation of water supply to this area. Hence, all the water had to be fluoridated at each source of the treatment plant. Sodium fluoride (NaF), in concentrations of 0.6 and 0.7 parts per million respectively were used in the estimates because the natural concentration of fluoride present in the water in South Western Cape averages around 0.05 parts per million (ppm) (Dreyer and Grobler, 1984).

Therefore, to raise the concentration to 0.65 or 0.75 ppm (allowing for diurnal, seasonal and environmental variation in source of fluoride), 0.6-0.7 ppm (parts per million) of fluoride had to be added.

Paucity of literature on opportunity costs

Application of the criteria of economic efficiency is essential when health administrators are confronted with choosing the best use of resources that will generate the greatest social benefit. The recent literature on health services contains a lot of statements that stress the importance of cost-benefit analysis for making decisions about allocating resources to or within the health field.

In the dental literature one often finds that a specific treatment has either a good or poor cost-benefit ratio. Few of these statements have been documented or are supported by suitable analytical methods. Most of these studies are either published in a foreign language or not available locally or concentrate on the cost effectiveness of water fluoridation and fissure sealants for example. Hence no comparisons were possible based on evidence from the literature on the subject of opportunity cost.

Use of the WHO/FDI Model

When using the WHO Model, it is necessary to have compatible age specific data on demography and oral epidemiology (with the cohorts used in the WHO Model) amongst other information such as patient profiles at clinics.

The results obtained via the programme should be carefully scrutinised before making any inferences as the programme tends to forecast an over supply of human resources if the proper information is not fed into the programme.

The Zimbabwean experience showed that oral health personnel projections using this approach, together with two other approaches, were all different and even the lowest projection was beyond the resources of the country (Khan and Sithole, 1991).

The author confirms the critique by Bronkhorst et al. (1991) that the model neglects cohort and period effects in it's calculations and agrees with Chikte (1994) and Hobdell (1995) that one must be very careful, in interpreting personnel projections based on the WHO/FDI Model, as operator-population ratios can be misleading, the reason being that within the same geographical location the concentration of the operators may vary, or the numerator may have operators which are a mixture of private and public sector operators. Nevertheless, the model is a quick and useful tool for preliminary planning and monitoring at district level provided there is a good oral health information system in place.

Record keeping

A limitation of the study was that estimates had to be made of patient profiles and variables such as patient attendance which are not recorded by patient category at the oral health centres. Hence it is essential that proper clinical records are kept for purposes of control and monitoring patients and stocks more efficiently. If there was a cost-centred budget system then it would have made information gathering a bit easier. It was also very difficult to estimate the exact time spent by oral hygienists doing oral health education and monitoring the brushing programmes.

Calculation of effective demand for dental services

The basis for calculating effective utilisation was based purely on clinical attendance, and assumes that each child visits the dental clinic at least once a year. This can lead to miscalculations as it is possible that the children may have visited the clinic more than once.

Ascertaining data on preschoolers

Last, but not least, estimates of the numbers of children under the age of five years attending creches could not be ascertained as precisely as the school-going children. Most of the creches in the area are not registered, and attendances and enrolments fluctuate, making it difficult to assess exact numbers. One is forced to use the population census, which in itself is problematic if the undercounts are not adjusted.

CONCLUSIONS

The results show that dental caries in the primary dentition is high and that basic care is needed to upgrade the oral health of the preschool and school-going children in the district. Reliance on the restorative strategy alone, cannot significantly contribute to improved oral health, unless this accompanied by preventive measure such as community water fluoridation. If the current oral disease burden is to be overcome, redefinition of acceptable levels of health and the training and employment of more auxiliary personnel should be considered.

The cost of fluoridating the water supplies of the Western Cape (R1.18 per person per year) is about eight times cheaper than that spent on curative care per child (R47.00 per attendance based on 20% utilisation).

The opportunity cost of continuing to render curative dental care using dentists is R2 871 929 and can be reduced to R437 059 if the same services were rendered by dental therapists in the district of Mitchells Plain. The cost estimates per child show that the current cost of curative care provided by dentists in the public sector which is R47.00 (with no fluoridation) and R21.00 after fluoridation can be reduced by almost a third to R13.00 if services are provided by dental therapists.

Contracting out the dental services to private dental practitioners would only be feasible if the services are purchased from this source at about 55% of the RAMS Scale of Benefits as the services can be provided by the dental therapists at 45-50% of the recommended tariff if the water is fluoridated and at 32% less than the tariff if the water is not fluoridated. The analysis comparing different modes of dental care at district level clearly shows that no matter what combination of personnel one chooses to render community dental care, the most cost effective (best) alternative is community water fluoridation with dental therapists providing the care needed.

RECOMMENDATIONS

In view of the results and foregoing discussion, there are a number of lessons which may assist in improving the delivery of dental public health services in general and guide district health managers in particular to develop a more equitable and cost effective environment for oral health.

This study indicates that community water fluoridation can reduce the opportunity cost of dental service provision. It should receive the highest priority, although efforts and resources under the current system of oral health care delivery should also focus on other aspects of prevention and promotive care.

The use of alternate personnel (eg employing dental therapists) is strongly recommended to curtail the costs of dental service provision in the public sector.

