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THE PLANNING AND EVALUATION OF
A SCHOOL DENTAL PROGRAMME

PART TWO

A thesis submitted to
fulfil the requirements
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of Dental Science

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GENERAL PRESENTATION OF THE THESIS

The thesis is presented in three parts
with the following contents:

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V INDIVIDUAL ASPECTS OF THE SCHOOL DENTAL PROGRAMME

1. Productivity

1.1 Introduction

It is important that health manpower requirements be predicted so that appropriate provisions can be made in training programmes. For a comprehensive planning of the School Dental Programme, the following should be estimated:

- (i) the potential size of the target population;
- (ii) the utilization rate;
- (iii) the eventual mean patient load per dental health provider;
- (iv) the prospective ratio of dentists to therapists, and
- (v) the mean working life spans of the individual categories of clinical staff.

The Federal government's Bureau of Statistics maintains population projections for specified age groups.²⁰³ The utilization rate has varied between 90 and 94 per cent since 1969, and this range seems appropriate as an estimate for the future. The possible mean working life span of therapists, and the prospective ratios of dentists to therapists, have been mentioned already.

The mean patient loads for dental health providers now are reviewed and projected. The respective productivity of dentists and therapists also is analysed for restorative care, in order to facilitate assessments of the therapists' skills.

1.2 Patient loads for dental health providers

1.2.1 Introduction

Logan reviewed the patient loads for New Zealand school dental personnel and concluded that the mean patient load per operator in 1972 was 440.¹⁷⁴ As there were no dentists employed in the school clinics, this figure would have been specific for therapists.¹⁷⁴ Children would have been included for areas where 49 per cent of the population had been exposed to fluoridation for varying periods.¹⁷⁴ As data neither were specified for non-fluoridated areas nor for areas where the effects of this measure were complete, the patient loads for these areas cannot be defined.¹⁷⁴ A study in one New Zealand region had indicated that an increase in patient loads of about 45 per cent resulted from fluoridation.²⁰⁴ However, it seemed that about a third of the children had not been permanent residents in the fluoridated area since birth.²⁰⁴ Administrators in the New Zealand School Dental Service have claimed that the patient loads for therapists increase by about 50 per cent following the total effect of fluoridation.¹⁷⁴

Compared with the New Zealand School Dental Service, the South Australian Programme seems to provide a wider range of care, which includes orthodontic therapy with removable appliances.²² Although it therefore could be anticipated that South Australian staff might manage smaller patient loads, New Zealand therapists have not had chairside assistance, nor the ready availability of high-speed cutting instruments.^{70,84} Accordingly, South

Australian patient loads might be as high or higher than the New Zealand counterparts.

In this study, South Australian patient loads are related to the percentages of patients "on recall", that is, the percentages receiving follow-up school dental attention. As no region had received the full effect of fluoridation, the review is limited to non-fluoridated areas.

1.2.2 Materials and methods

The following data were obtained for each year from 1972 to 1975, and for the individual non-fluoridated areas administered by the regional dentists:

- (i) the mean number of patients treated per operator;
- (ii) the mean number of patients receiving a complete course of treatment per operator;
- (iii) the mean number of courses of treatment provided per operator, and
- (iv) the mean number of courses of treatment completed per operator.

The data were obtained from standard records (Appendix 5.1).

The individual regions should not be regarded as independent elements, because dental staff occasionally transferred between them. Also, these regions were not considered to be independent in different years, because of varying degrees of retention of staff.

Nevertheless, regional data were plotted against the percentages of patients "on recall", and projections were based on a linear regression model (Appendix 7.1).^{167,205}

A Canola 167P electronic calculator was used for this purpose.

It is assumed that in a fully developed primary school dental programme, children in six of the seven school grades would be "on recall", that is, 85.7 per cent presupposing equal numbers of children in each grade. In fact, if the recall intervals averaged about nine months as will be indicated, this percentage could be marginally low. The recall percentage was calculated as follows:

$$\text{recall percentage} = \frac{\text{recall examinations}}{\text{recall examinations} + \text{initial examinations}} \times 100$$

As the patients were obtained almost entirely from primary schools, it does not seem appropriate to generalize from these data to patient loads for pre-schoolers and secondary school students.

1.2.3 Results and comments (Patient loads)

A. Patients treated

The mean numbers of patients treated per year per operator are presented by region and recall percentage in Appendix 7.2, and are expressed graphically in Figure 1. Patients examined, but not found to require care, nevertheless were regarded as "treated".

Assuming linearity, it is evident that the number of patients treated per operator could be represented by the regression equation:

$$\text{patients treated} = 2.0 \times \text{recall percentage} + 305.0$$

Therefore in a fully developed primary school dental programme where the recall percentage is 85.7, it may be

anticipated that the mean number of patients treated per operator would approximate 480 ($2.0 \times 85.7 + 305.0$).

It is evident from the data in Appendix 7.2 that for regions with recall percentages from zero to 50, the mean recall percentage was 23.3, and the mean of the regional means for the numbers of patients treated per operator was 332.6, as opposed to a projected figure of 351.6 ($2.0 \times 23.3 + 305.0$). That is, the projected figure was 5.7 per cent higher. For regions with recall percentages between 50 and 60, the mean recall percentage was 56.1, and the mean of the regional means for the numbers of patients treated per operator was 438.6, as opposed to a projected figure of 417.2 ($2.0 \times 56.1 + 305.0$). That is, the projected figure was 4.9 per cent lower. The corresponding mean recall percentages, means of the regional means for the numbers of patients treated per operator, and the projected figures were as follows:

- (i) for regions with recall percentages from 60 to 75 per cent, 69.5, 467.6 and 444.0 respectively, and
- (ii) for regions with recall percentages over 75, 79.2, 438.2 and 463.4 respectively.

That is, the projected means were 5.0 per cent lower and 5.8 per cent higher than the actual means respectively.

It seems that projected and actual figures were similar for the four groups of regions, despite the wide range of mean recall percentages from 23.3 to 79.2. Therefore, it is apparent that the linear regression model might be a reliable method of obtaining estimates for groups of regions. Nevertheless, the considerable depar-

tures of individual regional means from the projected figures suggest that the projections should not be regarded as precise estimates for single regions (Figure 1).

For the calendar years 1972 and 1973, the number of patients treated per year per operator could be represented by the linear regression equation:

$$\text{patients treated} = 1.9 \times \text{recall percentage} + 268.1$$

Whereas for 1974 and 1975, the corresponding equation is as follows:

$$\text{patients treated} = 1.9 \times \text{recall percentage} + 354.2$$

Therefore, the projected mean number of patients, who would be treated per operator in a fully developed primary school dental programme where the recall percentage is 85.7, would be

- (i) about 430 ($1.9 \times 85.7 + 268.1$) based on data for 1972 and 1973, and
- (ii) about 520 ($1.9 \times 85.7 + 354.2$) based on data for 1974 and 1975.

Therefore, when recall percentages are matched statistically, it is apparent that patient loads were higher for the 1974-1975 period.

B. Patients receiving a complete course of treatment

The mean numbers who received a complete course of care per year per operator are presented by region and recall percentage in Appendix 7.2, and are represented graphically in Figure 2. Patients examined, but not found to require care, nevertheless were considered to have received a "complete course of treatment".

Assuming linearity, it is evident that the number of

patients completed per operator may be represented by the regression equation:

$$\text{patients completed} = 2.3 \times \text{recall percentage} + 201.5$$

Therefore in a fully developed primary school dental programme where the recall percentage is 85.7, it may be anticipated that the mean number of patients receiving a complete course of care per operator would approximate 400 ($2.3 \times 85.7 + 201.5$).

It is evident from data in Appendix 7.2 that for regions with recall percentages from zero to 50, the mean of the regional means for the numbers of patients completed per operator was 234.7, as opposed to a projected figure of 255.1 ($2.3 \times 23.3 + 201.5$). That is, the projected figure was 8.7 per cent higher. The corresponding actual and projected means were as follows:

- (i) for regions with recall percentages between 50 and 60, 366.9 and 330.5 respectively;
- (ii) for regions with recall percentages from 60 to 75, 353.7 and 361.4 respectively, and
- (iii) for regions with recall percentages over 75, 371.7 and 383.7 respectively.

Compared with the actual figures, these projected means were 9.9 per cent lower, 2.2 per cent higher and 3.2 per cent higher respectively.

It seems that the projected and actual figures were similar for the groups of regions, despite the wide range of mean recall percentages. The similarity was most evident for groups with higher recall percentages.

Therefore, it is apparent that the linear regression model

might be a reliable method of obtaining estimates for groups of regions. The extensive departures of individual regional means from the projected figures suggest that the projections should not be used as precise estimates for single regions (Figure 2).

For the calendar years 1972 and 1973, the number of patients completed per operator could be represented by the linear regression equation:

$$\text{patients completed} = 2.6 \times \text{recall percentage} + 170.6$$

Whereas for 1974 and 1975, the corresponding equation is as follows:

$$\text{patients completed} = 2.0 \times \text{recall percentage} + 236.6$$

Therefore, the projected mean number of patients, who would be completed per operator in a fully developed primary school dental programme where the recall percentage is 85.7, would be

- (i) about 390 ($2.6 \times 85.7 + 170.6$) based on data for 1972 and 1973, and
- (ii) about 410 ($2.0 \times 85.7 + 236.6$) based on data for 1974 and 1975.

Only 18 regions presented data for the two time periods. Nevertheless, it seems that productivity might have been marginally higher in the latter two years.

C. Number of courses of treatment provided

The mean numbers of courses of treatment provided per year per operator are presented by region and recall percentage in Appendix 7.2, and are expressed graphically in Figure 3.

Assuming linearity, it is evident that the number of

courses of treatment per operator could be represented by the regression equation:

$$\text{courses of treatment} = 3.4 \times \text{recall percentage} + 287.8$$

Therefore, in a fully developed primary school dental programme where the recall percentage is 85.7, it may be anticipated that the mean number of courses of treatment per operator would approximate 580 ($3.4 \times 85.7 + 287.8$).

Data in Appendix 7.2 indicate that for regions with recall percentages from zero to 50, the mean of the regional means for the number of courses of treatment provided per operator was 351.8, as opposed to a projected figure of 367.0 ($3.4 \times 23.3 + 287.8$). That is, the projected figure was 4.3 per cent higher. The corresponding actual and projected means were as follows:

- (i) for regions with recall percentages between 50 and 60, 491.3 and 478.5 respectively;
- (ii) for regions with recall percentages from 60 to 75 per cent, 534.8 and 524.1 respectively, and
- (iii) for regions with recall percentages over 75, 555.3 and 557.1 respectively.

Compared with the actual figures, the projected means for these three groups were 2.6 per cent lower, 2.0 per cent lower and 0.3 per cent higher respectively.

The similarity of the projected and actual figures supports the assumption that the linear regression model is a reliable method of obtaining estimates for groups of regions. The differences between the individual regional means and the projected figures nevertheless suggest that projections should not be regarded as precise estimates

for individual regions (Figure 3).

The following regression equation was derived from data for 1972 and 1973:

$$\text{courses of treatment} = 3.4 \times \text{recall percentage} + 248.9$$

The corresponding equation for 1974 and 1975 is as follows:

$$\text{courses of treatment} = 3.3 \times \text{recall percentage} + 337.8$$

Therefore, in a fully developed primary school dental programme where the recall percentage is 85.7, the mean number of courses of treatment provided per operator would be

- (i) about 540 ($3.4 \times 85.7 + 248.9$) based on data for 1972 and 1973, and
- (ii) about 620 ($3.3 \times 85.7 + 337.8$) based on data for 1974 and 1975.

It is apparent that productivity might have been higher in the latter two years.

D. Number of courses of treatment completed

The mean numbers of course of treatment completed per year per operator are presented by region and recall percentage in Appendix 7.2, and are presented graphically in Figure 4.

Assuming a linear association between these numbers and the recall percentages, the following equation was derived:

$$\text{completed courses of treatment} = 3.4 \times \text{recall percentage} + 194.1$$

Therefore, it may be anticipated that about 490 courses of care might be completed per operator in a fully developed

primary school dental programme ($3.4 \times 85.7 + 194.1$).

Data in Appendix 7.2 indicate that for regions with recall percentages from zero to 50, the mean of the regional means for the numbers of courses of treatment completed per operator was 255.0, as opposed to a projected figure of 273.3 ($3.4 \times 23.3 + 194.1$). That is, the projected mean was 7.2 per cent higher. The corresponding actual and projected means were as follows:

- (i) for regions with recall percentages between 50 and 60, 416.9 and 384.8 respectively;
- (ii) for regions with recall percentages from 60 to 75, 407.4 and 430.4 respectively, and
- (iii) for regions with recall percentages over 75, 463.7 and 463.4 respectively.

Compared with the actual figures, the projected means for these groups were 7.7 per cent lower, 5.6 per cent higher and 0.1 per cent lower respectively.

The similarity of the projected and actual figures indicates that the linear regression model might be a reliable method of obtaining estimates for groups of regions. Nevertheless, the variation in results for individual regions demonstrates that projections should not be interpreted precisely for individual regions (Figure 4).

When data for 1972 and 1973 were processed separately, the following regression equation applied:

$$\text{completed courses of treatment} = 3.6 \times \text{recall percentage} + 163.6$$

The regression equation for 1974 and 1975 data was as

follows:

$$\text{completed courses of treatment} = 3.1 \times \text{recall percentage} + 229.8$$

Accordingly, in a fully developed primary school dental programme where the recall percentage was 85.7, the mean number of courses of treatment completed per operator would be

- (i) about 470 ($3.6 \times 85.7 + 163.6$) based on data for 1972 and 1973, and
- (ii) about 500 ($3.1 \times 85.7 + 229.8$) based on data for 1974 and 1975.

These results support the conclusion that productivity might have been slightly higher in 1974 and 1975.

E. Recall interval

The duration of the annual leave for school dental staff is one month, which must commence in late December. The working year therefore constitutes 11 consecutive months.

The annual number of courses of treatment per treated patient in a fully developed primary school dental programme was projected at 1.2 ($579.2/476.4$), based on data from 1972 to 1975. This ratio is consistent with an interval of about nine months between successive examinations during the working year ($11/1.2$). The ratios based on 1972-1973 and 1974-1975 data were 1.3 ($540.3/430.9$) and 1.2 ($620.6/517.0$) respectively.

The number of completed courses of treatment per patient completed in a fully developed primary school dental programme was projected at 1.2 ($485.5/398.6$), based on

data from 1972 to 1975. This ratio applied to both the 1972-1973 period (472.1/393.4) and 1974-1975 period (495.5/408.0), and is consistent with an interval of about nine months between successive examinations during the working year (11/1.2).

1.2.4 Discussion (Patient loads)

Data from 1972 to 1975 indicated that in a fully developed primary school dental programme with a recall percentage of 85.7:

- (i) the mean number of patients treated per year per operator might approximate 480;
- (ii) the mean number of patients receiving a complete course of treatment per year per operator might approximate 400;
- (iii) the mean number of courses of treatment provided per year per operator might approximate 580, and
- (iv) the mean number of courses of treatment completed per year per operator might be about 490.

Higher figures were obtained from data for the 1974-1975 period.

In fact, findings indicated that there could be a higher projected recall percentage resulting from an interval of about nine months between successive examinations during the working year. It seems that patients might receive an average of 8.5 examinations during the primary school years ($579.2/476.4 \times 7$), and 7.5 (88.2 per cent) would be recall examinations. If the number of children in each grade was the same, the recall percentage would be 88.2, and this figure is higher than the one used for

projecting the eventual patient loads (85.7 per cent). Nevertheless, the difference appears to be inconsequential.

Differences between the numbers of patients treated and completed often were considerable, as were differences between the numbers of courses of treatment provided and completed. In most regions, staff reported that they polished restorations and provided prophylaxes and topical applications of fluoride at the final appointment: apparently parents sometimes omitted to bring their children to the clinic for this purpose. Therefore it is possible that a child could be examined regularly and could obtain complete courses of restorative care without being reported as receiving a single completed course of treatment.

Although the regression model seemed to provide quite accurate projections of patient loads for groups of regions with wide variations in the mean recall percentages, the projections for individual regions should not be interpreted precisely.

A State-wide standard binds staff to examining patients at least once per year.²⁰⁶ It is evident that the average period between the examinations has been shorter than a year. Three North American reports indicate that recall intervals might be extended beyond a year for some age groups without a loss of effectiveness and with improved efficiency.^{101,129,190} The mean recall interval which is appropriate to maximizing effectiveness and minimizing costs has not been defined for the

South Australian School Dental Programme.

1.3 Restorative productivity of dentists and therapists

1.3.1 Introduction

When new types of dental operators are introduced, it is understandable that questions are asked concerning their levels of performance. South Australian school dental administrators often are questioned about the restorative productivity of therapists. Accordingly, the relative productivity of school dentists and therapists was analysed.

1.3.2 Materials and methods

From July to December 1972, dental staff were asked to record the durations of appointments in minutes. The appointment duration was defined as the period of occupancy of the dental chair.

Records for all the therapists (48) and dentists (15) were used. A further seven dentists commenced employment at the beginning of 1973, and their records were obtained from January to March so as to increase the number of participating dentists to 22.

The combinations of services for single appointments varied considerably. To facilitate comparisons, appointments were chosen where only one tooth was restored. It was assumed that if the time per restoration differed when restorations were provided in isolation, this would apply similarly to both categories of operators so that their relative productivity still would be evident.

The median times for specified types of restorations which were recorded as indicated in Appendix 5.1

were calculated for each operator. The median was chosen because only a few restorations qualified for some operators. The means and standard errors of these values were obtained for specific operator categories with a Canola 167P electronic calculator. Not all operators presented information for each category of restoration, and the numbers included are presented in Tables 70 and 71. For example, it was apparent that regional dentists delegated procedures to therapists and therefore did not provide all types of restorations.

Time registrations should not be interpreted as incorporating "stop-watch" precision. Nevertheless, data in Tables 70 and 71 indicate longer times for the more elaborate restorations, and so a degree of validity is apparent.

1.3.3 Results and comments (Restorat. productiv.)

The mean times for specified restorative care varied for dentists from 24.038 minutes for one-surface restorations, confined to single surfaces of primary teeth, to 35.556 minutes for restorations of three surfaces of permanent teeth where at least one proximal surface was included and each surface was restored by a compound restoration (Table 70). The extremes for therapists were 24.884 minutes for the former care and 42.300 minutes for the restorations of three surfaces of permanent teeth where two proximal surfaces each were included in a compound restoration (Table 71).

Shorter times were recorded by dentists for the 10 classifications of restorative procedures (Tables 70 and

71). The range varied from 3.4 per cent shorter for one-surface restorations confined to single surfaces of primary teeth to 17.0 per cent shorter for compound restorations of two surfaces of permanent teeth where a proximal surface was included (derived from Tables 70 and 71).

The dentists' mean for the classifications was

- (i) 8.1 per cent shorter for the restorative care of primary teeth;
- (ii) 14.0 per cent shorter for the restorative care of permanent teeth, and
- (iii) 10.9 per cent shorter collectively (derived from Tables 70 and 71).

For each classification, therapists who graduated before 1971 presented shorter times than the more recent graduates (Table 71). The former graduates' mean for the 10 classifications was 5.7 per cent shorter (derived from Table 71).

Dentists who graduated before 1971 presented shorter times than the more recent graduates for seven of the 10 classifications (Table 70). The difference was not consistent but the numbers were small and possibly misleading (Table 70).

1.3.4 Discussion (Restorat. productiv.)

It is apparent that data collected by staff during their normal duties would not incorporate bias from the artificialities of experimental environments. Staff were not aware that comparisons of productivity between dentists and therapists were planned, and so bias could not have followed from that knowledge.

The data nevertheless present drawbacks. Less precise records were possible than might have followed in an experimental environment. Bias could have resulted from differences in the complexity of care. For example, it seems plausible that regional dentists might delegate the less complex procedures to therapists. Attempts were made to avoid bias by excluding care which included direct or indirect pulp capping, the restoration of cusps, or the placement of supportive pins.

As the respective quality of restorations placed by dentists and therapists was not assessed, the total restorative skills of these operators cannot be evaluated.

Nevertheless, it seems from the results that therapists were less productive, particularly when treating permanent teeth. This might have resulted from their more limited chairside assistance. Whereas the ratio of assistants to operators was one to one for dentists, the ratio was one to two for therapists. Therefore it should not be concluded that therapists have a lower productive capacity.

1.4 Summary

Data from the South Australian School Dental Programme from 1972 to 1975 indicated that in a fully developed primary school dental programme in non-fluoridated areas, the mean number of patients treated per year per operator might approximate 480, and 400 of them might receive a complete course of care. An apparent reason for the difference in the figures was discussed. Higher figures were evident for the 1974-1975 period.

Although a linear regression model seemed a reliable method for projecting total turnover, individual regions varied considerably in their productivity and projections should not be interpreted as precise estimates of individual performance.

Results were consistent with a mean projected interval of about nine months between successive examinations during the working year. The interval appropriate to maximizing effectiveness at a minimum cost has not been defined for the School Dental Programme.

The productivity of therapists for specified restorative care seemed slightly lower than for dentists. This was most apparent for care of the permanent dentition. It seems that this difference could have resulted from the greater availability of chairside assistants for dentists.

Therapists who graduated before 1971 seemed more productive than the more recent graduates. A similar finding was apparent for dentists, but the results were less consistent possibly as a result of the small numbers of subjects.

The disadvantages of employing data which were collected by staff as part of their normal duties were outlined, as were the endeavours undertaken to avoid bias.

2. Diagnostic and treatment-planning skills of dental therapists

2.1 Introduction

In 1964, the Australian Dental Association expressed support for the introduction of dental therapists in its

National Dental Health Policy, and stated that diagnosis and treatment planning should remain with the dentist.²⁰⁷ In 1963, the Experimental Scheme Committee of the United Kingdom's General Dental Council provided similar advice on the oversight of therapists by dentists.²⁰⁸

These recommendations were contrary to established practices in New Zealand, where therapists have been responsible for diagnosing decay and for planning associated treatment.^{209,210} Many children do not see a dentist unless the therapist considers that referral is warranted.^{209,210} An editorial in the New Zealand Dental Journal stated that individuals who claim that all diagnosis and treatment planning should remain with the dentist are being over-cautious, as New Zealand's experience has proven them wrong.²³ A warning was issued that excessive supervision would be wasteful of manpower and could be dispiriting to the therapist.²³

In 1972, the Australian Dental Association restated its opinion that children require periodic examinations by dentists.¹⁸³ The Association claimed that the intervals between these examinations should not exceed two years.¹⁸³

In the South Australian School Dental Programme, dentists examine children before the initial course of treatment and at least every two years thereafter.²⁰⁶ After the initial examination, therapists are responsible for the following:

- (i) diagnosing decay and planning appropriate treatment, and

- (ii) recognizing poor oral hygiene and chronic marginal gingivitis, as an indication of the need for oral hygiene instruction.²⁰⁶

On these occasions, they refer patients to their regional dentists if other abnormalities are detected. It is required that children be examined for decay by therapists at least yearly.²⁰⁶ Dentists must check the therapists' diagnoses by examining at least 15 patients per therapist per year.²⁰⁶

The purpose of this study was to evaluate the competence of therapists to perform the following:

- (i) recognize decay, poor oral hygiene and chronic marginal gingivitis, and plan appropriate treatment for decay;
- (ii) detect conditions which their regional dentists consider need attention from a dentist, and
- (iii) provide statistical data which indicate the approximate prevalence of certain dental conditions.

Every therapist and regional dentist who directed therapists participated in the study. The investigation was undertaken in 1972 and was designed to provide inferences of the working performance of the therapists employed at that time.

2.2 Fundamental assumptions

It seems that no two examiners would perform identically. Therefore, it was expected that the treatment plans of the 47 therapists would differ from the plans of their 10 regional dentists. If the therapists were incompetent, the differences probably would be large.

Since dentists are regarded as competent to diagnose and plan treatment, variations between them must be considered generally acceptable. Consequently, the level of acceptable variation in this study was determined by arranging for two dentists to examine each child, namely:

- (i) the respective regional dentist, and
- (ii) one of the eight staff dentists from the School of Dental Therapy.

If therapists could not diagnose and plan treatment, it was anticipated that the variation between the therapists' and the regional dentists' performance would exceed this level of acceptability, that is, the staff dentist-regional dentist variation.

Also if therapists could not define those patients in need of referral, the therapist-regional dentist variation in referral would exceed the staff dentist-regional dentist variation.

Data collected by uncalibrated staff are used to indicate the approximate prevalence of various dental conditions. If this practice is justified, prevalence figures from the regional dentists and staff dentists would be similar.

If therapists could not classify the conditions effectively, their figures would vary markedly from those of the dentists.

2.3 Materials and methods

2.3.1 Sample and examination techniques

From each therapist's list of patients due for an examination, 10 children were selected at random. There-

fore, a total of 470 children participated in the study.

Each therapist examined her 10 patients, who then were examined by the respective regional dentist and by one of the eight staff dentists from the School of Dental Therapy.

Consequently, each child was examined three times at the same appointment and with the same instruments, but otherwise independently.

Staff dentists were briefed by the author and were responsible for the implementation of the survey in the regions allocated to them.

The numbers of children examined per dentist and the numbers of dentists are presented in Table 72. The regional dentists examined the patients of the therapists for whom they normally were responsible, and the staff dentists each examined the patients of a similar number of therapists (Table 72).

2.3.2 Recordings

A. Treatment plans and referrals

The treatment for each tooth was specified. When a restoration was needed, the site of the lesion or of the necessary restoration was indicated diagrammatically. The sequence of treatment of teeth was not recorded.

Each examiner indicated whether bite-wing x-rays were needed. If a condition which warranted referral to the regional dentist was apparent, the condition was described.

The levels of oral hygiene and gingival health were assessed to indicate the need for instruction in oral

hygiene practices.

B. Prevalence data

(a) Decay

Data were recorded so as to facilitate the compilation of DMF and df scores.⁶⁶

(b) Occlusion

The occlusion was classified according to Angle's method and crowding was recorded as "absent" or "present".²¹¹

(c) Oral hygiene and gingival health

Oral hygiene was classified as "very good" (1), "good" (2), "poor" (3) or "very poor" (4), and gingivitis as "absent" (1), "mild" (2), "moderate" (3) or "severe" (4).

