Muhleman (1967) estimated that the upper extreme of individual salt ingestion was 5 g salt per day. By calculating the maximum individual water intake, the upper limit of daily fluoride intake of individuals who consume 1 ppm fluoridated water was 1.5 mg without occurrence of mottled enamel. Based on these calculations he suggested that domestic salt fluoridation should be at the concentration of 300 mg F per kg salt which would give 1.5 mg fluoride ingested.

Ericsson and Anderson (1983) have recommended an even higher concentration. These workers, by measuring the fluoride ingestion with fluoridated domestic salt under Swedish dietary conditions, which varied between 1.2 to 1.8 mg F per day, concluded that a concentration of 380 mg F per kg salt would be adequate and comparable to that of 1 ppm fluoridated water.

In conclusion, it has been evident that fluoridated salt is efficacious in preventing caries. The concentration of 250-300 mg F/kg salt would be adequate and could be expected to have the same effect to that of 1 ppm water fluoridation. However, since different communities have different dietary patterns, adjustment to the concentration would be necessary. The implementaton of salt fluoridation is appropriate when water fluoridation is not technically possible. Evidence also suggests that salt fluoridation is much more economical when compared to water fluoridation (Toth 1978).

3.2.2.4 Fluoride mouthrinse

Fluoride rinses have been clinically evaluated since the 1940's

(Bibby et al 1946, Roberts et al 1948) under a variety of conditions and with different results. Although the first two studies failed to show its efficacy (Bibby et al 1946, Roberts et al 1948) subsequent studies suggested that there was a caries reduction of about 40% following daily, weekly or fortnightly mouthrinses with neutral pH fluoride solution (NaF) for 2-3 years (Birkeland and Torrel 1978).

Various fluoride compounds have been studied and these include: sodium fluoride, acidulated phosphate fluoride, stannous fluoride and amine fluoride. No report of rinses containing sodium monofluorophosphate appears to have been published. Although the differences were slight, studies favoured the superiority of NaF mouthrinse compared to other compounds (Heifetz et al 1973, DePaola et al 1977, Ringelberg et al 1979). Therefore most studies, especially those which were conducted in the 1980's, used NaF to be the compound tested. Murray and Rugg-Gunn (1982) suggested that sodium fluoride mouthrinse at neutral pH was the compound of choice at that time because of its more pleasant taste and its cheapness compared to other compounds.

Sodium fluoride mouthrinses have been tested in different concentrations varying from 200 to 3000 ppm and with different frequency of use. The frequency of rinsing were reportedly varying from once per day to once per four months.

The discussion in this section is focused on NaF compound and is limited to those studies which were carried out over at least a two year period time using DMFS as a caries index. The frequency of rinsing is also limited to daily, weekly or fortnightly use. The

studies included are those which were conducted in non-fluoridated areas. The studies that met these criteria are presented in table 61.

In the daily mouthrinsing programs, five studies met the criteria. From those studies, the concentration of 200-250 ppm was the most commonly used rinsing solution. The reduction of caries increment was reported to range from 23 to 51%. For the weekly rinsing, nine studies were recorded, five of which were conducted in the 1980's. With the concentration of 900 ppm F (0.2% NaF), the reduction of caries increment varied between 20 to 66%.

Regarding the study methodology, it can be noted that, unlike fluoride dentifrice studies, visual-tactile examinations were commonly used throughout the studies. Except for those of De Paola et al (1977), Heifetz et al (1973) and Ringelberg et al (1979), no study used radiographic examination. The absence of radiographs might result in an underestimated figure of caries increment. However any unreliability could be reduced by using a double blind method. Of the 16 studies, only those of Rugg-Gunn et al (1973) and Gallagher et al (1974) used this latter method.

The study of Rugg-Gunn (1973) is considered to be a well planned study. Conducted over three years, the study involved a total of 434 subjects aged 12 years who were divided into two groups ie: a test group (n=222) and a control group (n=212). The result showed a 36% reduction of caries increment in the test group after three year daily supervised mouthrinsing with 0.05% NaF solution (Table 62).

DePaola et al (1977) carried out a careful study in which the double

Table 61. Result of clinical trials of daily, weekly and forthnightly mouthrinsing with NaF solutions

Study	ppm F	age	n	Duration (months)	Percent reduction
DAILY					
Torrel & Ericsson (1965)	225	10	160	24	49
Aasenden et al (1972)	200	8-11	114	36	27
Rugg-Gunn et al (1973)	225	11-12	222	34	36
DePaola et al (1977)	1000	10-12	92	24	51
Ringelberg et al (1979)	250	11	179	30	23
WEEKLY					
Heifetz et al (1973)	3000	10-12	126	24	8
Gallagher et al (1974)	1800	10-11	306	24	34
Ripa et al (1978)	900	7-12	750	24	20
Eckhaus et al (1982)	900	6-13	1151	36	33
Ripa et al (1983)	900	11-12	125	72	55
Leske et al (1985)	900	12	125	84	58
Leverett et al (1985)	900	6-12	750	84	66
Ripa et al (1985)	900	12	131	84	50
FORTNIGHTLY					
Torrell & Ericsson (1965)	900	10	172	24	22
Koch (1967)	2225	10	85	36	23
Maiwald & Padron (1977)	900	6	100	88	56

blind method and radiographic examination were used. A total of 173 children aged 10-12 were involved in the two-year study. The subjects were randomly assigned into two groups of 92 (NaF group) and 81 (placebo group). After two years rinsing with 1000 ppm F (daily supervised in school), the result showed that the program could reduce the caries increment in the test group by 51% (Table 63).

In 1975, the National Institute of Dental Research implemented a Community Caries Prevention Demonstration Program which involved 17 different communities in the USA conducting school-based fluoride mouthrinsing programs (Ripa 1987). In this program elementary schoolchildren rinsed once a week with 0.2% neutral NaF solution.

The studies reported in the 1980's (Table 61) were actually the evaluation of this program. No limitation was involved in this evaluation except that no random allocation was made and no control group was used. Different from previous studies which used a longitudinal (follow-up) study design, a cross sectional method was used in these USA studies. Therefore, the influence of the past experience of the subjects cannot be ruled out. On the other hand this study design has a superiority in its external validity. It means that the same results are likely to be expected from a wide implementation of a program rather than from a very strict clinical trial.

The frequency of rinsing was not clearly defined. In the early study of Torrel and Ericsson (1965), which was a comprehensive multigroup trial, the caries reduction shown for the unsupervised daily use of an 0.05% NaF over a two-year period of time was 49%.

Table 62. Mean caries increments (DMFS) in adolescents aged 15 years completing a 3 year daily supervised mouthrinsing with a 0.05% NaF solution.
(Adapted from Rugg-Gunn 1973).

Groups	Initial	Final	Increment	Percent reduction
Test	8.7	15.3	6.6	36
Control	8.8	19.1	10.3	-

Table 63. Mean caries increment (DFS) in children aged 12 - 14 years completing 2 year daily mouthrinsing with a 0.22% NaF solution.
(Adapted from DePaola et al 1977)

Group	n	Increment	percent reduction
NaF	92	2.7	51
Placebo	81	5.5	-

This reduction was significantly greater than the 22% reduction obtained by supervised fortnightly rinsing with an 0.2% sodium fluoride solution. This indicated that more frequent fluoride exposure was preferable. Unfortunately no other study was conducted to compare different frequency of rinsing within a single study which would give more accurate (and methodologically acceptable) comparison. A rough comparison of unweighted mean reductions between daily and weekly rinsing studies which were carried out for the same duration (24-36 months) gives a slightly higher reduction with the daily rinsing. However, the difference (37% and 33% reductions for daily and weekly rinsing respectively) does not seem to be significant. Therefore it can be concluded that weekly rinsing with a higher concentration (900 ppm) is considered to be satisfactory and more practical. It is also preferable in terms of finance since weekly rinsing would be more economical than daily rinsing.

In conclusion, a caries reduction varying from 22 to 66% was reported to be achieved by mouthrinsing programs using NaF solutions. Concentrations of 225 ppm used daily, and 900 ppm used in weekly mouthrinsing were those most usually reported. The studies suggested that an optimum result could be achieved by using 900 ppm F in a weekly rinsing program. Such a program could be implemented in school under teachers' supervision. In communities where water fluoridation is not available, school-based fluoride mouthrinsing programs have a great public health potential.

3.3 Reduction in Sugar Consumption

Dental caries is a multifactorial disease in which there is a complex interplay between host factors, the bacterial plaque on the teeth, the diet and the time (Newbrun 1983). Within this context, the food item in human nutrition which significantly related to the occurence of dental caries is sugar.

Experimental evidence unequivocally suggested that the interplay between sugar and bacteria is pre-requisite for dental caries (Stephan 1940, Orland 1955, Graf and Muhleman 1966, Fitzgerald 1966, Kleinberg 1979, Fitzgerald et al 1981). In this connection, sugar acts as a substrate for the bacteria since sugar is required for microbial activity. All type of dietary sugars or fermentable carbohydrates such as sucrose, glucose, fructose and lactose are used in the energy metabolism of many plaque bacteria (Kleinberg 1985).

Fermentation of carbohydrates during the anaerobic metabolism of the bacteria causes an increase in the concentration of organic acids, mainly lactic acid in the plaque as an end product of the metabolism. This acid excretion by bacteria results in a pH drop which in turn causes tooth demineralisation. If these acid attacks become too frequent or too long duration in relation to the period of remineralisation, the final outcome will be a carious lesion (Theilade and Birkhed 1986).

The evidence which shows that sugar is essential in the etiology of dental caries is unequivocal (Makinen 1972, Bibby 1978, Bowen 1978, Sreebny 1982, Newbrun 1982, 1983, Rugg-Gunn and Edgar 1984). Several experimental studies in human population consistently showed that

dental caries was strongly related to the presence of fermentable carbohydrates.

The most comprehensive study on the effect of sugar in caries incidence was the Vipeholm study conducted in Sweden by Gustafsson et al (1954). Conducted in subjects who were institutionalised, the study revealed that in those who ate sweets in the forms of toffee or caramel between meals, caries activity increased tenfold. One of the main conclusion of the Vipeholm study was that the risk of sugar increasing caries was greatest if sugar is consumed between the meals and in a form in which the tendency to be retained on the surface of the teeth is pronounced (Gustafsson et al 1954).

In Australia, a study on the effect of sugar restriction on dental health were conducted by Sullivan and Harris (1958) and Harris (1963). These studies were basically an evaluation of the dental health of children who lived in a Home (Hopewood House) under a certain diet condition. Having had vegetarian foods, refined carbohydrate were excluded from their daily diets. At the end of a 10 year period, the children in the Home showed an extremely low caries occurence compared to the corresponding figure for the general children population in the State of New South Wales examined by Barnard (1956) (Table 64). Table 64 shows that the Hopewood House children had about 50 - 85% lower DMFT compared to those children in the State Schools from the same socioeconomic condition. Considering that the oral hygiene of the Hopewood House was poor, the study showed that dental caries can be reduced markedly by the exclusion of refined sugar from the diet, without beneficial influence of fluoride and in the presence of unfavourable oral hygiene.

Table 64. Comparison of the mean DMFT per Hopewood child at ages 10 to 15 years with that of similar age attending State Schools in New South Wales.
(Adapted from Harris 1963)

Age	Hopewood House		State School		Percent difference
	n	DMFT	n	DMFT	
10	14	0.85	689	5.28	83.9
11	22	1.00	717	6.98	85.7
12	28	1.81	667	9.32	80.6
13	49	3.50	696	10.70	67.3
14	75	6.20	620	12.78	51.5
15	65	6.46	428	13.91	53.6

The other long-term experimental study on human population was the Turku sugar study in Finland (Scheinin and Makinen 1975). In this study, 125 subjects aged 15 to over 45 years participated in a two year trial comparing the effect of sucrose-containing diet and diets in which sucrose was replaced by fructose and xylitol. The subjects were divided into three groups which received either sucrose (n=52), fructose (n=35) or xylitol-containing diet (n=38). The result after 1 year showed that sucrose and fructose had equal cariogenicity whereas xylitol produced almost no caries (Figure 4). By the second year caries had continued to increase in the sucrose group but remained unchanged in the fructose group indicating that sucrose was more cariogenic than fructose. The large caries increment in the sucrose and fructose group versus the very low increment in the xylitol group is another proof of the major role of fermentable sugars in caries etiology.

The effect of wartime on the occurence of dental caries further emphasized the role of sugar. Wartime rationing in the second World War had reduced the sugar consumption in several European countries and in Japan (Toverud 1957, Takeuchi 1961). An analysis of the dental caries rates in Norway, Finland and Denmark indicated that there had been a marked reduction in the caries rates in the first permanent molars in children aged 6 to 7 years about 2 - 3 years after the reduction of sugar intake. In the post-war period, the caries experience increased again due to the sugar availability and increased sugar consumption (Toverud 1957).

Sreebny (1982) conducted a study to investigate the relation between sugar consumption and dental caries experience in nations throughout the world. He collected data on the prevalence of caries primarily

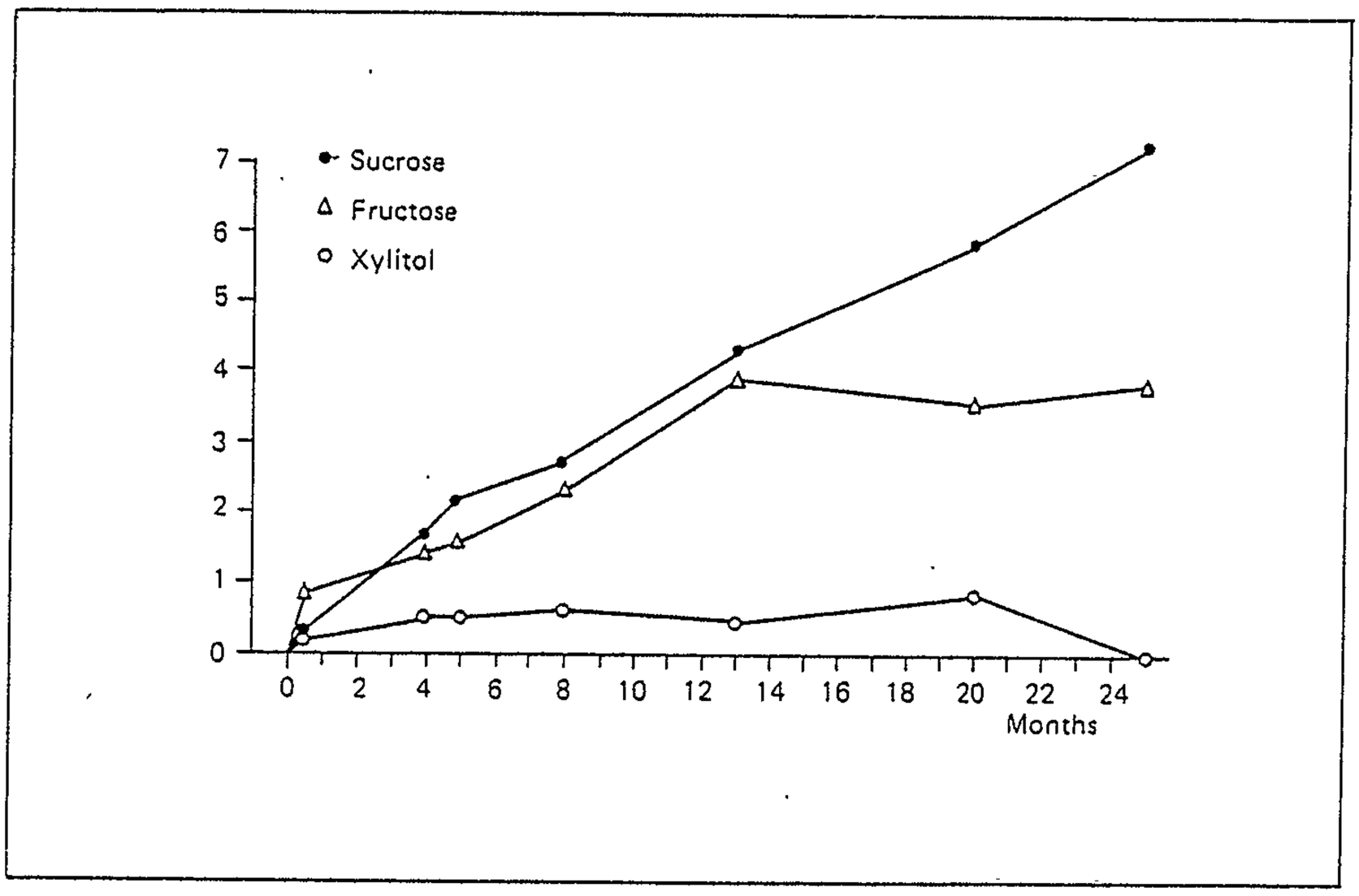

Figure 4. Comparison of the effect of sucrose, fructose and xylitol on caries activity.
(Adapted from Scheinin and Makinen 1975)

from the WHO's Global Oral Epidemiology Data Bank for children at ages 6 and 12 years. To represent the sugar consumption, per capita sugar supply data were obtained from food balance sheets which depict the overall pattern of a nation's food supply and utilisation compiled by FAO. The data are presented in table 65. Statistical examination of the data from 47 countries revealed that there was a highly significant relationship between the availability of sugar and the DMFT index. The linear regression has the form of Y = 0.06 + 0.04 X (Y = DMFT, X = sugar supply) and the correlation coefficient r = + 0.72 (Figure 5). The data in table 65 shows that the availability of less than 50 g sugar per person per day in a country was always associated with DMFT scores of less than 3.0. If a DMFT of 3 or less is acceptable as a level of caries for 12 year old children throughout the world, than 50 g per person per day (18.25 kg per person per year) may be put as an upper limit of acceptable sugar consumption.