Fast track training avenues could be set up to train auxiliaries and to retrain existing health and oral health personnel to acquire expanded duties.

Selective employment of more sessional as opposed to full-time salaried dentists is recommended in those busy clinics where the bulk of the patient load is in the mornings. This can reduce the opportunity costs of employing full-time dentists by 50% with additional savings

The purchase of dental care from private practitioners may be considered feasible at 55% of the current Scale of Benefits (RAMS), to curtail costs on State dental expenditure. This area needs further investigation and the development of a reliable methodology.

A time management study should be carried out to investigate whether there is poor management and administration, and to provide an audit of clinical work done.

A comprehensive data information system and monitoring thereof is needed for proper resource planning in the district. This system could provide for proper computerised record keeping of general and oral health data and profile of treatment by age to monitor the type of patients and utilisation of services in the district.

A cost-centred budgeting system is recommended to enhance the efficiency of analysis such as this.

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ANNEXURES

Annexure 1. Caries Research in the Western Cape: 1975 to 1995

Researcher		Study Group	Mean dmft (Mean DMFT)	NOHS (1988/89)
Yasin-Harnekar	1984	5 years	5.3	
Khalfe (MP Pilot)	1994	2-5 years	4.8	
Khalfe (MP- Pilot)	1994	6 years	4.2	4.0
Mohamood & Moola	1985	6-7 years	7.8	
Moola & Vergotine	1988		7.0	
Louw & Moola	1979	6 years	6.0	
Khalfe (MP- Pilot)	1994		4.2	
Williams	1985	12 years	(3.7)	(2.8)
Moola & Vergotine	1988		(2.2)	
Khalfe (MP Pilot)	1994		(2.8)	
Khalfe (MP Pilot)	1994	15 years	(5.3)	(5.7)
Myburgh	1984	16-35 years	(21.8)	

Annexure 2. Comparison of MP Pilot Survey results with other studies

Primary Dentition (Coloured Children)						
Age in years	Study		Decayed	Missing	Filled	dmft
2-5	Harnekar (W.Cape)	1984	4.0	1.2	0.1	5.3
	Khalfe (MP Pilot)	1994	3.7	1.0	0.1	4.8
6	NOHS (overall)	1988/89	2.4	1.6	0.1	4.1
	NOHS (W.Cape)	1988/89	2.2	1.4	0.2	3.8
	Khalfe (MP Pilot)	1994	2.9	1.0	0.2	4.2
Permanent Dentition (Coloured Children)						
Age in years	Study		Decayed	Missing	Filled	DMFT
6	NOHS (Overall)	1988/89	0.1	0.2	0.0	0.3
	Khalfe (MP Pilot)	1994	0.3	0.0	0.0	0.3
12	NOHS (Overall)	1988/89	1.0	0.5	0.7	2.0
	NOHS (W.Cape)	1988/89	1.5	0.7	0.6	2.8
	Khalfe (MP Pilot)	1994	2.6	0.0	0.2	2.8
15	NOHS (Overall)	1988/89	2.2	1.3	0.7	4.2
	NOHS (W.Cape)	1988/89	3.0	1.9	0.8	5.7
	Khalfe (MP Pilot)	1994	2.7	1.7	0.9	5.3

Annexure 3. **Comparison of Treatment Needs**[1]

Age Group In Years	National Oral Health Survey	Mitchells Plain Pilot
	Mean number of restorations needed per child	
2-5	not available	mean = 1 *
6	mean = 1.3 restoration	mean = 1 * 1 surface filling : mean = 1.9 2 surface filling : mean = 2.5 3 surface filling : mean = 0.0
12	mean = 1.1 restoration	mean = 1.6 * 1 surface filling : mean = 3.0 2 surface filling : mean = 1.6 3 surface filling : mean = 1.7
15	mean = 2.1 restoration	mean = 2.3 * 1 surface filling : mean = 2.7 2 surface filling : mean = 2.0 3 surface filling : mean = 2.3
Mean number of extractions to be performed per child		
Age Group in Years	**NOHS Data**	**MP Pilot**
2-5	N/A	0.9
6	1.0	2.0
12	0.2	0.3
15	0.2	0.3

[1] *Source of data: NOHS (du Plessis et al., 1994) compared with the pilot survey the author undertook in Mitchells Plain amongst selected groups of preschool and school children betweeen the ages of 2-19 years.*

Annexure 4.

Brief outline of various methods of manpower estimations

The Health-Needs Method

This method of estimating human resources is based primarily on medical and technological considerations. This normative method aids in assessing the services actually required for optimal health. Accordingly it assumes that all people should be provided with health care according to their needs. The social and economic conditions under which the consumers seek care, is ignored. It facilitates the study of productivity, utilisation and staffing ratios since the emphasis is on procuring and producing services and not on human resources. Potential disadvantages include the collection of extensive and detailed data on disease specific mortality and morbidity rates, which is quite costly. This model is especially applicable to countries with sophisticated data systems and an active will on the part of the government to deliver care (Hall and Mejia, 1978).