(d) Hypoplasia

This condition was recorded as "absent" (1), "very mild" (2), "moderate" (3) or "severe" (4).

(e) Fractured teeth

Fractures were classified as absent (1) or affecting

(i) the enamel only (2);

(ii) the dentine to a "small" extent (3),

or

(iii) the dentine to a "large" extent (4).

(f) Comments

These classifications were chosen, despite their qualitative nature, because they were in use throughout the School Dental Programme.

2.3.3 Statistical analysis

A. Treatment plans for decay

Each tooth was considered to need treatment, even if only a prophylaxis and topical application of fluoride. Specified treatments included restorations and extractions. Individual restorations were regarded as different when it was evident that different tooth surfaces would be affected. Decayed primary teeth which were near to exfoliation often were indicated to be left or to be restored with a temporary dressing. These alternatives were regarded as synonymous.

Each child received two scores pertaining to the number of teeth which would be treated differently for decay by

(i) the respective therapist and regional dentist, and
(ii) the respective staff dentist and regional dentist.
The difference in these scores (d) was calculated so that a plus value resulted when the former difference was the larger and a minus quantity resulted from the reverse.

The mean d value per child was derived for each therapist, and these values were pooled. The pooled d indicates whether the collective performance of the therapists was similar to the defined level of acceptability, and the standard error enables inference to the collective working performance of these operators. The paired t-test was used because of correlated samples (Appendix 8.1).¹⁶⁷

In a similar manner, the treatment of occlusal and proximal surfaces was investigated separately. An occlusal surface was ignored if it was included in an

occluso-proximal restoration or in an extraction in any treatment plan. In these instances, it often was difficult to know if these surfaces were decayed, or if they were included in the treatment for other reasons. Similarly, teeth indicated for an extraction in any treatment plan were ignored when analysing proximal surfaces.

The desirability of bite-wing x-rays was investigated similarly, and each child received two assessments depending on whether there was agreement or disagreement between the decisions of

- (i) the respective therapist and regional dentist, and
 - (ii) the respective staff dentist and regional dentist.
- Differences in these assessments were analysed with the McNemar test (X_M^2) because of dichotomous data and correlated samples (Appendix 8.2).¹⁶⁷

B. Care related to oral hygiene and gingival health

The analysis of differences was similar to that for decay, except that Wilcoxon's matched-pairs signed-ranks test (X_W^2) replaced the paired t-test because of loosely classified ordinal data (Appendix 8.3).¹⁶⁷

C. Referral

The investigation of the need for referral was the same as for x-rays. Each child received two assessments which were compared using the McNemar test (Appendix 8.2).
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D. Prevalence data, decisions on referral and interpretations of the need for bite-wing x-rays

Prevalence figures from each group of examiners were compared visually to see if they demonstrated similar

levels of dental health. Subsequently, statistical tests for homogeneity were applied to see if more precise interpretations were possible. The data were processed as if each group had one examiner. Therefore, findings relate to pooled data and could present misleading indications of the differences between specific therapists, staff dentists and regional dentists.

The Friedman two-way analysis of variance on ranks (X_F^2) was used for the DMF, df and their components, because it seemed that the three samples would be correlated.¹⁶⁷ This test was preferred to the parametric one, because frequency distributions of the components of these indices did not approximate a normal curve. This test also was applied to scores for oral hygiene, gingival health, hypoplasia and fractured teeth, because these conditions were weakly classified on ordinal scales (Appendix 8.4).¹⁶⁷

Similarly, dichotomous data were analysed using the Cochran Q test (X_Q^2) (Appendix 8.4).¹⁶⁷ This test was employed for the following characteristics:

- (i) the prevalence of crowding;
- (ii) the number of children requiring bite-wing x-rays,
and
- (iii) the number of children in need of referral.

Nominal data were analysed using the chi-square test of homogeneity (X^2) (Appendix 8.4).¹⁶⁷ This applied to occlusion classified by Angle's method and to the reasons stated for referral.

E. Statistical advice and processing

Advice was received from Mr. K.M. Cellier, Principal Research Scientist, Division of Mathematical Statistics, the Commonwealth Scientific and Industrial Research Organisation, Adelaide. The data were processed manually and with a Canola 167P electronic calculator.

2.4 Results and comments

2.4.1 Treatment plans

A. Decay

(a) Teeth

Collectively, the therapists indicated that 2,214 teeth were decayed, whereas the corresponding figures for the regional dentists and staff dentists were 2,025 and 2,183 respectively. The scores for both the permanent and the primary dentitions were statistically heterogeneous, and the regional dentists provided the lowest scores in both instances (Table 78). The respective frequencies with which broad categories of treatment were prescribed by each group of examiners were similar (Table 73).

There were considerable differences in the treatments prescribed per tooth. The mean number of teeth which would have been treated differently per child by the therapists and regional dentists was 2.787. The corresponding figure for the staff dentists and regional dentists was 2.840, and the consequent d value was -0.053 ± 0.083 (standard error), which is not statistically significant. Collectively, it seems that the therapists and staff dentists agreed with the regional dentists to an equivalent extent.

The mean d value for each therapist is displayed in

Table 74. A total of 22 therapists agreed more closely with their regional dentists than did the staff dentists, but the reverse applied to 21 therapists. A mean d score of zero resulted in four instances.

One hundred and sixty patients were new to the School Dental Programme and their mean d score was 0.013 ± 0.158 (standard error). The remaining 310 children had a mean d value of -0.087 ± 0.096 (standard error). Neither difference was statistically significant.

Decisions to extract teeth because of decay also were analysed separately. Of the 13 permanent teeth which were indicated for extraction by the regional dentists, the therapists agreed that nine should be extracted and the staff dentists agreed that 10 required this treatment. The regional dentists also indicated that 54 primary teeth should be extracted, and the therapists agreed in 39 instances and the staff dentists on 40 occasions. Conversely, the therapists indicated that one permanent tooth and 25 primary teeth should be extracted, contrary to the opinions of the regional dentists. Similarly, the staff dentists considered that one permanent tooth and 26 primary teeth required extraction, contrary to the wishes of the regional dentists.

(b) Occlusal surfaces

The mean d value per child was 0.043 ± 0.048 (standard error), which is not statistically significant. The mean d value for each therapist is displayed in Table 75. Nineteen therapists agreed more closely with their regional dentists than did the staff dentists, but the reverse applied to 24 therapists. A mean d score of

zero applied in four instances.

(c) Proximal surfaces

The mean d value per child was -0.128 ± 0.072 (standard error), which is not statistically significant. The mean d value for each therapist is displayed in Table 76. Thirty therapists agreed more closely with their regional dentists than did the staff dentists, whereas the reverse applied to 15 therapists. A mean d score of zero resulted in two instances.

B. Desirability of bite-wing x-rays

The therapists indicated that 280 children (59.6 per cent) required bite-wing x-rays, whereas the corresponding figures for the regional dentists and staff dentists were 313 (66.6 per cent) and 286 (60.9 per cent) respectively. These figures are heterogeneous ($\chi^2_Q = 8.43$: $df=2$: $p < 0.05$). The regional dentists considered that bite-wing x-rays were indicated more frequently than did the therapists or staff dentists.

The regional dentists agreed with the therapists but not with the staff dentists on 65 children, whereas for 85 children the reverse occurred. The difference is not statistically significant ($\chi^2_M = 2.41$: $df=1$: $p > 0.05$). Fifteen therapists agreed more closely with their regional dentists than did the staff dentists, but the reverse applied to 23 therapists. In nine instances, the therapists and staff dentists agreed equally with the regional dentists.

A separate pilot study had suggested that therapists could diagnose carious lesions from bite-wing x-rays.

Ten senior therapy students had examined 27 proximal surfaces and had found a mean number of carious surfaces equal to 12.100 ± 1.100 (standard error). The respective numbers found by four regional dentists and four staff dentists were 11.000 ± 1.915 (standard error) and 12.250 ± 1.652 (standard error) respectively. It seemed that the disagreement per surface between the therapy students and the regional dentists was equivalent to that between the staff dentists and the regional dentists. This investigation was cursory and requires confirmation.

C. Oral hygiene and gingival health

The difference between the therapist-regional dentist disagreement and the staff dentist-regional dentist disagreement was calculated for each child. The mean d value was -0.034 for oral hygiene and -0.051 for the gingival disease scores, and neither was statistically significant ($X^2_W = 0.85$ and 1.90 respectively for one degree of freedom, that is, $p > 0.05$). Collectively, the therapists agreed with their regional dentists as closely as did the staff dentists.

It was apparent from the hygiene scores that 22 therapists agreed more closely with their regional dentists than did the staff dentists, whereas the reverse applied for 18 therapists. In seven instances, the therapists and staff dentists agreed equally with the regional dentists.

When gingival scores were examined, 23 therapists were found to agree more closely with their regional dentists than did the staff dentists, but the reverse

applied for 15 therapists. In nine instances, the therapists and staff dentists agreed equally with the regional dentists.

2.4.2 Referrals

The therapists indicated that 281 children (59.8 per cent) should be referred to their regional dentists. The regional dentists considered that 287 children (61.1 per cent) should be referred, whereas this number was 285 (60.6 per cent) for the staff dentists. These figures do not differ significantly ($\chi^2_Q = 0.32$: $df=2$: $p>0.05$).

The reasons given for referral by each category of operator are presented in Table 77 and are homogeneous.

Decisions on whether individual children should be referred were analysed separately. The regional dentists agreed with the therapists but not with the staff dentists on 53 children, whereas for 65 children the reverse occurred. The difference is not statistically significant ($\chi^2_M = 1.03$: $df=1$: $p>0.05$). Fourteen therapists agreed more closely with their regional dentists than did the staff dentists, but the reverse applied to 20 therapists. In 13 instances, the therapists and staff dentists agreed equally with the regional dentists.

Of the 287 children nominated for referral by the regional dentists, the therapists did not refer 65 (22.6 per cent) and the staff dentists did not specify referral for 57 (19.9 per cent). The omissions related to a wide variety of dental conditions.

2.4.3 Prevalence data

A. DMF and df scores

Collective scores for each category of examiner are provided in Table 78. Although the three sets of data indicate similar levels of dental health, the D, F, d and f components are statistically heterogeneous. Therefore, data collected in this manner should not be interpreted precisely. Information collected by the therapists seems adequate.

B. Occlusion

Assessments classified by Angle's method are presented in Table 79. Although the three distributions are approximately the same, the data are statistically heterogeneous. Compared with the regional dentists, the therapists found fewer normal occlusions ($X^2 = 7.35$: $df=1$: $p < 0.01$), more class one malocclusions ($X^2 = 5.55$: $df=1$: $p < 0.05$), and fewer division two categories of the class two malocclusion ($X^2 = 4.52$: $df=1$: $p < 0.05$).

According to the therapists, 212 children (45.1 per cent) had crowding and the corresponding figures for the regional and staff dentists were 231 (49.1 per cent) and 230 (48.9 per cent) respectively. The data are homogeneous ($X^2 = 3.57$: $df=2$: $p > 0.05$).

C. Oral hygiene and gingival health

The scores for these conditions are presented in Table 80. Although the data for oral hygiene are homogeneous, the gingival scores are statistically heterogeneous and represent vastly different interpretations of the level of gingival health.

D. Hypoplasia and fractured teeth

Although the scores are statistically heterogeneous for both conditions (Table 81), the data for each group of examiners suggest a similar prevalence for both conditions.

2.5 Discussion

A. Treatment plans

The results indicated that these therapists were competent to recognize decay, bad oral hygiene and chronic marginal gingivitis, and to plan appropriate treatment for decay, but the findings should not be regarded as conclusive.

For example, it is conceivable that the types of disagreement between the therapists and the regional dentists might have been more critical than between the staff dentists and regional dentists. Moreover, the therapists might have compared less favourably, had x-ray findings been pooled with clinical observations. It also is possible that therapists' examinations need to be checked periodically, as required by existing standards, in order to maintain an acceptable standard of performance.²⁰⁶

Nevertheless, the results are consistent with the opinion that therapists can recognize decay and can plan appropriate treatment. The only reservation stated by the staff at the School of Dental Therapy related to large carious lesions, when the examiner must decide which of the following is appropriate:

- (i) an extraction;
- (ii) a large restoration, or

(iii) endodontic treatment followed by a large restoration.

B. Referrals

Although there was no statistically significant difference in the extent to which the therapists and staff dentists agreed with the regional dentists, many children were not referred in contradistinction to the wishes of the regional dentists. The therapists failed to refer 22.6 per cent of the children whom their regional dentists requested to see. These omissions related to a wide variety of dental conditions and apparently would be difficult to remedy.

C. Prevalence data

Generally the therapists seemed competent to provide statistical data which indicated the approximate prevalence of certain dental conditions. Nevertheless, this information might be of greater value, if the indices were based on defined objective criteria and indicated treatment needs. It seems that the indices for occlusion and gingival health required the most urgent modification. Consideration should be given to the recommended international standards outlined through the World Health Organization.⁶⁶

D. Statistical analysis

Statistical tests were used to infer from this sample of patients to a universe of patients, rather than to other dental operators. It was assumed that each child was an independent element in the sample.

Although the appropriateness of each test could be discussed at length, it nevertheless is evident that the

conclusions drawn from this study would have been similar, if based on descriptive statistics alone.

2.6 Summary

Each of 470 patients was examined independently by a dental therapist, a regional dentist who directed therapists, and a staff dentist from the School of Dental Therapy. The study included every operator in these categories, who was employed in the School Dental Programme throughout 1972. The relevant numbers were 47 therapists, 10 regional dentists and eight staff dentists.

The findings indicated that these therapists could recognize decay, bad oral hygiene and chronic marginal gingivitis, and could plan appropriate treatment for decay. Nevertheless, the findings are not regarded as conclusive. The only reservation stated by dentists at the School of Dental Therapy applied to large carious lesions, when the health of the pulp is uncertain and the appropriate course of treatment is not clear.

Each examiner indicated whether children had conditions which required attention from a dentist. The therapists disagreed with their regional dentists slightly more frequently than did the staff dentists, but the difference in disagreements was not statistically significant. The therapists would not have referred approximately 23 per cent of the children whom their regional dentists requested to see. These omissions related to a wide variety of dental conditions and apparently would be difficult to remedy.

Generally therapists seemed competent to provide data which indicated the approximate prevalence of certain dental conditions.

The examinations of South Australian therapists are checked periodically by their regional dentists. This practice might be necessary if therapists are to maintain an acceptable standard of performance. Further investigations of the use and interpretation of bite-wing x-rays by therapists seem appropriate.

3. The sealing of fissures by therapists

3.1 Introduction

By 1973, there had been extensive research into fissure sealants: some success had been achieved with cyanoacrylates, but they were receiving less attention because of inconsistent performance, difficult working properties and possible instability and toxicity.^{212,213,214,215,216,217,218,219} The results of four clinical trials with bis-GMA sealants had been encouraging, and Nuva-Seal (L.D. Caulk Co.) had been granted provisional acceptability by the American Dental Association's Council on Dental Materials and Devices in May 1972.^{220,221,222,223,224,225,226} This rating had been reaffirmed in January 1973, pending further investigation, and the results of a subsequent study had indicated the value of the material.^{224,227}

The potential public health benefits of sealants and their suitability for application by auxiliaries had been stated.^{220,228} Fluoridation is most effective on smooth

surfaces as opposed to fissures, and so sealant might be especially beneficial for the primary prevention of decay.^{229,230,231,232,233} Depending on the application time, the retention rate and the incidence of decay, sealants might reduce the cost of care. Even if the treatment of proximal decay required that the sealants be removed, they nevertheless might prevent a need to restore many teeth twice, that is, initially with an occlusal restoration and later with an occluso-proximal.

In 1973, the author explored the potential of sealants to prevent decay in permanent first molars by analysing the patterns of school dental care in fluoridated and non-fluoridated areas. As the South Australian School Dental Programme only had provided limited care before 1973, New Zealand school dental records were used. It seemed from the data already reported in this thesis and from published figures that New Zealand and South Australian decay rates were similar.²³⁴ The permanent first molar was chosen because its fissures seemed more susceptible to decay than other tooth surfaces in primary school children. Although supportive data were not available for South Australia, it was apparent that over 90 per cent of these teeth were decayed in non-fluoridated areas before children had graduated from a primary school. Further results of the base-line fluoridation study will be presented in the thesis, which will indicate that the mean number of permanent first molars affected by decay in 10-year-olds was 3.20.

Students at the South Australian School of Dental

Therapy had used Nuva-Seal without apparent difficulty in 1973, and so a pilot study was scheduled for the field clinics in 1974. Regional dentists would select the permanent first molars to be treated, but therapists would apply the sealant. As several investigations had indicated that fluoride might reduce the adhesion of sealants, it was decided that the study would include fluoridated and non-fluoridated areas.^{219,235,236,237} The retention and the effects on decay rates would be studied.

Relevant publications, the New Zealand study and the South Australian experiment are reviewed sequentially.

3.2 Review of the literature

Although cyanoacrylates have been tested as fissure sealants, it is evident from this review that they have been superseded by bis-GMA materials. In 1966, Takeuchi, Kizu, Shimizu, Eto and Amano reported preliminary results for a study of a cyanoacrylate sealant.²¹⁷ A total of 1,229 children in the first and second primary school grades was examined, and they normally were seven or eight years of age. Subsequently, 160 children with sound bilateral permanent first molars were selected so that test teeth could be matched with contra-lateral controls. After six months, 135 test teeth were re-examined and at least 77 per cent had retained sealant. After nine months, this percentage had decreased to 46, but no test tooth had decayed.²¹⁷ After the first year, re-sealing was performed six-monthly.²¹⁸ A total of 95 subjects was available after four years, and examinations indicated a 91 per cent "caries reduction rate".²¹⁸ Electric conduc-

tivity was employed to detect decay, and so results might not be comparable with information obtained by orthodox methods.^{217,218}

Cueto and Buonocore described the effects of a cyanoacrylate sealant in 269 five to 17-year-olds.²¹³ The sealant was re-applied after six months, and 201 subjects were available for 601 test and contra-lateral control teeth to be re-examined after one year. Approximately 90 per cent of the test teeth had retained sealant, and retention seemed complete for 71 per cent. The reduction in the decay rate apparently was 86 per cent on the test surfaces.²¹³

Ripa and Cole tested a cyanoacrylate sealant in 91 mentally retarded children from five to 10 years of age.²¹⁶ Of the 244 primary and permanent first molars which were sealed and re-examined after one year, 66 per cent had sealant and complete retention was evident for 32 per cent. A review of 85 pairs of test and contra-lateral control permanent first molars indicated a reduction in the decay rate on test surfaces of 84 per cent.²¹⁶

Parkhouse and Winter studied the effects of a cyanoacrylate sealant on the premolars and permanent molars of 100 five to 17-year-olds after about six months.²¹⁴ A total of 233 pairs of test and contra-lateral control teeth was included. The authors considered that the loss of sealant was massive and that differences in the decay rates for the test and control surfaces were marginal and not statistically significant.²¹⁴

Pugnier analysed the influence of a cyanoacrylate

sealant on the effectiveness of topical fluoride therapy.
215 Of the 104 eight to 13-year-olds who commenced the study, 71 presented 165 test permanent teeth for a re-examination after two years. Although a review of 24 patients after three months revealed that most sealant had been lost, test surfaces were afforded a 54 per cent reduction in decay rates over the two-year period. It should be known that both the test and the contra-lateral control teeth were treated with an "acidulated phosphate fluoride" solution, and test teeth then were sealed without prior etching.²¹⁵

Despite some success with cyanoacrylate sealants, bis-GMA materials were tested. In 1968, Roydhouse reported the results of an investigation of a bis-GMA sealant.
225 Test teeth were compared with contra-lateral controls in 62 of the 130 children in the original sample three years after the application of the "chemically-polymerised" material. A reduction in the decay rates for test surfaces of 29 per cent was evident. The extent of sealant retention was not specified.²²⁵

In 1970, Buonocore reviewed the effects of a bis-GMA sealant, which was polymerised by ultra-violet light, on 200 premolars and permanent and primary molars in 60 subjects from four to 15 years of age.²²¹ Follow-up examinations after 12 months indicated that the sealant was retained in all the teeth and that partial loss had occurred in one only. A reduction in decay rates of 100 per cent was evident for the test surfaces from comparisons with contra-lateral controls. After two years, 113

pairs of test and control permanent teeth were available, and complete retention of the sealant was evident for 87 per cent of the test surfaces. Apparently there was a 99 per cent reduction in decay rates. In the primary dentition, complete retention applied to 50 per cent of the teeth and an 87 per cent reduction in decay rates was evident.²²¹

Rock compared the performance of a bis-GMA sealant, which was polymerised by ultra-violet light, with a second material containing a polyurethane base.²²³ A total of 178 subjects aged from 11 to 13 years was included. After 12 months, the number of test molars and premolars which were compared with the contra-lateral controls was 146 for the bis-GMA and 139 for the polyurethane material. The bis-GMA sealant exhibited a 78 per cent retention rate, of which 54 per cent was complete and 24 per cent was partial. Whereas 14 per cent of the control surfaces had decayed, this percentage was only five for the test surfaces. Of the teeth which were sealed with the polyurethane material, only one showed evidence of sealant. The percentage of the test surfaces which had decayed was nine, as opposed to 17 for the controls, but the difference was not statistically significant.²²³

In similar follow-up investigations, Rock found better retention rates for a bis-GMA sealant, which was polymerised by ultra-violet light, than for alternative materials.^{224,238} After two years, the rate of complete retention of this sealant was 80 per cent, as opposed to 52 per cent for another material. Whereas three per cent

of the test surfaces which were treated with the former sealant had decayed, this proportion was 29 per cent for the controls.²³⁸

Luoma, Meurman, Helminen and Heikkila studied the effects of a bis-GMA sealant, which was polymerised by ultra-violet light, on premolars and permanent and primary molars in six to 12-year-old subjects.²³⁹ The sealant's condition was rated as excellent in 89 per cent of the permanent first molars and in 95 per cent of the premolars and primary molars after six months. The reduction in decay rates on the test surfaces apparently was 93 per cent for the permanent first molars and 100 per cent for the primary molars. Neither the test nor the control surfaces of premolars had decayed during the period of the study. The number of sealed teeth was 200 for permanent first molars, 43 for premolars and 119 for primary molars.²³⁹

McCune, Horowitz, Heifetz and Cvar investigated the performance of a bis-GMA sealant, which was polymerised by ultra-violet light, on the permanent posterior teeth of five to 14-year-olds.²⁴⁰ Sealant was rated as "intact" in 88 per cent of the 900 treated teeth after one year, and statistically significant reductions in decay rates were evident from comparisons with contralateral controls.²⁴⁰

Gourley completed a two-year study of a bis-GMA sealant which was polymerised by ultra-violet light.²⁴¹ The material was placed by hygienists in the premolars and permanent and primary molars of three to 11-year-

olds. After two years, the rate of complete retention for 239 permanent teeth was 78 per cent, as opposed to 93 per cent for 267 primary teeth. Statistically significant reductions in decay rates on the test surfaces were evident for both the permanent and the primary teeth when comparisons were made with contra-lateral controls.²⁴¹

Burt, Berman, Gelbier and Silverstone studied the effects of a bis-GMA sealant, which was polymerised by ultra-violet light, on permanent molars and premolars.²⁴² After six months, only 39 per cent of the sealed surfaces exhibited complete retention, and the corresponding figure for partial retention was 44 per cent. A total of 156 children and 310 pairs of test and contra-lateral control teeth was available for an examination after six months. Retention rates were higher for premolars than for molars, and this difference is supported by evidence from other studies.^{239,240,242} The possible reasons for the low retention rates were discussed. It seemed that the age range of five to 17 years included many young children, who might be difficult to manage, leading to unsatisfactory moisture control and an undesirable angulation of the ultra-violet light. The higher retention rate on premolars, it was considered, might result from their anterior location to the molars and consequently their easier management.²⁴²

3.3 The treatment of permanent first molars in the New Zealand School Dental Service

3.3.1 Introduction

It has been recommended that individuals without

decayed teeth, and whose teeth are free of deep fissures, not be treated with sealant.²¹² Although potential benefits of sealants are apparent, the desirability of sealing specific fissures in individuals with various decay rates requires investigation. To seal fissures which are not susceptible to decay, or when proximal lesions are imminent, would be futile.

In this study, the pattern of school dental care of the permanent first molars was analysed. It was anticipated that the probability of occlusal surfaces requiring occlusal and occluso-proximal restorations would become evident, and that the potential of sealant to preserve this natural surface therefore would be apparent. This potential is considered separately for

- (i) fluoridated and non-fluoridated communities, and
- (ii) subjects with varying histories of decay in the primary teeth before the sixth birthday. It seemed that these histories might indicate the appropriateness of sealants for the permanent teeth.

3.3.2 Materials and methods.

A. Samples

The samples were selected from the fluoridated and non-fluoridated communities which were most accessible to the national capital and which were known to contain adequate numbers of children.

Subjects were included when these criteria were satisfied:

- (i) school dental care had been received at maximum intervals of eight months since five years of age;

(ii) this care had been provided in the one locality,
and

(iii) the subject was at least 12 years of age when
receiving the final course of care before trans-
ferring to a secondary school.

A small number of subjects in the non-fluoridated
area was excluded, because they were known to have taken
fluoride tablets.

The fluoridated community was an urban locality
immediately adjacent to the capital. One hundred sub-
jects of each sex were selected at random from those
transferring to secondary schools in 1972 and 1973. As
fluoridation was introduced in 1959, most permanent first
molars would have received fluoride before eruption and
many throughout mineralization. Presumably, some subjects
would have moved from non-fluoridated areas before their
enrolment in the school dental programme.

The non-fluoridated community was predominantly
rural, but was served by a town of about 3,000 inhabi-
tants. One hundred subjects of each sex were selected
at random from those transferring to secondary schools
from 1970 to 1973. This period was necessary to obtain
the desired numbers of subjects.

It was expected that the decay rate in the fluori-
dated area would have been lower than the average for New
Zealand, and that the converse would have applied for the
other area. Opportunity therefore presented to consider
the potential role of sealants under these contrasting
circumstances.

B. Examination techniques

The examinations were performed by school dental therapists in the course of their normal duties. Approximately 40 operators could have contributed appreciably in the fluoridated area, whereas this figure was 20 for the non-fluoridated community.