One of the most profound impact of the Vipeholm study was the belief that the frequency of eating especially between meals play a major role in the occurence of dental caries. Frequency of eating is usually considered of greater etiological importance than total sugar consumed (Bowen and Birkhed 1986).

The Vipeholm study demonstrated that it was possible to increase the average sugar consumption from about 30 to 330 g per day with very little increase in caries (about 0.27 to 0.43 new carious surfaces per year) provided that the additional sugar was consumed at meal in solution (Gustafsson et al 1954). These observation on an institutional population should be interpreted with caution because conditions were artificial (Newbrun and Frostell 1978). If there is

Table 65. Sugar supply and mean DMFT of 12 year old children by country.
(Adapted from Sreebny 1982)

Country	Sugar supply (g/person/day)	DMFT
Consumption less than 50 g		
Algeria	49	1.9
Bangladesh	17	1.8
Botswana	45	0.9
Burma	17	0.8
Cameroon	14	1.2
Ethiopia	11	1.5
Kenya	27	1.3
Korea	11	1.3
Malawi	20	0.8
Mozambique	37	0.8
Nigeria	7	2.5
Papua New Guinea	40	0.8
Senegal	41	1.6
Somalia	47	1.1
Sudan	48	0.7
Tanzania	22	0.6
Thailand	48	2.7
Togo	11	1.6
Uganda	14	0.4
Zambia	27	0.1
Zimbabwe	42	0.6
Consumption between 50-120 g and DMFT < 3.0		
Fiji	92	3.0
Hong Kong	63	2.0
Libya	113	1.3
Morocco	71	2.6
Pakistan	69	2.1
Samoa	78	1.1
Singapore	116	2.6
Spain	115	1.9
Swaziland	99	1.1
Consumption : 50-120 g and DMFT between 3.0-5.0		
Dominica	94	4.8
France	113	3.5
Iraq	90	4.0
Japan	57	4.6
Mauritius	107	3.2
Malaysia	79	3.7
Portugal	76	4.6

Table 66 (continued).

Country	Sugar supply (g/person/day)	DMFT
South Africa	115	3.9
Suriname	70	4.5
Consumption between 50-120 g and DMFT > 5.0		
French Polynesia	74	6.2
Consumption more than 120 g		
Barbados	128	6.5
Canada	141	6.1
Denmark	135	10.1
Finland	121	7.5
Switzerland	128	10.6
United Kingdom	142	5.5
United States	137	4.0

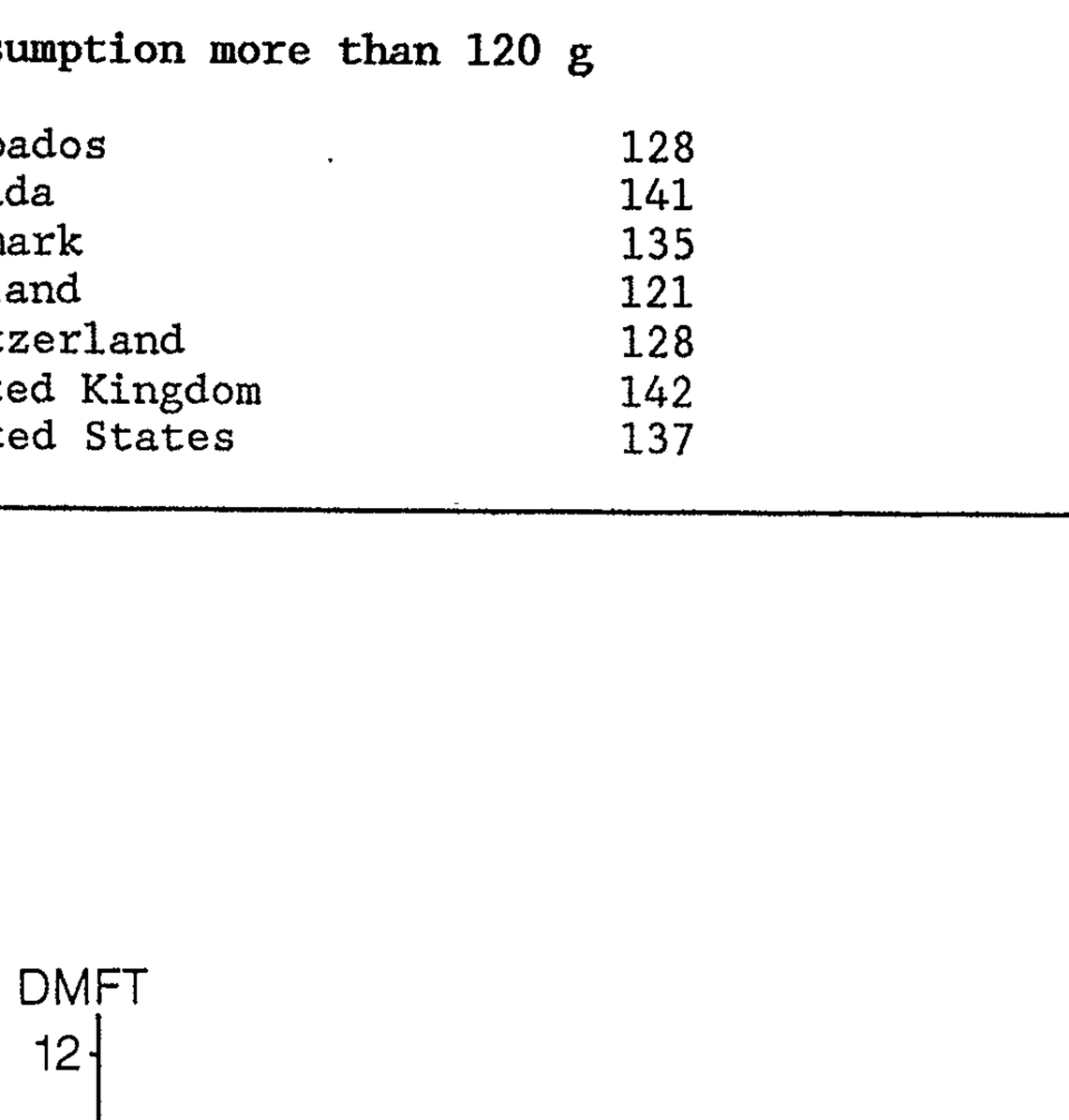

Figure 5. Regression line showing the relationship between sugar supply and DMFT of 12 year old children from 47 countries. (From Theilade and Birkhed 1986)

a free choice and access to sugar containing foods and beverages, such items are likely to be eaten between meals. Futhermore, a recent study conducted by Burt and his colleaques (1988) on the relation between frequency of ingestion and caries increment has failed to support the hypothesis that the higher the frequency, the higher the caries increment. This study suggested that the total sugar consumed is an important predictor of the caries activity.

In summary, all the mono and disaccharides in human diet are highly cariogenic since they are rapidly fermented by bacterial plaque. Bearing in mind that the major part of human dietary sugar is sucrose, the reduction of sugar consumption will decrease the caries occurence.

3.4 Increase of Dental Awareness and Change in Dental Health Behavior.

It was assumed that the increase of dental awareness and the change in dental health behavior resulted from extensive organised dental health education programs have played an important role in the declining trend of caries prevalence (Joint FDI/WHO Working Group 1985). The more preventive approach by dental practitioners and intensive marketing campaigns of the dentifrice companies are the factors that are commonly hypothesized that make the present children generation more exposed to dental information and more dentally aware.

For the past two decades, schemes of dental health education have been directed toward a number of different target groups (Holt et al 1982) amongst which have been schoolchildren. Toward this target group, classroom education has been considered an important

component of efforts to improve preventive dental behavior in general population (Walsh 1985). Apart from that organised dental health education, children are also exposed to the covert dental health-related information such as in the commercial advertisement which may result in their incidental learning (Frazier et al 1974).

The basis of dental health education programs lies in the principle that by altering knowledge, attitudes and beliefs a person is more likely to value teeth and to participate in preventive dental activities (Wright 1982). Kegeles (1974) regarded as preventive dental behavior one or more of the following : (1) visits to dentists periodically on a routine basis; (2) brushing teeth at appropriate times and intervals; (3) control of plaque through use of other mechanical procedures, and (4) maintenance of low cariogenic diets either through avoiding certain foods or increasing consumption of others. These are habits that are favourable to the absence of caries occurence. Therefore, theoretically a successful dental health education program would lead to the declining in caries prevalence. However, in order to adopt such favourable habits an individual definitely needs not only adequate information but also technical skills, a positive attitude toward applying them, and an ability to develop patterns of oral behavior to make them a daily routine (Heloe and Konig 1978). In changing a person's habit, a number of factors should be taken into account because a behavior is a result of both internal and external forces such as : beliefs, attitudes, interests, values, needs, motives, expectations, perceptions, biological and socio-economic factors plus the influence of family, peer groups and the mass media (DeSouza et al 1988).

The mechanism of adopting dental health habits are seemingly complicated: The relevance of established model, that dental health habits can be improved by altering knowledge (knowledge --------> belief ---------> temporary action ---------> habit) has been argued (Raynor and Cohen 1971, DeSouza et al 1988). This approach, which is based on a cognitive learning model, has failed to produce positive results (Podshadley and Shannon 1970, Chambers 1973, Raynor and Cohen 1974). The present approach to the dental health education process is based on a behavioral learning model (DeSouza et al 1988). The rationale is that behavior causes belief and knowledge rather than vice versa (Heloe and Konig 1978). Based on this concept, the change in children's habits would be more influenced by their parents' and teachers' dental behavior (Chen 1986, DeSouza 1988) and their dentists as identification models rather than by written information sources such as pamphletes, brochures, advertisements or by lecturing method in the classroom.

To date, studies have been conducted to determine the effectiveness of dental health education program using the behavioral learning approach. Considering that the ultimate goal of a dental health education program is to improve the community's dental health, evaluation of the effectiveness of such a program should be directed into measuring the dental health outcomes such as dental caries prevalence or periodontal disease. However, most studies were limited to measuring those intervening variables such as change in knowledge, attitudes and beliefs (Tan et al 1981, Walsh 1985, Croucher et al 1985, Chen 1986, Schou 1987, Uitenbroek et al 1989).

The study of McKee et al (1977) was one of the few which was

directed into measuring caries prevalence as the outcome. These workers carried out an experimental study designed to determine the effectiveness of a dental health educational program in reducing dental caries experience of a group of elementary schoolchildren. The education was delivered by school teachers who had previously been trained in a 20-hour workshop. The program included film presentation, and brushing and flossing practices. After a 4 year period of time the program was evaluated and the results showed that there was no significant difference between the control and the experimental group with regard to their DMFS count.

Following the failure in the implementation of water fluoridation in 1968, the city council of The Hague, the Netherlands decided to conduct a long-term dental health campaign based on nutrition and dental health information (Truin et al 1981). Since 1969, the parents of all children up to the age of 4 years were influenced systematically by providing educational material at birth of their children, 6 - 10 weeks after births and after check-ups at the well-baby clinics. The children at the age of 4 - 6 years were reached via kindergarten by providing health educative toys and learning material to the teachers once or twice a year. Since 1972 the 6 to 9 year old children and since 1972 the 9 to 11 year old children in elementary schools were reached by information and a variety of wall posters and learning materials. In order to evaluate the effectiveness of the campaign in reducing dental caries experience, Truin et al (1981) conducted a baseline examination in 1969 and repeat examinations in every three years period of time to children aged 5, 7 and 9 year old. No control group was used. In 1978, the last examination was carried out. The results of the study showed

that there was a marked reduction in caries experience of children aged 5, 7 and 9 years. At 5 year of age, there was a 44.2% reduction in the dmfs counts (Table 66), whereas in the age of 7 and 9 years, the recorded caries reduction were 45.7 and 43.3% respectively (Table 67). The results, however, do not seem to be attributable merely to the campaign program since it was reported that there was an increase in the use of fluoride tablets in those children reaching about 20% of the total children population in 1978, whereas the use of fluoride tablet was not included in the campaign. Moreover there was also a marked increase in the fluoride toothpaste use from 6% in 1969 to as high as 60% in 1978.

Another longitudinal sudy on the effectiveness of dental health education on dental caries occurence was conducted in France by Kerebel et al (1985). A total of 244 children aged 8 years were involved in a the three year study and were divided into an experimental and a control group. The experimental group received a program consisting of : reinforced motivation, daily supervised toothbrushing and prophylactic treatment every 2 months. The results suggested that there was a 66% lower caries increment in the experimental group compared to the control group. However, the effect of fluoride might have been responsible for the difference since children in the experimental group were suplied fluoride toothpaste and received regular fluoride prophylactic treatments whereas those children in the control group had no fluoride exposure.

Mothers with very young children have been thought to represent a particularly suitable target group for dental health education. Based on this thought, Holt et al (1985) carried out a study to

Table 66. Mean dmfs in children aged 5 years in The Hague in 1969 and 1978.
(Adapted from Truin et al 1981)

Caries index	1969	1978	Percent reduction
n	223	170	-
d	9.91	5.39	45.6
m	1.09	0.76	30.3
f	1.17	0.63	46.2
dmfs	12.16	6.79	44.2

Table 67. Mean DMFS in children aged 7 and 9 years in The Hague in 1969 and 1978.
(Adapted from Truin et al 1981)

Age	1969		1978		Percent reduction
	n	DMFS	n	DMFS	
7	209	3.26	191	1.77	45.7
9	200	6.95	179	3.94	43.3

examine the effect of a dental health education program for mothers of newborn babies on their children's dental health. A total of 302 mothers were involved in the study and were divided into three groups. Group 1 (n = 123) received dental health education in visits to their home by dental health educators when their children were 2 to 12 weeks, 6 to 8 months and 14 to 18 months of age. Dental health education literatures were sent via post to mothers in the group 2 (n = 99) whereas group 3 served as a control group. A caries examination was held when their children were 5 year old. The results suggested that there was no significant difference in mean defs or deft between children in the three groups (Table 68).

A recent study conducted by Grytten et al (1988) was designed to analyse the caries predictive behavior in a total of 231 preschool-children. The study suggested that the favourable dental behaviors were related to toothbrushing habits and use of fluoride; whereas the most unfavourable behavior was related to sugar consumption. In relation to sugar consumption, Wikner (1986) conducted an experimental study on the effectiveness of dietary conselling in children with high caries-risk. Fifty-eight 12 year old children with high lactobacillus count (exceeding 10^4 CFU per ml saliva) were divided into two groups ie an experimental (n = 24) and a control group (n = 34). Those children in the experimental group were given an intensive dietary conselling, in the form of lecturing and group discussion with the prime aim to reduce the total amount and frequency of sugar ingestion. Prior to the experiment and one year after the conselling, caries examinations were conducted. The results showed that there was a 1.46 caries increment in the experimental group compared to 4.18 in the control group, which was

Table 68. Caries experience in 5 year old children following a dental education program to their mothers in the experimental (Groups 1 and 2) and the control group (Group 3). (Adapted from Holt et al 1985).

Caries index	Group 1 (n=123)	Group 2 (n=99)	Group 3 (n=80)
defs	1.81	2.36	3.19 *
deft	1.12	1.60	1.73 *
Percent caries-free	69	54	58

* no significant difference in mean defs or deft.

a 65% reduction.

Olsen et al (1986) carried out a study aimed to investigate the effect of educational efforts provided by dental promotion health workers on the dental health status of high caries-risk children. The study was based on the proposition that a community health worker, by intervening and conselling parents of children at high risk, would be more able to identify perceived and prevailing barriers to preventive dental health than a clinical dental provider. A total of 310 schoolchildren aged 7 to 9 years were involved in the study and were divided into a study (n = 172) and a control group (n = 138). The results of the study suggested that no better performance in the DMFT count was recorded in the study group compared to the control group.

These studies have shown discouraging results when caries prevalence is used as a parameter in assessing the effectiveness of dental health education programs. This indicates that the assumption that dental health education through both planned program and incidental learning have played a major role in the declining trend of dental caries prevalence should be further verified, although theoretically this effort, under some favourable conditions, could reduce caries occurence.

3.5 Concluding Remarks

It has been unequivocally accepted that fluoride has 3 actions at physiologic concentration that could be concerned with its effect to the body : (1) it enters hydroxyapatite lattice to produce the less soluble fluorapatite; (2) it favours the precipitation of calcium phosphate from saturated solutions; and (3) it inhibits enzyme

actions.

The predominant affect of fluoride in various forms has been supported by several studies and the evidence that the widespread use of fluoride substantially reduces caries is incontrovertible.

On the other hand, the contribution of the other factors such as changing pattern of sugar consumption, increase in dental awareness and improved level oral health care through school-based dental program must remain cautionary, despite the long established theoretical relationships between these factors and caries reduction.

4. AUSTRALIAN STUDY

4.1 Introduction

It has been discussed in section 2.3 that Australia has successfully reduced the caries experience especially of the schoolchildren population. Regarding children at 12 years of age, there has been a 63% reduction of caries experience (DMFT) over a period of 11 years, from 4.79 in 1977 to as low as 1.79 in 1988. The recorded DMFT in some localities showed an even bigger percentage reduction (Figure 6) when compared to the 1960's figure which was very high at over 8 DMFT (Barnard and Sivaneswaran 1989).