Health Demand-Based Approach

Demand-based approaches are directed toward recognising and measuring market forces deemed to be important in generating demand and supply. This method seeks to correlate the amount of care sought with such variables as income, costs, education, age and access. Estimates of oral health personnel required are based on current levels of utilisation of the services including consumer behaviour patterns (De Fries and Barker, 1982).

One of the advantages of this model is that it attempts to identify the response of current users to changes in the delivery and financing of dental services. Demand studies provide a refinement to dentist-to-population ratio estimates. By applying economic principles, demand based approaches are important in identifying additional factors essential in understanding personnel requirements.

The demand-based approach is especially suitable in countries or areas with a dominant private sector or for private sector planning or where the government's attitude towards the delivery of services is passive. This method, measures only the current consumer market and is insensitive to changes in disease levels and in identifying special populations in need.

Service Targets Method

This is a normative approach and requires only modest data and planning capabilities. It is amenable to more sophisticated techniques. The standard setting may be liable to be based more on the real situation than on decision. The method has limited utility where the government is passive or lacks control over the health services delivery system.

Manpower/Population Ratios

Although it is easy to use and interpret, there are many limitations to this approach to oral health personnel planning. Manpower-to-population ratios assume that the relationship remains unchanged by such factors as demographic variation, socio-economic conditions, prices of health services, the level of third-party financing, human resource productivity including the use of auxiliary personnel and the organisation of the service delivery system. It may have short term utility as it's use may mask an over or undersupply of dental manpower due to varying degrees of concentrations of personnel in certain areas while the distribution of personnel in other areas may be scanty.

In Slack (1981), Sheiham mentions two additional models namely the Supply and Demand Model and the Functional Analysis Model.

The Supply and Demand Model is commonly used by health planners. Its implementation reflects a response to expressed political demand. Usually the existing form and structure of service delivery is maintained.

Additional numbers of human resources (usually dentists) are allocated to meet increases in demand. A number of significant changing social and political factors are omitted in such planning. Little attention is given to overall policy goals or impact on oral health of society by the system, leading to gross miscalculation of human resources that will be needed. It is unlikely that auxiliaries feature in the scenario thus generated.

The Functional Analysis Model involves matching the qualifications of oral health personnel to the requirements of "job performance". Out of this concept and its underlying assumptions of supply-demand and cost-benefit methodology, the use of auxiliary/ancillary workers has emerged. These workers carry out tasks usually done by dentists although, as Sheiham points out, the concept of such health care delivery has not managed to effect any radical remodelling of mainstream dental care systems.

Regardless of the method used, reference standards are always needed to calculate manpower requirements. They may be based on past experiences, professional opinion or international comparisons.

Annexure 5.

The District of Mitchells Plain (CCC, 1994).

Between 1950 and 1970 various surveys on income and the need for home ownership were undertaken by the Cape Town City Council. During 1971, the Nationalist Government gave the green light to establish Mitchells Plain, 27 kilometres from the Cape Town central business district.

The name, Mitchells Plain, originates from "Mitchell se vlakte", as this is the area of the Cape Flats situated on the False Bay coast previously owned by a farmer named Mitchell.

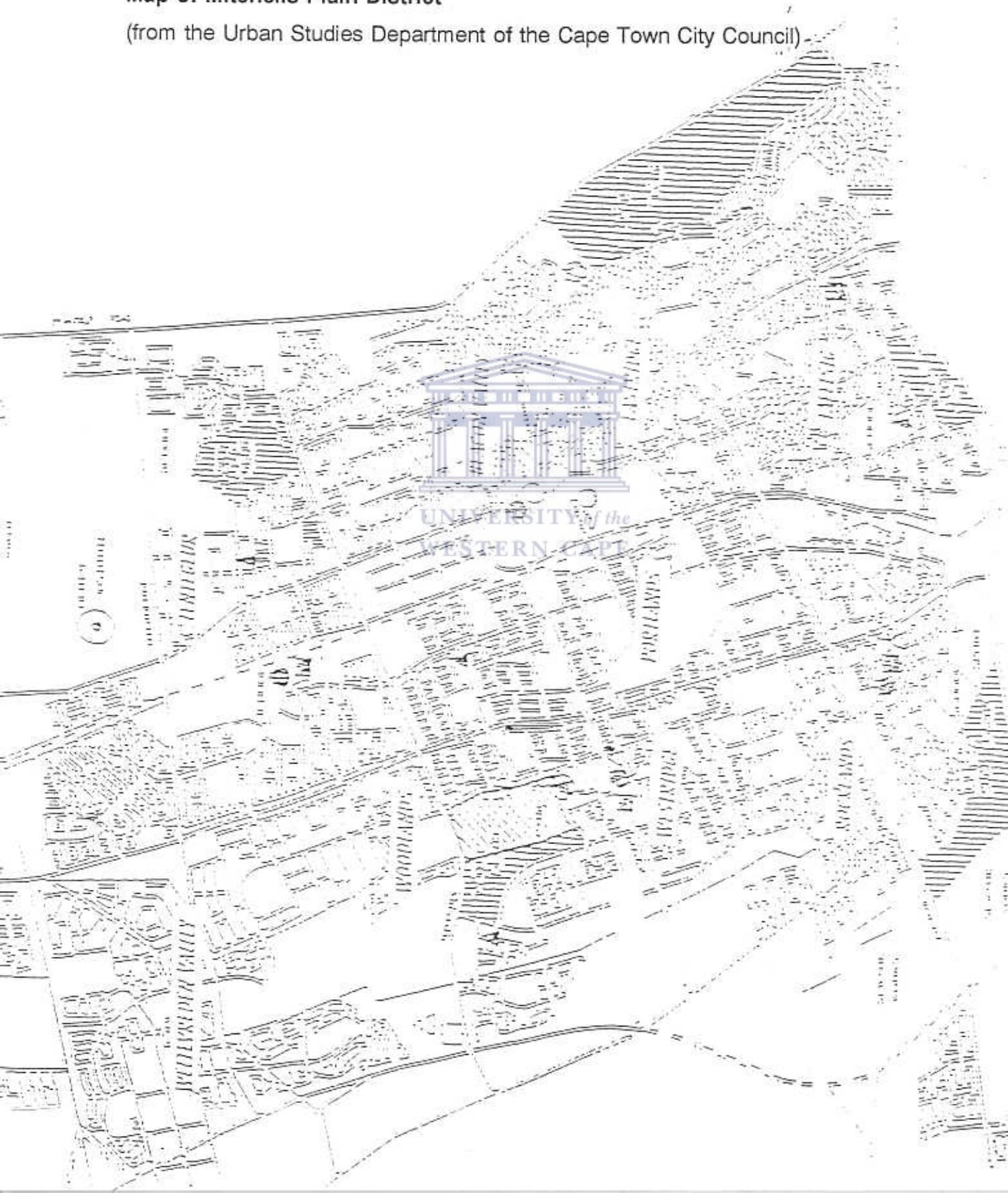
The first families moved into Mitchells Plain in April, 1976. The 10 000th family moved into the area in 1980. The railway line from Cape Town has been in operation since 17th July 1980.