The use of data from uncalibrated examiners would be suspect, if used for comparisons between different localities. The purpose of this study was to investigate the potential of sealants in a normal operational setting, and so the data seem appropriate for that objective.

C. Statistical analysis

The ages when occlusal and proximal surfaces of permanent first molars initially were considered to require a restoration were recorded for each subject. Proximal fillings without occlusal extensions were rare, and were ignored because they would not disturb fissure sealants.

Periodically, definite decay was recognized, but treatment was postponed because the child was young and particularly apprehensive. In these instances, the age at the initial recording of the lesion was employed.

The number of decayed, extracted, and filled occlusal and proximal surfaces was assessed for primary molars and canines at the last examination before the sixth birthday. The subjects' scores were classified as above or below the mean for the respective sex and community.

The ages when occlusal and proximal surfaces of

permanent first molars originally were considered to need a restoration were classified by the following:

- (i) sex;
- (ii) exposure to fluoridation, and
- (iii) whether decay rates in the primary teeth were above or below the mean.

Whereas several subjects were examined at 13 years of age, only records for the younger ages were used. Extractions of permanent first molars were not encountered.

3.3.3 Results and comments (N.Z. study)

A. Non-fluoridated community

(a) Occlusal surfaces

The ages when permanent first molars originally were considered to need occlusal restoration are presented in Tables 82 and 83.

No appreciable difference is evident between the quadrants nor the sexes. Occlusal restoration was required in 93.6 per cent of the teeth at a mean age of 7.29 years, and 501 (62.6 per cent) needed this care before the eighth birthday.

The proportion of teeth requiring occlusal restoration reached a minimum of 82.6 per cent for the lower left teeth in females with below average decay rates in the primary dentition (Tables 84 and 85). The maximum was 100 per cent for upper right and lower left teeth in females, and each group had higher than average primary-tooth decay rates. The proportion requiring this care was higher in subjects with above average primary-tooth decay rates in each sex-tooth specific group (Tables 84

and 85).

The percentage requiring occlusal restoration before the eighth birthday was lowest for the lower right teeth in females with below average primary-tooth decay rates, that is, 39.1 per cent. The highest proportion was 87.0 per cent for the lower right teeth in females with above average primary-tooth decay rates. In each sex-tooth specific group, the proportion was higher where there were above average primary-tooth decay rates (Tables 84 and 85).

(b) Mesial surfaces

The ages when the permanent first molars originally were considered to need a mesial restoration with an occlusal extension are presented in Tables 82 and 83.

Five hundred and seventy three teeth (71.6 per cent) needed this care at a mean age of 9.10 years. This percentage was higher in each sex-tooth specific group where there were above average decay rates in the primary teeth (Tables 84 and 85).

(c) Distal surfaces

One hundred and sixty nine (21.1 per cent) permanent first molars needed a distal restoration with an occlusal extension. The mean age at the initial treatment was 10.56 years. Details are presented in Tables 82 and 83.

The percentage needing this treatment was higher in each sex-tooth specific group when primary-tooth decay rates were above the average (Tables 84 and 85).

(d) Time lapse between the initial restoration of occlusal and proximal surfaces

The period elapsing between the initial restoration of the occlusal and the first proximal surface to be filled is presented for all teeth in Table 86.

The occlusal surface did not require a restoration in 51 instances (6.4 per cent). On 103 occasions (12.9 per cent), the occlusal surface was restored initially with an occluso-proximal filling. This number might be slightly high, because several teeth could have received an occlusal filling followed by an occluso-proximal during the same year of a subject's age.

Of the remaining 646 teeth which were filled occlusally, 164 (25.4 per cent) did not receive an occluso-proximal filling. Four hundred and eighty two (74.6 per cent) were treated with a subsequent occluso-proximal after a mean period of 2.44 years.

When the decay rates in the primary teeth were above the average, the percentage of teeth receiving occlusal, but not occluso-proximal restorations, was lower in six of the eight sex-tooth specific groups (Tables 84 and 85). The percentage receiving initial occlusal and proximal restoration in the one year was lower also, that is, 11.9 as opposed to 14.0 for the remainder.

B. Fluoridated community

(a) Occlusal surfaces

The ages when permanent first molars originally were considered to need occlusal restoration are detailed in Tables 82 and 83.

Three hundred and seventeen first molar teeth (79.3 per cent) in males required occlusal restoration at a mean

age of 8.69 years. Ninety teeth (22.5 per cent) needed this care before the eighth birthday.

For females, 341 teeth (85.3 per cent) needed restoration occlusally at a mean age of 8.46 years. One hundred and eighteen (29.5 per cent) required this care before the eighth birthday.

A minimum of 44 teeth (72.1 per cent) required occlusal restoration, and this applied to the lower left teeth in males with below average decay rates in the primary dentition. The maximum was 44 teeth (93.6 per cent) for the upper right and lower left teeth in females with higher than average primary-tooth decay rates. The proportion requiring this care was higher in each sex-tooth specific group when primary-tooth decay rates were above the average (Tables 84 and 85).

The proportion requiring occlusal restoration before the eighth birthday was lowest for the lower right teeth in males with below average primary-tooth decay rates, namely, 14.8 per cent (9 teeth). The highest proportion was 53.2 per cent (25 teeth) for the lower right teeth in females with above average decay rates in the primary teeth. For each sex-tooth specific group, the proportion was higher in those with above average primary-tooth decay rates (Tables 84 and 85).

(b) Mesial surfaces

The ages when permanent first molars originally were considered to need a mesial restoration with an occlusal extension are presented in Tables 82 and 83.

Three hundred and two teeth (37.8 per cent) needed

this care at a mean age of 10.09 years. This percentage was higher when there were above average primary-tooth decay rates in seven of the eight sex-tooth specific groups (Tables 84 and 85).

(c) Distal surfaces

Only 23 permanent first molars (2.9 per cent) apparently needed a distal restoration with an occlusal extension. The mean age at the initial treatment was 10.35 years. Details are evident in Tables 82 and 83.

Seven sex-tooth specific groups were affected and in five of these a larger proportion of subjects with above average primary-tooth decay rates received this care (Tables 84 and 85).

(d) Time lapse between the initial restoration of occlusal and proximal surfaces

The period elapsing between the initial restoration of the occlusal and first proximal surface to be filled is presented for all teeth in Table 86.

The occlusal surface did not need a restoration in 142 instances (17.8 per cent). On 93 occasions (11.6 per cent), the occlusal surface was restored initially with an occluso-proximal filling. This number might be slightly high, because several teeth could have received an occlusal filling followed by an occluso-proximal during the same year of the subject's age.

Of the remaining 565 teeth which were filled occlusally, 351 (62.1 per cent) did not receive an occluso-proximal filling. Two hundred and fourteen (37.9 per cent) were treated with a subsequent occluso-proximal after a

mean period of 2.78 years.

When the decay rates in the primary teeth were above the average, the percentage of teeth receiving occlusal but not occluso-proximal restorations was lower in five of the eight sex-tooth specific groups (Tables 84 and 85).

3.3.4 Discussion (N.Z. study)

Although mean ages have been presented with two decimal places, it should be known that the ages were recorded in years at the last birthday, as is conventional. Therefore, a "mean age" should be interpreted as a mean of these recorded ages rather than the mean of ages presented with a greater level of accuracy. It is evident that the conventional method understates the actual age: for example, six-year-olds would be recorded as aged six even though the actual age range could span from 6.00 to 6.99 with a mean of 6.50 years.

Although the data in this study were provided by uncalibrated examiners, the relative apparent effects of fluoridation on occlusal and proximal surfaces were as predicted. It is evident from Tables 82 and 83 that the number of occlusal surfaces which were restored in the fluoridated area was 12.1 per cent lower than for the non-fluoridated area, and the corresponding percentages for the mesial and distal surfaces were 47.3 and 86.4 respectively. That is, fissure sealants are directed towards those surfaces which apparently receive the least benefit from fluoridation.

Additional discussion is categorized under the headings of "non-fluoridated community", "fluoridated comm-

unity" and "further comments".

A. Non-fluoridated community

Apparently, sealants could have only a small effect in reducing the need for the occlusal restoration of permanent first molars over the long term. Most occlusal surfaces (94 per cent) needed restoration, but proximal decay rates were so high that only a fifth needed an occlusal but no occluso-proximal filling. This proportion was smaller when decay rates in the primary teeth were above the average before the sixth birthday.

The mean age when occlusal surfaces first needed care apparently was almost two years before the corresponding age for mesial surfaces, and over three years before the age for distal surfaces. Consequently, over 60 per cent of the teeth apparently were restored initially with an occlusal filling and subsequently with an occluso-proximal after a mean period of about $2\frac{1}{2}$ years.

It seems that sealants could remove the need to restore many occlusal surfaces more than once. If fissures can be sealed rapidly, economic advantages are possible. If retention rates are low, these advantages might not exist or be confined to subjects with high decay rates in the primary teeth. It seems more likely that these subjects would require occluso-proximal restorations during their early school years.

It might be difficult to encounter teeth which have erupted sufficiently for the placement of sealant, and which are not yet decayed. Almost two-thirds of the surveyed teeth required occlusal restoration before the

eighth birthday, that is, during or soon after eruption. This proportion was approximately three-quarters when there were above average decay rates in the primary teeth before the sixth birthday (Tables 84 and 85).

B. Fluoridated community

It seems that sealants could reduce the need for the occlusal restoration of permanent first molars appreciably. Almost half (44 per cent) needed treatment occlusally, but not occluso-proximally. This proportion was slightly larger when decay rates were below the average in the primary teeth before the sixth birthday.

As in the non-fluoridated area, occlusal surfaces usually needed restoration at an earlier age than the proximal surfaces. Consequently, over a quarter evidently were restored initially with an occlusal filling and subsequently with an occluso-proximal after a mean period of almost three years. Opportunity therefore presents for sealants to reduce the need to restore occlusal surfaces more than once.

Apparently occlusal surfaces do not become decayed so rapidly in fluoridated areas, and this would facilitate the placement of sealant when the tooth had erupted sufficiently. Only 26 per cent had become decayed before the eighth birthday, and this proportion was lower when there were below average decay rates in the primary teeth before the sixth birthday.

C. Further comments

The following was apparent in the fluoridated area:

(i) sealants could reduce the need for the occlusal restoration of permanent first molars appreciably, and

(ii) fissures become decayed at a later age, and so the time when sealants could be placed is prolonged.

However, as occluso-proximal restorations are comparatively rare, the need for the retention of sealants for long periods is increased. Accordingly, the evidence that fluoride might reduce the retentive qualities of sealants is discouraging.

If sealants only are retained for short periods, they might be more appropriate for permanent first molars in non-fluoridated communities. Of the associated proximal surfaces which were recorded as decayed in this study, 73.9 per cent (548 in 742) were so affected before the eleventh birthday (Tables 82 and 83). Therefore, a retention of sealants for about four years might lead to an appreciable decrease in the need to restore occlusal surfaces more than once. Subjects with deep fissures and above average decay rates in their primary teeth should receive especial consideration in this regard.

3.4 The sealing of fissures in the School Dental Programme

3.4.1 Introduction

Fissure sealants (Nuva-Seal) were placed by therapists in the permanent first molars of second-year children at primary schools. The teeth were selected by the respective three regional dentists and a follow-up survey was undertaken after one year by an independent dentist. The design and organization of the experiment,

and the relevant processing of data and writing of reports were the author's direct responsibility.

3.4.2 Materials and methods

A. Sample

Two regions were selected. The first was a town of 34,000 inhabitants, which was the largest non-fluoridated urban centre in South Australia.¹⁸⁰ The regional dentist and eight therapists, who were employed in the town's five school dental clinics, participated in the study.

The second region was the State capital which had been fluoridated about $3\frac{1}{2}$ years previously. The two most accessible sub-regions were selected and each was represented by the regional dentists and four therapists, who were employed in the two respective school dental clinics.

The subjects in the second grades at the schools with clinics, who had parental consent for school dental care (93.5 per cent), participated in the study. Their mean age was 6.90 years ± 0.68 (standard deviation).

B. Examinations and the selection of teeth

The regional dentists examined the permanent first molars and classified the occlusal surfaces as follows:

- (i) Category A - sound and unrestored, but susceptible to decay and suitable for sealant.
- (ii) Category B - sound and unrestored but inappropriate for sealant, either because they were not considered to be susceptible to decay or because the tooth was insufficiently erupted for sealant to be placed.

- (iii) Category C - restored or decayed. An occlusal surface also was placed in category C when
- (a) the presence of occlusal decay was questionable, or
 - (b) there was a lesion on another surface and it seemed that the appropriate restoration would include the occlusal surface.

(iv) Category D - associated with an unerupted tooth.

Only teeth in category A were classified as eligible for sealant. Eligible teeth were allocated to the test and control groups in the following manner:

- (i) teeth in the upper and lower arches were considered separately.
- (ii) test teeth were matched with contra-lateral controls. In isolated instances, test and control teeth were selected from different subjects because eligible pairs were not available in the same mouth.
- (iii) test teeth were selected alternately from the right and left quadrants.

A total of 817 children was examined and the permanent first molars were classified as indicated in Table 87. The placement of sealant was intended for 678 test teeth in 426 children, but only 650 teeth were treated. Ten teeth were excluded because they could not be isolated from saliva effectively, and the remaining 18 were lost because the subjects had left the school or were absent when the sealant was placed.

C. The placement of sealant

Dental therapists applied the sealant as instructed by their regional dentists. The therapists were permitted to practise the procedure before the commencement of the programme.

The etching time in the fluoridated areas was twice that elsewhere. It was considered that the conventional air and water supply might not be sufficiently pure for optimum effects, and so separate supplies were provided.

The placement of sealant was continual with children presenting in sequence. The numbers of teeth which were sealed in specified periods were recorded, and the mean time per tooth was calculated. The mean incorporated the time lost during the exchange of patients.

Although the need to comply strictly with the manufacturer's directions was stressed, it was learnt that the sealant was not setting rapidly in one locality and that exposure to the Nuva-Lite had been prolonged to achieve complete hardening. Therefore the Nuva-Lite globe was replaced, but a number of teeth would have been sealed with the faulty globe prior to its replacement. At most, this number would have represented 14 per cent of the total sealed.

D. Follow-up

Approximately 80 per cent of the test and control teeth (522 pairs) were re-examined after one year. The others were lost because subjects had left the school or were absent during the survey. The examiner had no prior knowledge of which teeth were sealed.

The occlusal surfaces were classified as follows:

- (i) decayed when the presence of decay was definite;
- (ii) restored, and
- (iii) sealed when the presence of sealant was definite.

These classifications were not mutually exclusive.

E. Statistical analysis

The proportions of the test teeth with retained sealant in sub-groups, which were classified by arch and region, were compared using the chi-square test of statistical significance (X^2).¹⁶⁷ The proportions of the test and control occlusal surfaces with decay or a restoration were compared by applying the McNemar Test (X_M^2), because of dichotomous data and correlated samples (Appendix 8.2).¹⁶⁷

The author processed the data with a Canola 167P electronic calculator.

3.4.3 Results and comments (S.A. experim.)

A. Retention of sealant

Of the teeth recorded as sealed, 128 (24.5 per cent) had retained sealant. A further 31 control teeth clearly displayed sealant. If these controls were sealed mistakenly instead of the corresponding test teeth, the retention rate would be 30.5 per cent (159 in 522).

These lower and upper estimates of retention rates are presented by dental arch and region in Table 88. The rates were higher in the fluoridated region for both arches, but the difference was statistically significant in the lower arch only (lower estimate $X^2=11.00$: $df=1$: $p<0.001$: upper estimate $X^2=11.33$: $df=1$: $p<0.001$).

The rates were higher in the lower than upper arch in the fluoridated region, and the difference was statistically significant for the upper estimates ($\chi^2=8.45$: $df=1$: $p<0.01$).

B. Decay rate

The occlusal surfaces of 93 test teeth were decayed or restored (17.8 per cent), and the corresponding figure for the control teeth was 123 (23.6 per cent). The corresponding reduction of 24.4 per cent might represent an underestimation of the effect of sealant, if a number of the control teeth were sealed inadvertently. Details are presented by dental arch and region in Table 89.

In three of the four arch and region specific groups, test teeth had lower decay rates (Table 89), but the difference was statistically significant in the lower arch in the non-fluoridated region only ($\chi^2_M=5.94$: $df=1$: $p<0.05$). Collectively, the difference was statistically significant in the lower arch ($\chi^2_M=8.51$: $df=1$: $p<0.01$), but not in the upper jaw.

C. Time for the placement of sealant

The mean time per tooth approximated 7.5 minutes for the non-fluoridated areas.

Time records for the fluoridated region included registrations for 91 teeth where in some instances, exposure to the Nuva-Lite had been extended to achieve complete hardening. The mean time for the 91 teeth was 11.0 minutes, as opposed to 9.4 minutes for the others.

It was apparent that the time per tooth was less when more than one tooth was sealed per subject, and so

these times might have been shorter had contra-lateral teeth not been excluded as controls.

3.4.4 Discussion (S.A. experim.)

The retention rate of 25 to 31 per cent compares unfavourably with rates obtained in several studies.^{221, 223, 224, 238, 239, 240, 241, 242} Although sealant in deep fissures might have been overlooked and the retention rate therefore underestimated, the rate in this study would have included instances where sealant was partially lost, and so the rate of complete retention cannot be estimated.

Often the external validity of experimental findings is questionable because of the artificial nature of the experimental setting. In this study, 16 therapists applied the sealant in their normal operational environment. Although they were instructed to follow the manufacturer's directions and in particular to avoid salivary contamination, the instructions were not reinforced during the programme and possibly were not emphasized sufficiently.

It seemed that the placement of sealant was unpopular. Several therapists indicated that the continuous sealing of teeth was tedious, but only one Nuva-Lite was available and so continuous sealing was necessary. Although teeth were chosen for sealant only when they were regarded as sufficiently erupted, therapists reported that it was difficult to maintain a dry field for some children. Therapists were requested to discontinue the operation if contamination with saliva occurred. Never-

theless, it is possible that the difficulty of treating permanent first molars in children with a mean age of 6.90 years led to an unsatisfactory technique. The need to seal permanent first molars at a young age is demonstrated by the status of their occlusal surfaces at the commencement of the programme, that is, 28.8 per cent yet to erupt and 17.6 per cent already restored or requiring a restoration.

It is possible that the method of selecting teeth strongly influenced the retention rate. At the commencement of the programme, 46.3 per cent of the permanent first molar occlusal surfaces were unerupted, restored, or about to be restored. Of the others, only 21.1 per cent were regarded as unsuitable for sealant, and the regional dentists stated that most of these were excluded because the teeth were insufficiently erupted. Therefore almost all the surfaces which were classified as sound and accessible apparently were included.

Previous studies testify to the potential value of fissure sealants, and the need for an exacting technique has been emphasized.²²⁰ In this programme, the mass application of fissure sealant by therapists to the permanent first molars of second-year primary school children was associated with a low retention rate. Consequently, the maintenance of records to compare the time taken to treat the test and control teeth throughout the primary school years has been discontinued.

Further studies of fissure sealant are planned for the School Dental Programme.

3.5 Summary

A considerable number of studies was reviewed which indicated the potential value of fissure sealants.

An analysis of the treatment of the occlusal surfaces of permanent first molars in the New Zealand School Dental Service indicated the respective potential of sealants in non-fluoridated and fluoridated communities. In non-fluoridated areas, the following was apparent:

- (i) only a fifth of these teeth required occlusal but not occluso-proximal restoration, and so the potential for sealant to preserve the natural occlusal surface seemed limited in the long term;
- (ii) this potential was less evident when decay rates in the primary teeth were above the average before the sixth birthday, and
- (iii) as over 60 per cent of the teeth were restored initially with an occlusal restoration and subsequently with an occluso-proximal, sealant might reduce the need to restore occlusal surfaces more than once, provided that these surfaces do not decay before erupting sufficiently for the sealant to be placed.

In fluoridated areas, the following was evident:

- (i) almost half of these teeth needed treatment occlusally, but not occluso-proximally, and so the potential for sealant to preserve the natural occlusal surface seemed appreciable throughout the included age span;
- (ii) this potential was more evident when decay rates in

the primary teeth were below the average before the sixth birthday, and

- (iii) as over a quarter of the teeth were restored initially with an occlusal restoration and subsequently with an occluso-proximal, sealant might reduce the need to restore occlusal surfaces more than once.

Apparently fissures become decayed at a later age in fluoridated areas, and so the time when sealants could be placed would be prolonged. It seems that the value of sealant largely would depend on the application time, the subsequent retention rate, and the incidence of decay which required the restoration of sealable fissures.

A total of 817 South Australian subjects of mean age 6.9 years was examined, and 42.4 per cent of their permanent first molars were assessed as suitable for fissure sealant. Of these teeth, 522 were sealed by 16 dental therapists and compared with controls after one year. The retention rate apparently was between 25 and 31 per cent, and the decay rate was reduced by 24 per cent on the test surfaces. The retention rate was extremely low when compared with the rates for other studies, and possible reasons were discussed. Consequently, the maintenance of records to compare the time taken to treat the test and control teeth throughout the primary school years was discontinued. Further studies of fissure sealant are planned for the School Dental Programme.

4. The effect of a pilot dental health education programme on secondary school students

4.1 Introduction

In a previous section, it was reported that second-year secondary school students with histories of care through the School Dental Programme had superior oral hygiene habits and were better informed than their peers, but that the effects of health education in the Programme apparently were not pronounced. Perhaps the most important finding was the lack of professional care after subjects left primary schools and were not eligible for school dental care.

The opinion that an informed community would adopt habits which are consistent with knowledge is not supported by

- (i) assessments of the effectiveness of school dental care in the intermediate term;
- (ii) the survey of dental knowledge, attitudes and habits already reported, nor by
- (iii) experience elsewhere.^{153,160,161,162,163}

A review of reports of school dental health education by Rayner and Cohen indicated that health education, which is aimed at senior secondary school students, might be more effective in the intermediate and long term than education aimed at young children.¹⁵⁸

In this pilot programme, 15 to 17-year-old secondary school students acted as chairside assistants, explored aspects of dental care and provided dental health education at local primary schools. The effects on the secon-

dary school students' dental health and behaviour were evaluated by comparisons with matched controls.

4.2 Review of the literature

Heifetz and Suomi reviewed the effectiveness of preventive measures and concluded that initiative probably would be required at the individual level for most advances in preventive dentistry.¹⁶¹ Whereas procedures like plaque control might be suitable for highly motivated patients, these practices were of questionable value in the public health context, as there was no established technology for impelling mass behavioural change.¹⁶¹ Consequently, they claimed that preventive methods which operated independently of the patient's co-operation should be pursued vigorously.¹⁶¹

Chambers reasoned that few individuals were likely to benefit from preventive messages, because only a minority had life-styles which were compatible with preventive behaviour like plaque control.¹⁶⁴ Established habits seemed to develop their own value defences: that is, by commencing with a habit, an individual often seemed to acquire information and attitudes which supported the habit.¹⁶⁴ Conversely, by commencing with information, one commonly achieved only half-remembered knowledge and appropriate behaviour of a temporary nature only.¹⁶⁴

Clark, Fintz and Elwell evaluated the effects of five-hour classes and subsequent reinforcement of plaque control for sixth-grade students.²⁴³ The students were instructed with the aid of phase-microscopy, motion films, chemical demonstrations of acid in vivo and in

vitro, peer-group pressure, and demonstrations and participation in staining, brushing and flossing activities. Subsequently, the students' teeth were stained and examined for plaque by class-mates for five consecutive days, and students with plaque received special counselling from a dental assistant. Over the subsequent eight months, a dental assistant provided weekly supervision of staining, brushing and flossing "whenever indicated". Controls received the same dental information during a one-hour lecture. Subsequently, floss, disclosing tablets and toothbrushes were distributed. After 14 months, plaque scores for the control subjects usually did not vary from base-line records to a statistically significant extent. Conversely, plaque scores for the test subjects usually were significantly lower than the base-line records.²⁴³ That is, the conventional method of instruction was not successful, whereas instruction plus sustained plaque control and reinforcement apparently led to improvements. The latter programme required active support from the teachers, who therefore received special instruction.²⁴³

A commercial project entitled the "Toothkeeper Program" appears similar to the one described by Clark, Fintz and Elwell.^{244,245} The "Toothkeeper" kit is supplied by a commercial company and might contain two motion films, a model of a quadrant of the mouth, disclosing tablets, toothbrushes, dental floss, mirrors and appropriate guides for parents, teachers, school admin-

istrators and dental consultants.²⁴⁵ The "Program" is directed towards the sixth and lower grades, and emphasis is placed on developing skills and habits in plaque control. Teachers are prepared for the roles of instruction and surveillance by a dental consultant, and are expected to implement the programme for 16 consecutive weeks.^{244, 245}

Smith, Evans, Suomi and Friedman evaluated the "Toothkeeper Program" in three Texan schools.²⁴⁶ A total of 118 test students from grades one to six was compared with 95 controls from the same schools after the 16-week programme and after a further 16-week period. Improvements in oral hygiene and gingival health were not apparent.²⁴⁶

Stamm, Kuo and Neil analysed the effects of the "Toothkeeper Program" on the oral hygiene and gingival health of a group of nine and 10-year-olds in Vermont.²⁴⁷ Children were examined after the 16-week programme and also after a further 16-week period. A total of 78 test subjects was compared with 77 controls from the same schools. Although improved scores were apparent for test students, they evidently did not reveal persistently superior changes, as assessed by comparisons with the controls.²⁴⁷

Graves, McNeal, Haefner and Ware compared the impact of a "Toothkeeper Program" for children from five to 12 years of age with the effect of providing information.²⁴⁸ A total of 217 test subjects was compared with 192 controls after the 16-week programme, and also approximately

seven months after the base-line examinations. Statistically significant reductions in plaque and gingivitis scores were observed for the test group when compared with the controls over the 16-week period of the programme, but these advantages were not apparent at the final examinations.²⁴⁸

It seems that the dental health educational model in the "Toothkeeper Program" often does not achieve permanent improvements in the oral hygiene practices of primary school children. The review by Rayner and Cohen of reports of school dental health education indicates that education might have greater intermediate and long-term effects if directed towards senior secondary school students.¹⁵⁸

Weiss and Lee reported a programme in which teenagers provided oral hygiene instruction to primary school children.²⁴⁹ Although the effects on the knowledge and oral hygiene skills of the primary school children were evaluated, the impact on the teenagers' oral health was not reported. The teenagers were considered to have reacted enthusiastically and to have regarded the experience as useful for career planning and for learning to manage responsibility.²⁴⁹ It seems that the programme was similar to the one now reported for South Australia.