The observed declining trend is obviously a result of various extensive preventive measures. The successful implementation of School Dental Services, water fluoridation measures, the use of other forms of fluoride, and the favourable ratio between dental resources and dental need are factors supposedly related to this trend.

The aim of this section is to review these various public health measures and to evaluate their relative contribution to the declining trend.

4.2 Geographic and Demographic Background

Australia is situated between $10^{o}41'$ (Cape York) and $43^{o}39'$ (South Cape, Tasmania) south latitudes and between $113^{o}09'$ (Steep Point) and $153^{o}39'$ (Cape Byron) east longitudes. With the latitudinal distance between Cape York and South Cape as far as 3680 kilometres and longitudinal distance between Steep Point and Cape Byron about 4000 kilometers, the country comprises a land area of 7,682,300

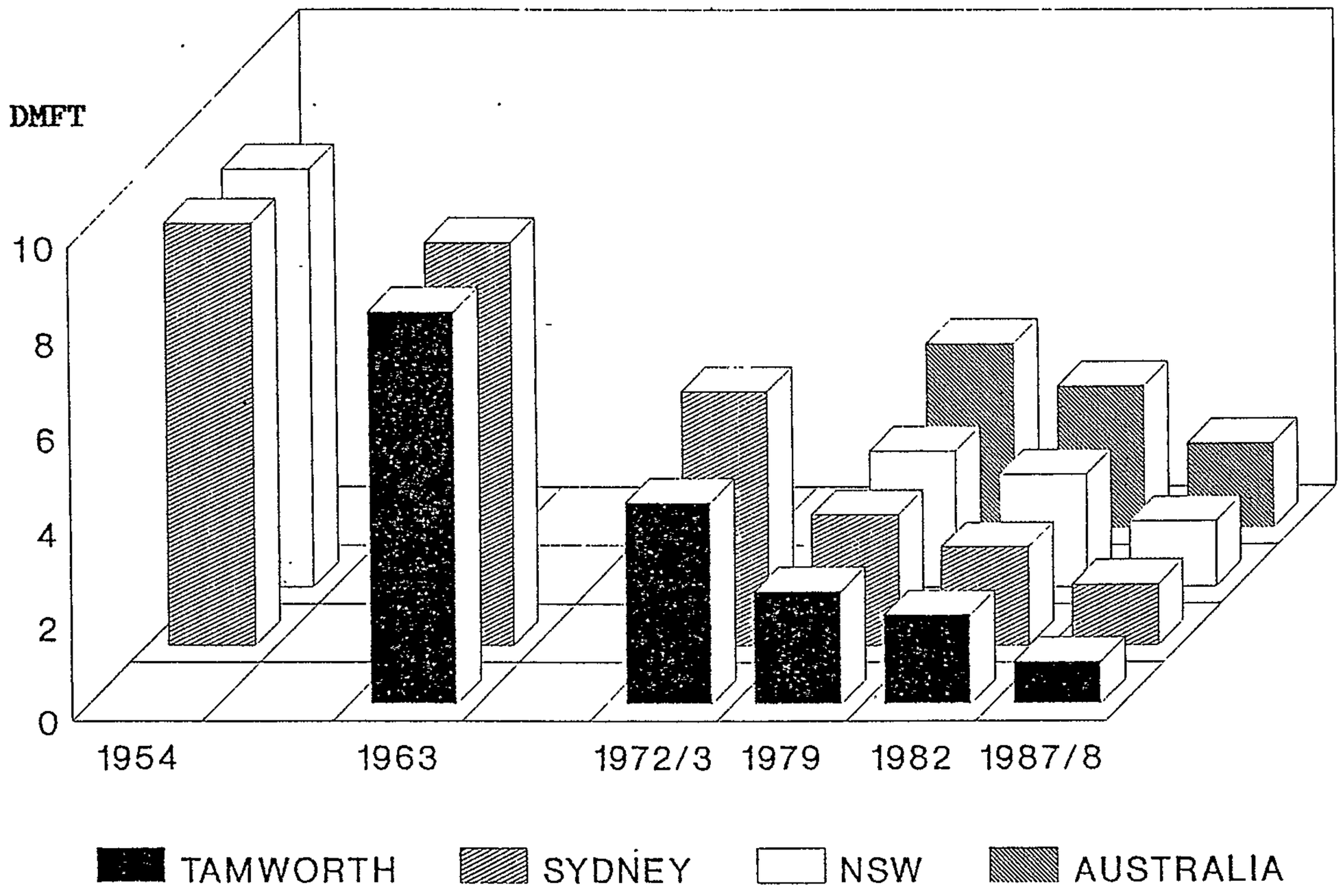

Figure 6. Declining trends of dental caries prevalence in Tamworth, Sydney, NSW and Australia.
(From Barnard and Sivaneswaran 1989)

square kilometres (ABS 1988). By way of comparison, the land mass of Australia is almost as great as that of the USA, 32 times greater than United Kingdom and about 80% of Indonesia's archipelago. The climate of Australia is predominantly continental varying from the northern tropical areas to temperate Tasmania.

Australia is a well developed country with a considerably high economic growth rate resulting from a good balance of primary and secondary industries (Barnard 1974). The Commonwealth of Australia was established in 1901. The country is a Federation of States consisting of 6 States and 2 Territories ie : New South Wales (NSW), Victoria (VIC), Queensland (QLD), South Australia (SA), Western Australia (WA), Tasmania (TAS), Northern Territory (NT) and the Australian Capital Territory (ACT).

In 1988, the country's total population was 16.532 millions (Barnard 1989), over 70% of whom live in capital or other cities that are mostly scattered along the eastern and south-eastern coastline. This puts Australia as one of the most urbanised countries in the world. With a land area of over 7.5 millions square kilometres, Australia's population density is in the order of 2 persons per square kilometre. However, most of the land has a population density of zero.

Of the 1988 population figure, 22.5% are children under 15 year old, 66.5% are those who are aged 15 to 65 years and the remaining 11% are those who are considered as the elderly population. This provide a dependency ratio of over 0.5. In the decade of the 1980's, the population growth rate was at the order of 1.6% per year. With the expected growth rate as low as 1.5% per year, the population will

Table 69. Population of Australia by age group in selected years, 1985 - 2001.
(Adapted from Barnard 1988, 1989)

(in millions)

Age group	1985	1986	1987	1988	1991	1996	2001
0 - 4	1.199	1.208	1.217	1.225	1.281	1.347	1.361
5 - 14	2.526	2.491	2.466	2.465	2.506	2.676	2.818
15 - 64	10.442	10.637	10.838	11.043	11.596	12.484	13.471
65 +	1.621	1.682	1.742	1.799	1.971	2.225	2.392
Total	15.788	16.018	16.263	16.532	17.354	18.732	20.042

become over 20 millions in the year 2001 (Table 69).

4.3 Dental Health Services System

The health care in Australia was originally developed in the last quarter of the 18th century coinciding with the establishment of the Colonial Medical Service by the British government (Cummins 1969). This government medical service was then augmented by private charity and private practice in response to the increasing need of medical care in that era and sharing responsibility between government and private sectors was begun, and has continued.

From this background, the present medical services system is very complicated in which seven types of health care institutions are involved. These being : (1) public hospitals, (2) private hospitals, (3) public nursing homes, (4) private nursing homes, (5) mental health institutions, (6) Repatriation Department institutions and (7) other institutions providing personal health care (Dewdney 1972).

Basically, the community health care which comprises personal health services and environmental control is delivered to the community through 4 types of services, as follows (Dewdney 1972) :

1. governmental and semi-governmental agencies
2. private professional practitioners
3. non-government, profit-seeking agencies and
4. non-government, non-profit-seeking agencies.

Governmental Agencies

Since the establishment of the Commonwealth in 1901, its political institutions are characterised by some division of power and

responsibility between the Federal and State governments. However, the institutional responsibility for health services between the Federal and State governments is still confused (Cummins 198?). It is hardly surprising to find that the division of responsibility has caused underservice in some areas and overprovision of others (Bates 1983). However, basically the Federal government tends to restrict itself to subsidising health institutions, owned by the State Government, without direct responsibility for their control and deployment. Therefore, the State governments are concerned with direct execution of personal health service, environmental and special health service, manpower and management control, and arranging finance and physical resources (Dewdney 1972).

In all of the three levels of government organising bodies (Federal, State and Local Authorities), the government health service may be rendered in two ways. First, the service is delivered directly through its departments and secondly, the government may establish a statutory body to manage the provision of the service. The second is which it is referred to as semi-governmental agencies. These semi-governmental authorities employ medical staff to provide an industrial-type service to their employees. While its management consists of government appointed persons, its staff are not public servants.

At the Federal level, not only the Commonwealth Department of Health has the responsibility for health services. Two other departmental bodies which have major involvement in the health field are the Commonwealth Department of Social Security and the Repatriation Department. At the State level, the bulk authority in the health field is held by the State Ministers of Health. Although each of

the Health Ministries in the six State governments has completely different structures, they have similar major areas of concern.

Private Sector

Services that fall into the category of private practice are those delivered by general practitioners and specialists who are mostly self-employed or employed by private enterprises. Whereas the term non-government profit-seeking agencies applies to private hospitals and private nursing homes run by commercial health agencies or private enterprises. These private hospitals are approved by the Commonwealth Department of Health based on certain standards and criteria. Being run to make profit, private hospitals and private nursing homes are free to determine the charge of the service.

Voluntary Institutions

Basically the voluntary institutions grew up from private charities. This originally arose through denominational agencies based on christian religion or from a community conciousness of a social need. Depending on the government's dependence on their services, these instituions are, to some extent, subsidised by the government.

Different from that of medical services, the dental health system in Australia is less complicated. Dental care services are rendered by three types of institutions ie : (1) governmental institutions, (2) private practitioners and (3) other dental clinics services.

On the government side, the institutions through which the services are delivered are generally public dental hospitals, dental clinics attached to public hospitals, school dental clinics, and some community health centers. Through these institutions, the government

provides a free dental service to a limited number and specific populations ie : armed forces, eligible veterans, the economically underpriviledged population, the disadvantages, pensioners and schoolchildren population up to the age of 15. In the system, two characteristics are noticeable, being : (1) very decentralised and (2) no established referral pathway.

To gain access to a public dental service, a person must be covered by Health Insurance Fringe Benefits which fall into three categories ie : Pensioner Health Benefits (PHB), Health Benefits (HB) and Health Care (HC). Therefore, to be eligible, a person must be a current holder of either a PHB card, HB card or a HC card which are mostly valid for 12 months.

Persons eligible for a PHB card are Department of Veteran Affairs' service pensioners, and recipients from the Department of Social Security of: sheltered employment or rehabilitation allowance; supporting parent's benefits; and aged, invalid, widow's pension whose income and assets fall within prescribed limits. Entitled to a HB card are those sickness beneficiaries regardless of income. Persons issued with a HC card are : (1) unemployed and special beneficiaries subject to the same income test that applies to pensioners receiving a PHB card; (2) low income earners; and (3) invalid pensioners and sheltered employment allowees entering the workforce (Grant and Lapsley 1988).

By way of illustration, in 1988 there were 2,282,024 social security pensioners with a PHB card (including their dependant children), 129,212 HB card holders (including their wives and dependant children) and a total of 631,851 HC card holders (Department Social

Security 1988). These figures provide a total of 3,047,087 persons eligible for public dental service which is about 18% of the total population.

Different from the medical service, dental care, for the vast majority of the population, in this country is provided by dental practitioners in private practice in which patients pay directly for the services required. The imbalance proportion of dental services shared by government and private practitioners can be seen in table 70 which shows the number of dentists employed in each type of service. Over 80% is held by private practice sector.

As well as government and private practice, dental service, to a far lesser extent, is provided by organisations, private companies, semi-governmental authorities and private insurance companies to their members or employees. Some Health Funds (a non-profit insurance company) have clinics that provide direct services for their members (Barnard 1989). This type of service, however, is of less importance since it employs only 0.8% of the total active dentists in the country (Table 70).

Table 70. Number of dentists employed by type of service, 1980, 1985 and 1987.
(Adapted from Barnard 1982, 1988, 1989).

Type of service	1980 number	1980 percent	1985 number	1985 percent	1987 number	1987 percent
Government*)	1163	18.7	1191	17.5	1196	17.2
Private practice	4999	80.5	5569	81.8	5695	82.0
Other	50	0.8	45	0.7	57	0.8
Total	6212	100.0	6805	100.0	6948	100.0

*) including dentists employed in the University as Teaching and Administrative Staff, also including adjustment for part time dentists.

4.4 Dental Health Expenditure

While expenditure on health care has grown substantially in the last twenty years, in both government and private sectors, the share of gross domestic product (GDP) spent on health care in the last five years remained constant at about 7.5% (Barnard 1989). In the fiscal year 1982-83, the total health expenditure was $12,640 millions and in 1986/87 this became $20,161 millions. Comparing the two figures, there had been about a 60% increase in the period of four years or a 15% increase annually. The increase was predominantly through the government source which shared 60% of the expenditure in 1982/83 made a 70% contribution in 1986/87 (Table 71). The expenditure from government source is shared between the Federal and State governments in varying proportion.

In contrast to the total health expenditure, an inverse proportion between government and private sources is observed in the dental expenditure. In the fiscal year 1982/83 the total dental expenditure was as much as $574.6 millions of which only a quarter was contributed by the government. In 1986/87 the expenditure became $993.1 millions, an increase of about 73% compared to the 1982/83 figure (Table 72). With regard to the government share, there had been a less pleasing trend from a 23.5% in 1982/83 to a 17.2% in 1986/87 indicating that the government sector trend is to less participation in financing of dental service.

The inverse proportion of the government dental contribution compared to medical service is probable because there are no large scale subsidised dental insurance schemes analoguous to the medical insurance arrangements. There are wide ranges of medical insurance benefits provided by the government such as : Hospital Benefits,

Table 71. Australian health expenditure, fiscal year 1982/1983 to 1986/1987.
(Adapted from Barnard 1989).

(in millions $)

Expenditure	1982/83	1983/84	1984/85	1985/86	1986/87
Government source	7,696	9,229	11,398	12,623	14,135
Private source	4,944	5,106	4,658	5,184	6,026
Total health expenditure	12,640	14,335	16,056	17,807	20,161
Health expenditure as percentage to GDP	7.16	7.44	7.52	7.58	7.55

Table 72. Australian dental health expenditure, fiscal year 1982/83 to 1986/87.
(Adapted from Barnard 1989).

(in millions $)

Expenditure	1982/83	1983/84	1984/85	1985/86	1986/87
Government source	135.318	145.708	159.512	166.935	171.582
Private source	439.321	540.187	619.647	775.380	821.505
Total dental expenditure	574.639	685.895	779.159	942.315	993.087
Dental expenditure as percentage to total health expenditure	4.5	4.8	4.9	5.3	4.9
Dental expenditure as percentage to GDP	0.34	0.36	0.37	0.40	0.38

Medical Benefits, Medicare Benefits, Pharmaceutical Benefits, Nursing Homes Benefits and Domicilliary Nursing Care Benefits.

On the other hand, government Dental Benefits is provided to a small proportion of the population such as pensioners, aboriginals, armed forces and indigent persons as have been mentioned previously. The other government Dental Benefits include Pensioner Denture Scheme, Royal Flying Doctor Service Dental Panel, Approved Dentists Scheme and Cleft Lip and Palate Scheme (Barnard 1989). The Approved Dentists Scheme covers Medical Benefits for service by dental practitioners. This provides patients access to Medical Benefits when the service is provided by Approved Dentists. The Cleft Lip and Palate Scheme provides benefits in respect to orthodontic services and some oral surgical services. For schoolchildren under the age of fifteen, the Federal goverment established a School Dental Scheme in 1973.

4.5 School Dental Service

The provision of dental services to schoolchildren in Australia has a long history and dates back to 1915, indicating that the concept that dental health program must start with the child is strongly held in this country.

As early as 1904, a meeting was held by the Minister of Public Instruction of New South Wales which considered the necessity of the implementation of school dental services (NSW Department of Health 1985). However, it was not until 1915 when the first travelling school dental service was established and dentists were appointed to deliver the service. Until 1946 little change was noted in the condition of the service in which 6 travelling clinics were in

operation. This stable condition was mainly caused by two basic difficulties ie : lack of treatment facilities and shortage of staff (NSW Department of Health 1985). Attempts were made in the 1940's and 1950's to increase the quantitative coverage and in 1959 equipped mobile clinics were introduced. A further progressive step was taken in 1962 when fully equipped fixed clinics were established at Naremburn, Parrammatta, Hurstville, Newcastle and Wollongong.

In response to the poor condition of children's teeth and lack of children's dental services, the South Australian government established its first school dental services in 1922 (Roder 1972, Blaikie and Weidenhofer 1978). Until 1968, the program had been staffed by dentists and chairside assistants and had been limited to fewer than three percent of the primary school population. It was not until 1969 that the South Australian School Dental Services adopted a static-design school-based system. However, the improvement in coverage was still gradual until 1973.

In the ACT, a School Dental Service was put into practice in 1949 when the Child Dental Health Service of the Commonwealth Department of Health was established. The objective of the service was mainly to provide regular and free dental treatment for children in the ACT (Carr 1957). However, no regular evaluation was performed.

On a national-wide basis, the actual provision of dental care to schoolchildren in Australia was greatly stimulated in 1973 with the establishment of the Australian School Dental Scheme (Commonwealth Department of Health 1980) following the creation of the Dental Services Branch within the National Health Division in 1972.