Today there are eleven residential areas in the district. In Westridge, Portlands, Rocklands, Lentegeur, Weltevreden Valley and Colorado the houses are almost all owned by the occupants. There are approximately 40 000, two and three bedroom units in the district. Woodlands, Tafelsig, Eastridge and Beacon Valley some of the houses and flats are privately owned whilst others are rented. The size of plots are on average 272 square metres and the houses range from 45 square metres to over 100 square metres. The official occupancy rate is 5.5 people per house. The majority of the houses cost between R20,000 to 30 000. All the houses are fully serviced with waterborne sewage, water, electrical and telephone connections. There are a few sports facilities, libraries, public halls, post offices, police stations and a host of shopping centres.

Annexure 6.

Map of Mitchells Plain District

(from the Urban Studies Department of the Cape Town City Council)



Annexure 7. **Estimation of population using the median method of Du Plessis (1994) assuming growth rate of 3% per annum**

Age	Population totals obtained from clinic records and schools	Estimated from median age *	Census Total	Estimated total
0	Actual[2]	6 523		
1	figures	6 340		
2	not	6 155*		
3	available	5 971		
4		5 797	30 775	30 776
5	6 037	6 634		
6	5 860	6 457		
7	5 795	6 280		
8	5 876	6 103		
9	6 518	5 926		
10	5 534	5 926		
11*	5 387	5 749		
12	4 725	5 572		
13	4 725	5 395		
14	4 356	5 218	59 262	59 260

[2] *Population totals obtained from the clinics and some creches were incomplete and unreliable as the attendance at the antenatal clinics and creches is at variance with actual population totals and the fact that not all of the creches are are registered.*

Age	Population totals obtained from clinic records and schools	Estimated from median age *	Census Total	Estimated total
15	3 665	5 708		
16	2 554	5 555		
17	1 764	5 402		
18	-	5 249		
19	-	5 096		27010
20	-	5 096*		
21	-	4 943		
22	-	4 790		
23	-	4 637		
24	-	4 484	50 964	50 960

Notes:

1. Actual totals of enroled students were obtained from school register
2. 0-14 year cohort (90,036 equivalent to 38% of total population in 1991)
3. 15-19 year cohort (27,010 equivalent to 11% of total population in 1991)
4. 0-19 year cohort total for 1991 (90,036 + 27,010) = 117 046
5. Projected total of 0-19 year cohort (assuming 3% growth rate) for the year 1995: 131,736; for the year 2000: 152,718
6. It should be borne in mind that only 73% of the above totals are dependent on the State for dental services, if one were to exclude the children who are on medical aid (Meijer and Mc Loughlin, 1992; Edmondson and Molloy, 1993). The projected total of children dependent on State dental services would then be 105,389 in 1995 and 122,174 in 2000.

Annexure 8. Scholars treated during 1994 at MP Community Dental Clinics

CURATIVE SERVICES	LENTEGEUR	WESTRIDGE	OHC	TOTAL
Attendance	2952	2932	16 547	22 431
Examination with charting	84	108	1 093	1 2485
Partial Dentures	6	6	6	18
Full Dentures	12	12	-	24
Fillings	252	240	375	867
Extractions	2976	1584	10 298	14 858
Root Canal Therapy	60	12	22	94
X-rays	180	144	121	445
PREVENTION SERVICES	**LENTEGEUR**	**WESTRIDGE**	**OHC**	**TOTAL**
Attendance	1080	1332	1456	3868
Scaling & Polishing	1080	1332	360	2772
Fissure Sealants	780	1440	600	2820
Health Education (Individual)	300	1332	300	1932
Dental Screening	1080	1200	500	2780
Number of Groups on Brushing Programme	67	45	-	112
Curative/preventive care ratio based on patient attendance at clinics	73:27	69:31	92:08	83:17
Education talks at School	196	478	-	674

Annexure 9.