4.3 Materials and methods

A. The educational programme

Each student participated for four days over a three-week period. On the first day, students discussed dental health in groups of four with a dental therapist,

and received fundamental information on the aetiology of dental diseases and on the preventive measures which were appropriate at home and in the dental surgery. Subsequently, they observed the delivery of treatment and were shown how to provide chairside assistance.

On the second day, groups of two students were assigned to school dental clinics near their school. Throughout the day, they provided dental health education to primary school children. The children mostly participated in groups of five, but limited instruction also was provided in the classrooms and at the chairside. Additional activities included the mass supervision of tooth-brushing.

On the third day, students normally reviewed diet records which they had completed during the previous week, and discussed the dental and nutritional implications with a therapist. Each student stained his plaque with sodium fluorescein and observed the associated fluorescence under a "black" light. Elective activities included

- (i) the implementation of surveys in supermarkets;
- (ii) the preparation and restoration of cavities in plaster teeth;
- (iii) the review of motion films on dental health, and
- (iv) chairside assisting.

On the final day, students explored aspects of dental practice by visiting a dental hospital and a teaching clinic at the School of Dental Therapy. The South Australian Branch of the Australian Dental Association agreed to arrange for interested students to visit private

practices.

There was no deliberative reinforcement after the students had left the programme, and the total exercise continued for seven months.

B. Samples

All fourth and fifth year students at a secondary school in an industrial area of the State capital were invited to participate. A total of 124 (26.7 per cent) chose to do so, and were examined and interviewed for evaluative purposes before the programme commenced.

Similarly, all fourth and fifth year students at a nearby secondary school were examined and interviewed for control purposes. Only students who elected to be examined were included, that is, 170 (64.2 per cent).

A considerable number left the schools during the year, but 91 pairs of matched test and control subjects nevertheless were examined after the educational programme had been completed.

C. Examination techniques

(a) Clinical

The labial surfaces of the incisors and the buccal surfaces of the two most posterior teeth in each quadrant were scored for debris in accordance with the criteria for the oral hygiene index.¹⁴⁴ Gingival disease scores were obtained for the buccal and labial aspects of all teeth by using the criteria for the periodontal index.¹⁴⁶ The scoring methods for these indices were described for the 1971-1972 and 1974 surveys of secondary school students. The presence of a carious lesion also

was noted for each subject.

Examinations were undertaken by one dentist in a mobile clinic, as described for the fluoridation base-line survey but without x-rays. The extent of examiner variability for debris and gingival disease scores was indicated by the results of duplicate independent examinations of 38 students. The mean debris score ranged from 1.025 ± 0.067 (standard error) for the initial examination to 0.952 ± 0.077 (standard error). The decrease seems small and possibly was influenced by the removal of debris with a probe during the examination process. The corresponding gingival disease scores were 0.738 ± 0.035 and 0.715 ± 0.044 respectively, which constituted a decrease of 3.1 per cent.

(b) Interviews

Immediately after the examinations, students were interviewed by a research assistant in a separate room. Questions were unstructured, and ordered and phrased with the aim of eliciting a valid response.

The purpose was to determine the proportion of the test and control students who had performed the following:

- (i) consumed sweets or chocolate on the day preceding the survey;
- (ii) brushed their teeth on the morning of the survey;
- (iii) normally used a fluoride toothpaste;
- (iv) normally used a soft toothbrush, and
- (v) visited a dentist in 1974 (base-line) or in 1975 (follow-up).

Although it was anticipated that some subjects would provide inaccurate information, it was assumed that the

associated effects on the test and control data would be similar, and that health education effects nevertheless would be apparent.

D. Statistical analysis

Test students were matched with controls by school year, sex, debris scores and where possible according to their intention to complete prerequisite examinations for a university education.

Mean debris scores for the test and control groups at the commencement of the study were 1.267 ± 0.070 (standard error) and 1.269 ± 0.069 (standard error) respectively, and the corresponding gingival disease scores were 0.780 ± 0.057 and 0.764 ± 0.063 respectively. The means for sub-groups classified by sex and period of participation in the educational programme are displayed in Table 90.

A total of 48 test subjects (52.7 per cent) initially had a carious lesion, as opposed to 54 controls (59.3 per cent). The respective percentages for the test and control groups were as follows:

- (i) 50.0 and 63.6 for males;
- (ii) 55.3 and 55.3 for females;
- (iii) 50.0 and 60.0 where test subjects participated in the last two months of the programme, and
- (iv) 54.1 and 59.0 where these subjects participated in the first five months of the programme.

The paired t-test was employed when analysing differences between the changes in debris and gingival disease scores for the test and control groups, as a result of correlated samples (Appendix 8.1). Similarly,

changes in behaviour within the test and control groups were investigated with the McNemar test (X_M^2), because of dichotomous correlated data (Appendix 8.2). The data were processed on a 167P Canola electronic calculator.

E. Limitations in the research design

If this style of dental health education is to be considered for the State, a random selection of students from that area would have been appropriate with a subsequent random allocation to the test and control groups. Similarly, a random State-wide selection of school dental clinics and corresponding staff would have been desirable. It is possible that the students and staff in this study were atypical. For example, the test students elected to participate, as did the school, and this factor could have influenced the effects of the programme.

Control subjects were obtained from a nearby school. This school elected to participate, and only students who volunteered for dental inspections were included. It was thought that volunteers might be similar to test subjects who were volunteers also. Neither the test nor the control subjects were informed that they were being examined to evaluate an educational programme.

The selection of the test and control subjects from different schools was necessary, but introduced the potential for bias from dentally-related differences or examiner variability between the schools. Ostensibly, the two schools were comparable, serving adjacent areas of the same industrial community. No dental project apart from the pilot programme was undertaken in either

school during the year, and the school canteens were similar.

The examiner was not conscious of variations in diagnostic performance between the schools. During the base-line inspection, short surveying periods were alternated between the schools in order to reduce the chances of bias from any diagnostic variations over time. The independent duplicate examinations, which were described previously, infer the level of examiner variability.

It was anticipated that the matching of test and control students would minimize the potential for bias from inter-school differences and self-selection.

Data for students who participated in the last two months of the programme were analysed separately. If the educational activity was effective, but some predictable relapse occurred over time, then data for these students might indicate more substantial effects. If this pattern of effects was evident from the results, the conclusion that positive differences resulted from the test programme, and were not entirely spurious, would be strengthened. When surveying the test students, the examiner did not know when the individuals had participated: that is, the examinations were "blind" in that regard.

F. Further comments

The author planned and organized the educational project and the research programme, processed the data and wrote the reports. Staff employed in the School Dental Programme implemented the educational project, and

an independent dentist performed the surveys.

4.4 Results and comments

A. Oral debris and gingival disease

Reductions in the growth of debris and gingival disease scores in test students, as indicated by comparisons with controls, are presented in Table 91.

The collective reduction was 59.1 per cent for the debris scores and 40.1 per cent for the gingival disease scores, and both reductions were statistically significant. Reductions were more pronounced for subjects who had participated in the last two months of the educational programme, that is, 75.1 and 45.2 per cent respectively (Table 91).

Reductions were evident for both sexes, but a level of statistical significance was not reached by reductions in the gingival disease scores for females (Table 91).

The prevalence of carious lesions in the test subjects evidently decreased from 52.7 to 33.0 per cent ($\chi^2_M = 10.32 : df=1 : p < 0.01$), whereas a decrease from 59.3 to 39.6 per cent was registered for the controls ($\chi^2_M = 9.03 : df=1 : p < 0.01$). The degrees of improvement in the two groups seemed similar. Reductions in the prevalence scores were as follows:

- (i) from 50.0 to 36.4 per cent for the test males ($\chi^2_M = 2.08 : df=1 : p > 0.05$), and from 63.6 to 45.5 per cent for their controls ($\chi^2_M = 3.50 : df=1 : p > 0.05$);

- (ii) from 55.3 to 29.8 per cent for the test females ($\chi^2_M=7.56$: $df=1$: $p<0.01$), and from 55.3 to 34.0 per cent for their controls ($\chi^2_M=4.50$: $df=1$: $p<0.05$);
- (iii) from 50.0 to 30.0 per cent for the test students who participated in the last two months of the educational programme ($\chi^2_M=3.13$: $df=1$: $p>0.05$), and from 60.0 to 50.0 per cent for their controls ($\chi^2_M=0.44$: $df=1$: $p>0.05$), and
- (iv) from 54.1 to 34.4 per cent for the test students who participated in the first five months of the educational programme ($\chi^2_M=6.05$: $df=1$: $p<0.05$), and from 59.0 to 34.4 per cent for their controls ($\chi^2_M=8.52$: $df=1$: $p<0.01$).

B. Dental behaviour

The base-line characteristics are presented in Tables 92 and 93. Test and control groups had similar base-line scores, except for the use of a soft tooth-brush and the consumption of sweets or chocolate on the day before the survey.

A substantial increase in the use of soft brushes, as recommended by the school dental staff, was evident in the test but not in the control group. All sub-groups within the total test group experienced improvements in scores which were statistically significant (Table 92).

The use of a fluoride toothpaste apparently increased to a statistically significant extent in all the sub-groups within the total test group, but significant

improvements were evident for the control males only (Table 92).

Although apparent increases in the use of soft brushes and a fluoride toothpaste by test subjects were statistically significant for each sub-group, these increases seemed greater for subjects who had participated in the last two months of the educational programme (Table 92).

The percentages of students who reported (i) toothbrushing on the morning of the survey, and (ii) consuming sweets or chocolate on the preceding day, seemed similar for the base-line and follow-up surveys (Tables 92 and 93).

Surprisingly, more control subjects apparently had visited a dentist in 1975 than in 1974, but a similar change was not apparent for the test students (Table 93).

4.5 Discussion

Increases in the debris and gingival disease scores for the test and control students apparently resulted from extraneous influences. Nevertheless, reductions in the scores for test students, as indicated by comparisons with controls, support the conclusion that the programme was effective. This conclusion is strengthened by the greater reductions for test students who participated in the last two months of the educational programme.

The increased use of recommended toothbrushes and fluoride paste by the test students also is encouraging, but the greater demand for care by the control students in 1975 is surprising. Both the test and control students

were referred for care after the base-line survey, but a commensurate increase in care for the test students was not apparent. Perhaps some parents mistakenly thought that their children might receive care through the test programme, and therefore did not seek care privately. It was hoped that the educational programme would increase the demand for care, particularly as a lack of care after leaving the School Dental Programme seemed a significant problem.

Overall, students evaluated the educational programme positively. Activities cited as most worthwhile were as follows:

- (i) providing dental health education to school children;
- (ii) assisting at the chairside, and
- (iii) placing restorations in plaster teeth.

The teacher who supervised the programme at the secondary school considered that the school's aim was to acquaint students with an aspect of community life, to foster a sense of responsibility through participation in a community programme, and to provide a career orientation.

The reactions of school dental staff varied with the clinic. The staff at two clinics seemed moderately enthusiastic, whereas at one clinic the response was most positive and at another a negative reaction was apparent. Staff at the latter clinic considered that many students were not interested, and that they denied the staff an acceptable degree of privacy. Other staff enjoyed the variation of working with secondary school students and

appreciated the use of student manpower.

Resources were insufficient to evaluate the effect of the students' education on primary school children.

South Australian schools are introducing formalized health education programmes, and organizers are completing preparatory courses at a tertiary college. Selected therapists are participating in these courses to facilitate the introduction of dental components. Methods whereby students at secondary and primary schools can culture organisms from plaque, and can perform experiments with the aid of disclosing material and audio-visual records, are being evaluated. It is anticipated that teachers will arrange most of the teaching experiences but that dental staff will initiate programmes and act as resource personnel.

It is considered that an effective dental health education programme might include

- (i) a greater participation of parents than has occurred previously in the School Dental Programme;
- (ii) a dental component in the health education courses being established by teachers in secondary and primary schools, and
- (iii) the participation of students as educators for the younger children.

Home visits by dental staff require considerable time, and probably will be reserved for children with special problems.

4.6 Summary

The lack of professional care, once subjects no longer are eligible for school dental care, has been reported in this thesis. A previous review of reports of school dental health education indicated that education aimed at senior secondary school students might be more effective in the intermediate and long term than education directed towards young children.¹⁵⁸

In this pilot programme, 15 to 17-year-old secondary school students acted as chairside assistants, explored aspects of dental care, and provided dental health education at local primary schools.

A total of 91 test subjects was compared with controls who were matched by school year, sex, initial oral debris scores and where possible, according to their intention to complete prerequisite examinations for a university education. Both the test and the control students were volunteers from nearby schools.

Follow-up examinations indicated that there were improvements in debris and gingival disease scores in the test subjects, as assessed by comparisons with controls. The prevalence of carious lesions also decreased, but similar reductions applied to both the test and the control groups.

Test subjects increased their use of recommended brushes, and an extended use of fluoride toothpastes occurred for both the test and the control groups.

Improvements in the test subjects usually were more pronounced for students who had participated more recently in the educational programme. This finding indicates that

regression might occur with time, but that improvements resulted from the test programme.

Whereas control subjects apparently expressed an increased demand for dental care, a similar change was not apparent for the test subjects. Further experimentation with educational methods has been planned for secondary school students.

5. The appropriateness of employing dental therapists

5.1 Introduction

It seems that the following characteristics are relevant when considering the appropriateness of therapists in the dental team:

- (i) the quality of their care;
- (ii) their productivity as related to their cost of employment, and
- (iii) their acceptability to the community.

These features are discussed under appropriate headings.

5.2 Quality of care

Therapists may provide the following services:

- (i) examine patients and expose bite-wing x-rays when they consider these films to be appropriate. The x-rays may not be exposed for individuals at intervals shorter than 18 months without approval from a dentist. Therapists record decay and chronic marginal gingivitis, and plan associated treatment. Therapists may commence the treatment without direction from a dentist after recall examinations only.

- (ii) control decay by the excavation of softened dentine and by the insertion of temporary dressings.
- (iii) provide oral prophylaxes and topical applications of fluoride.
- (iv) arrange dental health educational experiences.
- (v) expose intra-oral x-rays when so directed by a dentist.
- (vi) obtain local anaesthesia with inferior dental nerve blocks or supra-periosteal infiltrations.
- (vii) place composite and amalgam restorations after preparing the cavities, and after inserting retentive pins in posterior teeth when appropriate.
- (viii) perform pulpotomies of the exposed vital pulps of primary teeth, and mummify the pulp tissues in the root canals with formocresol.
- (ix) provide emergency care of the exposed pulps of permanent teeth by capping with calcium hydroxide and by placing a sedative dressing.
- (x) extract primary teeth when so directed by a dentist.
- (xi) obtain impressions and study casts of the teeth.
- (xii) place copper bands over sedative dressings for reinforcement.

Further details are included in a policy document.²⁰⁶

The delegation of these activities was based on their apparent frequent need, the expectation that the necessary skills could be acquired in a two-year training programme, and the subjective assessment that therapists performed competently in these fields.

Statistical evaluation of the therapists' perfor-

mance at diagnosing decay and chronic marginal gingivitis, planning treatment for decay, referring appropriate patients to the regional dentist, and at providing data to indicate the approximate prevalence of certain dental conditions, has been discussed already. Results supported the opinion that therapists could perform their assigned duties. As they apparently would not refer many children whom their regional dentists would wish to see, the dentists are expected to maintain a periodic surveillance of each child.²⁰⁶

The quality of the therapists' restorations has not been evaluated in a rigorously scientific manner. Subjectively, the quality seems good. Failure rates of restorations in second-year students at secondary schools have been lower in subjects with histories of school dental care, but differences were small and considered to be inconsequential. This finding was reported for the 1971-1972 and 1974 surveys of secondary school students. If therapists were not competent to place restorations, it seems that the failure rates would have been higher than for students who had not received school dental care, and who therefore only would have been treated by dentists. As numerous potentially related variables were not controlled, the respective restorative performance of dentists and therapists cannot be defined. For example, the relative complexity of restorations placed by dentists and therapists, and any difference in quality between private and government dental systems, were not controlled

statistically.

Collectively, it seems that therapists perform adequately, and statistical data support this observation with regard to diagnosis, treatment planning, and the provision of prevalence data and of specified restorative care. It is encouraging that teams of dentists and therapists apparently have provided preventive benefits in the short and intermediate term, and that therapists have implemented a pilot dental health education programme for secondary school students with beneficial effects, but comparative standards based on the achievements of dentists are not available for assessments of performance. Conversely, the poor retention rate of the sealants which therapists placed in second-grade primary school children was discouraging. However, the absence of a comparative standard based on the accomplishments of dentists in this circumstance prevents a definition of the therapists' performance. Although therapists seem to perform adequately when exposing x-rays, excavating softened dentine, placing sedative dressings, providing local anaesthesia, performing pulpotomies in primary teeth, capping the exposed pulps of permanent teeth, extracting primary teeth and obtaining impressions and study casts of the teeth, this observation is totally subjective. The placement of copper bands is so rare that the performance of therapists is difficult to appraise.

5.3 Productivity as related to cost

Although it seems from casual observation that therapists have the same capacity for productivity as dentists, the therapists' performance only has been assessed statistically for restorative productivity.

It has been reported in this thesis that the times for dentists to perform specified restorations were shorter than for therapists. Collectively, the dentists' mean times were 10.9 per cent shorter. As there was one chair-side assistant for two therapists, as opposed to one for each dentist, it was not concluded that the therapists had a lower capacity for productivity. In fact, the restorative productivity of the therapists seemed reasonable to the author in the context of their more limited chair-side assistance.^{250,251,252,253}

If it is assumed that dentists and therapists have a similar capacity to be productive and to provide quality care, insofar as this care is within the therapists' scope, then the appropriateness of employing therapists in a cost-effectiveness perspective largely would depend on the relative training costs, working life spans and salaries of therapists and dentists. It is assumed that the periodic checking of the therapists' diagnoses, and of their planning of treatment for decay, would demand an inconsequential amount of the dentists' time. State-wide standards bind regional dentists to checking at least 15 patients annually from each therapist's records for this purpose.²⁰⁶ Whereas each child must be examined by a dentist at least once every two years, these exami-

nations usually exclude the diagnoses of incipient decay and of chronic marginal gingivitis, and concentrate on conditions which are beyond the therapists' scope of care. 206

As therapists do not attempt comprehensive diagnoses of these conditions, there does not seem to be a substantial duplication of effort.

The median estimate of the mean training costs for therapists in 1972, after excluding the "fee-for-service" cost standard for care provided at the School, was about \$9,800 (9,846.95). If therapists were to average an eight-year working life span, which is consistent with loss rates from 1969 to 1975, this training cost per year of working life would have represented 27.7 per cent of their mean salary in 1972. Details have been presented already.

If this percentage applied in 1975, it is evident that the cost of employing therapists with an eight-year span of working life would have been \$9,021.05 per therapist per year (Appendix 5.11). Assuming a ratio of one regional dentist to seven therapists, the annual cost per operator would be \$9,829.44 if the training costs of these dentists were ignored and their mean working life span were presumed to be 30 years (Appendix 5.11). As the second-year annual salary for field dentists who do not direct therapists would be \$10,464 with a final salary of \$13,986 after six years, it is evident that the cost of employment per operator would be cheaper for teams of regional dentists and therapists (Appendix 5.11). The exclusion of the training costs of dentists would have

caused an underestimation of the apparent cost advantage of the team approach.

Assuming that therapists and qualified chairside assistants both would be employed for a mean span of eight years, the respective mean annual salaries would be \$7,064.25 and \$5,723.75 in 1975 values (Appendix 5.11). Therefore, if the ratio of assistants to therapists were to be increased to one to one, the collective salaries for therapists and assistants would increase by approximately 28.8 per cent per therapist. This increase would require accommodating improvements in performance to maintain the existing cost-effectiveness.

5.4 Social acceptability

In the section on the short-term effects of care at 14 regional dental clinics, a collective utilization rate of 93 per cent was reported. It is apparent that most parents considered the Programme to be sufficiently acceptable to enrol their children.

Nevertheless, it is conceivable that utilization rates might have been higher had these clinics been staffed by dentists and chairside assistants only. This seems unlikely as mobile clinics which are so staffed are associated with similar acceptance rates. For example, an analysis of the utilization rates for mobile clinics in 1973 indicated a collective rate of 90.3 per cent (2,106 in 2,332).²⁵⁴ The corresponding rate for the static clinics, which were staffed by dentists, therapists and chairside assistants, was 90.7 per cent

(24,731 in 27,267).²⁵⁴

5.5 Discussion

Insofar as statistical information is relevant to appraisals of the therapists' quality of care, their productivity as related to their cost of employment, and their acceptability to the community, there is support for the opinion that they should be employed. It is evident that statistical evaluation of the therapists' performance is incomplete, and so subjective assessments are necessary.

Although the appropriateness of employing therapists largely seems to depend on their quality of care, productivity, cost of employment and social acceptability, additional considerations could be relevant. If there were an excessive supply of dentists, the social and economic costs of reducing their potential for employment would be pertinent. Therapists are trained in two years, as opposed to five years for dentists, and so it seems that the dental work force could be modified more readily in a system with large numbers of these auxiliaries. Therefore, the employment of therapists might be more appropriate when future manpower needs are uncertain. The potential adaptability of dental systems to future changes in technology also might be relevant. If it seemed that the appropriate employment of auxiliaries would be difficult in the long term because of a likelihood of industrial action, then this aspect should receive attention. The merits of employing alternative types of auxiliaries also should be considered.

It is apparent that a review of numerous indefinite factors is necessary when contemplating the appropriateness of employing therapists.

5.6 Summary

It seems that the appropriateness of therapists in the dental team primarily depends on the quality of their care, their productivity as related to their cost of employment, and their acceptability to the community. Other considerations like the need for dental manpower, the required flexibility of the dental system to accommodate changing manpower and technical requirements, the availability of methods for controlling auxiliaries, and the desirability of alternative types of auxiliaries, also seem relevant.

Substantial statistical evidence supports the opinion that therapists can

- (i) diagnose decay and chronic marginal gingivitis;
- (ii) plan treatment for decay, and
- (iii) provide prevalence data for certain dental conditions.

Limited data also support the attitude that therapists provide restorations of an adequate quality.

It is encouraging that teams of dentists and therapists evidently have provided preventive benefits in the short and intermediate term, and also that therapists have implemented a pilot dental health education programme for secondary school students with apparent beneficial effects, but comparative standards based on the

achievements of dentists in these circumstances are not available to enable a definition of the therapists' performance. Also, the quality of their application of sealant cannot be determined in the absence of a suitable standard.

The competence of therapists to expose x-rays, excavate softened dentine and place sedative dressings, provide local anaesthesia, perform certain pulpotomies, cap exposed pulps, extract primary teeth, and to obtain impressions and study casts of the teeth, only can be assessed subjectively at this time.

There is statistical support for the conclusion that the capacities of therapists and dentists for restorative productivity are similar, but productivity must be assessed subjectively for other tasks. The high utilization rates for care which is provided by teams of dentists and therapists suggest a level of acceptance of these auxiliaries by the community.

Insofar as statistical information is relevant to appraisals of the therapists' performance, cost of employment and acceptance by the community, there is support for the contention that they should be employed.

6. The attitudes of South Australian school dental staff to their occupations and working environment

6.1 Introduction

With the introduction of therapists to South Australian school dental clinics in 1969, a new era in the School Dental Programme commenced. For planning pur-

poses, it seemed appropriate to investigate the following:

- (i) the performance of clinical and supportive staff;
- (ii) the training of staff;
- (iii) the degree to which staff found their occupations satisfying;
- (iv) the design of clinics, and
- (v) the merits of the available dental materials and equipment.

Therefore a survey of staff attitudes to these and other features was undertaken in 1974. It seemed that participation in the survey might reduce perceived feelings of insecurity amongst the staff, which evidently resulted from the Programme's fast rate of growth and their dependence on somewhat remote administrators.

6.2 Materials and methods

A. Sample

Questionnaires were forwarded to all the staff at school dental clinics. A total of 111 subjects (86.0 per cent) responded. The response rate was as follows:

- (i) 100 per cent (11 in 11) for regional dentists who direct therapists;
- (ii) 87.5 per cent (7 in 8) for field dentists who do not direct therapists;
- (iii) 90.5 per cent (57 in 63) for therapists, and
- (iv) 76.6 per cent (36 in 47) for chairside assistants.

B. Questionnaires

A separate questionnaire was designed for each category of staff. These questionnaires are presented

in Appendices 9.1, 9.2, 9.3 and 9.4.

Scope was provided for elaborate answers. In fact, subjects frequently provided comprehensive responses on supplementary sheets of paper, which were distributed for this purpose. The range of times reported to complete a questionnaire extended from three to eight hours.

Questionnaires were identified as relating to specified staff categories, but the individual respondents were anonymous.

C. Comments

The author designed the questionnaires in consultation with several field staff, and then processed the results manually. Selected results are presented.

6.3 Results and comments

6.3.1 Communication

Responses to the following questions were used to evaluate the adequacy of communication between the field staff and both the central administrators and the tutors at the School of Dental Therapy:

- (i) How would you rate the apparent performance of the professional administration at head-office?
- (ii) How would you rate the relationship between the professional administration at head-office and the field staff?
- (iii) How would you rate the relationship between tutors at the School of Dental Therapy and the field staff?
- (iv) Do you feel that your category of staff, that is, regional dentists, field dentists or therapists (chairside assistants excluded), has a sufficient say in deciding the general policy of the Service?

(v) Do you feel that chairside assistants should have a significant say in deciding the general policy of the Service? (posed to assistants only).

A. Responses of regional dentists

The performance of the professional administration was classified by the cited number of dentists as follows:

- (i) "ideal" - three;
- (ii) "less than ideal" - six, and
- (iii) "don't know" - two.

That is, the majority considered that the administration was "less than ideal". Six dentists claimed that the administrators were poor communicators and were not sufficiently familiar with problems in the clinics.

Predictably, the relationship between the professional administration at the head-office and the field staff was evaluated similarly, that is:

- (i) "satisfactory" - five, and
- (ii) "somewhat unsatisfactory" - six.