With the prime aim to improve the dental health and dental awareness of this sub-community group, the Scheme was obviously established in response to a need for provision of free dental care for all schoolchildren up to the completion of their primary school education. More specifically, the objectives of the Scheme were :

1. to reduce the incidence and severity of caries by both clinical and non-clinical methods of preventive care.

2. to reduce the prevalence of the existing dental caries by regular treatment of each patient.

3. to improve children's understanding and appreciation of good oral health and to motivate changes in dietary and oral hygiene practices that favour good oral health.

4. to establish the awareness amongst children of the concept of "good teeth for life" and thus establish the foundation of maximum oral health throughout all the community in the future.

It can be drawn from the above objectives that one of the basic principles of the Scheme is that prevention and dental education are regarded as integral parts of dental care. Basically the contents of the Scheme are : (1) comprehensive treatment to all schoolchildren except some specialist treatments, (2) dental health education and (3) clinical prevention.

At the commencement of the Scheme, it was agreed to put as a target that in 1980 the Scheme would cover all primary schoolchildren (Commonwealth Department of Health 1973). However, the target could not be achieved and only 40% of the primary schoolchildren population was covered in 1980 (Table 73). Table 73 shows the coverage of the Scheme from 1974 which peaked in 1986 with a 69% coverage. The difficulty in reaching a 100% coverage was percieved to be related with the lack of workforce, particularly dental therapists.

As stated in the Scheme's guidelines, the service in the Scheme is based on the training and employment of dental therapists working under the general direction and control of dentists (Commonwealth Department of Health 1980b). Therefore, the dental therapists are the primary provider of dental care in the Scheme.

The use of dental therapist was inspired by the employment of dental auxilliaries for treating schoolchildren in New Zealand. Following reports of a successful school dental program employing operating auxilliaries in New Zealand (Fulton 1951), the Federal Council of the Australian Dental Association advocated in 1965 for the employment of these auxilliaries in Australian school dental services system (Australian Dental Association 1968). The other support for the utilisation of these auxilliaries was from the National Health and Medical Research Council (NH&MRC 1965).

With this background, the first School of Dental Therapy was established in Tasmania in 1966 and shortly afterwards, South Australia opened its first School in 1967 (Roder 1972).

New South Wales established its first 2 Schools in 1974 at Westmead and Sylvania, together with four other Training Schools at Somerton Park (SA), Mt Henry (WA) and Stafford and Holland Park (QLD) (Commonwealth Department of Health 1975). A further five training schools were opened in 1976 at Shell Harbour (NSW), St Kilda (VIC), Yeronga and Townsville (QLD) and Warwick (WA). Some training schools were later closed for lack of funds and need. Currently there are 7 schools in operation with an average output of approximately 110 per year (Table 74).

Table 73. Coverage of the School Dental Scheme from 1974 to 1987. [Adapted from Carr (1980) and Barnard (1989)]

Year	Percent of coverage
1974	9.3
1975	11.0
1976	13.7
1977	16.9
1978	22.5
1979	30.1
1980	40.0
1981	38.2
1985	65.0
1986	69.0
1987	56.0

Table 74. Dental therapist output from 1982 to 1988. (Adapted from Barnard 1983, 1984, 1986, 1988, 1989).

Year	Number of training schools	Output
1982	8	176
1983	8	111
1984	8	148
1985	8	79
1986	8	80
1987	8	69
1988	7	102
Average output		109

Table 75. Clinics and dental therapist employed in the Australian School Dental Services, 1973 - 1981 and 1985 - 1987.

Year	Static clinics	Mobil clinics	Total clinics	Dental therapist
1973	149	74	223	120
1974	162	72	234	151
1975	179	79	258	192
1976	245	89	334	341
1977	297	103	400	515
1978	381	154	535	779
1979	517	178	695	1041
1980	572	242	814	1208
1981	618	279	897	1285
1985	359*	204*	563*	1254
1986	356*	208*	564*	1184
1987	695	311	1006	1134

* data for NSW, WA and NT are not available

Sources :
1. Commonwealth Department of Health (1975)
2. Commonwealth Department of Health (1978a)
3. Commonwealth Department of Health (1981)
4. Barnard (1989)

At the commencement of the Scheme it was calculated that the ratio of dental therapist to schoolchildren as high as 1 : 900 would be ideal. In reality the ratio has never been achieved. Futhermore, the production of dental therapist has been devastated by the closure of some training schools due to lack of funds.

One of the main problems concerning the operation of the Scheme has been the high resignation rate of dental therapists. By way of illustration, in South Australia the resignation rate in the period between 1973 and 1982 was 11% annually with the bulk attributable to family commitments (Klunder 1984). The other reason for resignation was a total lack of career opportunity in the future resulting a great dissatisfaction among dental therapists. It should be borne in mind that dental therapists may only work as public servants who at present are only allowed to treat schoolchildern in the School Dental Scheme. Roder (1980) suggested that the rationally expected resignation rate was 5% per annum.

With the present annual intake (as many as 110 dental therapists) combined with a 5% resignation rate and slightly increasing schoolchildren population, an irritating question arose : "would the ideal ratio be achieved ?".

The establishment of the Scheme in the early 1970's basically arose from concern about the level of dental decay in children. Consequently the main duty of the dental therapist was to cope with the problem of dental caries. The dental caries experience has now dropped sharply and the percentage of caries-free children is increasing, the writer suggests that the "corrected" ideal ratio be re-calculated. Provided that a dental therapist has 1650 working

hours and 20% of this figure is spent to deliver dental health education (Roder 1980) the actual clinical productive time would be 1320 hours per year. In 1986, the average DT and dt components for children aged 4 to 13 years were 0.39 and 0.75 respectively with the IT and it components being almost negligible (Commonwealth Department of Health 1987). The figures provide a total of 1.14 decayed teeth per child to be restored. Using this figure as an estimate and that 45 minutes is required to restore dental decay per child, a total of 1543 schoolchildren can be completely treated per year by one dental therapist suggesting that a ratio of 1 : 1500 would be acceptable.

Table 76 presents the total number of dental therapists, total schoolchildren population, and the ratio between them, from 1987 to the year 2000. The number of available dental therapists in operation in the next decade is calculated using an estimate of 110 intake and 5% resignation rate with the 1987 figure as the base of calculation. Since the long-term aim of the Scheme was to provide free dental care up to and including 14 year olds, the population of children in 5 - 14 age group are presented in the table.

It should be borne in mind, however, that some of the schoolchildren are not likely to participate in the School Dental Service since they are taken into private practice by their parents. Recent data from the Australian National Oral Health Survey (NOHSA) 1988 suggested that amongst children in 5 - 9 age group who reported to make dental visit during the previous year (79% of the sample), 65% utilised government services including school dental clinics. In the age group of 10 - 14 years, 82% of the interviewees attended dental services during the previous year and 48% of them were seen by

Table 76. Estimated number of dental therapist, schoolchildren population aged 5 to 14 years and therapist : children ratio, 1987 - 2000.

Year	Population of 5-14 age group	Number of children who are likely to utilise the SDS	Dental therapist available	Ratio
1987	2 466 200	1 233 100	1134	1:1087
1988	2 465 000	1 232 500	1187	1:1038
1989	2 469 400	1 234 700	1238	1: 997
1990	2 485 900	1 242 950	1286	1: 966
1991	2 506 700	1 253 350	1332	1: 940
1996	2 676 200	1 338 100	1492	1: 896
2000	2 818 000	1 409 000	1624	1: 867

government dental personnels. It can be estimated, therefore, that about 50% of the schoolchildren population have their dental problems treated by private practitioners and the remaining 50% are those who are likely to utilise school dental clinics.

Using this estimate for the calculation, the therapist : children ratio would be in the range of 1:1100 to 1:800 during this decade (Table 76). The ratio would be higher as the number of dental therapist increases. These figures are far higher then the re-calculated ideal ratio (1:1500).

In conclusion, the implementation of the School Dental Services in Australia obviously does not face any significant problem.

4.6 Water Fluoridation

As early as 1947 interest was shown by the Beaconsfield Municipal Council (Tasmania) in the possibility of fluoridating the water supply in that area. After having conducted some feasibility studies, official approval was finally given in 1952 to the scheme and in September 1953, Beaconsfield became the first Australian community to have their water supply fluoridated (Brothers 1956). Using sodium silico-fluoride as the reagent, a 0.2% fluoride solution was required in the reagent pump to provide 1 ppm fluoride in the reticulation system at the average temperature of 17^{o} C.

Although the district population at Beaconsfield was about 8,000 only 2,000 to 3,000 people were served by the water supply (Brothers 1956). This population receiving fluoridated water was almost negligible as a percentage of the total Australian population at that time. However, it was of paramount importance as a milestone in the history of preventive dentistry in the country, bearing in mind the strong opposition to fluoridation measures.

Ten years after the commencement of water fluoridation in Beaconsfield, the Public Health Act containing authorisation of fluoridation was passed by the Tasmanian Parliament although political support had been endorsed by the Tasmanian Health Department since 1953 (Chen and Martin 1967). Most cities in Tasmania had been fluoridated by the 1970's (Commonwealth Department of Health 1985), and 77% of the Tasmanian population is now receiving fluoridated water.

Fluoridation of Canberra's water supply was commenced in September 1964. Prior to fluoridation, the water supply in Canberra contained

less than 0.1 ppm fluoride. From September 1964 to April 1970, the mean concentration of fluoride in the water was 0.87 ppm and since April 1970 the concentration has been increased to 0.94 ppm (Carr 1972, 1976). There were 160,000 persons receiving fluoridated water in 1970 and the population increased to 220,000 in 1974. At present the ACT is the only territory in Australia to have 100% of its population consuming fluoridated water (Barnard 1989).

Yass, a country town of NSW, became the second city in Australia to be fluoridated (Commonwealth Department of Health 1985a). When the Fluoridation of Public Water Supplies Act was passed by the NSW Parliament in 1957 (Chen and Martin 1967), Yass, with the total population of 3970 had been artificially fluoridated for one year. It was not until 1968 that Sydney, the capital city of NSW, had its water supply fluoridated. With a total of 4.6 millions people receiving fluoridated water, NSW contributes the biggest proportion of population supplied with fluoridated water in Australia.

The Fluoridation of Public Water Supply Act was passed by the Queensland Parliament in 1963 (Chen and Martin 1967) and in 1964 the cities of Townsville and Biloela became the first cities to have their water supplies fluoridated in this State. However, less pleasing has been the trend of the coverage and up to now only about 5% of its population consumes fluoridated water.

Although there had not been any legislation and political policy on water fluoridation in Victoria, the city of Bachus Marsh, with a total population of 3,500 fluoridated its water supply in 1962. Most cities, including Melbourne, started fluoridation in 1977, and over 70% of its total population now consumes fluoridated water (Barnard

1989).

In 1966, the Western Australian Parliament passed legislation authorising mandatory fluoridation of water supply (Chen and Martin 1967). Two years later, fluoridation in Perth's water supply commenced. In the ensuing six months, the measure was progressively introduced to various cities in the State.

On the grounds of financial reasons the Northern Territory Administration postponed the fluoridation of water supply despite the Darwin City Council vote in favour of this measure in 1963 (Chen and Martin 1967). It was not until 1972, fluoridation of Darwin's water supply commenced and was introduced to several towns in the ensuing eight years namely Alice Spring (1974), Groote Eylandt (1981), Jabiru (1982) and Katherine (1982) (Commonwealth Department of Health 1985a).

In 1964, the South Australian House of Assembly appointed a Committee to assess the possibility of fluoridating the community water supply. In its report, the committee expressed the desirability to implement this measure (Chen and Martin 1967). Although there was also a favourable support from the State Department of Health, the South Australian Government had not considered to fluoridate its public water supply. It had to wait until 1971 when the city of Adelaide had its water supply fluoridated. The present figure shows that over 69% of the State's population consume fluoridated water (Barnard 1989).

Having been endorsed by the National Health and Medical Research Council, the Australian Medical Association and the Australian Dental Association (Chen and Martin 1967, Commonwealth Department of

Table 77. Total number and percentage of Australian population consuming artificially fluoridated water, 1966 to 1988.

Year	Population	Population using fluoridated water	Percentage
1966	11 599 498	457 300	3.9
1968	12 008 635	3 339 233	27.8
1975	13 506 800	6 418 100	47.5
1976	13 548 472	6 447 400	47.6
1977	14 047 000	9 462 400	67.2
1978	14 259 500	9 564 400	67.1
1979	14 376 400	9 639 122	67.0
1980	14 605 400	9 680 150	66.3
1981	14 926 800	9 808 450	65.7
1982	15 179 500	9 959 110	65.6
1983	15 369 200	10 065 700	65.5
1984	15 564 500	10 243 100	65.8
1985	15 751 510	10 370 158	65.8
1986	16 018 350	10 522 634	65.7
1987	16 248 836	10 666 976	65.6
1988	16 531 929	10 842 794	65.6

Sources :

1. Chen and Martin (1967)
2. Australian Department of Health (1976, 1977)
3. Commonwealth Department of Health (1978b, 1979, 1980a, 1983)
4. Barnard (1982, 1983, 1984, 1986, 1988, 1989).

Health 1985b), Australia has been experiencing water fluoridation since 1953. Table 77 presents the overall coverage of water fluoridation in Australia from 1966 to 1988. From 3.9% in 1966 the coverage increased to 27% in 1968. In 1975 the figure became 47.5%. The coverage peaked at a 67% in 1978 and slightly declined to 65.6% and has remained constant since then.

4.7 Contribution of Related Factors to the Declining Trends of Dental Caries Prevalence

That regular and complete dental treatment, such as in the School Dental Scheme, induces a slight lowering of the DMF figure of schoolchildren, was shown by Carr (1957). In a study conducted to assess the implementation of the Child Dental Health Services in Canberra, this worker found that the longer the children were experiencing the service the less the DMFT figure they had. It was assumed that the increase in the FT component experienced from the service reduced the number of open carious lesions that shelter bacteria resulting in some decrease in caries susceptibility (Carr 1957, Burt 1985).

To assess the effect of the School Dental Scheme on the DMFT figure, a comparison was made in 1977 between children who had been under the care of the Scheme for three or more years (group A) and those who were first examined (group B) (Commonwealth Department of Health 1980). The figures presented in table 78 show that there is a slight reduction of DMFT figures in children aged 8 to 12 years in group A than their counterpart (group B) varying from the order of .4 to 8 percent.

Beside the reduction in caries susceptibility assumed by Carr (1957) and Burt (1985) the slight reduction in DMFT might be caused by the successful dental health education which is an integral part of the service. The possibility of this assumption is supported by data showing improvement in children's oral hygiene (Table 79) indicating that there has been an increase in dental awareness amongst the children. It can be concluded, therefore, that the regular and complete dental treatment combined with intensive dental health

Table 78. Comparison of mean DMFT between children who had been under the care of the School Dental Scheme for three or more years (group A) and those who were first examined (group B) in 1977.
(Adapted from Commonwealth Department of Health 1980).

Age	Sample size		DIMFT		Percent reduction
	A	B	A	B	
8	6865	9955	1.86	2.04	8.8
9	8835	8462	2.50	2.61	4.2
10	9538	8155	3.08	3.30	6.6
11	9472	8186	3.85	4.08	5.6
12	5271	4355	4.76	5.03	5.4

Table 79. Comparison of mean debris, calculus and oral hygiene index between children who had been under the care of the School Dental Scheme for three years or more (group A) and those who first examined (group B) in 1977.
(Adapted from Commonwealth Department of Health 1980).

Age	Group A			Group B		
	DI	CI	OHI	DI	CI	OHI
8	1.9	0.1	2.0	2.6	0.1	2.7
9	1.8	0.1	1.9	2.6	0.2	2.8
10	2.0	0.1	2.1	2.6	0.2	2.8
11	1.8	0.1	1.9	2.7	0.3	3.0
12	2.0	0.1	2.1	2.8	0.3	3.1

education led to the reduction of dental caries prevalence. However, the reduction is very small, varying from 4 to 8 percent in the period of three or more years. Compared to the great decline in dental caries prevalence, this is almost negligible. Therefore, it does not seem that the effect of the School Dental Scheme itself has a great impact on the overall reduction that has been noted.

An other factor which could influence the trend is sugar consumption. There has been some change in sugar intake, however the total sugar consumption has remained constant. Obviously, there was a marked reduction in use of refined sugar in households from 32.0 kg in 1938/39 to as low as 8.6 kg per person per year in 1986/87. On the other hand sugar consumption from manufactured foods more than doubled from 16.3 kg per person per year in 1938/39 to 35.3 kg per person 1986/87 (Table 80). This kept the total sugar consumption high and constant at a level of around 50 kg per capita per annum. Based on this fact, it can be justified that the declining trend of dental caries prevalence is not related to the pattern of sugar consumption in this country, which has remained relatively constant for over five decades.

Having two factors, implementation of the School Dental Scheme and sugar consumption, shown to be unrelated to the trend, the declining prevalence must have been resulted from the influence of fluoride use.

The available data suggest that the use of fluoride in various forms by Australian schoolchildren falls into three categories ie : (1) water fluoridation, (2) fluoride dentifrices and (3) fluoride supplement. Little is known on the extent of the use of other forms

Table 80. Per-capita sugar consumption in Australia from 1938/1939 to 1986/1987.
(Australian Bureau of Statistics 1989).