Restorative Care Calculation Items (Source Health Through Oral Health: WHO/FDI GRP,1989)

COHORT (1)	END OF AGE RANGE			RESTORATION FRACTION (5)	REQUIRED DURING PERIOD		RATIO S/T (8)	SEALANTS, ARRESTING AGENTS, REMINERALISATION (9)	REQUIRED DURING PERIOD		X L A (12)
	DMF (2)	FT (3)	MT (4)		NFT (6)	RFT (7)			NFS (10)	RFS (11)	
0-14 Primary	dmf	////// //////	////// //////	a	a.dmf	15 a.dmf / 2XR	v	(1-a)dmf	COL(6).v	COL(7).v	////////// ////////// ////////// /
0-14 Permanent	DMF(i)	F(i)	M(i)	A	A.DMF(i)	15 A.DMF(i) / 2XR	W	(1-A)DMF(i)	COL(6).W	COL(7).W	M(i)
15-19	DMF(ii)	F(ii)	M(ii)	B	B(DMF(ii)-DMF(i))	5[F(i)+½B(DMF(ii)-DMF(i)]	X	(1-B)(DMF(ii)-DMF(i))	COL(6).X	COL(7).X	M(ii)-M(i)

NOTES

The assumption is made for the primary dentition that all teeth will be filled or have arresting caries treatment, in which case no estimate is made for mt which, in any case, would represent care that took a little less time than filing, or a little more than arresting care and would thus average about the same as the time allotment reached using this assumption. The system could be modified by making such an estimate. As there is no continuation of the primary dentition into the second cohort, no estimate of it is needed. Time estimates for the primary dentition are combined with counterpart estimates for the permanent dentition for the first cohort and entered in Form X. For all cohorts, with respect to the permanent dentition, the total DMF is accounted for by FT, plus 1/2 MT, plus the sum of the teeth to have, or which have had non-interventive care; or by NFT (newly filled teeth), plus number of teeth previously filled, plus 1/2 the number of teeth previously extracted, plus the sum of the teeth to have, or which have had non-interventive care. MT entries assume that half the teeth lost had been previously filled. FT entries are thus reduced in comparison to cumulative NFT figures by 1/2 MT.

Annexure 10.

Estimation of Periodontal Care Needs

Time estimates for scaling for cohorts 0-14, 15-19 years are made using the CPITN data for mean number of sextants needing scaling i.e., Treatment Need 2 (TN2). It should be noted that TN1 is included under Periodontal Care.

If W and X sextants need scaling in cohorts (i) and (ii) and (iv) respectively, and

PS(i-iv) = number of sessions (periodicity) per cohort for scaling
T(S) = minutes for scaling per sextant and

Then, scaling time per person per year

$$= \frac{W \times T(S) \times PS(i)}{15} \text{ for the 0-14 cohort}$$

$$= \frac{X \times T(S) \times PS(ii)}{5} \text{ for the 15-19 cohort,}$$

Modified from Health Through Oral Health: Guidelines for Planning and Monitoring for Oral Health Care, page 29. Quintessence Publishing Company Ltd, London, UK, 1989.

Annexure 11. Fluoride Ion Requirements by Treatment Site.

Fluoride ion required at 0.6 and 0.7 ppm at various treatment plants			
Treatment Plant	**Capacity: ML/Day[3]**	**at 0.6 ppm**	**at 0.7 ppm**
Constantia Nek	3	1.8	2.1
Kloof Nek	16	9.6	11.2
Steenbras	150	90.0	105.0
Wemmershoek	250	150.0	1750.0
Voëlvlei	270	162.0	189.0
Faure	300	180.0	210.0
Blackheath	400	240.0	280.0
Total	1389	833.4	972.3

Annexure 12. Chemicals Required by different Treatment Plants to deliver the necessary Fluoride ions on daily basis.

Chemicals Required to Deliver 833.4 Kg (and 972.3 Kg) Fl ion per day				
Chemical	Form	Kg/Day to deliver 833.4 kg Fluoride	Kg/Day to deliver 972.3 kg Fluoride	Cost/kg
Sodium Fluoride	Powder	1 833.5	2 139.1	R4.73
Total Cost of chemicals in rands for Fluoridation (for a population of 3 000 000)				
Sodium Fluoride	@ 0.6 ppm	R8 672.45 per day	R1.05 per person per year	
	@ 0.7 ppm	R9 476.21 per day	R1.15 per person per year	
Maintenance and monotoring @ R30,000 p/a			R0.01 per person per year	

[3] *Average maximum capacity of each treatment plant/site in mega litres per day*

Annexure 13. Equipment Costs by Treatment Plant (CCC 1995; Bi-Water Ltd., 1995)