Of the dentists who provided a rating of "somewhat unsatisfactory", five cited poor communication as the main problem.

Poor communication also was mentioned as the reason for an "unsatisfactory" (two responses) or "somewhat unsatisfactory" (six responses) relationship between tutors and the field staff.

Ten regional dentists claimed that they had an insufficient influence on the general policy of the School

Dental Programme.

Overall, it was apparent that communication was regarded as inadequate, and that relationships between the field staff and both the central administrators and tutors consequently suffered. Regional dentists apparently considered that they had an insufficient influence on policy decisions, which therefore were formulated by administrators who might not be sufficiently familiar with problems in the clinics.

B. Responses of field dentists

The performance of the professional administration was classified as follows:

- (i) "ideal" - one;
- (ii) "less than ideal" - five, and
- (iii) "don't know" - one.

The findings are consistent with the ones for regional dentists. Moreover, four of the five field dentists who rated the performance as "less than ideal" cited poor communication as the main problem.

Predictably, the relationship between the professional administration at the head-office and field staff was evaluated similarly, that is:

- (i) "satisfactory" - two;
- (ii) "somewhat unsatisfactory" - two, and
- (iii) "unsatisfactory" - three.

Of the five field dentists who classified the relationship as "unsatisfactory" or "somewhat unsatisfactory", three claimed that poor communication was the main prob-

lem.

Field dentists apparently were undecided whether the relationship between the tutors and field staff was satisfactory. Three did not seem to know, whereas one claimed that the relationship was "satisfactory" and the others classified it as "unsatisfactory" (two responses) or "somewhat unsatisfactory" (one response). These dentists considered that inadequate communication was the main problem.

Six field dentists reported that their influence on general policy was insufficient.

It is evident that the results for field dentists supported those for the regional dentists by indicating that communication was inadequate and that relationships between the field staff and the central administrators suffered as a consequence. Field dentists also considered that their influence on policy decisions was insufficient.

C. Responses of therapists

The performance of the professional administration was classified as follows:

- (i) "ideal" - 12;
- (ii) "less than ideal" - 28, and
- (iii) "don't know" - 12.

Five therapists did not respond. Of the 28 who rated the performance as "less than ideal", 21 cited poor communication as the major problem, whereas two stated that administrators were not sufficiently familiar with

problems in the clinics.

Predictably, the relationship between the professional administration at the head-office and field staff was evaluated similarly, that is:

- (i) "satisfactory" - 16;
- (ii) "somewhat unsatisfactory" - 21;
- (iii) "unsatisfactory" - 12, and
- (iv) "don't know" - eight.

Of the 33 who rated the relationship as "unsatisfactory" or "somewhat unsatisfactory", 25 cited poor communication as the main problem.

The relationship between the tutors and the field staff was classified as "satisfactory" (12 responses), "somewhat unsatisfactory" (18 responses), and "unsatisfactory" (13 responses). Twelve therapists did not know how to assess the relationship and two did not respond. Of the 31 who rated the relationship as "unsatisfactory" or "somewhat unsatisfactory", 21 cited poor communication as the main problem.

A total of 37 therapists considered that they had an insufficient influence on policy decisions, whereas 14 disagreed and six either did not comment or were undecided.

Generally, the findings for therapists seemed consistent with those for the regional dentists and field dentists. Poor communication and less than satisfactory relationships between the field staff and the central administrators and tutors were common perceptions, as was

an insufficient influence of therapists on policy decisions.

D. Responses of chairside assistants

The performance of the professional administration was classified as follows:

- (i) "ideal" - nine;
- (ii) "less than ideal" - 10, and
- (iii) "don't know" - 12.

Five assistants did not respond. Of the 10 who rated the performance as "less than ideal", four cited poor communication as the main problem. The other six each indicated a different drawback.

Predictably, the relationship between the professional administration at the head-office and field staff was evaluated similarly, that is:

- (i) "satisfactory" - 10;
- (ii) "somewhat unsatisfactory" - seven;
- (iii) "unsatisfactory" - five, and
- (iv) "don't know" - 11.

Three assistants did not respond. Of the 12 who rated the relationship as "unsatisfactory" or "somewhat unsatisfactory", 10 cited poor communication as the main problem.

Six assistants considered that the relationship between the tutors and the field staff was "satisfactory", whereas three regarded this relationship to be "unsatisfactory" or "somewhat unsatisfactory". A total of 27 either stated that they did not know how to rate the

relationship or did not respond.

Of the 32 assistants responding, 24 considered that they should have a significant voice in policy decisions.

Although chairside assistants did not seem to be as critical of the relationship between the field staff and the central administrators, as were the field dentists and therapists, their general response was similar. Most considered that they should have a significant voice in policy decisions.

6.3.2 Available clinics, equipment and materials

A. Responses of regional dentists

(a) Design of static clinics

Four regional dentists classified the design as "ideal" and seven as "not ideal". Four were critical of the limited storage space and one claimed that the use of this space could be improved by adapting shelves to accommodate the existing dimensions of containers. Three claimed that the waiting rooms were too small and three also considered that there should be a separate radiography room. There were numerous isolated suggestions for modifying the clinic design.

(b) The location of static clinics

Seven regional dentists considered the locations to be "ideal", whereas one regarded them as "not ideal" and three apparently did not know. Two claimed that clinics often were too remote from school buildings with the consequence that contact with school teachers was limited and children found it difficult to reach the

clinics during periods of rain.

(c) The desirability of "one-chair" static clinics for some regions

Three regional dentists considered that these clinics would be "desirable" whereas seven disagreed. One apparently did not know. Seven considered that "one-chair" static clinics would increase the isolation of dental operators to the detriment of job satisfaction and performance. Three dentists volunteered the opinion that therapists should not be employed in these clinics because of the lack of an available chair for a visiting dentist.

(d) The desirability of "two-chair" or "one-chair" mobile clinics for therapists

Whereas all regional dentists agreed that it would be "desirable" for therapists to be assigned to mobile clinics, six stated opposition to the concept of a "one-chair" mobile clinic because of clinical isolation, or because a visiting dentist would not have direct access to a dental chair.

(e) Available equipment

Six regional dentists classified the equipment as "ideal", four as "not ideal", and one provided no opinion. Two claimed that motor-driven model trimmers should be available and two mentioned that distilled water often became contaminated. Numerous isolated suggestions were offered.

(f) Maintenance of equipment

Nine regional dentists regarded their training in equipment maintenance to be "less than ideal", whereas seven classified the corresponding training of therapists

in this manner.

It was apparent that most considered that the maintenance staff was competent. However, six regional dentists rated the maintenance staff's performance as "less than ideal" because of "staff shortages".

(g) Available materials

Materials were classified as "ideal" by seven dentists and "not ideal" by the others. No criticisms were directed towards the types and varieties of materials, but five were critical of the delays in receiving supplies.

(h) Storeroom staff

The performance of the storeroom staff was assessed as follows:

- (i) "ideal" - three;
- (ii) "less than ideal" - five, and
- (iii) "don't know" - three.

Those who considered the performance to be "less than ideal" emphasized the delays in receiving supplies.

B. Responses of field dentists

(a) Design of mobile clinics

One dentist did not present an opinion, but the other six classified the design as "not ideal". Four were critical of the lack of room.

(b) Available equipment

Five dentists rated the equipment in mobile clinics, and four considered it to be "not ideal". Numerous isolated criticisms were provided, for example:

- (i) the equipment is outmoded;

- (ii) the air conditioners are inadequate, and
- (iii) the water supply is insufficient for adequate hygiene.

(c) Maintenance of equipment

Six field dentists regarded their training as "not ideal" in this respect. Although three of the five who rated the performance of the maintenance staff considered this performance to be "ideal", four qualified their remarks by stating that a more complete service should be available.

(d) Available materials

Materials were classified as "ideal" by two field dentists and "not ideal" by four. One dentist provided no opinion. There were isolated claims of the need for alternative or additional items, and that supplies should be dispatched more rapidly.

(e) Storeroom staff

Of the five field dentists who classified the performance of these staff, three considered it to be "ideal". The others claimed that storeroom staff were insufficiently acquainted with dental materials. One dentist was critical of the delays in receiving materials.

C. Responses of therapists

(a) Design of static clinics

The therapists provided these ratings:

- (i) "ideal" - 26, and
- (ii) "not ideal" - 29.

One therapist did not respond and the other apparently was unable to classify the design. Of the 29 who termed

the design "not ideal", 11 claimed that there should be a separate radiography room, 10 indicated that the waiting room should be larger, six criticized the lack of storage space, five mentioned the need for a low sink and mirror for oral hygiene instruction, and four stated that there was inadequate privacy in the surgery from patients in the waiting room. There were 18 additional isolated suggestions for improvement.

(b) The location of static clinics

Thirty therapists considered the location to be "ideal", whereas 24 regarded it as "not ideal" and three did not comment. Seventeen claimed that clinics often were too remote from school buildings, and three remarked that clinics should be placed at a central point in the community so that parental contact might be facilitated.

(c) The desirability of "one-chair" static clinics for some regions

Eighteen therapists considered that these clinics would be "desirable", whereas 37 disagreed. Two presented no opinion. A total of 28 claimed that "one-chair" clinics would promote feelings of isolation with a loss in job satisfaction. Seven stated opposition because there would be no available chair for the regional dentist.

(d) The desirability of "two-chair" or "one-chair" mobile clinics for therapists

Of the 54 therapists who offered an opinion, 51 considered that these clinics would be "desirable" for

therapists. However, 10 stated that "one-chair" clinics would be less suitable because of isolation, or because a visiting dentist would not have direct access to a dental chair.

(e) Available equipment

Equipment was rated as "ideal" by 23 therapists and "not ideal" by 32. Two offered no opinion. Thirteen therapists were critical of the frequent operational disorders and another six claimed that there was a need for modernization. Five indicated that the saliva ejectors were ineffective or cumbersome.

(f) Maintenance of equipment

Of the 53 therapists who provided an opinion, 43 considered that their training was "not ideal" in this regard. The performance of the maintenance staff was rated as "ideal" by 23 therapists and "less than ideal" by 29, whereas five provided no opinion. Only four questioned the competence of these staff, but 25 criticized the lack of manpower for this purpose.

(g) Available materials

Materials were classified as "ideal" by 39 therapists and "not ideal" by 12, whereas six provided no opinion. Criticisms were diverse with none predominating.

(h) Storeroom staff

The performance of the storeroom staff was assessed as follows:

- (i) "ideal" - 25;
- (ii) "less than ideal" - 11, and

(iii) "don't know" - 19.

Two therapists did not respond. It is evident that most therapists were satisfied with this performance, but there were criticisms of delays in receiving stores and also that field staff often were not informed when ordered stores were unavailable.

D. Responses of chairside assistants

(a) Design of static clinics

Of the 33 assistants who were employed in static clinics and who rated the design, 18 and 15 termed it "ideal" and "not ideal" respectively. Seven indicated that there should be a separate radiography room, three claimed that the waiting room should be larger, two stated that the storage space was inadequate and two that the staff room should be larger.

(b) The location of static clinics

Of the 33 assistants who were employed in static clinics and who rated this feature, 18 and 15 termed it "ideal" and "not ideal" respectively. Twelve stated that clinics often were too remote from school buildings.

(c) Available equipment

Eighteen assistants regarded the equipment as "ideal", 15 as "not ideal", and three provided no opinion. Nine assistants expressed concern at the numerous mechanical failures.

(d) Maintenance of equipment

Of the 25 assistants who volunteered an opinion, 22 considered that they were inadequately trained in this

regard. Eleven of the 26 who rated the performance of maintenance staff considered it to be "less than ideal". A serious shortage of maintenance staff was claimed, and 11 assistants stated that there should be a more complete maintenance service.

(e) Available materials

Materials were classified as "ideal" by 26 respondents, "not ideal" by six, and no opinion was provided by four.

(f) Storeroom staff

The performance of storeroom staff was assessed as follows:

- (i) "ideal" - 13;
- (ii) "less than ideal" - 10, and
- (iii) "don't know" - 11.

Two assistants did not respond. Seven claimed that there were frequent delays in receiving stores.

6.3.3 Performance, training and job satisfaction

A. Responses of regional dentists

(a) Performance of staff

The performance of the dentist in charge of evaluation was rated as "ideal" by six regional dentists and "less than ideal" by one, whereas four offered no opinion. One dentist claimed that the results of evaluative studies should be more readily available.

Of the six who classified the performance of the regional dentists, four and two considered it to be "ideal" and "less than ideal" respectively. One indicated that

there was an inadequate emphasis on community relationships, whereas another questioned their performance at orthodontics.

Ten respondents rated the performance of therapists as "ideal" (six respondents) or "less than ideal" (four respondents). Limited performance was mentioned on at least two occasions for the following:

- (i) providing dental health education;
- (ii) establishing satisfactory community relationships;
- (iii) exposing x-rays;
- (iv) extracting teeth;
- (v) obtaining impressions for study casts of the teeth;
- (vi) administration;
- (vii) the maintenance of equipment, and
- (viii) the management of patients.

All regional dentists claimed that therapists were competent to treat pre-schoolers and primary school children, and that they were as skilled as dentists at performing therapy functions.

Of the 10 respondents who qualified the performance of chairside assistants, eight rated it as "ideal" and two as "less than ideal".

(b) Training

Ten of the eleven regional dentists provided opinions on their training, and each one considered it to be "not ideal" insofar as it related to their responsibilities. Nine expressed a need for more training in orthodontics.

Six regional dentists rated their training in dental health education as "not ideal", and five as "ideal". Four mentioned a need for extended training in this field.

The training of regional dentists in administration was classified as "ideal" by three respondents and "not ideal" by eight. Three volunteered the opinion that in-Service training programmes should be introduced.

Four regional dentists mentioned that there was a need for in-Service training in "community relations". Although three considered that their basic training was "ideal" in this regard, seven disagreed and one apparently was undecided.

Five regional dentists also volunteered the opinion that there should be in-Service training in public health dentistry. Whereas one dentist apparently was unable to rate his undergraduate training in this field, 10 claimed that it was "not ideal".

Collectively, the regional dentists seemed satisfied with their training in patient management, although two stated that there was a need for instruction in relative analgesia. Although three classified their training in patient management as "not ideal", eight disagreed.

It was apparent that regional dentists normally were satisfied with the standard of the therapists' training in dental health education. Nine classified this training as "ideal" and two as "not ideal".

All regional dentists considered the training of therapists to be "ideal" for the following:

- (i) the performance of oral prophylaxes and topical

applications of fluoride, and
(ii) the charting and planning of treatment for incipient decay.

Similarly, 10 regional dentists indicated that the training of therapists in infiltration anaesthesia was "ideal", whereas one disagreed. This dentist considered that more emphasis should be placed on aspiration. The numbers who classified the therapists' training in the provision of an inferior dental nerve block as "ideal" and "not ideal" were eight and three respectively. As before, criticism was levelled at the inadequate stress on aspiration.

Although two dentists considered that therapists were ideally trained to expose x-rays, nine disagreed and claimed that angulation often was unsatisfactory.

All regional dentists classified the therapists' training as "ideal" in the provision of amalgam restorations, including the varieties where cusps were restored. However, two dentists rated the therapists' training as "not ideal" for the placement of composite restorations. One considered that there was insufficient experience before graduation, whereas another claimed that more attention should be given to adaptation at the gingival margin.

Whereas six of the eleven regional dentists assessed the therapists' training in exodonture as "ideal", the others claimed that the therapists were too hesitant.

The training of therapists to perform pulpotomies

was evaluated as "ideal" by each regional dentist. However, nine did not consider that the therapists had received enough training to obtain satisfactory impressions for study casts and orthodontic models.

There seemed to be considerable indecision amongst regional dentists about the quality of the therapists' training in administration. Whereas five claimed that it was "ideal", three disagreed, two apparently did not know, and one did not respond.

Most regional dentists (6) classified the therapists' training in "community relations" as "not ideal", whereas three disagreed and two provided no opinion. Dentists who were critical claimed that few therapists seemed to communicate effectively with parents.

Six regional dentists also stated that the therapists' training in patient management was "not ideal", whereas five disagreed. Critical respondents sometimes considered that the therapists did not understand children sufficiently, and were preoccupied with the teeth at the expense of the child's total needs.

(c) Performance at dental health education and at establishing appropriate relationships with the community

No regional dentists rated the existing dental health education as "highly effective", but 10 considered it to be "fairly effective" and one claimed that it was "ineffective". Eight stated that too little time was reserved for this purpose, and six claimed that there should be more visual aids.

The community's awareness of the School Dental Programme was rated as follows:

- (i) "adequate" - two;
- (ii) "inadequate" - eight, and
- (iii) "don't know" - one.

Isolated comments were directed towards the need to obtain more parental participation, to provide information through the press and through addresses to civic groups, and for the research unit to provide more information on the Programme for local distribution. Five dentists claimed that parents had an "inadequate" knowledge of the Programme, and only two rated this knowledge as "adequate".

(d) Job satisfaction

Most regional dentists (7) considered their occupations to be "interesting", whereas the number who classified it as "most interesting" and "somewhat interesting" was two in both instances. Isolated criticisms were directed towards the following:

- (i) the limited opportunity for extended education;
- (ii) the tedium associated with the examinations of the therapists' patients;
- (iii) the narrow scope of pedodontic care when most routine care was delegated to therapists, and
- (iv) the lack of males amongst therapists and chairside assistants.

Each regional dentist ranked his tasks by commencing with the most interesting. The median scores for the tasks were as follows:

- (i) orthodontics - one;
- (ii) endodontics and the restoration of fractured incisors - both three;
- (iii) dental health education - four;
- (iv) "community relations" and oral surgery - both five;
- (v) routine restorative care - six, and
- (vi) administration and exodonture - both seven.

The median was 10 for each of the following:

- (i) examinations;
- (ii) prophylaxes and topical applications of fluoride, and
- (iii) the exposure of x-rays.

Regional dentists were questioned about the satisfaction which they obtained from treating specified groups. It seemed that the treatment of the senior primary school grades was popular. Four rated this care as "very satisfying", whereas three provided a similar rating for children in the two most junior primary school grades. The others considered that the care for these groups was "satisfying". Three dentists provided no response for the treatment of pre-schoolers, but the others either rated this treatment as "very satisfying" (2) or "satisfying" (6). Least overall satisfaction was evident for the treatment of the emotionally or physically handicapped, and for the care of individuals who were receiving a pension because of financial hardship. In each instance, two dentists specified that the care was "not satisfying". Although only one dentist classified the

treatment of pensioners as "very satisfying", three provided this rating for the care of the emotionally or physically handicapped.

Eight regional dentists did not consider that there were "adequate" incentives in their occupation. They criticized the limited scope of clinical care, the lack of opportunity for extended training, and the isolation of positions in the country areas. Seven did not consider that therapists had "adequate" incentives, and the lack of scope for promotion or for refresher training was emphasized. Four dentists stated that there should be a career ladder for chairside assistants. Field dentists in remote rural communities were considered to have "inadequate" incentives by six regional dentists, who cited geographic isolation, the lack of opportunity for extended training, and the unpleasant environment for accommodation and practice as major drawbacks.

The dominant advantages of employment as a regional dentist, when compared with the role of a private practitioner, were claimed to be the following:

- (i) the lack of pressure - 10;
- (ii) the lack of business concerns - 10, and
- (iii) the occupational security - five.

Additional advantages, which were quoted in isolated instances, were as follows:

- (i) the opportunity to provide ideal care unhindered by consumer constraint;
- (ii) the chance to concentrate on children;

- (iii) the opportunity for extended training;
- (iv) the freedom to move from one location to another,
and
- (v) the regular hours of work.

Compared with the role of a private practitioner, the following numbers of regional dentists nominated these major disadvantages of their role:

- (i) the narrower clinical scope - six;
- (ii) the lack of autonomy - six, and
- (iii) the lower income - four.

Further isolated criticisms were directed towards geographic isolation in the country areas, the apathy of many patients, the low image of the salaried dentist in the profession, the limited range of available materials, and the extensive records which were required.

B. Responses of field dentists

(a) Performance of staff

Only three field dentists classified the performance of the dentist in charge of evaluation. Two considered it to be "ideal", whereas the other claimed that research findings should be more readily available.

Of the five field dentists who qualified the performance of their peers, three provided a rating of "less than ideal". These dentists contended that the working conditions and the occupational role were not conducive to an adequate morale nor to a high level of performance. One claimed that field dentists were not sufficiently industrious.

Six field dentists qualified the performance of chair-side assistants, and two considered it to be "less than ideal". No reasons were provided for the negative classifications.

(b) Training

Six field dentists regarded their training as "not ideal" for their responsibilities. Four expressed the need for more training in orthodontics.

Four considered that their training was "not ideal" in dental health education, and seven similarly rated their training in "community relations" and public health dentistry. Five classified their training in administration and three considered it to be "not ideal".

Four termed their training in patient management to be "not ideal", whereas three disagreed.

(c) Performance at dental health education and at establishing appropriate relationships with the community

No field dentist rated the existing dental health education as "highly effective", whereas it was classified as "ineffective" by four and "fairly effective" by two. One did not provide a rating. Five claimed that too little time was reserved for dental health education, four indicated a need for more visual aids, and three considered that the quality of these aids could be improved. An isolated criticism was levelled at the extended recall intervals, which were not considered appropriate for the necessary reinforcement in dental health education.

The community's awareness of the School Dental Programme was rated as "inadequate" by five field dentists. One did not respond and another apparently could not rate this factor. There were isolated statements of a need for more parental participation and for the provision of information on the Programme through the press. Six field dentists rated the level of knowledge of the School Dental Programme amongst parents, and five considered the knowledge to be "inadequate".

(d) Job satisfaction

The field dentists rated their role as follows:

- (i) "interesting" - one;
- (ii) "somewhat interesting" - two;
- (iii) "most interesting" - one, and
- (iv) "uninteresting" - three.

Five were dissatisfied with the limited scope of clinical care, and there were infrequent criticisms of the geographic isolation and of the lack of opportunity for follow-up care.

Each field dentist ranked his tasks by commencing with the most interesting. The median scores for the tasks were as follows:

- (i) orthodontics - one;
- (ii) oral surgery - two;
- (iii) endodontics and exodonture - both three;
- (iv) routine restorative care - four;
- (v) restorations of fractured incisors - five;
- (vi) dental health education and the exposure of x-rays
- both seven;
- (vii) "community relations", and prophylaxes and topical

applications of fluoride - both nine, and
(viii) administration and examinations - both 10.

Field dentists were questioned about the satisfaction that they derived from treating specified groups.

The responses were as follows:

- (i) junior primary school children - "very satisfying" (3), "satisfying" (3) and "not satisfying" (1);
- (ii) senior primary school children - "very satisfying" (2), "satisfying" (4) and "not satisfying" (1);
- (iii) pre-schoolers - "very satisfying" (2), "satisfying" (2) and "no comment" (3), and
- (iv) the emotionally or physically handicapped - "very satisfying" (3), "satisfying" (2) and "no comment" (2).

Six field dentists did not consider that there were "adequate" incentives in their occupation. Four stated that a broader scope of clinical care was required, and three indicated the need for extended training. An isolated criticism was levelled at the geographic isolation. Of the four dentists who rated the adequacy of incentives for the chairside assistants, two regarded them as "adequate" but two disagreed and claimed that assistants should provide more preventive services.

Compared with the role of a private practitioner, the following numbers of field dentists cited these major advantages of a regional dentist's role:

- (i) the lack of pressure - five;
- (ii) the lack of business concerns - five, and

(iii) the opportunity to provide ideal care unhindered by consumer constraint - four.

Additional advantages mentioned in isolated instances were the occupational security and the regular hours of work.

Four field dentists considered that the narrow clinical scope was a major disadvantage of employment as a regional dentist. Further isolated criticisms were directed towards the apparent lack of autonomy, the geographic isolation, the lower income, the excessive administrative requirements with reduced chairside time, and the extensive records which were required.

C. Responses of therapists

(a) Performance of staff

The performance of the dentist in charge of evaluation was rated by 42 therapists. Forty considered it to be "ideal", whereas two disagreed because they considered that the research findings were not communicated sufficiently to the field staff.

Of the 50 therapists who classified the performance of the regional dentists, 29 rated it as "less than ideal". Eight therapists claimed that some regional dentists were not sufficiently industrious. Isolated criticisms were directed towards the limitations in performance which were imposed by the lack of laboratory support and by ineffective communication with their staff.

Although 12 therapists rated the performance of tutor dentists as "less than ideal", 27 considered it to be "ideal". Occasionally it was claimed that

- (i) the tutors confused the students with conflicting advice, and
- (ii) the tutors required training in teaching as well as in dentistry.

Of the 25 therapists who classified the performance of the tutor therapists, 18 considered it to be "ideal".

A total of 47 therapists rated the therapists' performance and 29 classified it as "ideal". Fifty four considered that therapists were competent to treat pre-schoolers, whereas two disagreed and one was undecided. All claimed that therapists were competent to treat primary school children. Compared with the dentists' performance at therapy functions, 23 therapists stated that their own performance was superior, 30 that it was similar, and four that it was inferior.

Twenty eight therapists classified the performance of chairside assistants as "ideal", and 23 as "less than ideal". Isolated criticisms were directed towards the lack of an in-Service training programme for assistants, the limited enthusiasm of some assistants, and the perceived drawbacks of assigning only one assistant to two therapists.

(b) Training

Of the 53 therapists who rated their training in dental health education, only 30 considered it to be "ideal". Occasional criticisms were levelled at the limited experience of students in teaching, the inadequate instruction in teaching methods, and the insufficient extended training to maintain a modern approach.

All of the 56 therapists who provided an opinion considered that their training was "ideal" for prophylaxes and topical applications of fluoride, and for charting and planning treatment for incipient decay.

Similarly 54 of the 56 therapists, who rated their training in the provision of infiltration anaesthesia, termed it "ideal". This rating also was provided for the inferior dental nerve block by 45 of the 55 therapists who offered an opinion.

Of the 54 therapists who qualified their training in the exposure of x-rays, 27 considered it to be "not ideal". Most of the latter therapists claimed that students received insufficient experience, particularly in peri-apical exposures.