(in kilogram)

Type of sugar	1938/39	1948/49	1958/59	1968/69	1978/79	1986/87
As refined sugar	32.0	31.2	27.0	21.0	14.9	8.6
In manufactured foods	16.3	23.1	23.6	27.7	34.6	35.3
Total*	50.8	56.8	53.0	51.9	54.5	49.9

* include sugar content of syrups, honey and glucose.

of fluoride such as professionally and personally administered topical application and fluoride mouthrinsing.

The implementation of water fluoridation in Australia has been mentioned previously and currently it covers over 65% of Australian total population. Previous studies consistently showed that the use of water fluoridation could reduce dental caries occurence by a magnitude of 50 to 60%. On the other hand, studies on the efficacy of fluoride dentifrices provided a varying results depending on the compound added in the toothpaste, the concentration of fluoride ions and whether or not the study was supervised. However studies suggested that a 20 to 40% caries reduction could be achieved by this measure.

Systemic fluoride supplements also produced varying outcomes. This depends on the age of the child, frequency of administration and the dose of the tablets, but in the majority of school based fluoride tablet studies reductions of 20 to 40% were observed (Haugejorden and Heloe 1981). Whereas in an extensive review of 51 home-based trial conducted between 1949 to 1978, Murray and Rugg-Gunn (1982) suggested that a 40 to 80% caries reduction could be expected in both deciduous and permanent teeth if suplementation is commenced before 2 years of age.

In order to estimate the relative contribution of these fluoride forms, the factors must be simultaneously modelled into a mathematical equation. Three studies have been conducted by Spencer (1984, 1986a, 1986b) to formulate the equation model by using a multiple regression statistical analysis.

On the grounds that topical effect at the tooth surface have been

suggested as the more important mechanisms of fluoride action, Spencer (1984) hypothesized that the benefit of water fluoridation was more strongly related to the proportion of life time exposure than to a limited period of exposure during tooth formation. Based on this assumption, a calculation was made to set up a series of data concerning the mean proportion of life time exposures of Australian adolescents at age 12 to 17 years from 1965 to 1990. The calculation was based on the history of the introduction of water fluoridation in each city and geographic distribution of the total population in those cities.

As a second predictor, the proportion of the adolescents who regularly used a fluoride supplement was calculated from the available data reported by Crisp (1968), Prichard (1969) and McEniery and Davies (1979)(Table 81). From these data Spencer made a regression equation ($Y = -33.03 + 1\ X_1 - 22\ X_2$, where Y = proportion of regular users of fluoride supplements, X_1 = year and X_2 = age) on which interpolation and extrapolation to various ages and years can be done. This method provided a series of data set concerning the proportion of regular users of fluoride supplements from 1965 to 1990 in the age of 12 to 17 years.

The market share of fluoride dentifrices in Australia has risen markedly from a 26% in 1971 to as high as 94% in 1982 (Table 82) and has remained constant since then. To estimate the market share held by fluoride dentifrices before 1971, an extrapolation was made.

In addition to these three predictors, Spencer (1986a) introduced 2 interaction variables into the model. Interaction model 1 was built by multiplying the proportion of life time exposures to fluoridated

Table 81. Data available on percentage of Australian children and adolescents who regularly use fluoride supplements. (Adapted from Spencer 1986b)

Year	Age					
	6	7	8	10	12	14
1966[1]	-	-	6.2	-	-	-
1967[1]	-	-	13.6	-	-	-
1967[2]	27.5	24.1	18.8	-	-	-
1877[3]	29.0	-	23.0	26.0	29.0	14.0

1 data from Crisp (1968)
2 data from Prichard (1969)
3 data from McEniery and Davies (1979)

Table 82. Market share held by fluoride dentifrices in Australia 1971, 1976 and 1982. (Adapted from Joint FDI/WHO Working Group 1985)

Year	share of market (percent)
1971	26
1972	62
1982	94

water and market share held by fluoride dentifrices. The rationale of the introduction of this variable was the proposition that if a sample had already received the benefits of a fluoridated water supply, the benefit of fluoride dentifrices was likely to be diminished from what it might have been in the absence of fluoridated water supply (Spencer 1986a). Interaction variable 2 was developed from the product of proportion of lifetime exposures to fluoridated water supplies, market share held by fluoride dentifrices and age. The purpose of the introduction of this variable was to allow for the influence of age on DMFT to vary (Spencer 1986a). Also entered into the model were indicator variables for socio-economic bias which was divided into two categories ie: low and high society.

The outcome of the statistical analysis using a multiple regression method was as follows :

$$Y = -9.6 + 1.38\ X_1 + 5.27\ X_2 - 2.72\ X_3 - 1.37\ X_4 + 19.62\ X_2X_4 - 1.59\ X_1X_2X_4 + (1.75\ X_5 - 1.23\ X_6)$$

where :

Y = caries severity expressed as DMFT

X_1 = age

X_2 = proportion of life time exposures to optimally fluridated water supplies

X_3 = proportion of regular users of fluoride supplements

X_4 = market share held by fluoride dentifrices

X_5 = indicator variable for low socio-economic bias

X_6 = indicator variable for high socio-economic bias

The analysis of variance approach for the hypothesis testing provided F statistics = 220.1 which was highly significant ($p < 0.001$), with multiple correlation coefficient = 0.98.

The importance of this model is that the relative contribution of the three predictors measured (fluoridated water, fluoride supplements and fluoride dentifrices) can be estimated. In order to answer this question Spencer (1986b) further provided results that in 1980, for 12 year old children some 63% of the overall caries reduction since 1965 was attributed to water fluoridation, 32% to fluoride dentifrice, and another 5% to the regular use of fluoride supplements.

These studies are not free from limitations. The DMFT data used in building the model were collected from different local studies in which different examiners and diagnostic criteria might have been used. In addition, in estimating the proportion of regular users of fluoride supplements by way of interpolation and extrapolation from a regression equation has produced a bias in which the data would be more likely to highly correlated with the DMFT.

However, the studies conducted by Spencer have been able to give an indication of the relative contribution of the three fluoride vehicles when they are simultaneously used.

It can be justified, therefore, that from the overall reduction of caries prevalence in Australian schoolchildren, the use of fluoride has played a prominent role in which water fluoridation provides the greatest effect, followed by regular use of fluoride dentifrices and the least is regular use of fluoride supplements. It is not

surprising that the regular use of fluoride supplement has the least effect because children are more likely to cease consuming fluoride tablets when they start drinking fluoridated water. The discussion also suggests that the regular implementation of School Dental Services has less effect than that of the use of fluoride, and the pattern of sugar consumption has not proved to be related to the declining trend.

5. INDONESIAN STUDY

5.1 Demographic Background

Indonesia is the world's most expansive archipelago, stretching almost 5,300 km from Sabang (95° east longitude) to Merauke (141° east longitude) and 1800 km from 6° north to 17° south latitude. It divides the Pacific and Indian Oceans at the equator and stretches between the Asian and Australian continental mainlands. Consisting of five main islands and 30 smaller archipelagoes, it has a total of 13,677 islands, 6000 of which are inhabited. The five main islands are Sumatra, Java, Kalimantan, Sulawesi and Irian Jaya. Divided into 27 provinces, the country has 302 regencies/municipalities and 3576 districts (BPS 1986).

Located on the equator, Indonesia has a tropical climate with plentiful rainfall. The high rainfall and the tropical heat (average temperature ranging from 28° to 32° C) makes for a very humid climate ranging from 85 to 90%.

The 1980 census put the country's total population at over 146 million, 78% of whom live in rural areas. Compared with the 1971 figure (120 million), Indonesia's population was growing at a rate of about 2.34% per year in that decade (Ministry of Health 1988). Between 1980 and 1985 the rate decreased to 2.15% per year. This was partly contributed by the decreased Crude Birth Rate (CBR) to about 31.47 per 1000 population in the same period. Having massive family planning programs, it was estimated that the CBR would decrease to 23.2 per 1000 population in the period 1995-2000 which would lead to a declining population growth rate of 1.58% per year in the same period. If the growth rate continues as it is expected,

the population would be around 216 million by the turn of the century (Table 83) (BPS 1987).

Regarding children in the schooling age at primary levels (7-12 year old), the 1980 census revealed a total of 24 million children in this age group. By the year 2000 the population of this age group would be over 35 million (Table 84).

With that large population, the country is obviously still facing many problems in the health sector. The morbidity rate is considerably high although it shows a declining trend. Gastrointestinal diseases and nutritional deficiency are still prevalent among infants especially in rural areas including vitamin A, iron and iodine deficiencies. The national crude death rate (CDR) in the period 1971-1980 was 13.2 per 1000 population. However it appears to show a declining trend which leads to the CDR of 10.5 in the period 1980-1985. This declining trend of the CDR causes an increase in life expectancy. In 1980-85 the life expectancy at birth was 56 years which was very low compared to that of developed countries. With the declining trend of the CDR, it is estimated that the life expectancy at birth would increase to 70 years in the period 2000 - 2005 (Ministry of Health 1988).

5.2 Dental Health Services System

Dental health services in Indonesia are virtually shared by both government and private sectors. Although the exact proportion of contribution is not known, it is strongly believed that the vast majority of the services are delivered by the government side. The private sector renders mainly curative treatment and this is mostly

Table 83. Indonesia's population estimates by age group, 1985-2005 (BPS 1987)

(in millions)

Age group	1985	1990	1995	2000	2005
0 - 14	63.932	66.567	67.137	68.277	67.539
15 - 64	95.081	108.904	123.748	137.409	151.678
65 +	5.616	7.179	8.762	10.429	12.195
Total	146.629	182.650	199.647	216.115	231.412

Table 84. Estimates of schooling age at primary levels population (7 - 12 year old)* by rural and urban area. (BPS 1987)

(in millions)

Area	1980	1985	1990	1995	2000
Rural	19.337	21.705	24.063	26.302	28.472
Urban	4.954	5.560	6.165	6.738	7.294
Total	24.291	27.265	30.228	33.040	35.766

in urban areas to a certain group of the community on an individual basis. Government dental services, on the other hand, include not only curative measures but also prevention, promotion, (dental) health education, screening and monitoring dental epidemiology and, to some extent, organising community participation such as activation of community leaders and selection of dental health volunteers to share the government responsibility in their own local areas.

Similar to that in the general medical sector, the dental health services system is very complicated (especially in terms of financing) and involves various bodies and levels of management. However, basically it can be expressed that it is structured with three levels of governing bodies at central, provincial and regency levels (Tomasowa 1981).

At the central level, the management is carried out by the Directorate of Dental Health which is part of the Directorate General of Medical Care in the Ministry of Health. This central body is managed by a Director who has a national-level responsibility in dental health care policy formulation, including directing, planning, monitoring and evaluation of the national dental health service. It consists of five Sub-Directorates, ie: Preventive Dentistry, Research and Development, Health Service, Referral and Integration and Professional Development.

At the provincial level, a Provincial Dental Officer (PDO) is the person in charge of implementation of the oral health programs in its corresponding territory. A PDO is responsible to the Provincial Medical Officer (PMO) who manages the whole administrative structure

at the provincial level. In other words, a PMO represents the national body in a provincial jurisdiction. It is unique that a PMO has a dual function. With regard to provincial government authority, a PMO has a high degree of automomy in the decisions on the health care delivery within the provincial structures of health services. In this case, the PMO is accountable to the Governor. On the other hand, a PMO acts as the Deputy of the Minister of Health and is responsible for the execution of the national health care policy in that province. This dual function, that is also owned by a PDO, provides authority to modify the definite set-up national programs according to the provinces' conditions and priority.

At the regency level, a similar structure to that of the provincial level is established. Regency Medical Officer is responsible for the structure which covers several basic health care service units, ie: Community Health Centres (CHCs).

As a primary health services unit, a CHC is virtually the first contact point between the community and the system. The establishment of CHCs was initiated in 1968 based on the philosophy that the units would provide basic health services through an integrated and comprehensive community care. The CHCs are located in district (sub-regency) levels with a condition that a district could have more than one CHC depending on the total population covered and how large the area is. In some cases a CHC could have one or two satellites set up in remote areas.

The CHC constitutes a health service package consisting of 12 essential services in the following:

1. Medical care
7. Health education

2. Maternal & child health
3. Family planning
4. Communicable disease control
5. Environmental hygiene
6. Community health nursing
8. Nutrition
9. School health services
10. Dental health
11. Mental health
12. Laboratory Services

However, not all CHCs could cover these complete services and some CHCs provide only very limited range of services. Ideally, CHC staff consist of a physician (who acts as the CHC manager), a dentist, several nursing personnel, a dental nurse, a sanitarian, a pharmacist and some clerical staff. In addition, the CHC also serves as the base for school health programs including dental health.

Up to 1988 there were 5524 CHCs out of which 3164 (57%) were completed with dental facilities. (Ministry of Health 1989). A total of 5270 physicians and 1977 dentists are employed in the CHC throughout the country. The figures show that the ratio between dentists and the CHC which have dental facilites would be 1: 1.8.

In the regency, provincial and central levels, general as well as dental health care is rendered by hospitals. Compared to the CHC, hospital services are more clinical and less community oriented, more curative and less preventive. According to their sophistication, facilities (specialists, equipment and beds available) and expected catchment area, there are four types of hospitals, ie: types A, B, C and D. Basically, type D hospitals are located at the regency level, types B and C at the provincial level, whereas type A hospitals are set up at central level. Dental care is an integral part of hospitals' services. Since health services

in the CHC stress prevention, promotion, simple restorative and contingency curative care, complicated cases are referred to regency hospitals, provincial hospitals and the highest referral at central level. Recent data revealed that there are two type A, 15 type B, 79 type C and 219 type D hospitals. Dental clinics are completed in all of those types A, B and C hospitals, whereas only 210 (96%) of type D hospitals have dental services in their outpatient polyclinics (Roder 1987).

5.3 Health Expenditure

The national expenditure for health in 1986/1987 was reported to be as much as Rp. 2,615.9 billions (Bureau of Planning Ministry of Health 1987). As much as 35% out of this amount was expended by the government and the other 65% was contributed by the private sectors. These percentages show that the vast majority of the expenditure was placed upon the private or non-government's responsibility. From the government source, the finance comes from various levels of funds. Basically there are six sources of funds on the government side as follows:

1. Sources at central government (in relation with the Ministry of Health).
   a. Central Ministry of Health Development Budget.
   b. Central Ministry of Health Routine Budget.
   c. Non-salary Expenditure Grant for Regional Government.

2. Sources at provincial government
   a. Provincial Health Department Development Budget
   b. Provincial Health Department Routine Budget.

3. Source at regencial government

   a. Regencial Health Department Development Budget.

   b. Regencial Health Department Routine Budget.

4. Source at other Ministries (Ministry of Defence and Security for health expenses of the Armed forces, Ministry of Education and Culture, Ministry of Religion and Ministry of Transmigration).

5. Sources at the state-owned companies under the Ministry of Health.

6. Foreign Assistance.

In the private sector, four kinds of sources are involved in financing the national health expenditure, ie:

1. Household or individual in the form of out-of-pocket money or direct payment.

2. Finance for health expenditure for the employees (and their dependants) of private companies and state-owned companies other than those under the Ministry of Health.

3. Financing through Health Insurance Companies.

4. Funds raised from social activities and charities.

The national health expenditures in the fiscal year 1982/83 to 1986/87 are presented in Table 85. It is obvious that the expenditures had, in that five year span, been showing a less pleasing trend. Comparing the 1986/1987 figure (2,616 billions),to that of 1982/83 (1,834 billions), it can be calculated that there

Table 85. Indonesian national health expenditure, fiscal year 1982/83 - 1986/87.
(Adapted from Bureau of Planning Ministry of Health 1987)

(in billions Rp)

Source	1982/83	1983/84	1984/85	1985/86	1986/87
Government	586	655	715	842	917
Private	1,248	1,291	1,379	1,565	1,699
Total					
- Nominal	1,834	1,945	2,094	2,407	2,616
- Constant price 1983	2,061	1,945	1,921	2,111	1,855

Note :
The selection of 1983 as the base year was based on the observation that on a national scale economic condition in 1983 was sufficiently normal and satisfactory, although the 1982's economic recession impact was still felt (BPS 1985).

was a 42.6% increase, or a 8.5% annual increase. However, when the figures are adjusted to the basis of 1983 prices, it is evident that there was about a 10% decline or an average of 2% decline per year in health expenditure when adjusted for inflation.

With regard to per capita expenditure on health, the situation does not differ much from that of national figures (Table 86). In 1982/1983 and 1986/87 the per capita expenditures were Rp 11,858 and Rp 15,561 respectively, which showed a 31.2% increase. However, when the figures were adjusted to the basis of 1983 constant prices, deterioration seemed to be taking place. Using that adjusted figure, it can be calculated that there was 17% less funds spent in the health sector in 1986/87 compared to that of 1982/83.

When the expenditures were converted to the US dollar, the situation was much worse. In 1982/83 a total of $17 was spent to health whereas in 1986/87 the figure became as low as $9. There was a relative decline of 47% within a five year period of time. These figures were lower than other countries which had the same per capita income as that of Indonesia and were even smaller when compared to that of the rest of the ASEAN countries (Bureau of Planning Ministry of Health 1987). In comparison to developed countries, in 1985, Australian per-capita health expenditure was US$655 (calculated from Barnard 1988) and in the USA in 1982 the figure was US$1407 (Bureau of Planning Ministry of Health 1987).