Dry-feeder System Equipment Costs complete with building [4]*	
Treatment Plant	**Total Cost in Rands**
Constantia Nek	70 167
Kloof Nek	70 167
Steenbras	72 837
Wemmershoek	72 837
Voëlvlei	72 837
Faure	74 620
Blackheath	74 620
Grand Total Cost	**508 085**
Equipment amortised over 10 year period	**< R0.01 per person per year**

[4] * *Note: quotation obtained from Bi-Water Cape (supplier and installer of feeders, is subject to alteration and final architectural design of various sites where the equipment will be installed.*

Annexure 14. Operating Costs[5] for MP State Dental Clinics

Description	Westridge	Lentegeur	UWC	Total
Rental,equipment & maintenance[6]	22,746	22,746	90,043	135,535
Electricity,water,telephone & transport	9,240	9,240	10,680	29,160
Dentist salary (all benefits inclusive)	101,436	101,436	253,396	456,288
Oral hygienist salary (all benefits included)	30,200	60,400	****[7]	90,600
Support Personnel	64,595	64,595	103,103	232,293
Cost of Materials and Sundries	12,000	12,000	38,439	62,439[8]
Total Cost of the services (TC):	240,2175[9]	70,417	95,661[10]	1006,295[11]
Total Cost of Curative Care per clinic(CC)	175,358	186,588	456,008	855,350
Total cost of preventive care per clinic (PC)	64,859	83,829	****	150,945
Cost of employing a Dentist per clinic	175,358	186,588	152,002	171,070
Cost of employing an Oral Hygienist per clinic	64,859	41,915	*****	50,315
Cost of operating a chair (unit)= TC/no of chairs	120,108	135,208	49,566	71,878
Cost per patient : TC divided by attendance	60.00	63.00	28.00	38.00

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5 *All the tabulated costs and estimates are in rands per annum for the specific items as specified in the table above*

6 *Equipment costs have been amortised over a period of ten years at original purchase price as obtained from the Sectional Head of the service rendering clinics*

7 *Please note that the exact cost of employing an oral hygienist cannot be ascertained as the services are dentist-driven*

8 *This estimate is for 20% utilisation; for 100% utilisation the estimate is five-fold*

9 *Includes remuneration of one oral hygienist*

10 *Excludes remuneration of oral hygienists*

11 *Total cost of the entire school dental services*

Annexure 15.

Summary of Common Medical Aid Tariffs (RAMS Scale of Benefits).

CODE	PROCEDURE	FEE in RANDS
8104	Consultation	R 17.70
8107[13]*	*Intra oral x-ray (Average cost)	13.69
8159	Scaling and polish	49.60
8161	Fluoride treatment	26.90
8151	Oral Hygiene Instruction	26.90
8341-8352	Average cost per filling irrespective whether amalgam or composite	31.05
8163*	*Average cost per sealant	11.42
8201*	*Average cost per extraction	12.91
8231 + 8099	*Average cost per full denture (includes laboratory fee)	894.00
8236 + 8099	*Average cost per partial denture (includes laboratory fee)	296.00
8332 + 8338	*Average cost per root canal therapy	242.00

[13] *All the tariffs marked with asterisks are median figures per procedure. They were arrived at by taking the range of tarrifs for a particular procedure and then finding a suitable unbiased and fair estimate for that particular procedure.*

Annexure 16. Costing the Services using Medical Aid Tariffs (RAMS Tariffs: in Scale of benefits).

CURATIVE SERVICES		
No. of Procedures	**Description**	**Cost in rands**
22431	Consultations	397,028.70
445	X-rays	6,092.05
18	Partial Dentures	5,328.00
24	Full Dentures	21,456.00
867	Fillings	26,920.00
14858	Extractions	191,816.78
94	Root Canal Therapy	22,748.00
Total cost for curative care :		**671,389.88**

PREVENTION SERVICES		
No. of procedures	**Description**	**Cost in rands**
3868	Consultations	68,463.60
2772	Scaling & Polishing	74,566.80
2820	Fissure Sealants	32,204.40
2780	Screenings (code:8104)	49,206.00
674	OHI @ school (code:8151)	18,130.60
112	Monitoring of brushing (8151)	3,012.80
1932	OHI at clinic	51,970.80
2772	Fluoride Treatment	74,566.80
Total cost for preventive care		**106,121.80**

Total Cost of all services	**777,511.68**
Average Cost per patient	**28.80**
Cost per curative visit	30.00
Cost for prevention visit	27.00

Annexure 17.

Public Oral Health facilities (Background Information)

Presently there are five public oral health facilities delivering dental services in the Mitchells Plain district. These include the University of the Western Cape Oral Health Centre which has a satellite at the Mitchells Plain Day Hospital; the Westridge Dental Clinic which has a satellite at the Lentegeur Psychiatric Hospital and the Lentegeur Dental Clinic.