All of the 56 therapists who provided an opinion considered that their training at providing amalgam restorations, which excluded cusps, was "ideal". Further ratings were as follows:

- (i) for the provision of cuspal restorations in amalgam - "ideal" (48), "not ideal" (7) and "don't know" (2), and
- (ii) for the provision of composite restorations - "ideal" (42), "not ideal" (11) and "don't know" (4).

Nine claimed that their experience in placing composites as students was insufficient.

Forty five of the 56 therapists who rated their training at extracting primary teeth considered it to be "ideal", and 51 similarly classified their training for

pulpotomies.

Of those who presented an opinion, the majority considered

- (i) that their training at obtaining impressions for study casts and orthodontic models was "not ideal" (31 in 55);
- (ii) that their preparation for administration was "not ideal" (33 in 50), and
- (iii) that they were not trained ideally in "community relations" (35 in 51).

Twenty five of the 43 therapists who rated their training in patient management classified it as "ideal". Isolated criticisms were directed towards their limited training in child psychology and their inadequate experience in the treatment of difficult patients.

(c) Performance at dental health education and at establishing appropriate relationships with the community

The impact of the existing dental health education was assessed as follows:

- (i) "fairly effective" - 33;
- (ii) "ineffective" - 22;
- (iii) "highly effective" - one, and
- (iv) "don't know" - one.

A total of 41 therapists stated that more time should be devoted to this aspect, and 33 claimed that visual aids were "inadequate". Isolated criticisms were directed towards the outmoded teaching methods and the limited inclusion of parents and secondary school students in health education programmes.

Most therapists (47 in 57) considered that the community's awareness of the School Dental Programme was "inadequate", and opinions were volunteered that there should be more publicity through the press, more addresses to civic groups and a greater parental participation in the Programme. The level of knowledge of the School Dental Programme amongst parents was rated as follows:

- (i) "fairly adequate" - 16;
- (ii) "inadequate" - 35;
- (iii) "adequate" - four, and
- (iv) "don't know" - one.

The other therapist did not respond.

(d) Job satisfaction

Most therapists rated their role as "most interesting" (13) or "interesting" (25), whereas the remainder termed it "somewhat interesting" (17) or "uninteresting" (1). One therapist did not respond.

Each therapist ranked her tasks by commencing with the most interesting. The median scores for the tasks were as follows:

- (i) amalgam restorations of cusps and "community relations" - both three;
- (ii) dental health education - four;
- (iii) amalgam restorations which exclude cusps, composite restorations, and pulpotomies for primary teeth - all five;
- (iv) extractions of primary teeth - six;
- (v) administration, examinations, exposures of x-rays,

and impressions for study casts and orthodontic models - all eight, and

- (vi) prophylaxes and topical applications of fluoride - 11.

The satisfaction derived from treating certain groups of patients was expressed by the cited numbers as follows:

- (i) for junior primary school children - "very satisfying" (26), "satisfying" (29), and "not satisfying" (2);
- (ii) for senior primary school children - "very satisfying" (25), "satisfying" (27), and "not satisfying" (5);
- (iii) for pre-schoolers - "very satisfying" (17), "satisfying" (14), "not satisfying" (7) and "no comment" (19), and
- (iv) for the emotionally or physically handicapped - "very satisfying" (13), "satisfying" (18), "not satisfying" (7) and "no comment" (19).

That is, least satisfaction apparently applied to the treatment of pre-schoolers and the emotionally or physically handicapped.

Thirty one therapists rated the incentives for regional dentists, and 16 considered them to be "inadequate". Most of these therapists cited the narrow clinical scope as a major drawback.

Of the 54 therapists who qualified the incentives in their occupation, 44 classified them as "inadequate".

Isolated therapists volunteered the opinion that the therapists' role lacked variation and that there was an inadequate scope for career development.

Forty seven therapists rated the incentives for chairside assistants, and 33 considered them to be "inadequate". Occasional criticisms were levelled at the lack of scope for advancement and at the exclusion of assistants from field conferences. Several stated that assistants should have an in-Service training course and should perform certain preventive services.

D. Responses of chairside assistants

(a) Performance of staff

Only 16 assistants rated the performance of the dentist in charge of evaluation, and 15 classified it as "ideal". The performance of the regional dentists was assessed as follows:

- (i) "ideal" - 15, and
- (ii) "less than ideal" - 14.

Isolated criticisms were directed towards the excessive work load of regional dentists, and it was claimed that some dentists were not sufficiently industrious.

Of the 32 assistants who classified the performance of therapists, 26 considered it to be "ideal". Whereas eight assistants considered that dentists were more competent than therapists at therapy functions, 23 regarded dentists and therapists to be equally competent and five did not provide an opinion.

The performance of chairside assistants was qualified

by 31 of these personnel, and 20 considered it to be "ideal". Isolated opinions were volunteered that some assistants were not sufficiently industrious.

(b) Training

Chairside assistants usually considered the training of therapists to be "ideal" in dental health education (27 in 32) and in patient management (18 in 28). Of the 24 who classified the therapists' training in administration, 13 claimed that it was "ideal". Isolated criticisms were aimed at the therapists' limited knowledge of recording systems and chairside assisting.

(c) Performance at dental health education and at establishing appropriate relationships with the community

The impact of existing dental health education was evaluated as follows:

- (i) "highly effective" - one;
- (ii) "fairly effective" - 21, and
- (iii) "ineffective" - 13.

One assistant did not respond. Twenty two stated that too little time was devoted to this aspect, and 14 claimed that the visual aids were "inadequate". Nine contended that there should be more parental participation in the Programme, and isolated assistants claimed that secondary school students should be included also.

Of the 35 assistants who rated the community's awareness of the School Dental Programme, 27 classified it as "inadequate". Only two considered that parents had an "adequate" knowledge of school dental care, whereas the others described this knowledge as "fairly adequate"

(11) or "inadequate" (19), or provided no opinion (4).

(d) Job satisfaction

Chairside assistants classified their role as follows:

- (i) "most interesting" - eight;
- (ii) "interesting" - 23;
- (iii) "somewhat interesting" - four, and
- (iv) "uninteresting" - one.

The satisfaction derived from the treatment of certain groups was expressed by the specified numbers of assistants as follows:

- (i) for junior primary school children - "very satisfying" (15), "satisfying" (20) and "not satisfying" (1);
- (ii) for senior primary school children - "very satisfying" (5), "satisfying" (24) and "not satisfying" (7);
- (iii) for pre-schoolers - "very satisfying" (15), "satisfying" (12), "not satisfying" (5) and "no comment" (4), and
- (iv) for the emotionally or physically handicapped - "very satisfying" (14), "satisfying" (2), "not satisfying" (7) and "no comment" (13).

It seemed that participating in the treatment of junior primary school children was the most popular.

Of the 24 assistants who rated the adequacy of incentives for regional dentists, 17 considered them to be "adequate". A total of 32 assistants rated the adequacy

of incentives for therapists, and 18 regarded them as "adequate". Several claimed that there should be more scope for advancement and a wider range of responsibilities.

Whereas 13 assistants considered that there were "adequate" incentives for assistants, 18 disagreed. Five mentioned that there should be a formal in-Service training programme and that these personnel should attend in-Service conferences. Several claimed that they should be permitted to provide certain preventive services.

The main advantages of employment as assistants in the School Dental Programme, as opposed to private employment, were considered to be the shorter working hours, the higher salaries, the pleasant working environment, and the frequent contact with children. Disadvantages included the limited scope of clinical care, the infrequent contact with adults, and the narrow range of responsibilities. Each advantage and disadvantage was cited in isolated instances only.

6.4 Discussion

The principle purpose of the survey was to provoke criticisms for consideration when making administrative decisions. Accordingly, respondents often were compelled to rate a feature as "ideal" or "not ideal" and there were provisions for suggesting remedial action. That is, the purpose usually was not to assess whether a characteristic was reasonable but whether there was scope for improvement. It seems that criticisms were stimulated

which were relevant to administrative decision-making. As the provision for describing drawbacks and for suggesting solutions was unstructured, it is possible that comments might have been more forthcoming had there been specific prompting. The subsequent discussion is categorized under appropriate headings.

A. Communication

Results indicated that the central administration often seemed remote from the field staff and so scope for improved communication was evident. It seemed that the field staff considered that they provided an insufficient contribution to the general policy of the Programme. Consequently, one central administrator now visits every field clinic on two or three occasions each year to act as a medium for communication. Task forces of field staff, who were nominated by their peers, specify organizational goals and objectives, and formulate appropriate mechanisms for the feedback of regional data from the research unit. Task forces have established standards for orthodontic supplies and general materials with incorporated provisions for review. In 1975, all the dental staff reviewed State-wide standards on the roles of dentists and therapists, and specified appropriate changes in writing. Annual field conferences for all staff, including the chairside assistants, provide a venue for reviewing the Programme and for scientific sessions. Tutorial staff from the School of Dental Therapy participate to increase their communication with the field

staff. Regional dentists sometimes devote time to tutoring, and it is considered that communication between the tutors and the field staff consequently is strengthened.

B. Available clinics, equipment and materials

It seems that many staff were critical of the limited storage space, the small waiting rooms, and the absence of separate radiography rooms in the static clinics. The storage space and waiting rooms have been enlarged in subsequent facilities, but separate radiography rooms still are unavailable. Recently, mobile lead screens were introduced to further protect the staff from radiation. Low sinks and mirrors have been installed for oral hygiene instruction, and the waiting rooms have been located so as to increase privacy in the surgery. In response to the criticism that clinics sometimes were too remote from school buildings, clinics have been sited closer to these structures.

The concept of one-chair static clinics for therapists apparently was not popular, and problems of isolation and of the lack of availability of a dental chair for a visiting dentist were mentioned. It seems that multi-chair clinics impose a substantially lower cost per chair than do one-chair designs, but cause inconvenience when children must be transported from outlying schools. Mobile multi-chair clinics overcome this problem, but possibly impose greater capital depreciation costs and are more confined with less comfort for the staff.¹⁹⁰ One-chair clinics for therapists would require an increase in the

ratio of chairside assistants to therapists from one-to-two to one-to-one. Accommodating improvements in performance would be necessary to offset increased salary costs.

Field staff often were critical of the level of maintenance of equipment. Consequently, the number of maintenance staff per 100 dental operators has been increased, and there is scope for additional temporary staff in an emergency. Similarly, the number of storeroom staff has been increased. Although dentists are not confined to a standard list of stores, task forces have defined standard lists to simplify the purchasing of stock. Dental staff know that the rapid dispatch of stores is more likely if standard items are ordered, and so there is encouragement for them to conform. Nevertheless, regional dentists are urged to test alternative items, and to ensure that there is appropriate evaluation so that superior materials might be identified for inclusion in the standard lists. Testing may be undertaken by employing the facilities of the research unit or of the Department of Restorative Dentistry at The University of Adelaide.

C. Performance, training and job satisfaction

Most staff appeared to be satisfied with the performance of the dentist in charge of evaluation, but there were isolated claims that the results of studies should be more readily available. As a consequence, the results of all studies now are relayed to staff frequently.

Occasionally, regional dentists were criticized for not being sufficiently industrious, and this is consistent

with the claim that salaried services are associated with a low productivity.¹⁰⁰ It is apparent that many dentists considered that they required more training for their responsibilities in orthodontics, dental health education, "community relations", administration and public health dentistry. Since the survey, dentists have participated in extended training courses in orthodontics. Two have obtained postgraduate qualifications in public health or an allied field, one is basing a postgraduate research programme on dental health educational methods for school children, and two tutor dentists are pursuing diplomas in health administration. Despite these developments, it is apparent that many school dentists do not feel adequately trained for the orthodontic and non-chairside aspects of their role. Recently, laboratory assistance was introduced to the Programme, and so dentists no longer are obliged to construct orthodontic appliances.

It seems that therapists usually were considered to be as competent as dentists at performing therapy duties, but substantial criticisms were levelled at their performance and training in "community relations", patient management, exposing x-rays, extractions, obtaining impressions for study casts and orthodontic models, administration and in the maintenance of equipment. Especial emphasis has been directed towards achieving a high performance in these areas since the survey, but training in exodonture is difficult in one teaching clinic because most patients are "on recall" and extractions are rare.

Performance in dental health education and in "community relations" was not assigned a high rating. It seems that inadequate attention is devoted to these spheres because staff are anxious to treat existing disease. Restorative care leaves tangible evidence of care, and therefore facilitates job satisfaction and is a means of obtaining peer respect. Moreover the benefits of restorative care are immediate, and an instant sense of achievement is possible. It seems likely that some staff might not place an appropriate emphasis on dental health education and "community relations", because of an established reparative orientation. Since the survey, more comprehensive visual aids have been provided and a dental health education unit has been established. The one full-time and three part-time members of this unit encourage health educational activities by the following means:

- (i) by organizing extended training courses for school dental staff;
- (ii) by implementing pilot schemes which are evaluated by the research unit;
- (iii) by seeking the introduction of dental health educational features to school curricula and to the activities of "non-dental" health providers;
- (iv) by visiting individual dental clinics and discussing dental health education programmes with staff, and
- (v) by providing supportive services for these staff.

The current emphasis is directed towards including parents and secondary school students in school dental health

education programmes. Members of the unit contribute to the training of dental therapy students in health education, which previously was not assigned a particularly high rating by therapists.

Regional dentists apparently considered their occupation to be relatively interesting, but there were criticisms of the limited scope for extended education, the tedium of repetitive examinations of the therapists' patients, and the narrow scope of clinical care. Field dentists seemed less satisfied with their occupations, and cited geographic isolation and a lack of scope for follow-up care as additional drawbacks to the major one of a narrow clinical scope. Dentists apparently obtained most interest from orthodontic care, but endodontic care also was a popular source of interest for both the regional and field dentists.

Diagnosis and administration were relatively unpopular amongst both groups. As accumulated dental needs are met and most patients are placed "on recall", it seems that regional dentists will devote more of their time to diagnostic and administrative responsibilities. If they do not achieve sufficient job satisfaction, it might be necessary to modify the school dental system. For example, the number of therapists per dentist could be reduced to enable the dentists to devote more time to providing care which is within the therapists' scope. Alternatively, the dentists' time could be shared between school dental responsibilities and the treatment of adults

in either private or public dental facilities.

School dentists normally are permitted to complete one external training course per year at governmental expense, providing that the duration of the course is not longer than a week. In each of the past three years, one dentist has obtained full-time leave to complete a one-year postgraduate course of study. An elaborate library service has been introduced in which all dentists, therapists and chairside assistants are informed of the contents of the recent issues of major journals, so that they may request copies. The purpose of these developments is to offer incentives and interest and to avoid technological stagnation.

Therapists seemed reasonably satisfied with their roles. It was apparent that they obtained little satisfaction from exposing x-rays, obtaining impressions for study casts and orthodontic models, and from prophylaxes and topical applications of fluoride. When the percentage of patients "on recall" increases, it seems that therapists will devote more time to these tasks. Perhaps consideration should be given to delegating these responsibilities to auxiliaries with a more limited training, in order to reduce the training and salary costs, and also to promote the therapists' job satisfaction. Nevertheless, the danger of excessively fragmenting the provision of care to the detriment of quality and job satisfaction should be considered.

Whereas most chairside assistants seemed satisfied

with their occupation, several considered that

- (i) there should be a formal in-Service training programme for assistants;
- (ii) assistants should be included in in-Service conferences, and
- (iii) assistants should be permitted to provide certain preventive services.

Consequently, assistants now are included in conferences. Although there is no formal in-Service training programme, assistants now receive a comprehensive manual on assisting in the School Dental Programme. Perhaps a system of progressive training, whereby assistants could be taught to provide preventive services and could progress to become hygienists and then therapists, would provide incentives and also would reduce the cost of school dental care.

Sundram has analysed additional results from this survey.²⁵⁵ It is apparent that the questionnaires provided considerable information which influenced the development of the School Dental Programme.

6.5 Summary

A survey of field staff was undertaken through questionnaires to obtain information which might assist administrators to influence the development of a rapidly growing Programme in a constructive fashion.

A participation rate of 86 per cent was achieved, and attitudes towards communication, clinic design and location, equipment and materials, supportive services for maintenance and supply, the performance and training of

staff, and the levels of job satisfaction, were presented in this report.

Results indicated that central administrators often were regarded as remote, and that there was scope for improved communication. Field staff considered that they had an insufficient influence on general policy.

Static clinics sometimes were regarded as having limited storage space and small waiting rooms and as requiring separate radiography rooms. The need for a more fully developed maintenance and supply service also was expressed.

Many dentists considered that their performance would benefit from further training in orthodontics, dental health education, "community relations", administration and public health dentistry. Although it seemed that therapists usually were considered to be as competent as dentists at performing therapy duties, substantial criticisms were levelled at their performance and training in "community relations", patient management, exposing x-rays, extractions, obtaining impressions for study casts and orthodontic models, administration and in the maintenance of equipment. The performance of the School Dental Programme in dental health education and "community relations" was not assigned a high rating.

It seemed that staff usually found their occupations to be relatively interesting, but regional dentists were critical of their narrow clinical scope, their limited opportunity for extended education, and the tedium assoc-

iated with the repetitive examinations of the therapists' patients. Field dentists seemed less interested in their occupations and were critical of their narrow clinical scope, the geographic isolation, and the lack of opportunity for follow-up care. Although orthodontic care was popular, dentists obtained little satisfaction from diagnostic and administrative responsibilities. Therapists apparently received least satisfaction from administration, examinations, the exposure of x-rays, obtaining impressions for study casts and orthodontic models, and from prophylaxes and topical applications of fluoride.

The actions taken and contemplated to overcome specified problems were discussed.

7. The exposure of x-rays in the School Dental Programme

Australia's National Health and Medical Research Council considers that radiology plays an essential role in dentistry.²⁵⁶ The Council nevertheless has warned that x-rays should not be used until a clinical examination confirms that they are essential for diagnosis and treatment planning.²⁵⁶ That is, the concept of routine exposures of x-rays for the periodic examinations of all patients is not endorsed. The Council considered that no preferred numerical frequency of radiographic examinations could be defined, and that decisions should be based on judgement after reconciling the potential benefits and drawbacks.²⁵⁶

The extent of exposure of x-ray films in the total South Australian School Dental Programme approximates 50

films per 100 patients each year. For example, the number of films per 100 patients in the field section was 53.4 in 1974 and 44.2 in 1975. Despite this degree of overall consistency, there are vast differences in the extent of exposure throughout the State. For example, the number of films per 100 examinations varied with the region from 4.8 to 146.5 in the first quarter of 1976 (Appendix 10).

The detailed policy on the use of x-rays must be formulated by the regional dentists, but decisions on the exposure of bite-wing films may be delegated to therapists, provided that they do not obtain films for individual patients more frequently than once every 18 months.²⁰⁶ The extent to which dentists and therapists would expose bite-wing films seems similar, as indicated in the section entitled "Diagnostic and treatment-planning skills of dental therapists". A pilot study which was reported in that section suggested that therapists could interpret decay on x-ray films. The dentist can monitor an individual therapist's use of x-rays when checking 15 or more of her examinations each year.²⁰⁶ A total appreciation of the extent of exposure of x-rays could be achieved when the regional dentist

- (i) examines all patients, and
- (ii) reviews quarterly statistical feedback on the services provided in the region.²⁰⁶

It is evident that the exposure of bite-wing films increases the number of carious lesions detected. For example, the DMF(S) scores increased in the base-line

fluoridation study when the findings from posterior bite-wing films were accumulated with clinical observations (Table 94).

The services provided by nine teams of dentists and therapists were analysed for July to December, 1971. The mean number of x-ray films exposed per operator per day was calculated for each team. If the exposure of bite-wing films increased the detection of proximal lesions, it was anticipated that the proportion of amalgam restorations which included more than one surface might relate directly to the extent of exposure of x-rays. Despite the inclusion of some restorations which did not include proximal surfaces, and a number of peri-apical films with the bite-wing radiographs, a direct association is evident from the data (Table 95).

Similarly, the types of restorations provided through

- (i) the School of Dental Therapy;
- (ii) teams of dentists and therapists, and
- (iii) solo field dentists,

were analysed for 1972. The mean number of x-ray films per exam increased from 0.27 for solo dentists to

- (i) 0.66 for teams of dentists and therapists, and
- (ii) 1.63 for the School of Dental Therapy.

The percentages of teeth receiving a multi-surface proximal restoration amongst the ones restored with amalgam were as follows:

- (i) for the primary teeth - 70.3 for solo dentists,

- 76.0 for teams of dentists and therapists, and 83.3 for the School, and
- (ii) for the permanent teeth - 20.5 for solo dentists, 23.9 for teams of dentists and therapists, and 34.4 for the School.

That is, a direct association between the exposure of x-ray films and the provision of multi-surface proximal restorations was apparent both for the primary and the permanent teeth.

Although these analyses were superficial, results nevertheless support the conclusion that x-rays increase the diagnostic sensitivity for proximal lesions. Additional diagnostic benefits of x-rays would include

- (i) the detection of recurrent decay and of faulty adaptations of restorations at the gingival margin;
- (ii) the locating of unerupted teeth, and
- (iii) the discernment of peri-apical lesions and of other intra-osseous pathology.

Although x-ray facilities are not readily available in the New Zealand School Dental Service, it is claimed that carious lesions invariably are detected at a stage when ideal restorative care is possible.⁷⁰ If this is so, perhaps bite-wing films seldom should be used for the diagnosis of carious lesions.

New Zealand therapists routinely examine children for decay every six months.²⁰⁹ If the use of bite-wing films were to increase the interval possible between successive examinations, cost advantages might occur.

These advantages might be greater if the need to restore teeth more than once was reduced. That is, teeth might have been restored initially with an occlusal restoration and subsequently with an occluso-proximal, when the use of x-rays would have indicated the need for an occluso-proximal at the initial appointment only.

If the time taken to expose bite-wing films is small when compared with the time saved from increasing the recall intervals, the use of these films would be desirable unless

- (i) extended intervals between the examinations introduced overriding drawbacks; for example, a reduced opportunity for necessary reinforcement in dental health education, or
- (ii) there were associated health hazards which warrant a pre-eminent consideration.

It seems that research should be undertaken to compare the effectiveness and cost-effectiveness of dental systems where the use of x-rays differs.

VI PERIPHERAL SCHEMES WHICH COULD DIRECTLY INFLUENCE
THE PERFORMANCE OF THE SCHOOL DENTAL PROGRAMME

1. The sale of sweets in school canteens

1.1 Introduction

It has been customary for school canteens to provide sweets, despite the importance placed by the World Health Organization and Australia's National Health and Medical Research Council on the total school environment as a source of health education.^{257,258}

It is apparent that the sale of sweets is contentious, and parents have voiced antagonism to this practice. The South Australian Department of Public Health has received numerous complaints from parents who argue that the control of their children's diet is difficult when canteens offer a bad example and children consequently are encouraged by their peers to eat sweets frequently. Moreover, school dental staff are distressed when high disease rates apparently are supported by canteen menus and the problems of controlling decay seem greater.

Fanning, Gotjamanos and Vowles analysed the decay rates of 1,266 secondary school students and disclosed that students with access to sweets in canteens acquired 1.57 more decayed surfaces than the others over a two-year period.²⁰¹ The investigators claimed that further research should be undertaken over a longer period and that primary school students should be included.²⁰¹

Therefore the author organized and implemented add-

ditional studies and educational programmes. Initially a survey was conducted by telephone to discern the quality of canteens in the State capital. Follow-up discussions were arranged with haphazardly selected groups of canteen personnel, teachers and parents to determine why cariogenic confectioneries were sold. Available data were reviewed superficially to see whether an association of decay with the availability of sweets in canteens was apparent. The economic characteristics of canteens were analysed according to their sale of sweets. Following these studies, four canteens removed cariogenic items and the apparent effects on decay rates and canteen profit were assessed. An educational programme aimed at improving menus was based on the experience obtained from these investigations. Periodic surveys were undertaken to evaluate subsequent changes in menus.

1.2 Survey of canteen menus in 1969

The survey was undertaken by telephone with occasional follow-up interviews, and included the canteens in the capital city's government schools and 20 largest private schools. All canteens were found to sell cakes, buns and carbonated drinks. A total of 28 (23.5 per cent) apparently did not provide sweets, and this number was eight (15.1 per cent) for the government primary schools, 10 (21.7 per cent) for the government secondary schools, and 10 (50.0 per cent) for the private schools.

There were 21 schools which were reserved for males, and five (23.8 per cent) of their canteens did not sell

sweets. The corresponding number was 12 (54.5 per cent) for the canteens in schools for females, but the difference was not statistically significant. It seemed that a tendency for menus to be better in schools for females resulted from a greater concern of parents for the appearance of girls, and the concern that sweets would encourage tooth decay, obesity, and skin lesions.

The proportion of canteens which did not sell sweets in private schools was significantly higher than for the government secondary schools ($X^2 = 4.02$: $df=1$: $p < 0.05$) and for government primary schools ($X^2 = 7.74$: $df=1$: $p < 0.01$). These differences apparently resulted from the higher socio-economic characteristics of the private schools and the stronger resolve that canteens should not contribute to bad health and appearance. Canteens in private schools often were administered by the school through the headmaster, rather than by the parents' association, and this difference could have influenced the types of items sold. Furthermore, private schools seemed to restrict students to the school grounds during recreational periods to a greater extent than did government schools, and so the canteens were not forced to compete so directly with neighbourhood stores.

The impression was received that canteen managers frequently had low socio-economic backgrounds and were not orientated towards preventive health care. Suggestions that sweets should be removed from their canteens seemed to engender resentment, because managers perceived that

their past performance was being criticized. They were uncertain of the effects that this action would have on the need for voluntary labour and on the profitability of their enterprises. Canteen managers seemed to enjoy gratifying children with sweets, and wanted to obtain a high profit for the parents' associations. The practice of selling sweets apparently was reinforced continually by the distributors of confectioneries, who promoted their products forcefully.

Teachers sometimes supported the practice and declared that it assisted them to confine children to the school premises during recreational breaks.

The most frequent claims made by canteen personnel, teachers and parents who supported the sale of sweets were that

- (i) this practice would have little effect on decay rates because school canteens would contribute only a small proportion of a child's total diet, and
- (ii) the profitability of the canteen would suffer markedly if sweets were not available.

1.3 Association of dental decay with the availability of sweets in school canteens : an exploratory review based on available data

1.3.1 A comparison between two primary schools

The School of Dental Therapy provided care to from 70 to 75 per cent of the children at two metropolitan primary schools where the availability of sweets differed. At one school, the sale of sweets was restricted to a 10

to 15 minute period immediately after the school lunch, whereas the canteen at the second school provided sweets during each recreational period.