From the Gross Domestic Product (GDP) point of view, it can be seen that the trends of health expenditure within that period of time remained stable (Table 87). The percentage of the total health expenditure as against the GDP was 2.93% and 2.71% in the 1982/83

Table 86. Per-capita health expenditure of Indonesia, fiscal year 1982/1983 - 1986/1987.
(Adapted from Bureau of Planning Ministry of Health 1987)

Expenditure	1982/83	1983/84	1984/85	1985/86	1986/87
Nominal (Rp)	11,858	12,304	12,957	14,574	15,561
1983 constant price					
* Rp	13,325	12,304	11,887	12,790	11,036
* US$	17	12	12	13	9

Table 87. National health expenditure as percentage of gross domestic product (GDP), fiscal year 1982/1983 - 1986/1987.
(Bureau of Planning Ministry of Health 1987)

(in billions Rp)

Expenditure	1982/83	1983/84	1984/85	1985/86	1986/87
Gross Domestic Product	62,646	73,679	87,535	94,491	96,489
National Health Expenditure	1,834	1,945	2,094	2,407	2,616
National Health Expenditure as Percentage to GDP	2.93	2.64	2.40	2.54	2.71
Government Health Expenditure as Percentage to GDP	0.94	0.89	0.82	0.89	0.95

and 1986/87 fiscal years respectively which showed a slight decline. Compared to the WHO standard, which is 5%, the figures were obviously very low. Australian health expenditure in 1985/86 as a percentage of GDP was 7.25% (Barnard 1988).

As the government's contribution to the health expenditure was only around 35%, any effort to increase the percentage of health expenditure as against the GDP would involve mainly the government role. However, as the percentage of government financing for health as a percentage of the GDP remained stable at 0.9%, attempts to raise the percentage seems to be difficult.

Due to the lack of data, the dental expenditure is difficult to estimate. In the private sector, there has not been any study conducted to reveal the contribution to the dental expenditure by households, individuals and private enterprise. On the government side, the circumstances remain the same since the finance allocation to each utilisation unit is not categorised to either dental or medical purpose. However, an estimate has been put forward that dental expenditure by the government source would be about 1% of all government health expenditure (Effendi 1989).

The only available data were the finance from the Central Ministry of Health Development Budget source. The figures, however, definitely do not indicate any trend since in gaining the funds the Directorate of Dental Health had to compete with other Directorates. Basically the decision on how much would be purchased through the Directorate of Dental Health is based on the priority scale set up on each occasion at the General Directorate level.

In estimating the future trends of dental as well as general health

expenditure in the forthcoming years, the projected GDP calculated by the Central Bureau of Statistics can be utilised.

The projected GDP was based on the estimated GDP growing rate calculated by the World Bank as much as 2.3% in 1988, 3% during the period 1988-1990 and 4% for the period 1991-1994. Using the same percentage of the government source against the GDP (0.9%) the future figures could be estimated (Table 88). In nominal value, what could be expected from that estimation is that not much difference in the health expenditure would be taking place in the future. The implication of this circumstance in dental health services is that there would not be any significant change in the forthcoming years. With regard to dental preventive measures as well as school dental services, the improvement, if it is there, would be at the same rate as that of the previous years.

Table 88. Projected GDP and estimated government source health expenditure (calculated at 0.9% of the GDP)

(in billions Rp)

Expenditure	1988/89	1989/90	1990/91	1991/92	1992/93	1993/94
GDP	102,065	105,535	109,123	113,489	118,803	122,748
Government sources health expenditure	898	929	960	999	1,039	1,080

5.4 Dental Manpower

Having been previously served by traditional healers and artisans, Indonesia proceeded into the era of modern dentistry in 1928 with the establishment of the first dental school in Surabaya. However, until the 1940's there was no evidence that dental practitioners were committed to community oriented programs. It was reported that in that decade there were fewer than 200 dentists who served as private practitioners (Tomasowa 1981). It was not until 1950 that dentistry was organised on a community basis which was mainly directed by the central government.

With the establishment of modern dental schools in the 1950's and 1960's in four cities, Jakarta, Bandung, Yogyakarta and Surabaya, the production of dentists rose sharply. As the government initiated the development of Community Health Centers (CHCs) in 1968, most young graduates were deployed in those service units and obvious community oriented programs have been implemented since then.

The increase in productivity of health manpower, however, was not concomitant with the increasing population growth. On the other hand, geographical conditions have been a significant burden on the distribution of health manpower. Obviously the country still faces three major problems regarding health manpower, ie: (1) low productivity (2) uneven distribution and (3) manpower stagnation (Ilyas and Teja 1989). With regard to the level of productivity, Ilyas and Teja (1989) revealed further that, based on a study conducted in six CHCs in West Java, there was only a 53.2% effective worked hour spent by CHC staff. That percentage could be further broken down into 39.9% which was utilised for supporting services

such as administrative duties and, therefore, only 13.3% of CHC staff's working hours was spent in providing actual curative services.

As previously mentioned, the latest data showed that there were 5244 CHCs set up in Indonesia of which 3164 were complete with dental services. The data also showed that a total of 1799 dentists and 1730 dental nurses were employed in the CHCs throughout the country. That dental manpower is unevenly distributed, can be seen in table 89 which shows the different ratio of dentist to population in each province. Table 89 also demonstrates that 66.4% of the dentists are posted in Java which is considered to be more "promising" than any other island. By comparing the number of dentists per CHC in each province, the lack of even distribution is clearly shown (Figure 7).

In its plan, the Directorate of Dental Health has set up a target to have a total of 6990 dentists in the year 2000 (Directorate of Dental Health 1982). This total would give one dentist to 30,000 population. The target total is logically acceptable if it is related to the low utilisation rate. The 1971 Household Survey revealed that the utilisation rate was as low as 0.1% and increased by 100% to become 0.2% by 1980. If the utilisation rate continues to grow at that rate, it could be expected that in the year 2000 it would reach 0.8%. Given a total population of 216 million in the year 2000, there would be 864,000 people seeking dental treatment. The total would give a ratio of dentist to population as high as 1:125 persons seeking treatment. However, this calculation does not apply to the situation if the future planning of dental manpower is

Table 89. Population and primary dental services in Indonesia by province, 1988.

Province	Population (millions)	CHC	CHC with dental service	CHC dentist	Population served by a dentist
Aceh	3.158	149	31	24	131,000
North Sumatra	9.887	303	140	124	80,000
West Sumatra	3.924	156	115	32	122,000
Riau	2.655	104	73	27	98,000
Jambi	1.889	83	57	13	145,000
South Sumatra	5.755	187	84	31	185,000
Lampung	6.772	135	95	31	218,000
Bengkulu	1.026	79	36	9	114,000
Jakarta	8.465	308	92	226	37,000
West Java	32.625	716	394	306	107,000
Central Java	28.127	706	490	267	105,000
Yogyakarta	2.938	113	85	70	42,000
East Java	32.013	827	605	327	98,000
West Kalimantan	2.883	149	82	33	87,000
Central Kalimantan	1.195	101	53	5	239,000
South Kalimantan	2.371	161	70	19	125,000
East Kalimantan	1.782	113	82	27	66,000
North Sulawesi	2.453	119	81	33	74,000
Central Sulawesi	1.662	74	40	32	52,000
South Sulawesi	6.765	249	173	41	165,000
South East Sulawesi	1.154	68	38	6	192,000
Bali	2.747	91	60	46	60,000
West Nusa Tenggara	3.171	91	30	27	117,000
East Nusa Tenggara	3.099	143	41	2	1,550,000
Maluku	1.702	102	53	16	106,000
Irian Jaya	1.396	132	50	21	66,000
East Timor	.629	65	14	4	157,000
Total	172.243	5524	3164	1799	96,000

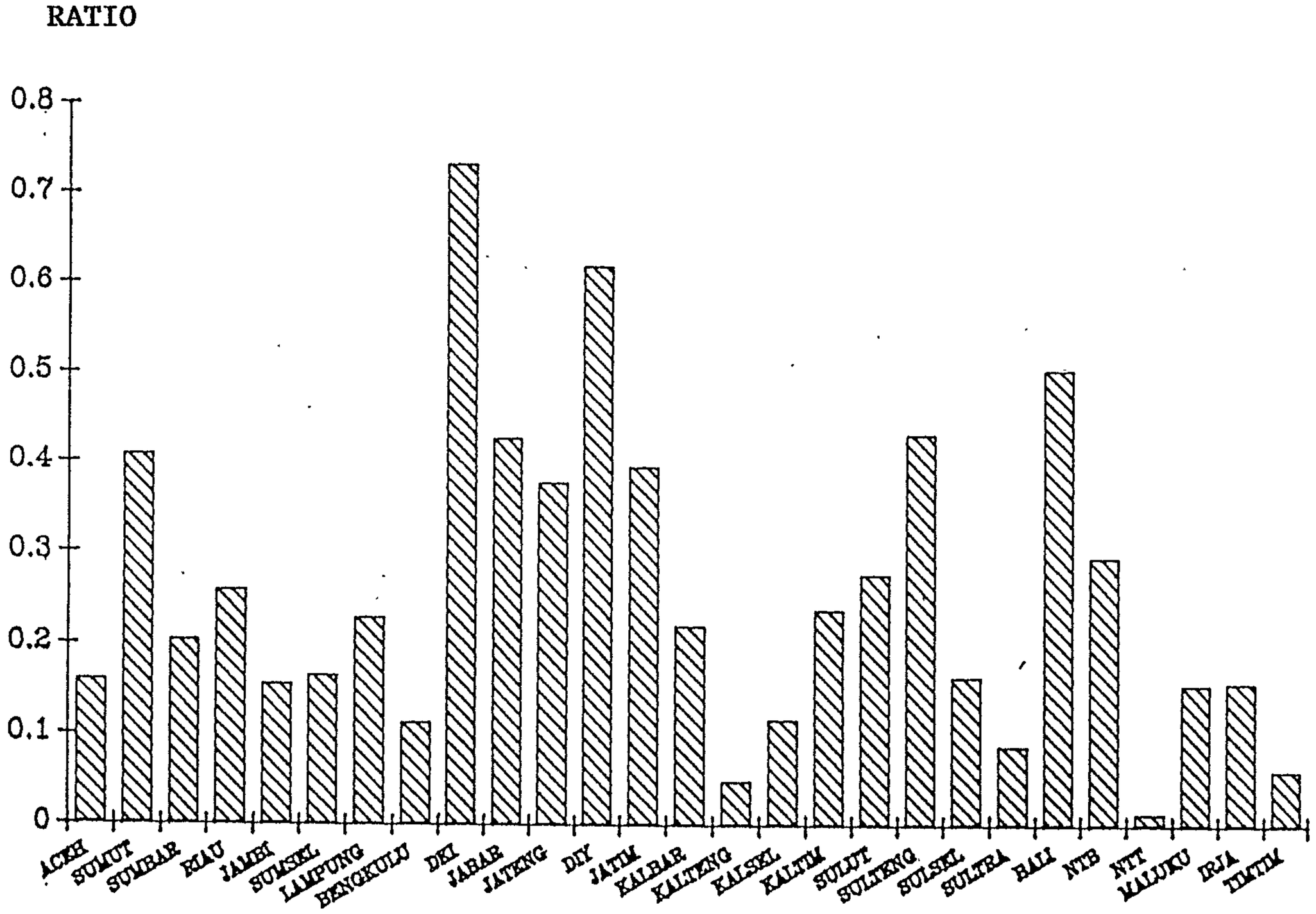

Figure 7. Dentist : Community Health Centers ratio by province. (Ministry of Health 1988)

put in the context of School Dental Services where no active participation of schoolchildren is expected.

It is estimated that 67% of the target total dentists would be employed in the Ministry of Health, about 10% out of whom would be serving in managerial positions and another 5% would be deployed in the hospitals, (Directorate of Dental Health 1982). As a result, it would provide a total of 4000 dentists employed in the CHCs in the year 2000. Compared to the 1988 figures (1799 dentists), it can be calculated that an annual intake of about 200 dentists is required. A question arising from this is: "could that intake be achieved?".

Based on the projected health expenditure and WHO consultancy (Godfrey 1982) there would not be any immediate action in increasing health manpower since it would not be supported by financial considerations. Therefore, the intake should be in line with the previous rate which matches the existing ability of the government to absorb dentists. Examining the absorbtive capacity of the government to employ dentists in the last five years, it seems that the expected annual intake would be met. Table 90 depicts that in the period of 1984-1988, new positions increments made available by the government for dentists ranged from 200 to 866 with the average of about 380. Therefore, the expected annual intake would not cause any pressure on the government's economy.

With regard to dental graduate outputs, the 8 dental schools (2 of which are private schools) appear to be able to supply the planned annual intake. Table 91 shows that in the period 1984 to 1987 the output ranged from 431 to 700 dentists. Whereas the estimated dental graduate output in the period 1990 to 1994 would be in the

Table 90. New dentists deployed in Community Health Centers, 1984 - 1988.
(Directorate of Dental Health 1989b).

Year	Regular Program	Crash Program	Total
1984	209	100	309
1985	108	100	208
1986	100	100	200
1987	224	100	324
1988	666	200	866

Table 91. Dental graduate output from 8 universities, 1984 - 1988
(Directorate of Dental Health 1989a)

University	1984	1985	1986	1987	1988
USU	33	51	77	78	32
UI	27	77	72	68	61
USAKTI	91	103	129	25	160
UPDM	41	56	184	12	70
UNPAD	47	48	29	46	n.a
UGM	61	82	95	100	n.a
UNAIR	107	101	90	117	n.a
UNHAS	24	22	24	45	n.a
Total	431	540	700	491	n.a

Table 92. Estimated dental graduate output from 8 universities, 1990 - 1994.
(Directorate of Dental Health 1989a)

University	1990	1991	1992	1993	1994
USU	81	82	82	88	88
UI	70	70	70	70	70
USAKTI	100	100	100	100	100
UPDM	132	79	79	94	84
UNPAD	60	60	60	60	60
UGM	82	95	100	103	104
UNAIR	136	94	86	95	148
UNHAS	45	45	45	45	45
Total	706	625	622	655	699

Table 93. Dental nurses deployed in Community Health Centers, 1984 - 1988.
(Directorate of Dental Health 1989b)

Year	Regular program	Crash program	Total
1984	16	66	82
1985	100	100	200
1986	62	100	162
1987	100	100	200
1988	600	250	850

order of 600-700 per year (Table 92). Furthermore, there is no doubt that they would be absorbed by the private sector since under the government rules, new graduates are initially committed to government service. The only problem that appears to occur in deploying dentists in the CHC seems to be the large number of female graduates (over 70%) who frequently have family commitments which preclude their transfer to remote rural areas. Therefore, while the target would be quantitatively met, the distribution may tend to be much worse.

With regard to operating dental auxilliaries, the Directorate of Dental Health has set up a target to employ at total of 10315 dental nurses in the year 2000. It was estimated that 8700 (85%) of them would be stationed at CHC level (Directorate of Dental Health 1982). Compared to the 1988 figure (1730), it can be calculated that an increase to about 640 dental nurses is required annually. Examining data for the last five years, the absorbtive capacity of the Ministry of Health to deploy dental nurses ranged from 82 in 1984 to 850 in 1988 with the average of about 299 (Table 93). Therefore little doubt is perceived if the absorbtion could be increased in line with the requirement. On the other hand, the production of dental nurses from 18 dental nurse schools is about 570 annually (Roder 1987). It could be estimated, therefore, that the target could not be fulfilled unless the production and government intake were increased.

5.5 School Dental Services

The implementation of School Dental Services in Indonesia was started in the 1950's but this was limited to big cities on an

occasional basis (Directorate of Dental Health 1977). With the establishment of the CHC in 1968 School Dental Services were incorporated into the CHC service and handled by the CHC staff. Consisting of three types of services (curative, preventive and dental health education), the program delivered an Incremental Care System for a small number of schoolchildren with the emphasis on curative care. This system consisted of initial care for those children entering the schools and was followed up with annual maintenance care for the second to sixth graders.

On the grounds of lack of manpower and the considerable caries increment (0.5 DT per child/year), it was realised that the system was not suitable for Indonesia's conditions since it provided a very limited coverage of children. Based on the government policy to enlarge the coverage of the School Dental Services, the system was then substituted with a Selective Care System to spread the available dental manpower. The system was put into practice in 1979 with emphasis on preventive efforts. It comprises 2 activities, ie: (1) promotive-preventive and (2) selective treatment. The promotive-preventive service includes: dental health education, scaling and oral hygiene instruction, caries prevention using fluoride mouthrinsing and primary orthodontic prevention. The selective treatment consists of: comprehensive care for the sixth graders and treatment on demand for the first to firth graders including relief of pain, control of infection and simple restorative treatment.

It has to be borne in mind that the Selective Care School Dental Service is designed on the basis of a territory concept. The concept considers that a CHC, in which the School of Dental Service

is based, could provide an optimal service to the surrounding area within the radius of 3 kilometres. The practical implication of this concept is that the School Dental Service is directed only to primary schools which are situated in this limited catchment area (Wijati and Tomasowa 1980). Provided that one dental nurse is posted in each CHC, only 4 primary schools are selected to be involved in the program. Each of the four primary schools is estimated to hold about 300 schoolchildren in six grades. Therefore, it is the responsibility of a dental nurse to provide comprehensive care to a total of 200 pupils in the four sixth grade classes. The dental nurse is also responsible for providing contingency care and guidance in oral hygiene for the remaining 1000 pupils in collaboration with teachers.