The University of the Western Cape Oral Health Centre, employs approximately 150 academic and non-academic staff including 3 sessional dentists (appointed against 2 full-time posts) who render dental services to pre-schoolars, scholars and adults. At the Primary Oral Health Centre (POHC, which is part of the UWC OHC), at the MP Day Hospital a paediatric and special care patient service is being provided. The Lentegeur and Westridge Dental Clinics together each employ one dentist, an oral hygienist, two chair-side assistants. The driver is shared by both clinics in the district. The Westridge staff also provides the services at the Lentegeur Psychiatric dental clinic. These service rendering clinics operate on five-day week, from 8am to 4pm. School-children are supposed to receive comprehensive dental care but the clinical statistics show that the dental care provided is mainly of a curative nature (See Annexure 8 for dental statistics). Sixty percent of the operator's time is spent on school-going children while the rest is devoted to care of the adults. There are a total of 25 dentists practising in the private sector in Mitchells Plain. Of these 2 are employed by the garment and municipal unions. Two part-time maxillo-facial oral surgeons and an orthodontist are located in the private hospital. At present there are 120 oral hygienists working in the public sector in South Africa (these exclude 10 who are in the South African Medical Services). 34 are employed in the public health dental services in the Western Cape (DNHPD,1992). In the Mitchells Plain District there are 3 oral hygienists rendering preventive and clinical services (DNHPD,1992). For the public sector oral hygienists, the ratio for Mitchell's Plain is 1: 79 887 which is less than half the national ratio of 1:192 218. A further discussion of these ratios will be dealt with in the section under results of the WHO/FDI System analysis.

Annexure 18. Worksheet Y: Baseline Restorative care calculation items[14]

Cohort	End of range			Required during period		Ratio S/T	Required during period		X L A
	DMFT	FT	MT	NFT	RFT		NFS	RFS	
(i) 0-14 Primary	3.8	0.2	1.4	3.8	2.9	1.5	5.7	4.4	1.4
(ii) 0-14 Permanent	2.8	0.6	0.7	0.6	0.7	1.5	4.2	3.1	0.7
(iii) 15-19	5.7	0.9	1.7	4.4	1.2	1.5	4.4	4.7	0.2

[14] *The abbreviations used in the Table above will apply to all WHO Worksheets "X" calculations. These include S/T = Surface to tooth ratio; NFS and NFT denoting new filled surfaces and teeth respectively; RFS and RFT meaning replacement of previously filled teeth (See Annexure 10 for full list of abbreviations).*

Annexure 19. **Form X: Estimate for Preventive and Restorative Services in minutes per child per year for 0-14 year cohort.**

Type of Care (1)	Time symbol (2)	Total time in mins (3)	Divide[15] Column (3) Entries by 15	Mins per child per year
Periodontal	T (S&P)	138.0	138.0/15	9.2
Restorative	T (Arr)	-	276.8/15	18.5
	T (NFS)	148.5		
	T (RFS)	112.5		
	T (XLA)	15.8		
			Total	27.7

Basis for calculations in column 3:

T(XLA): [Extraction: 7.5 mins x (0.7+1.4) = 15.8]

T(RFS): [Replacement of filled surfaces: 15 mins x (4.4+3.1) = 112.5]

T(NFS): [New filled surfaces: 15 mins x (5.7+4.2) = 148.5]

T(S&P): [Scale,Polish,Fluoride & Oral Hygiene Instruction: 30.0 mins x (2.3 sextants) x 2 sessions= 138]

[15] *The entries are divided by 15 to obtain an average for the 0-14 year olds (15 groups per cohort)*

Annexure 21. Worksheet Y: Restorative Care calculation items
Estimates for year 2000 (at the end of plan)[17].

A: CARIES STABLE

Cohort	End of range			Required during period		Ratio S/T	Required during period		XLA
	DMFT	FT	MT	NFT	RFT		NFS	RFS	
(i) 0-14 Primary	3.8	0.2	1.4	3.8	1.9	1.5	5.7	2.9	1.4
(ii) 0-14 Permanent	2.8	0.6	0.7	2.8	1.4	1.5	4.2	2.1	0.7
(iii) 15-19	5.7	0.8	0.9	2.9	2.1	1.5	4.4	3.1	0.2

B: CARIES RISING Worksheet Y: Restorative Care calculation items.
Estimates for year 2000 (at the end of plan).

Cohort	End of range			Required during period		Ratio S/T	Required during period		XLA
	DMFT	FT	MT	NFT	RFT		NFS	RFS	
(i) 0-14 Primary	4.8	0.2	0.1	4.8	2.4	1.5	7.2	3.6	0.1
(ii) 0-14 Permanent	2.8	0.6	0.7	2.8	1.4	1.5	4.2	2.1	0.7
(iii) 15-19	5.3	0.9	1.7	2.5	9.2	1.5	3.7	13.8	1.0

[17] *Source of caries data : NOHS OF 1988/89 (Khalfe et al., 1994).*

Annexure 22. **Form X: Estimate for Periodontal and Restorative Services in minutes per person per year for 0-14 year cohort for year 2000.**

Type of Care (1)	Time Symbols (2)	Total time in mins (3)	Divide Column (3) Entries by 5[18]	Minutes per child per year
Periodontal	T (S&P)	138.0	150/5	9.20
Restorative	T (Arr)	-	144/5	17.0
	T (NFS)	149.0		
	T (RFS)	90.0		
	T (XLA)	16.0		
			Total	26.2

[18] *The entries are divided by 5 to obtain an average score for the 15-19 year olds (5 groups per cohort)*