Children were examined at the School of Dental Therapy by the same examiners, who ordinarily were not aware of the schools attended by individual children. A total of 180 pairs of children from the two schools was matched by race, age and sex. Their DMF(T) scores were calculated with a "Contex 30" mechanical calculator and are presented in Table 96.

In each age group, children at the school where sweets were not restricted presented higher DMF(T) scores. Collectively their scores were 22.6 per cent higher than for their matched counterparts.

Although the schools seemed similar socio-economically, and insofar as the availability of private shops with sweets was concerned, it cannot be concluded that differences in the DMF(T) scores resulted from variations in the availability of sweets at the canteens. Nevertheless, the results are consistent with the view that school canteen menus can influence decay rates.

1.3.2 The decay rates of secondary school students according to their utilization of canteens with sweets

During the base-line fluoridation survey, subjects aged 14 and 16 years were examined at three schools where canteens sold sweets.

A research assistant, who was not aware of the results of the clinical examinations, questioned subjects

about their frequency of use of the canteen. Where the existing use seemed inconsistent with practice in the immediately preceding years, an average utilization was estimated.

Whereas subjects were not differentiated according to their purchase of sweets at the canteens, it was anticipated that frequent customers might have higher decay rates if the canteens were an appreciable source of decay.

A total of 352 students, who were classified as generally using the canteen on fewer than three days a week, was compared with 305 more frequent users. The permanent first molars were excluded from the DMF scores to reduce the inclusion of components which related to the primary school years. The DMF scores were calculated with a "Contex 30" mechanical calculator and are presented in Table 97.

The more frequent users presented higher DMF(T) and DMF(S) scores in each age-sex group. Although these differences support the opinion that canteens with sweets are a substantial source of decay, it is possible that frequent and infrequent users were different in other respects, and it was these differences which influenced the DMF scores, not variations in their utilization of school canteens.

1.4 Association of profit with the availability of sweets in school canteens

Subsequent to the survey by telephone of canteen menus, information on canteens was requested from the

schools where sweets were not sold. The following information was sought for the 1968 period, namely:

- (i) whether sweets were sold, and
- (ii) the gross income and cost of stores.

The difference between the gross income and the cost of stores was interpreted as the "profit from sales". In fact, 29 schools were approached where canteens did not sell sweets in 1968, and 35 similar schools were selected as controls. A larger control group was chosen because it was anticipated that these schools might be less cooperative and therefore might provide less complete information. A response was obtained from 59 schools, but only 49 provided meaningful data. These schools are classified by the sale of sweets and school type in Table 98.

The gross incomes per student, and the profits from sales per student, were calculated with a "Contex 30" mechanical calculator and are presented in Table 99. In three of the four school categories, gross incomes and profits from sales per student were higher where the canteens sold sweets. The mean of the scores for these categories was 5.0 per cent higher for gross incomes and 6.2 per cent lower for profit from sales where canteens sold sweets (Table 99). That is, although substantial differences were evident for individual school categories, it seems that the collective gross incomes and profits from sales did not vary markedly with the provision of sweets.

In 1969, a primary school removed sweets from the canteen and a research assistant from the School Dental

Programme assisted in this process. After one year, the headmaster reported that the gross income of the canteen was consistent with the previous years. An analysis of canteen expenditure for individual food items was undertaken prior to the change and one year subsequently, and results are presented in Table 100.

As only minor relative changes in unit costs of items occurred over the period of the study, relative changes in canteen expenditure for the different items are considered to reflect relative changes in turnover. Whereas 48.6 per cent of expenditure related to sweets, cakes, buns and sweet biscuits before the change, the corresponding percentage was 2.1 subsequently. A compensating collective increase applied to the expenditure for nuts, potato crisps, dried fruits, savoury biscuits, pies, pasties, sausage rolls, milk, ice-cream, carbonated drinks and fruit juice. That is, substantial improvements in the canteen menus apparently were possible without a loss of gross income.

1.5 An analysis of the association between decay and the sale of sweets in four canteens: a detailed investigation

1.5.1 Introduction

The studies of canteens which have been described were exploratory. As there was an indication that sweets in canteens might be a substantial source of decay, a detailed investigation was undertaken.

It was intended that the investigation would extend for three years, but it was terminated after two years because one control school removed sweets and it seemed

that two of the others would act accordingly.

1.5.2 Materials and methods

A. Samples

Four pairs of schools were studied. Each included a test school, which removed sweets at the commencement of the study, and a control school which continued to sell these items.

A representative from the School Dental Programme assisted in the establishment of satisfactory menus in three of the test canteens over a four-week duration. The fourth canteen achieved a substantial improvement without this assistance. All test canteens removed sweets, sweet biscuits and heavily iced buns, and two also deleted other varieties of buns.

The test and control schools were matched by

- (i) the apparent socio-economic levels of their students (a subjective assessment);
- (ii) whether they were government or private, and
- (iii) the sexes of the students.

The private schools were for boys only, whereas the government schools were integrated.

In the government schools, 1,072 subjects were selected at random from grades two, three and four (approximately 270 from each school). The parents of 902 (84.1 per cent) agreed to include their children in the investigation. Of these students, 745 (82.6 per cent) remained to be re-examined two years later.

In the private schools, 1,154 male subjects aged

from seven to 13 years were selected at random from six grades (approximately 290 from each school). The parents of 936 (81.1 per cent) consented to their children's participation in the study. Of these subjects, 799 (85.4 per cent) remained to be re-examined after two years, but 34 (17 from both the test and control groups) had fixed orthodontic appliances and were deleted from the study.

The loss of subjects from the test and the control groups was similar.

B. Examination techniques

Examinations were performed in a mobile clinic by one examiner with a standard head-lamp, mouth mirrors, sickle probes which were replaced after 50 examinations, and posterior bite-wing x-ray films exposed in a standard manner with a reproducible device.¹⁴¹

The DMF(T) and DMF(S) indices were used, and diagnoses were made as mentioned previously.^{142,143} The interpretation of the x-ray films was the same as for the base-line fluoridation survey. X-ray and clinical findings were pooled.

The consistency of recordings was checked by dual independent examinations of 67 students, and was considered satisfactory. As these students possessed a higher D to DMF ratio than did the total sample, the overall level of consistency possibly was underestimated. Details are presented in Table 2.

Periodically the schools were visited after the lunch period, and students were asked whether they had

used the canteen on that day. Most students were checked on 15 days over the two-year period. When a subject was surveyed on fewer than five days because of absences from school, the information was considered to be meaningless and was not used.

Questionnaires which related to the dental habits of students were completed by parents to enable an approximate assessment of other variables which relate to dental health. The questionnaire was virtually identical to the one for the base-line fluoridation survey (Appendix 1).

C. Statistical analysis

(a) Preliminary

Initially the data were explored superficially by comparing the mean DMF(S) increments of test and control groups for each pair of schools separately. Collective and age specific means were studied. In the private schools, small numbers required that the ages be clustered into three groups, namely, seven to nine years, 10 to 11 years and 12 to 13 years.

Decay increments were calculated by assigning the increments and reversals an equal weighting.

(b) Detailed

As there were differences between the age and initial DMF(S) distributions of the test and control groups, subjects were matched by these variables. A previous study had demonstrated an association between the initial and incremental DMF(S) scores.²⁵⁹ Age was interpreted in years as is conventional, and initial

DMF(S) scores were stratified into blocks of three (0-2, 3-5, 6-8, 9-11 etc.). As the decay increments for males and females did not differ significantly, students were not matched by sex.

Pairs of subjects were formed by randomly selecting subjects of the same age and initial DMF(S) scores from the test and control schools. Students also were paired according to whether they had taken fluoride tablets. Differences between decay increments were explored with the paired t-test because of correlated samples (Appendix 8.1).¹⁶⁷

The earlier investigation of canteen incomes indicated that students in combined primary and secondary private schools spent approximately 50 per cent more money in canteens than did students in government primary schools (derived from Table 99). Therefore, results for these two types of schools were analysed separately.

The samples are described in Tables 101 and 102, and pooled initial mean DMF(T) and DMF(S) scores in the matched samples are presented in Table 103.

(c) Statistical advice and processing

The data were processed with a 167P Canola electronic calculator, and advice was received from Mr. K.M. Cellier, Principal Research Scientist, Division of Mathematical Statistics, the Commonwealth Scientific and Industrial Research Organisation, Adelaide.

D. Limitations in the research design

There were several unavoidable limitations, which increased the chances of spurious findings, for example:

- (a) Individual subjects could not be randomly assigned to the test and control groups. Conceivably, the decisions to improve canteen menus could have been associated with other factors which were related to dental health. Nevertheless, the chances of spurious results might have been reduced by the initial matching of the test and control groups in the manner described, so indirectly balancing other factors which were associated with decay. For example, information from the questionnaires indicated that the matched samples had similar dental habits. The percentages of students who evidently
- (i) brushed their teeth at least twice daily were 31.3 and 31.5 per cent for the test and control groups respectively;
 - (ii) always used a fluoride toothpaste were 48.7 and 44.4 per cent for the test and control groups respectively, and
 - (iii) visited a dentist every six months were 49.3 and 45.1 per cent for the test and control groups respectively.

The subjects were assumed to be independent elements in the respective samples, and the three differences were not found to be significant using the chi-square test of statistical significance (Appendix 8.4).¹⁶⁷ The research design was strengthened by comparing the decay increments of the frequent and infrequent users of canteens within the test and con-

trol groups separately. Frequent users were classified as students who reported using the canteen on at least half of the days checked.

- (b) The investigator examined the test and control groups separately. It was impracticable to pool the subjects at a central point and examine them "blind". The possibility of bias from this factor was checked by pooling the x-ray films and examining them "blind". Subsequently, DMF(S) increments for the posterior proximal surfaces, which were based on x-ray findings only, were assessed and compared with the overall results. Forty one students were excluded from this part of the study, because x-rays were considered to be unnecessary.
- (c) Subjects were aware of the groups to which they belonged, and this could have affected their dental habits. It was not possible to camouflage test and control canteens to appear the same. Moreover, such a procedure would have been artificial and would have prompted questions about the external validity of the results. However, the information on dental habits from the questionnaires, and the separate comparisons of the frequent and infrequent users of the test and control canteens, apparently would have reduced the chances of false conclusions from this factor.
- (d) Only students with parental consent participated in the investigation, and 17.8 per cent were lost during the study. It is assumed that any effect of this loss

on the remaining dental characteristics would have been similar for the test and the control groups.

E. Profit

Each headmaster of a test school compared the profitability of the canteen after the sweets were removed with previous profit levels. Originally it was intended that more detailed analyses would be performed, similar to those already reported. Unfortunately the canteen records of one test school were not available, and those of a second test school did not provide information in a suitable form. The investigator considered that the task of adapting the records for the study would have overtaxed the school's co-operation.

1.5.3 Results and comments (Canteen investig.)

A. Preliminary

The mean DMF(S) increment in each test school was lower than for the corresponding control school. In three pairs, this difference was consistent in the three age specific groups, whereas it applied to two of the three groups in the fourth pair.

That is, the findings were consistent in the four pairs of schools and in general across the age-specific groups.

B. Detailed

(a) Government schools

Mean differences in decay increments for the government schools are presented in Table 104. The differences are demonstrated separately, as indicated by the

DMF(T), DMF(S), DMF(S) for proximal surfaces, and DMF(S) for posterior proximal surfaces based on x-ray evidence only. As there were few five and nine-year-olds, they were pooled with six and eight-year-olds respectively. All the five-year-olds were almost six and most nine-year-olds had just turned nine.

Each index demonstrates a higher mean increment for the control schools (schools with sweets) in each age specific group. Pooling seems justified as age specific values generally are homogeneous. Whereas only one age specific difference is statistically significant, the pooled differences in both the DMF(T) and DMF(S) increments are significant.

Collectively, students in the schools without sweets developed

- (i) 14.5 per cent fewer DMF(T) increments;
- (ii) 16.3 per cent fewer DMF(S) increments;
- (iii) 13.0 per cent fewer proximal DMF(S) increments,
and
- (iv) 10.7 per cent fewer posterior proximal DMF(S)
increments,

based on x-ray evidence only.

(b) Private schools

Mean differences in decay increments for the private schools are presented in Table 105. Subjects were grouped into the specified age clusters because of limited numbers.

Each index demonstrates a higher mean decay incre-

ment for the control schools (schools with sweets) in each cluster. The differences are statistically significant in each instance as indicated by the DMF(S), and in two of the three age clusters as demonstrated by the other three indices. Pooled figures should be regarded cautiously because age specific values are heterogeneous (Table 105).

Collectively, students in the schools without sweets developed

- (i) 27.3 per cent fewer DMF(T) increments;
- (ii) 29.7 per cent fewer DMF(S) increments;
- (iii) 29.0 per cent fewer proximal DMF(S) increments,
and
- (iv) 25.7 per cent fewer posterior proximal DMF(S) increments, based on x-ray evidence only.

C. Comparison of frequent and infrequent users of canteens

These comparisons are detailed in Tables 106 and 107 for the government and private schools respectively.

It is interesting that pooled data for the government schools indicate that

- (i) the frequent users of canteens with sweets had the highest decay increments, and
- (ii) the infrequent users of canteens without sweets had the lowest decay increments.

Whereas pooling probably is justified for these schools, the private schools presented a wide age span with heterogeneous age specific increments. Accordingly, their pooled results should not be regarded as important.

Age specific DMF(T) increments indicate that frequent users of canteens selling sweets had the highest decay increments in the six age groups in the government and private schools. The DMF(S) scores support this finding in five of the six groups. Although the initial balance of the DMF(T) and DMF(S) scores varied, this factor does not seem to account for the reported trend (Tables 106 and 107).

Frequent users had higher increments in government test schools as well as in the control schools. Several explanations seem plausible, for example:

- (i) the difference might have resulted from chance;
- (ii) frequent users also might have been frequent users before the sweets were removed, and therefore might have possessed more incipient cavities which escaped detection at the initial examination;
- (iii) one test canteen provided drinks with added sugar and the second also sold buns; that is, the test canteens still sold cariogenic items, and
- (iv) frequent users might have possessed other characteristics which were related to decay.

D. Profit

Collectively, the profitability of the test canteens seemed unchanged after the removal of sweets. Specifically, one headmaster reported an increase in profit, two indicated no change, and the fourth reported a minor reduction which was not considered to be serious.

In the government schools, 46.3 and 41.4 per cent

of the students were frequent users of the test and control canteens respectively. The difference was not statistically significant. The corresponding figures for the private schools were 62.0 and 70.8 per cent for the test and control schools respectively. This difference was statistically significant ($\chi^2_m = 6.46$: $df=1$: $p < 0.05$) according to a method which tests and allows for heterogeneity between age specific groups (Appendix 4.3).¹⁷⁰ Although the collective profitability of the canteens did not seem to be affected by the removal of sweets, a reduction in utilization might have occurred in the private schools.

Canteens in the private schools apparently were used more frequently. This finding agrees with the results of the previous study which indicated that more money was spent in these canteens (Table 99). This might have resulted from age or socio-economic influences.

1.5.4 Discussion (Canteen investig.)

A. Decay

The consistency of the results indicates that a real difference existed between the test and control groups. All four indices demonstrated lower decay increments in the test groups in each age category, and this applied to both the government and private schools. X-ray evidence confirmed that differences were not a result of examiner variability. Findings in the matched samples were supported by those in the total samples. Moreover, frequent users of canteens with sweets evidently had the highest decay rates, which further indicates that these

canteens were decay causing.

Apparently canteens in the private schools affected decay rates more appreciably. This difference might have resulted from chance or from spurious factors, but it appears that these canteens were used more frequently and accordingly might have been more influential.

B. Profit

Apparently there was little change in the overall profitability of the test canteens after the removal of sweets, and this finding is consistent with the results of the previous study.

It does not follow that all canteens therefore could remove sweets without a loss of profit. Canteens might replace sweets promptly if profit is reduced, and so they might not have been available for the previous cross-sectional study. Apparently several canteens have replaced sweets when it seemed that trade was diminished. There seem to be three relevant factors, namely:

- (i) if there are no nearby stores, the canteen is not forced to compete;
- (ii) if students are not permitted to leave the school grounds during the lunch or recess periods without specific consent from their parents, then canteens need not compete so directly with neighbourhood stores. Many schools exercise this policy for reasons of safety. Some secondary schools allow only the most senior students to leave the school grounds freely during "breaks"; and

(iii) the attitudes of the students to the removal of sweets seem to be important. If they support the change, the chance of success appears to be greater. The attitude of senior students in secondary schools seems particularly significant.

It seems that the canteen's profitability is not the only financial consideration associated with the removal of sweets. The impact on the community's cost of dental treatment also is relevant.

C. Significance of the research

The value of this research depends on the extent to which results will prompt canteen personnel and related groups to improve canteen menus.

1.5.5 Summary (Canteen investig.)

This study included two government and two private test schools which ceased the sale of sweets and four similar control schools which continued with this practice. A sample of students at the test schools (757) and control schools (753) was examined when sweets were removed and again two years later.

Collectively, students at each school without sweets had lower decay increments than students at the corresponding control school, and the differences usually were consistent across the age specific groups. Frequent users of canteens with sweets had the highest mean decay increments.

When students at the two types of schools were matched by age, initial DMF(S) scores and past exposure to fluoride tablets, those attending schools without sweets were found to have lower decay increments in each

age specific group. The total differences were 14.5 per cent (DMF(T)) and 16.3 per cent (DMF(S)) in the government schools, and 27.3 per cent (DMF(T)) and 29.7 per cent (DMF(S)) in the private schools. Canteens in the private schools were used more frequently and apparently affected decay increments more appreciably.

The collective profitability of the canteens apparently was unchanged after the removal of sweets.

The value of this research depends on the extent to which results will prompt improvements in canteen menus.

1.6 Educational programme

Since 1969, The University of Adelaide's Department of Dental Health and the South Australian School Dental Programme have used the results of surveys to emphasize the importance of canteens to dental health and to demonstrate that canteens without sweets can be profitable.

Schools have been informed by post of the following:

- (i) the results of surveys;
- (ii) the availability of recommended menus;
- (iii) that demonstration canteens exist where canteen managers may obtain detailed information on the methods of improving menus, and
- (iv) that speakers are available to address parents and students.

An example of one communication to schools is included (Appendix 11).

The State government's previous Minister of Education encouraged all canteen personnel to consider the

advice of health specialists when determining menus. The National Heart Foundation provided information on diet for distribution to the schools in the State capital, and the South Australian Branch of the Australian Medical Association stated its support for the improvement of canteen menus.

It has been reported that 23.5 per cent of surveyed canteens in the State capital did not sell sweets in 1969. A comprehensive survey of 195 canteens in the capital and adjacent country areas in 1971 indicated that improvements had occurred (Table 108). Collectively, the proportion which did not sell sweets was 35.9 per cent, and a further 22.6 per cent did not sell items which the canteen personnel classified as "sweets". A total of 119 schools was included in both surveys, and results indicated that 17 had removed sweets during the interim period, and a further 16 claimed that this had been achieved but still were classified as selling sweets for the purpose of the survey. Of the 16 schools:

- (i) six sold licorice;
- (ii) three sold dried fruits with added honey or glucose;
- (iii) one sold cough sweets, and
- (iv) six sold two or more of these items.

Subsequently, a research assistant from the School Dental Programme, who was accompanied by an ex-canteen supervisor employed by the South Australian Branch of the Australian Dental Association, visited approximately 70 canteens. It seems that constant personal contact with

canteens is important. Distributors continually visit canteens and persuade canteen managers to stock attractive items which cause decay. Often distributors have been criticized for making misleading claims about the healthful qualities of products. Sometimes these claims are reinforced by the advertisements of "health food" groups, but conflict with the recommendations of acknowledged health providers. Furthermore, it seems that canteen personnel constantly are urged by the students to provide sweets.

It is apparent that a considerable work force would be necessary to provide the frequent contact with canteens that seems essential. With a high turnover of canteen staff, parents and teachers, canteen menus sometimes change frequently.

A telephone survey in 1973 included the same geographic area as in 1971, and incorporated an additional 14 canteens which apparently had been established in the interim period (Table 109). Although the proportion where canteen personnel claimed that sweets were not sold had increased from 58.5 per cent in 1971 to 68.4 per cent in 1973, the actual proportion without sweets apparently had decreased from 35.9 to 14.8 per cent (Tables 108 and 109). The change in the proportion for each classification was statistically significant, that is:

- (i) for those which did not sell sweets ($\chi^2 = 22.76$:
df=1 : $p < 0.001$);

- (ii) for those which sold sweets but where canteen staff considered that the reverse was true ($X^2 = 39.66$: $df=1$: $p < 0.001$), and
- (iii) for those which sold an unrestricted variety of sweets ($X^2 = 3.90$: $df=1$: $p < 0.05$).

Differences are presented by school type in Tables 108 and 109. The collective results of a further telephone survey of the same area in 1976 were similar to the 1973 results, although the findings were less similar by school type (Tables 109 and 110). Changes in the numbers of canteens in the surveys apparently resulted from decisions to establish or discontinue canteen services.

It is evident from the 1976 survey that approximately two-thirds of the canteen managers claimed that they did not sell sweets, but that most of these nevertheless provided restricted varieties. Of this group:

- (i) 111 (89.5 per cent) sold dried fruits which were not recommended because sweetening agents were included. These products are promoted forcefully by the "health food" groups as totally beneficial to health.
- (ii) 61 (49.2 per cent) sold licorice, which managers often considered to be good for health. Many claimed that licorice was not cariogenic and that it was beneficial as an aperient.
- (iii) 34 (27.4 per cent) sold cough sweets, and several managers claimed that these items were medicines, not sweets.

(iv) 20 (16.1 per cent) sold chocolate and stated that it was healthful because of its milk content.

It seems that unless the State government were to forbid the sale of sweets in schools, an intensive and continuous educational programme would be necessary to stop this practice. The establishment of dental clinics on school premises might enable health providers to manage the problem effectively. It is evident from Table 111 that canteens present markedly superior menus in primary schools with dental clinics. The difference in the numbers without sweets is statistically significant ($X^2 = 4.61 : df=1 : p < 0.05$).

1.7 Summary

It has been customary for school canteens to provide sweets, despite the contrary advice from health authorities and from parents who claim that the control of their children's diet is complicated when canteens offer a bad example.

In 1969, a survey by telephone of canteens in the State capital's government schools and 20 largest private schools indicated that 24 per cent did not sell sweets. The percentage was higher in private schools possibly as a result of socio-economic factors, the greater authority of headmasters than of parents' associations for canteen administration, and the more binding policy evident in these schools of restricting students to the school grounds during recreational periods. The sale of sweets apparently was reinforced by the following:

- (i) the attitudes of canteen managers to diet, which seemed to relate to their socio-economic backgrounds;
- (ii) the tendency of canteen personnel to defend past practices;
- (iii) fears of the potential effects of removing sweets on profit and on the need for voluntary labour;
- (iv) a desire to gratify children;
- (v) the continual promotion of sweets by distributors;
- (vi) the advertising of so-called "health foods", and
- (vii) the use of sweets as an enticement for children to remain on the school premises during recreational periods.

It frequently was claimed that sweets in canteens would have little effect on decay rates and that profit would suffer markedly if these items were not available.

An exploratory study which was based on clinical records from the School of Dental Therapy indicated that 180 children from a school where sweets were restricted had lower decay rates than matched children from a nearby school where sweets were freely available. Moreover, data from 657 students at three secondary schools in the baseline fluoridation survey suggested that decay rates were higher for frequent than infrequent users of school canteens with sweets.

The gross incomes and costs of stores for 49 canteens in 1968 were analysed according to whether sweets were sold. In three of the four categories of schools, mean gross incomes and profits from sales per student were

higher where the canteens sold sweets. Where there were sweets, the average of the scores for each category was five per cent higher for gross incomes and six per cent lower for the profits from sales. A detailed longitudinal investigation of expenditures in one canteen revealed that there were substantial improvements in the menu without an apparent loss of gross income.

In a subsequent investigation, four test schools removed sweets and 757 students were compared with 753 controls at four schools where the sale of sweets continued. Collectively, the test students had lower decay increments over a two-year period, and this finding was confirmed in each age specific group by scores for subjects who were matched by initial DMF(S) scores and histories of exposure to fluoride tablets. According to the headmasters, the total profitability of the canteens remained unchanged after the removal of sweets.

The results of surveys have been used to emphasize the importance of canteens to dental health, and to demonstrate that canteens without sweets can be profitable. Educational programmes have been supported by a previous Minister of Education, the National Heart Foundation and the South Australian Branch of the Australian Medical Association. Although certain improvements in menus apparently have occurred, it seems that continuous personal contact with canteens is necessary to counter the encouragement by confectionery distributors and students to sell sweets. The retention of sweets, which are regarded

mistakenly as healthful, seems to have prevented substantial improvements in menus.

The establishment of dental clinics in schools might enable health providers to manage the problem effectively. It is evident that canteens present markedly better menus in primary schools with clinics.

2. Fluoridation

2.1 Introduction

It has been reported that over 150 million people in more than 30 countries drink fluoridated water.²⁶⁰ In Australia, treated water is provided to approximately 46 per cent of the inhabitants, but this proportion soon should exceed two-thirds following the Victorian Government's decision to fluoridate the State's water system.²⁶¹

Fluoride was added to the water supply of the South Australian capital in February 1971. A base-line dental survey was undertaken and has been reported already.

In 1974, a brief follow-up survey was implemented by the author with methods which were identical to those for the base-line study. The aim was to discern the early effects of fluoridation. A more comprehensive evaluation is planned for 1977.

2.2 Review of the literature

The suggestion that fluoride should be used for public health purposes first was adopted in North America in the mid-1940's when water fluoridation was introduced to the towns of Grand Rapids, Brantford, Newburgh and Evanston.^{60,67} Results from the corresponding evaluative studies now will be reported.