Table 94 shows the planned coverage of the program in the first five years of the implementation of Selective Care System. Although there was an increase of about 400% within 5 years, the coverage was still extremely low compared to the total schoolchildren population in that period. There is no available data for the rapid increase in coverage in recent years. However, by 1988 there were 1730 dental nurses posted in the CHC. Assuming that each nurse serves 4 primary schools, it could be estimated that a total of 2 million are now involved in the program. This number is still only about 6% of the total schoolchildren population.

To increase coverage, the Directorate of Dental Health introduced an Integrative School Dental Service in addition to the Selective Care System in which more teachers and parents participated and less dental auxilliary intervention was involved (Tomasowa and Wijati

Table 94. Planned coverage of the Selective Care School Dental Service, 1979/80 - 1983/84.
(Wijati and Tomasowa 1980)

Year	Number of school	Number of schoolchildren
1979/1980	26	7,800
1980/1981	46	13,800
1981/1982	74	22,200
1982/1983	105	31,500
1983/1984	133	39,900

1980). It is an adaption of the existing Integrative Oral Health Care (IOHC) program which is initially directed to the community other than the schoolchildren population.

The IOHC program is run on the principle that dental and medical health services delivered merely with professional intervention does not yield maximum success. The notion of integration is derived from the general concept of primary health care which emphasises: (1) self evaluation of health status, (2) self help by the individual; (3) use of knowledge and practice of prevention, and (4) general integration of hygiene, nutrition and specific prevention to promote health (Tomasowa and Wijati 1980).

In the field, the IOHC program is run by the Village community Health Development (VCHD)'s volunteers. With the establishment dating back to the 1960's, the main concept of VCHD is activation of community leaders and selection of health volunteers who, to some extent, substitute for the use of dental/health professionals.

Having been trained by dental and health professionals, the VCHD's volunteers are, in terms of dental health, expected to: (a) conduct oral health screening examination and identification of oral disease requiring professional treatment including arrangement of referral to the CHC; (2) deliver simple emergency therapeutic procedures such as providing analgesics for pain control, removing debris and scaling of soft calculus; (3) supervise the employment of a mouthrinsing program in primary schools, and (4) provide dental health education by applying a variety of educational strategies in order to improve self evaluation of personal oral status.

It is the main concept of the Integrative School Dental Program that

the schoolchildren who are not covered by formal Selective Care System will be served by the VCHD's volunteers. Although there is a general evaluation of the IOHC program being carried out, there is no available data on the extent of the Integrative School Dental Program.

It appears that the IOHC program is not easily run. A successful IOHC program appears to need some prerequisites such as: (1) readiness of the community to promote its own oral health; (2) regular supervision of the volunteers; and (3) continuing guidance and support from the dental supervisors. Godfrey (1982) commented that low educational levels in the community, culture and traditions are potential barriers to improving the community participation. Some school teachers are not able or ready, for various reasons, to participate in the IOHC programs. Lack of supervision by dental personnel appears to be a major factor for not improving the success of the IOHC programs as well as that of the Integrative School Dental Services. Moreover, it is perceived that the Selective Care System for rendering comprehensive care to sixth graders in schools within a 3 kilometre range of a dentally equipped CHC is not functioning, being under-utilised or are under-supervised. In many places, the Selective Care System is run without any performance review and rarely offers promotion of health care and prevention. The slight increase of caries experience (DMFT) in children aged 14 years from 2.5 (urban) and 1.85 (rural) in the period 1979-1984 to 2.64 (urban) and 2.50 (rural) in the period 1984-1989 can be used to support this proposition. It is evident, therefore, that the implementation of School Dental Services either with Selective Care or Integrative System has not been, quantitatively and

qualitatively, established.

5.6 Future Trends of Caries Prevalence in Schoolchildren.

The future trend of dental caries prevalence in Indonesian schoolchildren is not easily predicted. However, an attempt is made to analyse several determinants that would play an important role in influencing the trend.

One of the factors related to the declining trend of dental caries in industrialised countries is increase in dental awareness. In Indonesia, the community behaviour however does not appear to be favourable for a decline in dental caries prevalence. Public apathy of the vast majority of the population, especially those who live in rural areas, still persists as the main barrier to their positive dental health services. The belief that dental disease does not cause death, combined with inadequate infrastructure and lack of communication, are the main factors for ther widespread ignorance of dental prevention. Tradition and superstition such as mutilation of teeth are still retained in the community. In some areas, the role of traditional healers such as witchdoctors is still dominant since most remote areas cannot be reached by modern medical services rendered by the CHC.

In general, awareness toward dental and general health has not changed much in recent years. This can be seen from the results of two Household Surveys conducted in 1971 and 1980 revealing that the utilisation of health services in 1971 was as low as 0.1% and in 1980 it was only 0.2% (Ministry of Health 1988). Although the utilisation rate in 1980 was doubled that of 1971, the increase was

very low in absolute terms.

A clearer picture of the unchanged community health behaviour is shown in table 95. The figures depict the percentage of persons who reported symptoms during the surveys. It is shown that the percentage of those who seek treatment from traditional healers and modern health services has remained stable over the 6 year period. However, untreated symptoms increased from 26.2% in 1980 to 36.8% in 1986. It is evident that the awareness of the community toward health cannot be said to be increasing.

On the other hand, sugar consumption is reported to be increasing. In the period 1974-1979 during the second Five Year Development Plan (Pelita II) the consumption of sugar was 7.5 kg per person per year whereas in the Pelita III (1979-1984) period the consumption became 12.5 kg per person per year (Roder 1987). It is believed that the consumption will continuously increase and the Ministry of Agriculture puts an estimate of between 28.6 to 43.4 kg for sugar consumption per person per year by the year 2000 (Ministry of Agriculture 1985). These figures include sugar intake from mass-produced drinks and foods with high sugar and starch content which are penetrating both urban and rural markets. These high sugar content products may not appear harmful to schoolchildren, except that they are usually eaten indiscriminately without consideration of their adverse effects, or how these adverse effects can be prevented or minimised. On the other hand prevention or minimisation measures such as increasing tooth resistance has not been well implemented. Community-based fluoridation measures have not even been planned. It seems that there is no political will for the government to implement such measures which are highly cost-

Table 95. Percentage of population surveyed who had symptoms and type of treatment, 1980 and 1986.
(Adapted from Ministry of Health 1988)

Type of treatment	1980	1986
Untreated	26.2	36.8
Treated		
- medically	43.5	45.9
- traditionally	4.6	3.4
- self care	25.7	13.9

effective.

In most areas of the country, fluoride water content was reported to be very low, ranging from 0.1 to 0.2 ppm (Effendi 1978). In addition, the pH level of some community water supplies was observed to be below 6. There is a limited and irregular mouthrinsing program in the School Dental Services and the use of other topical fluoride is not as widespread as it is expected. Little is known about the use of fluoride dentifrices but it is believed that only those urban dwellers with higher socio-economic status can afford to purchase, and are using fluoride dentifrices. Moreover, a study conducted to measure the fluoride content in both imported and locally produced fluoride dentifrice indicated that the level of active ingredient was lower than that written on the labels (Agustina 1989). Nine brands (three imported) of fluoride dentifrices, widely available in urban markets, were tested using a spectrophotometric method. All toothpastes, including imported, had much less fluoride content than that claimed in the labels. This worker suggested further that the higher the price of the fluoride dentifrices, the less the fluoride content compared to that written in the packages. This might indicate that high price fluoride dentifrices are retained much longer in the shops or storage, suggesting that even urbanites, who are economically more secure than rural people, prefer the less expensive toothpastes.

The other factor that could strongly influence the inclining trend of dental caries in the future is the accessibility of dental services. Table 89 shows that the dentist-population ratio is extremely low. With the ratio of 1:96,000 it is hard to provide adequate services, especially for the schoolchildren population. It

is obvious that a high increase in dental manpower is required. However, given the various current and forseeable economic constraints discussed in section 5.3 and the present difficulties in absorbing the existing output of dental manpower, increasing the present manpower supply would be a matter of continuing review rather than immediate actions. Therefore, the low dentist:population ratio is likely to remain unchanged.

Having considered various factors that are strongly related to trends of dental caries prevalence, it could be predicted that there will be an increasing trend of caries prevalence in the near future.

6. DISCUSSION

6.1 General Comparison

It is not the aim of the present study to compare every aspect of the two countries, Australia and Indonesia. However, an attempt is made to draw some differences as well as similarities in dental health systems in these nations. On this basis, any dental problem, in its broader context, can be proportionally and understandably placed.

Bates (1983) suggested that there are several factors which contribute to the the structuring of the health system in any country. These being : (1) geographic and demographic background, (2) political structure, (3) economic resources, (4) past history and (5) values within the society. Some of these factors will be discussed with regard to Indonesian and Australian health services systems, particularly for the dental sector.

The health services systems in Indonesia and Australia are of similar pattern in that they are considered to fall in the same category which, as suggested by Sheiham (1981), of "the Western European Type" in which the social and political philosophy encourages increasing governmental responsibility in the provision of health services.

Similarly, in both countries, the government health services are augmented by private practices, or in a broader term, private enterprises. In dental health services, however, the proportion contributed by the two sectors are not the same. While in Australia most dental services are delivered by the private sector and only a

small part of it is left under government responsibility, in Indonesia the situation is reversed. In Indonesia, government plays a prominent part of the service since private practice in this country are mostly those government-employed dentists who are permitted to practice dentistry after normal government working hours.

With regard to the political structure, there is a polarity between the two countries. With a very centralised government, dental health services in Indonesia is a centralised-type. There is a delegation of the responsibility to the provincial level, but it is limited only in the program execution whereas responsibility in basic policy formulation is held by central government, ie the Directorate of Dental Health. On the other hand, Australia, which is a Federation of States is characterised by some division of political power and responsibility between the Federal and State governments. The impact of this structure to the medical and dental health services system is a very decentralised system. The Federal government provides a higher responsibility to the State government which in turn delegates much autonomy to the regional bodies within the States. Although it varies between States, usually the common pattern is that the central (State) dental officer is responsible for the development of policy and advice on services throughout the State, liaison with the private sector and support with the general administration. This central body, however, has only an advisory role and has no ability to require regions to develop dental services nor any power to determine where funds are to be allocated. Consequently, this provides a higher level of responsibility to the regional level for the development of services which is held by a

regional dental officer. It is not surprising, therefore, that dental service varies between regions within a State. No established referral system pathways is also a result of this political structure.

From the demographic point of view, some other differences between the two countries emerge. Australia which has a total population of less than one-tenth of that of Indonesia, with about 70% living in urban areas, has a relatively more concentrated population so that it is easier to distribute dental health services to the community. Consequently, gaining access to the dental services system is more likely. Indonesia by contrast has more than 165 millions population with about 80% living in rural areas. This provides many pressures to the government to enlarge the coverage of dental services since the infrastructures and communications may not be favourable. The outcomes of this situation, as a compromised approach, are the establishments of small clinics known as Community Health Centers rather than the hospital-type services which are common in Australia. However, while such clinics have been established by the Indonesian government according to the community dental need, there is, paradoxically, a lack of public demand for dental care compared to Australia where a higher public dental demand is evidenced.

With a very stretching complex of islands combined with a very centralised system, implication on the deployment of dental manpower in Indonesia is quite obvious : uneven distribution with most personnel posted in the main islands such as Java and Sumatra. This is accompanied by the lack of supervision to the field dental personnel resulting in a very low of productivity.

Finally from the economic point of view, Australia with more industrialised economic support spends a much higher percentage of its GDP on health. Many kinds of health insurance benefits are introduced by the government to break the financial barrier in getting access to health services system. In the dental health sector, services are delivered free of charge to a small part of its population which is considered to be in a high priority and in a high risk such as : schoolchildren, the elderly and indigent persons. In Indonesia, any person can get access to any public dental service which is not free of charge but is considered to be "low price". However, for some elements of the population, the term of low price is still percieved to be expensive. In fact, only those who are low income earners and low educational background are using the public dental facilities, while the higher socioeconomic community prefer to have their dental problems overcome by private practitioners because there is a general tacit perception that low price service equals low quality of treatment.

Table 96 shows the comparison of per-capita health expenditure in the two countries and in the UK and the USA. Although the figures for Australia are far less than that of the USA, they are still higher than that of the UK. When Indonesian per-capita expenditures are put into the comparison, these constitute less than 2 percent of that of Australia. The practical implication of this lack of funds is that the dental program has to compete with other health programs that are considered to be more "dramatic" or those that constitute visible public hazard. Again, the widespread belief that dental disease does not cause death has put the dental program at a very low priority amongst other health programs. Consequently, this does

Table 96. Per-capita health expenditure of Indonesia, Australia, UK and the USA, 1982/83 to 1986/87.

Fiscal year	Indonesia ($US)*	Australia ($US)	Calendar year	UK ($US)	USA ($US)
1982/83	17	784	1983	493	1521
1983/84	12	845	1984	461	1646
1984/85	12	737	1985	456	1776
1985/86	13	723	1986		
1986/87	9	886	1987		

* 1983 constant price

Sources :

1. Barnard (1988, 1989)
2. Grant and Lapsley (1988)
3. Bureau of Planning Ministry of Health (1987)
4. Australian Institute of health (1988)

not allow the allocation of sufficient budget and other resources for the dental program. From the political background point of view, it can be regarded as being less of strong community pressure to the government to implement public health measures when compared to the Australian system which is relatively much more open to public scrutiny (Bates 1983).

6.2 Goals for The Year 2000

To isolate the problems concerning dental health especially dental caries in schoolchildren, the situation will be discussed from the context of achieving the goals for the year 2000.

In 1978, the Indonesian dental health goals for the year 2000 were proposed by the Directorate of Dental Health. These were based on the WHO's goals in the oral health sector as an integral part of the WHO's overall drive toward Health for All in the Year 2000. The goals were revised in 1986, in terms of dental caries, as follows :

1. At age 8, 50% of all children will be caries free.
2. At age 14, the mean DMFT will be no more than 3.
3. At age 18, 85% of the population should retain all their teeth.
4. At age 35 - 44, 90% of the population should retain at least 20 functional teeth.

In the same year, in discussion with a WHO consultant, these goals were revised to formulate a definite objective. In terms of dental caries, they were as follows (Effendi et al 1986) :

1. At age 8, at least 60% of the children will be "caries free".

2. At age 14, at least 40% of the children will be "caries free".
3. At age 18, 80% of the population will have all their permanent teeth retained, sound and functional.
4. At age 35 - 44, 90 % of the population will retain at least 20 functional teeth.

The term "caries free" should be regarded with caution because it does not necessarily mean having sound teeth or no previous dental caries. "Caries free" has been taken as meaning free of active decay without a DT component. With regard to children at age 8 and 14, the goals appear to be rather awkward and seem to be difficult to implement and achieve. Instead of using a mean DMFT or DMFS which could stress prevention, the goals tend to be directed to restorative measures. In addition, the goals seem to be discriminating by having some sub-group with their decay fully restored and others with their caries remaining untreated.

The Directorate of Dental Health has estimated the dental manpower requirement to meet these goals, but it is a fallacy to calculate the requirement in a cross sectional way since it is not possible to measure the backlog of untreated caries and caries increment expected. In addition, the population is moving in a cohort way. Therefore, in order to estimate the restorative treatment required, an attempt is made by the writer to set up a cohort table. This is based on the available data regarding population growth rate and age composition for each year from 1990 to the year 2000 (Table 97). In creating the table, an assumption is that the age specific death rate and migration rate in the 6 - 14 age group are zero is involved. The discussion, however, would be limited to the first two goals since they apply to schoolchildren. Therefore, the populations

at age 8 and 14 years are to be the focus of attention.

The 1979-1984 survey revealed that the mean DFS for 8 and 14 year old schoolchildren to be 1.39 and 4.0 respectively (Wibowo 1984), with the percentage of F component almost negligible. Based on the prevalence, calculation of surfaces which require restoration have been made. These are presented in table 97, at the bottom of 8 and 14 year age cells, by multiplying the population of 8 and 14 year old with the corresponding DFS (1.39 and 4.0 respectively). According to the year 2000 goals, the outcome in the 8 year age group and 14 year age group are multiplied by 0.6 (60%) and 0.4 (40%) respectively. These are the number of DS component to be restored to achieve the year 2000 goals. In a cohort way, the population of children at 14 year old in 1996 are those who were 8 year old in 1990. As those children have received restoration at age 8, the restoration required at age 14 is substracted by the number of cavities that have been restored when they were 8 year old with an assumption that there is no secondary caries from the previous restoration. Table 97 then provides the total cavities to be restored in each year from 1990 to the year 2000, assuming that the prevalence of dental caries in the 8 and 14 year old groups remains constant.

On the other hand, table 98 shows the CHC dental staff from 1990 to the year 2000 estimated from the Directorate of Dental Health's projection. By assuming that each dental personnel has 1650 working hours per year, the total working hours provided by CHC dental personnels in each year can be estimated. The total working hours required to restore the dental cavities in children aged 8 and 14

Table 97. A cohort analysis to estimate the number of dental cavities to be restored in children aged 8 and 14 years, 1990 - 2000.