Annexure 23. **Form X: Estimate for Periodontal and Restorative Services in minutes / person / year for 15-19 year cohort for year 2000**

Type of Care (1)	Time Symbols (2)	Total time in mins (3)	Divide Column (3) Entries by 5	Minutes per per person per year
Periodontal	T (S&P)	150.0	150/5	30.00
Restorative	T (Arr)	-	129.8/5	23.0
	T (NFS)	66.0		
	T (RFS)	47.0		
	T (XLA)	2.0		
			Total	53.0

Basis for calculations in column 3:

T(XLA): [Extraction: 7.5 mins x (0.9) = 1.5]

T(RFS): [Replacement of filled surfaces: 15 mins x (3.1) = 46.5]

T(NFS): [New filled surfaces: 15 mins x (4.4) = 66]

T(S&P): [Scale, Polish, Fluoride & Oral Hygiene Instruction: 30.0 mins x (2.5 sextants) x 2 sessions = 150]

Annexure 24.

Worksheet Y: Restorative Care calculation items Estimates for year 2000, assuming an actual reduction in caries of 50% due to community water fluoridation

Cohort	End of range			Required during period		Ratio S/T	Required during period		X L A
	DMFT	FT	MT	NFT	RFT		NFS	RFS	
(i) 0-14 Primary	1.9	0.1	0.7	1.9	1.0	0.75	2.9	1.5	0.7
(ii) 0-14 Permanent	1.4	0.3	0.4	1.4	0.7	0.75	1.1	0.5	0.4
(iii) 15-19	2.9	0.4	0.5	1.5	1.6	0.75	1.1	1.2	0.1

Annexure 25. **Form X: Estimate for Periodontal and Restorative Services in minutes per person per year for 0-14 year cohort for the year 2000, "after fluoridation"**

Type of Care (1)	Time Symbols (2)	Total time in mins (3)	Divide Column (3) Entries by 5	Minutes per child per year
Periodontal	T (S&P)	138.0	138/15	9.2
Restorative	T (Arr)	-		
	T (NFS)	60.0	98/15	7.0
	T (RFS)	30.0		
	T (XLA)	8.3		
			Total	26.2

Basis for calculations in column 3:

T(XLA): [Extraction: 7.5 mins x (0.7+ 0.4) = 8.3]

T(RFS): [Replacement of filled surfaces: 15 mins x (1.5 + 0.5) = 30]

T(NFS): [New filled surfaces: 15 mins x (2.9 + 1.1) = 60]

T(S&P): [Scale, Polish, Fluoride & Oral Hygiene Instruction: 30.0 mins x (2.3 sextants) x 2 sessions= 138]

Annexure 26. **Form X: Estimate for Periodontal and Restorative Services in minutes per person per year for 15-19 year cohort (after fluoridation, in 2000)**

Type of Care (1)	Time Symbols (2)	Total time in mins (3)	Divide Column (3) Entries by 5	Minutes per child per year
Periodontal	T (S&P)	150.0	150/5	30.0
Restorative	T (Arr)	-	35.5/5	7.1
	T (NFS)	16.5		
	T (RFS)	18.0		
	T (XLA)	1.0		
			Total	37.0

Basis for calculations in column 3:

T(XLA): [Extraction: 7.5 mins x (0.1) = 1.0]

T(RFS): [Replacement of filled surfaces: 15 mins x (1.2) = 18.0]

T(NFS): [New filled surfaces: 15 mins x (1.1) = 16.5]

T(S&P): [Scale,Polish,Fluoride & Oral Hygiene Instruction: 30.0 mins x (2.5 sextants) x 2 sessions = 150]

Annexure 27. Estimating the Time spent by Dentists doing Curative Care.

Curative Care	Estimates for resources for various procedures			
Tx Needed	**NOHS Mean**	**Mins /Procedure**	**Time in mins per group**	**FTES**
Extractions	1.0	7.5	111,435	4331 hrs divided by 1750
Fillings	1.5	15	13,005	
Dentures Tx[19]	n/a	40	480	
Examinations	1.0	10	124 850	
X-rays[20]	n/a	10	6,675	
Root canal Tx[21]	n/a	60	5 640	
				2.5

[19] *Estimate based on clinical records: a total of 24 full and 18 partials were delivered in one year: average time per denture = 40 mins*

[20] *A total of 445 intra-oral X-rays were taken in one year. Average time per x-ray including developing is in vicinity of 10 mins*

[21] *94 teeth were root treated. Average time per complete treatment 60 mins.*

Annexure 28. Determining Resources for Preventive Care based upon actual work load

Preventive Care	Resources for Preventive Care			
Treatment (Tx) Needed	Minutes per procedure	Tx time in min for grp	Tx time in hrs	FTES Needed
Examinations	10	38,680	645	2812 hrs divided by 1750
Scale and polish	20	55.440	924	
Oral Health Education at Clinic	10	19 320	322	
Fluoride Tx	10	27,720	462	
Fissure sealant application	5	14,100	235	
Education talks at schools[22]	20	10,110	168	
Monitoring Brushing programme [23]	30	3,360	56	
				1.6

[22] *The estimate for Oral health education includes travel time to schools*

[23] *Time estimate includes travel time*