(in millions)

AGE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
6	5.631	5.749	5.867	5.990	6.116	6.155	6.254	6.355	6.456		
7	5.266	5.631	5.749	5.867	5.990	6.116	6.155	6.254	6.355	6.459	
8	5.100 4.253	5.266 4.931	5.631 4.696	5.749 4.794	5.867 4.893	5.990 4.996	6.116 5.100	6.155 5.133	6.254 5.216	6.355 5.300	6.456 5.384
9	5.312	5.100	5.266	5.631	5.749	5.867	5.990	6.116	6.155	6.254	6.355
10	3.949	5.312	5.100	5.266	5.631	5.749	5.867	5.990	6.116	6.155	6.254
11	4.971	3.949	5.312	5.100	5.266	5.631	5.749	5.867	5.990	6.116	6.155
12	3.923	4.971	3.949	5.312	5.100	5.266	5.631	5.749	5.867	5.990	6.116
13	3.771	3.923	4.971	3.949	5.312	5.100	5.266	5.631	5.749	5.867	5.990
14	4.370 6.992	3.771 6.034	3.923 6.276	4.971 7.953	3.949 6.318	5.312 8.499	5.100 3.907	5.266 4.034	5.631 4.313	5.749 4.404	5.867 4.494
TOTAL CAVITIES TO BE RESTORED IN 8 & 14 YEAR OLD	11.245	10.425	10.972	12.747	11.211	13.495	9.007	9.167	9.530	9.704	9.878

Table 98. Projection of total CHC dental personnels and total working hours, 1990 - 2000.

Dental personnel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Dentists	2000	2200	2400	2600	2800	3000	3200	3400	3600	3800	4000
Dental nurses	2340	2980	3620	4260	4900	5540	6180	6820	7460	8100	8740
Total	4340	5180	6020	6860	7700	8540	9380	10220	11060	11900	12740
Total working hours*	7.161	8.547	9.933	11.319	12.705	14.091	15.477	16.863	18.249	19.635	21.021

*) one dental personnel equivalent = 1650 working hours per year.
*) in millions

Table 99. Percentage of total working hours to be devoted solely to restoring dental decay in children aged 8 and 14 years, 1990 - 2000.

(in millions)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Working hours											
Working hours to restore cavities in children aged 8 and 14	5.623	5.213	5.486	6.374	5.606	6.748	4.504	4.584	4.765	4.852	4.939
Total Working hours	7.161	8.547	9.933	11.319	12.705	14.091	15.477	16.863	18.249	19.635	21.021
Percentage	79	61	55	56	44	48	29	27	26	25	23

years can be calculated as a percentage of the total working hours available.

The calculation indicates that in 1990, 79% of the total working hours of all CHC dental staff would be required to provide the restorative care to schoolchildren aged 8 and 14 years in order to meet the year 2000 goals (Table 99). As dental manpower increases, the percentage will be decreased to about 23% in the year 2000. These percentages are considered to be very high keeping in mind that the CHC dental staff has to deal with disease other than caries only, such as high prevalence of periodontal disease, and also provide services to community groups other than schoolchildren only. By way of illustration, Tomasowa (1981) has estimated that in 1994, a total of 327.6 millions working hours would be required for treatment of periodontal disease in the age group 15 to 50 years. Therefore, provided that there are no significant changes in the prevalence of dental caries, the goals for the year 2000 would not be achieved since there would not be adequate numbers of dental personnel. Moreover as, discussed in section 5 the prevalence of dental caries, especially in 14 year old schoolchildren, is increasing and a further increase in the forseeable future is expected.

6.3 Applicability of Australian Experience to Indonesian Situation

From the abovementioned discussion, the special dental problem in Indonesian schoolchildren can be summarised as follows:

1. Increasing trend of caries level from low to moderate and from moderate to high especially in those who are at age of fourteen

years. Although the increase is relatively small, the problem becomes huge because of the large number of school children to be cared for.

2. The huge problem abovementioned is not accompanied with massive increase in dental personnel intake, which should have been anticipated earlier, resulting in a chronic manpower shortage in which dental workload of unmet needs is much greater than the present dental manpower can cope with.

Devastatingly, these two problems are augmented by two apparent constraints ie : (1) lack of funds resultant to a very low health expenditure either in terms of absolute values or as percentage against GDP and (2) insufficient awareness of the extent of the problem (for example disregard that dental health is an integral part of the total health) amongst health planners and decision makers in the central level resulting in an imbalance in priority of dental program in relation to other health programs.

Considering the facts, the solution of the problem regarding dental caries prevalence in schoolchildren is not merely how to achieve the year 2000 goals, but in a broader context, it should reduce the prevalence of the disease to a certain extent so that the unfavourable dental personnel workload can be diminished.

From the Australian experience, it can be justified that the use of fluoride plays a prominent role in the declining trend of caries prevalence. The experience also suggests that water fluoridation has performed a predominant role in such a decrease in caries level. This measure is followed in importance by the regular use of fluoride dentifrice, whereas the use of fluoride supplement is the

least practical.

Before determining the applicability of such measures in the Indonesian situation, particular attention should be paid to the first constraint. Any dental public health program implemented in the future would be most likely funded by finance allocated on a public health program. The Bureau of Planning Ministry of Health (1987) indicated that health expenditure on public health programs had shown a less pleasing trend (Table 100). In 1982/83 the total expenditure spent on the public health program was 75,166 millions rupiah of which the government contributed 87.9% of that total whereas the remaining 12.1% came from foreign assistance sources. In 1986/87, the expenditure became as much as 103,045 millions rupiah, which had been a 37% increase over a 5 year period of time, or 7.4% annually. However, the increase was predominantly contributed by the foreign assistance source which was 32.1% in 1986/87. This showed the inability of the governments, at three levels, to finance this program as well as confirming the government dependency on the foreign assistance source. Moreover, if the expenditure was calculated on the basis of 1983 constant price, there was a drop of 13.5%. The implication of this situation for the dental public health program is obvious ie: there would not be any immediate action which would take place in the near future. If so, the action would tend to concentrate on mass programs which are feasible to implement without much use of expensive technology or a large number of manpower. Futhermore, the dental sector has to compete with other public health measures which are also funded by this source of expenditure.

Table 100. Expenditure on the community health program by the source of finance, 1982/83 - 1986/87.
(Bureau of Planning Ministry of Health 1987)

(in million Rp)

Source of finace	1982/83	1983/84	1984/85	1985/86	1986/87
Central government	55 861 (74.3)	56 010 (73.6)	52 793 (71.0)	67 311 (70.3)	51 534 (50.0)
Provincial government	9 159 (12.2)	6 637 (8.7)	9 847 (13.2)	12 640 (13.2)	16 668 (16.2)
Regencial government	1 055 (1.4)	1 083 (1.4)	1 315 (1.8)	1 686 (1.8)	1 774 (1.7)
Foreign assistance	9 091 (12.1)	12 413 (16.3)	10 439 (14.0)	14 149 (14.7)	33 069 (32.1)
Total	75 166 (100)	76 143 (100)	74 394 (100)	95 786 (100)	103 045 (100)

Note : in brackets are percentages against the totals.

With these backgrounds and constraints, the most seemingly apt answer to the problem of caries in schoolchildren is salt fluoridation. The use of fluoridated salt will break the goverment's financial burden since the manufacturing cost of this fluoride vehicle lies in the private sectors. As suggested by WHO (1972), salt fluoridation is the most preferable method of choice after water fluoridation.

Studies have consistently showed that the use of fluoridated salt could reduce the caries increment by the order of 40 to 60% (Toth 1976, 1979, Murray and Rugg-Gunn 1982) and that salt fluoridation is more economical than water fluoridation (Toth 1978). The concentration of 250-300 mg F per kg salt would be adequate and could be expected to have the same effect to that of 1 ppm water fluoridation. However some preliminary studies would be required to determine the adequate concentration before implementing this preventive measure since different communities have different dietary patterns which would influence the amount of salt ingestion.

If salt fluoridation measure were implemented early in the next decade, some benefits would be achieved by the turn of the century. Data from the Pelita IV survey (1984-1989) showed that the DMFT figures for children aged 8 and 14 years were 0.9 and 2.6 respectively. It provides a DMFT increment as much as 1.7 in the period of six years. In the implementation of salt fluoridation the increment could be reduced to only about 50% of the present increment and therefore an increment of 0.85 is expected. This would provide a DMFT figure for children aged 14 years as low as 1.75 if the DMFT figure for children aged 8 years is used as the basis of

the calculation. The benefit would be shown also by the increase in the percentage of caries-free children. This illustrates that such a measure could reduce the prevalence of dental caries without active involvement of dental manpower.

It should be borne in mind, however, that some of the domestic salt available in the market are produced by traditional salt makers who are not equipped with an adequate technology to add fluoride in salt. This would provide the community a free choice of whether or not they use fluoridated salt. Consequently, water fluoridation is strongly considered although the initial investment for the installation may not be easily gained. Water fluoridation is technically feasible to be implemented in urban areas since the water reticulations in the capital cities of most provinces supply about 20% of its population (Directorate of Dental Health 1987). Keeping in mind the first constraint abovementioned that there is a lack of funds available for a country-wide measure, water fluoridation could be limited to those particular areas which show an increasing trend of caries prevalence or have moderate to very high caries experience. Table 101 depicts the caries experience on Indonesian schoolchildren aged 14 by province in two surveys ie during Pelita III (1979-1984) and Pelita IV (1984-1989). Examining the table, eleven provinces meet the criteria abovementioned. These provinces being :

1. South Sumatra
2. North Sulawesi
3. West Java
4. West Kalimantan
5. Bali
6. South Kalimantan
7. West Sumatra
8. South Sulawesi
9. Jambi
10. South East Sulawesi
11. Maluku

Fluoridation of public water supply in the capital cities of those

Table 101. Mean DMFT of schoolchildren aged 14 years in the Pelita III (1979-1984) and Pelita IV (1984-1989).

Province	Pelita III		Pelita IV		Category		
	rural	urban	rural	urban			
South Sumatra	2.23	2.70	2.57	4.04	M	I	*
Central Java	2.84	1.67	1.31	1.09	L	S	
East Kalimantan	1.45	1.94	1.45	1.94	L	S	
North Sulawesi	2.51	2.79	3.83	3.86	M	I	*
East Java	1.95	2.33	1.72	2.33	L	S	
West Java	1.43	2.96	2.87	2.85	M	I	*
West Kalimantan	3.94	6.11	5.27	7.15	VH	I	*
Bali	0.94	0.94	2.94	2.17	M	I	*
East Timor	-	1.23	-	-	L		
East Nusa Tenggara	0.94	1.72	2.51	1.88	L	I	
South Kalimantan	2.91	5.67	-	-	H		*
West Sumatra	1.74	2.62	-	-	M		*
South Sulawesi	3.42	4.00	-	-	M		*
Riau	0.70	2.33	-	-	L		
Yogyakarta	1.72	1.74	1.64	1.85	L	S	
West Nusa Tenggara	1.68	1.38	-	-	L		
Jambi	3.71	3.41	-	-	M		
Lampung	1.24	2.42	-	-	L		
South East Sulawesi	0.59	2.60	1.38	2.86	M	I	*
Aceh	2.13	1.55	-	-	L		
Maluku	3.24	3.65	-	-	M		*

Note : L = Low (1.2 - 2.6) I = Increasing
M = Moderate (2.7 - 4.4) S = Stable
H = High (4.5 - 6.5) * = meet the criteria of being priority
VH = Very High (6.6 +)

eleven provinces would be beneficial for urban schoolchildren who significantly have a higher caries experience than rural children. To cope with the financial burden, finance from foreign assistance source, which is increasingly dominating the expenditure for public health measures, could be considered. Water fluoridation should also be initiated in cities which have their water supply up-graded. As a matter of fact, WHO has urged countries to commence water fluoridation if their water supply systems are up-graded with the World Bank financial support.

Fluoride dentifrices are available only in the urban market and it is strongly believed that only those who are in the higher socioeconomic level and with higher educational background are using fluoride dentifrices. Futhermore, the caries inhibitory effect of fluoride toothpaste is reliant on regular and sustained application achieved from good toothbrushing habits. It seems that only those children in urban areas whose parents favourably encourage a good oral hygiene habit will be experiencing the benefit of fluoride toothpaste.

It has been well established that the caries inhibitory effect of fluoride dentifrices to be in the magnitude of 20 - 40%. To gain the beneficial effects from fluoride dentifrices a mutual collaboration between the government and the fluoride dentifrice manufacturers should be initiated in the forms of mass educational campaigns and providing affordable fluoride toothpaste. The government could pass a legislation as well as endorse a political pressure to put up tarrifs which will be returned as an award to the manufacturers to supply cheaper fluoride dentifrices. A promising measure that could be endorsed by the government is to establish a cooperation between

fluoride dentifrice manufacturers and schools to supply very low priced fluoride dentifrices to schoolchildren on a large scale basis. This meausre, which could be considered as an advertisement of the product, will in turn be beneficial to the manufacturers.

Apart from those abovementioned measures, the other method of fluoride use that would be financially acceptable is the reinforcement of the existing fluoride rinsing program in the School Dental Service. A weekly mouthrinsing program with a 900 ppm NaF has been reported to have a significant effect in reducing caries increment varying from 22 to 66% over a period of 2 to 4 years. The regular administration of this fluoride form in schools that have been covered by the School Dental Service would be an additional effect to that of salt fluoridation. This measure does not seem to be precluded by government's financial burden since the program has been set up as an integral part of the School Dental Service.

To increase the benefits from the mouthrinsing program, the coverage of the School Dental Services should be enlarged, particularly in those eleven provinces which show moderate to very high caries experience. It should be borne in mind that the enlargement of the School Dental Service coverage requires increase in dental personnels, especially dental nurses. To have a clearer picture of the dental resources in those eleven provinces, table 102 presents the total schoolchildren population and dental nurses available in each province. The figures show that in all provinces except South Sumatra, Bali and South Kalimantan, there are dental nurse positions remaining unfilled which could have enlarged the coverage of the School Dental Service. Consideration should be given to those

Table 102. Schoolchildren population and dental nurses employed in eleven provinces which performed moderate to very high DMFT figures.

Province	Schoolchildren population*)	CHCs (dental)	Dental nurses	Children per nurse
South Sumatra	885 523	84	94	9 420
West Sumatra	596 670	115	30	19 889
Jambi	283 444	57	40	7 086
West Java	4 722 426	394	270	17 490
Bali	391 222	60	56	6 986
West Kalimantan	420 676	82	25	16 827
South Kalimantan	380 534	70	88	4 324
North Sulawesi	376 219	81	18	20 901
South Sulawesi	1 080 079	173	144	7 500
South East Sulawesi	185 076	38	10	18 507
Maluku	262 097	53	5	52 419

*) 1985 figure

provinces, in which a severe shortage of manpower exist, to place a higher priority on the deployment of dental nurses.

6.4 Centralised vs Decentralised Systems

The difficulty in deployment to certain provinces can be considered to be related to the present very-centralised system in which the decisions and quotas are made at the central level resulting in a very uneven distribution of dental manpower. If this burden could be avoided by providing some extent of autonomy to the provincial or even the regency level to employ dental manpower, the coverage of School Dental Service might have been rising at a greater rate. The decentralised system in Australia can be used as a model showing that the system encourages regional level to utilise dental resources as efficiently as possible so that higher outcomes can be achieved.

In terms of finance, the decentralisation system would provide a liberty to allocate the available funds according to their specific community needs. In the present system, the management of funds by the regional level is perceived to be difficult since the funds are inflexible in nature and are fragmented. This is because every type of expenditure has been decided at central level so that the region functions as a mere transit camp.

Overall, with the decentralisation-type system, a higher responsibility would be delegated to the provincial or regency dental officers who in turn would strengthen the monitoring and the field supervision on every dental program implemented in a certain area. This would provide a better performance review of the implementation of dental programs which are reported to be

undersupervised and, in some areas, not functioning.

7. CONCLUSION

1 Trends of Caries Prevalence in Indonesian Schoolchildren

Indonesian schoolchildren are, similar to those in other developing countries, experiencing an increasing trend of dental caries prevalence varying from low to moderate and from moderate to high or very high. Considering various factors such as low levels of dental demand, lack of dental resources, massive manpower shortage, increasing trends of sugar consumption and absence of sound preventive measures, the level of caries experience in Indonesian schoolchildren will continue to increase in the forseeable future.

2 Preventive Measures in Australia

Systematic recorded national data concerning dental caries experience in Australian schoolchildren reveals that there is a continuing trend in reduction of dental caries prevalence. The present study suggests that the use of fluoride has played a prominent role in such a declining trend. Of the various types of fluoride used, water fluoridation has been showen to have the predominant effect, followed by the widespread and regular use of fluoride dentifrices in the second rank, whereas regular fluoride supplement administration has been least effective. The implementation of the School Dental Scheme has induced a slight lowering of the DMFT figures amongst schoolchildren resulting from an intensive dental health education program as part of the Scheme. The sugar consumption pattern, on the other hand, which has remained at a constant and vey high level around 50 kg per person per year for more than five decades, does not seem to relate to the

declining trend of caries prevalence.

3 Applicability of Australian Experience to Indonesian Problems

The difference of various backgrounds between Australia and Indonesia has resulted in different perspectives towards the necessity of preventive measures in dental health. The inappropriate approach to dental disease, particularly caries, amongst decision makers and health planners coupled with the insufficient budget has put dental caries prevention in a very low priority in Indonesia. Considering various constraints, predominantly financial, salt fluoridation is the most apt solution to cope with the the problem in dental caries particularly in schoolchildren population. In some areas which show an increasing trend of dental caries prevalence or have moderate to very high caries experience, water fluoridation should be strongly considered. The government, in collaboration with dentifrice manufacturers, could initiate actions in mass campaigns of using fluoride dentifrices and in providing affordable fluoride toothpaste. Performance review and reinforcement of fluoride mouthrinsing program set up as an integral part of the School Dental Service is also urged.

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