In 1950, Dean, Arnold, Jay and Knutson reviewed the effects of fluoridation in Grand Rapids after approximately four years of operation.²⁶² Base-line data had been obtained for approximately 19,700 continuous residents in 1944 and 1945, and follow-up information was based on 3,672 continuous residents who were examined in 1949 and 1950. Whereas a decrease in df scores of only four per cent was apparent for nine-year-olds, the decrease varied from 39 to 19 per cent for younger age groups. The substantial decreases in scores for seven and eight-year-olds could have resulted from examiner variability or sampling error, but post-eruptive effects of fluoridation might have been instrumental. The permanent dentition's DMF(T) scores apparently were reduced by

- (i) 51 per cent for six-year-olds;
- (ii) 27 per cent for eight-year-olds, and
- (iii) 28 per cent for subjects aged 10 years.²⁶²

In 1962, Arnold, Likins, Russell and Scott compared data from a follow-up survey in 1959 with base-line scores.²⁶³ Decreases in DMF(T) scores of between 50 and 63 per cent were evident for 12 to 15-year-olds who had been exposed to treated water from birth or early infancy.²⁶³

Hutton, Linscott and Williams compared base-line data for Brantford with follow-up scores approximately three years after the commencement of fluoridation.²⁶⁴ From the data presented, it was evident that the mean DMF(T) scores had decreased as follows:

- (i) from 0.40 to 0.25 for six-year-olds - a decrease of 38 per cent;
- (ii) from 2.44 to 1.67 for eight-year-olds - a decrease of 32 per cent, and
- (iii) from 3.80 to 3.24 for 10-year-olds - a decrease of 15 per cent.²⁶⁴

A subsequent review of the DMF(T) scores for 16 to 17-year-olds in Brantford and in the control town of Sarnia indicated that exposure to fluoride from birth was associated with a reduction in the mean DMF(T) score from 10.44 to 4.74, that is, a decrease of 55 per cent.²⁶⁵

In 1950, Ast, Finn and McCaffrey compared base-line DMF(T) scores with data obtained after three to four years of fluoridation in Newburgh.²⁶⁶ Mean scores had decreased by 62 per cent for six to seven-year-olds, 36 per cent for eight to nine-year-olds and 27 per cent for 10 to 12-year-olds.²⁶⁶ After 10 years of fluoridation, the DMF(T) scores for six to 12-year-olds had decreased by more than 50 per cent.²⁶⁷

Hill, Blayney and Wolf contrasted base-line data for Evanston with scores obtained after three years of fluoridation.²⁶⁸ The mean DMF(T) score apparently had decreased by 67 per cent for six-year-olds and by 39 per cent for subjects aged eight years. Reductions in df scores were not evident for these age groups, and a post-eruptive effect of fluoridation therefore was not apparent.²⁶⁸

It seemed that after 10 years of fluoridation, the DMF(T) scores for Evanston's 12-year-olds had dropped by 53 per

cent.²⁶⁹

In a further North American study, Russell and Hamilton noticed a decrease in DMF(T) scores for the permanent first molars after eight years of fluoridation.

²⁷⁰ Data were consistent with a reduction of 78 per cent for six-year-olds, 70 per cent for eight-year-olds and 45 per cent for 10-year-olds.²⁷⁰

Ludwig evaluated the effects of fluoridation in Hastings, New Zealand.²⁷¹ After 18 months of intermittent exposure to fluoridation and a further continuous exposure for 27 to 30 months, DMF(T) scores apparently were reduced by 42 per cent for six-year-olds, 18 per cent for eight-year-olds and only 0.4 per cent for subjects aged 10 years.²⁷¹ After about $8\frac{1}{2}$ years of fluoridation, the DMF(T) scores apparently had been reduced by 78 per cent for six-year-olds, 66 per cent for seven-year-olds and 58 per cent for eight-year-olds.²⁷² Reductions in the decay experience of the primary teeth also were evident, but these reductions seemed less dramatic than for the permanent dentition.²⁷²

With over 150 million people reported as drinking fluoridated water, there have been many evaluative studies which demonstrate the benefits of this measure.^{260,273}

2.3 Materials and methods

A. Sample

Whereas the base-line survey included students aged six, eight, 10, 12, 14 and 16 years at nine primary and six secondary schools, only six, eight and 10-year-olds at the nine primary schools were included for the

preliminary evaluation in 1974.

Questionnaires relating to dental habits and residence in the State capital were distributed to the parents of 2,360 subjects, that is, all subjects in the cited age groups (Appendix 1). A total of 2,139 (90.6 per cent) questionnaires was returned, but 102 (4.8 per cent) were discarded because the parents did not consent to their children's participation in the survey.

Of the remaining 2,037 subjects, the following were excluded:

- (i) 535 (26.3 per cent) who had been absent from the State capital since birth for periods of at least three months. Some of these subjects also could have been excluded because they drank tank water or had been exposed to fluoride therapy.
- (ii) 463 (22.7 per cent) with histories of fluoride therapy. Some of these also drank tank water.
- (iii) 96 (4.7 per cent) who apparently drank tank water in preference to "city water".
- (iv) 112 (5.5 per cent) who were absent from school during the period of the survey.

Therefore, 831 subjects were examined who were considered to be continuous residents of the State capital without histories of systemic or professional fluoride therapy, and who drank "city water" in preference to tank water. In these respects, they resembled subjects in the base-line survey.

B. Examination techniques

Techniques were the same as for the base-line survey, but with these exceptions:

- (i) posterior bite-wing x-ray films were not exposed. Therefore x-ray results for the base-line study were ignored when comparing the surveys' results.
- (ii) only half-mouth examinations were undertaken, and scores were doubled to estimate those which would have applied for whole mouths. This procedure is recommended in a World Health Organization publication, and has been supported by previous research.

66,171

C. Statistical analysis

Initially, mean DMF(T) and df scores for the two surveys were compared after adjusting 1974 data to account for differences in sex distributions by age. Age specific scores were derived by the following formula:

$$\begin{array}{rcl}
 1974 \text{ mean (females) x base-line} &) & \\
 \text{no. of females} &) & - \text{ no. in the age} \\
 &) & \text{group} \\
 + &) & (\text{base-line}) \\
 &) & \\
 1974 \text{ mean (males) x base-line no.} &) & \\
 \text{of males} &) &
 \end{array}$$

Exfoliation and extractions would cause df scores to underestimate the total decay experience, and it is theoretically possible that higher decay rates could lead to lower scores through higher extraction rates. Therefore, the numbers of teeth which were identified as missing for any reason in the two surveys were compared to review this possibility.

Subsequently, more detailed analyses of DMF(T) scores were performed separately for nominated groups of teeth. To avoid potential bias from differences by sex and

school, age specific means were obtained by calculating the mean of the means for sex-school specific data.

Results are presented separately for

- (i) the first molars;
- (ii) the incisors, and
- (iii) the canines, premolars and second molars.

D. Comments

Permanent first molars have been reported to erupt at six or seven years of age.¹⁴⁷ Therefore those in the six and eight-year-olds would have received fluoride before eruption, and might be associated with greater reductions in decay than the corresponding teeth in 10-year-olds.²⁷³

Permanent incisors usually erupt between six and nine years of age.¹⁴⁷ Therefore, most teeth in eight-year-olds and some in 10-year-olds would have received fluoride before eruption. Whereas the initial lesion in a first molar usually affects a fissure, incisors are relatively free of fissures and it is more likely that their lesions would be located on smooth surfaces.¹⁴⁷ Previous studies indicate that the benefits of fluoridation are greater for smooth surfaces than for fissures, and so greater decreases in DMF(T) scores were anticipated for the incisors than for molars.^{229,230,231,232,233,272,274}

Permanent canines, premolars and second molars have been reported to erupt between nine and 13 years of age.¹⁴⁷ Therefore, these teeth in 10-year-olds would have received fluoride before eruption. It was anticipated that the

surfaces most susceptible to decay would be the fissures of the premolars and second molars, and that the accumulated reductions for the canines, premolars and second molars might be lower than for the incisors.

In a comparison of DMF(T) scores for permanent teeth in fluoridated and non-fluoridated areas of the United States, Klein discerned greater apparent reductions for anterior than posterior teeth, and similar observations have been reported by other investigators.^{266,268,275}

Although there was no control group to facilitate an assessment of extraneous influences like examiner variability and modified dental habits, it was anticipated that reductions would be greater for teeth which had received fluoride before eruption, and especially for the anterior teeth.^{266,268,273} It seemed unlikely that extraneous influences would produce this pattern.

2.4 Results and comments

Data indicated reductions in decay rates both for the permanent and primary dentitions, and this was most pronounced for the younger age groups (Table 112).

As the number of primary teeth which was missing for any reason was lower in the follow-up survey, it is probable that the lower df scores in that survey reflected lower decay rates (Table 112). The reductions in df scores are surprising, as the primary teeth would not have received fluoride before eruption.¹⁴⁷ Even so, similar reductions were apparent in Grand Rapids and Newburgh, although not in Evanston.^{262,268,276}

Predictably, the apparent reduction in decay experience for the permanent first molars decreased with age from 19.4 per cent for six-year-olds to 6.6 per cent for subjects aged 10 years (Table 113). For 10-year-olds, apparent reductions were 60.0 per cent for the incisors and 29.5 per cent for the canines, premolars and second molars (Table 113).

As anticipated, the newly erupted permanent teeth which were associated with the greatest reductions evidently were the anterior teeth.

2.5 Discussion

The pattern of change of the DMF(T) scores typifies the anticipated effect of fluoridation: that is, reductions were more pronounced for teeth that had received fluoride before eruption, and anterior teeth apparently were afforded the greatest protection.

Although results might have been influenced by examiner variability, sampling error and extraneous variables, the characteristic pattern of change supports the conclusion that benefits have followed from fluoridation. The apparent reductions in the permanent dentition seem lower than might be anticipated from the corresponding results for Grand Rapids, Brantford, Newburgh and Evanston. 262,264,266,268

Greater reductions should be achieved when fluoridated water has been ingested from an earlier age, and substantial decreases in the need for dental manpower should follow. 199,204,273

2.6 Summary

Fluoridation of the South Australian capital commenced in February 1971, and a base-line survey of continuous residents attending nine primary and six secondary schools was undertaken. A follow-up survey of 831 six, eight and 10-year-olds at the primary schools was implemented in 1974 by employing comparable methods.

Results indicated a reduction in decay rates for both the permanent and primary dentitions. The greatest reduction for the permanent teeth applied to the incisors of 10-year-olds where a 60 per cent decrease in DMF(T) scores was evident, whereas the smallest apparent reduction was seven per cent for the permanent first molars in this age group. Many of these molars only would have been exposed to fluoridation after eruption.

Subsequent evaluative studies will be more comprehensive and will include 12, 14 and 16-year-olds.

3. Malocclusion: its significance and treatment

3.1 Introduction

When the decision was made to introduce therapists to the South Australian School Dental Programme, the first priority was the control of decay. Periodontal disease appeared to be the next most urgent problem, and malocclusion seemed to warrant less consideration. It was apparent that the comprehensive management of orthodontic disorders would be expensive, and that it might be difficult to define those anomalies in need of care. Although the importance of orthodontic disorders as causes of social, psychological and dental problems was apparent,

an attitude was evident outside dentistry that orthodontic care was a cosmetic service only.

It seemed important that the orthodontic requirements of school dental patients be considered and that provision be made for treatment. If patients were to be referred to private specialists, the orthodontic effects of school dental care would depend on the appropriate availability of private orthodontic services.

In this context, a survey of the prevalence of various occlusal features was undertaken, and their statistical associations with oral hygiene, periodontal disease, decay and fractured teeth were investigated. It was anticipated that the results would be useful when requesting administrators to allocate resources to the orthodontic field. The study now will be reported and the development of private orthodontic services briefly discussed.

3.2 The prevalence of features of occlusion and their associations with oral hygiene, periodontal disease, decay and fractured teeth

The investigation was performed in 1969 with the sample of 2,026 subjects for the base-line fluoridation survey, plus an additional 31 subjects with histories of fluoride therapy. The main purpose was to determine the associations between occlusal features and oral hygiene and gingivitis with survey data, and also by a review of publications which then were available. However, superficial investigations of prevalence figures and of the

associations of occlusion with decay and fractured teeth also were undertaken.

Although the author reviewed the literature, designed the study, performed the survey, processed the data on prevalence and on the associations of occlusal features with decay and fractured teeth, and wrote the relevant reports, statistical advice was obtained from Mr. K.M. Cellier, Principal Research Scientist, Division of Mathematical Statistics, the Commonwealth Scientific and Industrial Research Organisation, Adelaide. Miss Maureen Arend, an experimental officer at that establishment, computed the data for the analysis of associations of occlusal features with oral hygiene and periodontal disease. The data were processed at a Federal government computing centre and also by the author with a Canola electronic calculator.

3.2.1 Crowding

3.2.1.1 Review of the literature

A. Prevalence

Comparisons of prevalence data from different studies did not seem justified as numerous indices were employed, but analyses of relative prevalences by sex and by location of the mouth were reviewed.^{277,278,279,280,281,282}

In a study of 6,619 Rostock children, Dahl found a significantly higher prevalence of anterior crowding in females.²⁷⁷ Helm also found more crowding amongst females in approximately 4,000 Danish subjects aged from

six to 18 years, but higher crowding scores were restricted to the upper jaw.²⁷⁸ Lavelle and Foster surveyed 328 British subjects aged from 18 to 25 years, and found higher prevalence scores for lower anterior crowding in females.²⁷⁹ Equivalent scores were evident for the sexes in the other regions of the mouth.²⁷⁹

Despite these results, Sutcliffe found no difference in the prevalence of crowding in males and females.²⁸⁰ This finding was supported by the results of two further studies, but these were based on Chippewa Indians and Bantu Africans.^{281,282} Therefore, three of the four studies on Caucasians indicated a higher prevalence of crowding in females.^{277,278,279,280}

Helm found more crowding in the lower than upper jaw and cited Seipel, Huber and Reynolds as providing similar results.²⁷⁸ Jacobson obtained similar findings for Bantus, as did Haralabakis in a study of 592 dental students in Athens.^{282,283} Nevertheless, contradictory results were reported by Lavelle and Foster, and a similar prevalence was evident in both jaws from an investigation by Sutcliffe.^{279,280} Collectively, a slight tendency for crowding to predominate in the lower jaw was apparent.^{278,279,280,282,283}

B. Associations of crowding with oral hygiene and periodontal disease

Eight studies were reviewed which indicated a positive association between crowding and periodontal disease.^{280,284,285,286,287,288,289,290} Sutcliffe found

a direct association of crowding with poor oral hygiene and gingivitis.²⁸⁰ Clements and Kirkpatrick surveyed 920 Australian school children and pre-schoolers, and observed a direct significant association of crowding with gingivitis.²⁸⁴ Hellgren found that crowding was directly related to gingivitis in a study of 128 males from 14 to 19 years of age.²⁸⁵ Similar results were obtained by the following: McCombie and Stothard for 1,501 subjects aged from seven to 15 years in British Columbia; Poulton and Aaronson for 908 North American males aged from 17 to 26 years; Herulf for Scandinavian dental students; Ditto and Hall for 143 periodontal patients aged from 14 to 75 years, and Sakuda and Matsumoto for 44 orthodontic patients.^{286,287,288,289,290}

Nevertheless, no clear association of crowding with periodontal disease was evident from three studies.^{291, 292,293} Forsberg surveyed 101 Swedish subjects aged from 20 to 35 years and 102 aged between 60 and 83 years.²⁹¹ Although crowded occlusions apparently were associated with gingivitis, the associations were not statistically significant and it was concluded that the incidence of gingivitis was not notably different when the teeth were crowded.²⁹¹ In a survey of 188 periodontal patients, Geiger did not discern a positive association of crowding with periodontal disease, and Gould and Picton obtained similar findings for 80 subjects ranging in age from early adulthood to over 50 years.^{292,293}

Collectively, a tendency for crowding and periodontal

disease to be directly related was evident, particularly when gingivitis was studied.

C. Association of crowding with decay

Nine studies suggested a positive association between malocclusion and decay, but contradictory findings were evident.^{277,280,284,285,294,295,296,297,298,299,300,301,302}

Hixon, Maschka and Fleming studied decay and occlusion in 193 dental students in Iowa and found that the 20 subjects with the most crowded arches had higher decay scores.²⁹⁸ Even so, other studies did not reveal a significant association between crowding and decay.^{280,284,285} Comparisons of crowding in fluoridated and non-fluoridated communities appear to indicate the effects of decay on crowding rather than the reverse.^{303,304}

On the basis of theoretical considerations, it may be supposed that crowding is the dominant occlusal feature that predisposes to decay, but most of the reviewed studies did not demonstrate a statistical association.

D. Association of crowding with fractured teeth

No studies were reviewed where the association of crowding with fractured teeth was analysed, but it seems conceivable that the two conditions might be related. For example, crowding might so affect occlusion that forceful closure of the jaws could result in fractures from an acute concentration of forces. Rotation associated with crowding might cause external blows to concentrate on prominent edges of the teeth, therefore

predisposing to fractures.

3.2.1.2 Materials and methods

A. Sample

The sample included the subjects in the base-line fluoridation survey, plus 31 individuals with histories of fluoride therapy.

Individuals were classified by dental age with a technique akin to procedures described elsewhere.^{305,306}

The classifications were as follows:

- (i) Age one: no permanent teeth clinically visible;
- (ii) Age two: permanent first molars or permanent incisors clinically visible and erupting;
- (iii) Age three: all permanent first molars and permanent incisors fully erupted, and no additional permanent teeth clinically visible anterior to the permanent first molars;
- (iv) Age four: all permanent first molars and permanent incisors fully erupted, and an additional permanent tooth anterior to the permanent first molars erupting and clinically visible, and
- (v) Age five: all permanent teeth fully erupted anterior to the permanent first molars.

The sample is presented by dental age and sex in Table 114.

B. Examination techniques

Each dental arch was classified as one anterior segment and two segments posterior to the canines.

Crowding in the anterior segments was measured in units of 0.8 millimetres. The number of additional units

of space which was considered necessary to accommodate all the teeth in ideal alignment was assigned as the score for the segment. A graded ruler facilitated this assessment. Crowding in the posterior segments was rated as 0, 1 or 2, depending on whether there was no crowding, crowding sufficient to cause at least one millimetre of vertical or horizontal malalignment, or crowding sufficient to prevent occlusion of a tooth in centric occlusion respectively.

Oral debris and gingival disease scores were obtained for the facial aspects, as detailed for the 1971-1972 and 1974 surveys of secondary school students, except that all the teeth were included. Segment scores were the means for tooth specific scores. Similarly, mean DMF(S) scores were obtained for each segment, but only proximal scores for the upper anterior segment were employed in this study.¹⁴³

Independent duplicate recordings were obtained for 65 subjects, and examiner consistency was tested by calculating Spearman's rank correlation coefficient (Appendix 12.1).³⁰⁷ Independent recordings of debris apparently were impeded by the removal of debris during the measurement process. Nevertheless, duplicate recordings correlated significantly (Table 115). Posterior crowding was too rare for an assessment of examiner consistency. The reliability of the total DMF(S) scores was reported for the base-line fluoridation survey. The circumstances of the survey prevented duplicate examinations to check examiner consistency throughout the survey.

The validity of the oral debris and gingival disease scores was verified by obtaining linear regression coefficients of gingival disease scores on debris (Appendices 7.1 and 12.2). Although it seemed that these scores might have a normal distribution, a test of normality was not undertaken and so the tests of statistical significance should be interpreted cautiously. It was assumed that the regression was linear. The validity of the debris and gingival disease scores was supported by confirming the anticipated direct statistical association between them (Table 116).

C. Statistical analysis

Associations between prevalence figures were undertaken using 2 x 2 contingency tables for the age-sex specific groups (Appendix 8.4).¹⁶⁷ Pooling was achieved by a technique which tests and allows for heterogeneity between age-sex specific associations (Appendix 4.3).¹⁷⁰

The high DMF(S) and crowding scores in the upper anterior segments of the 14 and 16-year-olds facilitated analysis of their statistical association. Similarly, the high frequency of upper anterior crowding and fractured teeth in subjects of dental ages four and five simplified analysis of their statistical association. Previous studies had indicated that most fractures affected the upper incisors.^{21,308,309,310,311,312} Therefore, the association of fractures with crowding was analysed for this segment.

Associations of crowding with debris and gingival

disease scores were investigated by obtaining linear regression coefficients (Appendix 7.1).^{167,205} Although standard errors and p values were calculated, the normality of the distributions of debris and gingival disease scores was not tested, and so these values should be interpreted cautiously (Appendix 12.2).^{167,205} Results were evaluated mostly by seeking trends of positive or negative coefficients. It was assumed that the regressions of debris and gingival disease scores on crowding were linear.¹⁶⁷

3.2.1.3 Results and comments (Crowding)

A. Prevalence

The percentages of subjects with crowding in the various segments and dental age-sex specific groups are presented in Table 117. An increase in crowding apparently occurred during the transition from the primary to the permanent dentitions. At dental age five, 74.5 per cent of males (298 in 400) and 70.5 per cent of females (310 in 440) had crowding in at least one segment.

A consistent difference in the prevalence of crowding by sex was not apparent, although females evidently were more severely affected in the upper anterior segment at dental age two ($X^2 = 6.06$: $df=1$: $p < 0.05$) and the reverse applied for the lower right segment at dental age five ($X^2 = 3.91$: $df=1$: $p < 0.05$) (Table 117). If females' teeth erupt at an earlier age, then standardization by dental age might have prevented higher scores for females in age specific groups.

In all regions of the mouth, the prevalence of crowding seemed consistently higher in the lower jaw (Table 117). A tendency was evident for crowding to be more prevalent in the left than right lower posterior segments (Table 117). The difference was statistically significant for females at dental age five ($X^2 = 6.57$: $df=1$: $p<0.05$) and collectively ($X_m^2 = 15.29$: $df=1$: $p<0.001$).

Although results confirm the trend in previous studies for a higher prevalence of crowding in the lower jaw, the conclusion that crowding predominates in females is not supported by the results of this investigation.

B. Associations of crowding with oral debris and gingival disease scores

Of the 36 regression coefficients for debris on crowding, 31 were positive (Table 118). Whereas positive coefficients seemed less definite in the posterior segments, collectively a positive association was suggested for both the anterior and the posterior regions of the mouth (Table 118).

Overall, 33 of the 36 regression coefficients for gingival disease on crowding were positive (Table 119). A trend for positive associations was evident for both the anterior and the posterior regions of the mouth (Table 119).

C. Association between crowding and proximal decay

The prevalence of proximal decay in the upper anterior segments of the 14 and 16-year-olds was classified by the presence of crowding in Table 120.

Collectively, the prevalences of proximal decay and crowding were directly related ($X_m^2 = 14.82 : df=1 : p<0.001$). Significant associations were evident for 14-year-old females ($X^2 = 7.88 : df=1 : p<0.01$), 16-year-old females ($X^2 = 3.92 : df=1 : p<0.05$) and 16-year-old males ($X^2 = 6.15 : df=1 : p<0.05$).

D. Association between crowding and dental fractures

No association was apparent between fractured teeth and upper anterior crowding (Table 121). Conceivably a positive relation could have been masked by a negative association of upper anterior crowding with overjet.

3.2.1.4 Discussion (Crowding)

A high prevalence of crowding, as defined in this study, was evident for children at dental age five. The degree of crowding apparently increases during the transition from the primary to the permanent dentition, and is most pronounced in the lower jaw. In this study, approximately one in eight children at dental age five had at least four millimetres of insufficient space in the lower anterior segment.

Direct associations of crowding with oral debris, gingival disease and decay supported the claim that crowding can cause pathology. It seems unlikely that the crowding in this study resulted from oral debris, gingival disease or proximal decay. Furthermore, it seems improbable that these conditions were associated only as consequences of a common cause.

Therefore the study suggests that crowding of the

teeth is a public health problem. If the condition cannot be prevented nor treated simply, special consideration should be given to plaque control, and where appropriate to sophisticated corrective care.

3.2.2 Overbite and overjet

3.2.2.1 Review of the literature

A. Prevalence

As common indices did not apply to the different studies, comparisons of absolute prevalence did not seem justified. Even so, analyses of relative prevalences by sex were reviewed.^{278,281,313,314}

In Helm's study of Danish children and teenagers, males had more extensive overbites and confirmatory findings from another investigation were cited.²⁷⁸ Similar results were evident from the survey of 651 Chippewa Indians already reported, although the difference by sex was not statistically significant.²⁸¹ Mills studied the prevalence of deep overbite in 1,455 eight to 17-year-olds, and discovered significantly more deep overbites in males.³¹³ Conversely, significantly more overbite was evident for females in a survey of the primary dentitions of 313 three to five-year-olds in Israel.³¹⁴ Collectively, a slight trend for males to have more pronounced overbites was evident.^{278,281,313,314}

A number of investigations has suggested that post-normal jaw relationships might be more common in males, although the differences sometimes seemed small and possibly a chance occurrence.^{315,316,317,318,319} Consequently it may be anticipated that males might have

larger overjets. In fact, Helm found more extensive overjets in males, but the difference was not statistically significant.²⁷⁸ Similar findings were evident from two further reports.^{313,316} Kaufman and Koyoumdjisky concluded that there were no significant differences in the extent of overjet by sex.³¹⁴ Collectively these studies are inconclusive, although it seems that extensive overjets might be more prevalent in males.^{278,313,314,315,316,317,318,319.}

B. Associations of overbite and overjet with oral hygiene and periodontal disease

Indications of the associations of overbite and overjet with periodontal disease are conflicting.^{286,288,289,292,293,320,321,322,323}

Gould and Picton considered that a positive correlation between extensive overbite and periodontal disease was evident from their study of 80 adults.²⁹³ McCombie and Stothard concluded similarly from a study in British Columbia, and confirmatory evidence was provided by Poulton and Aaronson for young male adults.^{288,289} Nevertheless, no positive correlation was apparent from: Ditto's and Hall's study of 143 periodontal patients; Emslie's analysis of data from 804 periodontal patients; Geiger's study of 188 periodontal patients, and Hellgren's investigation of 28 middle-aged dental patients.^{286,292,321,322} In fact, Geiger's results suggested that an inverse association might prevail.²⁹² A definite trend for positive associations between overbite and periodontal disease was

not apparent from these results.^{286,288,289,292,293,321,322}

Gould and Picton concluded that extensive overjets and periodontal disease were directly related in a sample of 80 adults, and similar findings were obtained by McCombie and Stothard.^{288,293} Confirmatory evidence was presented by Poulton and Aaronson, and Emslie also concluded that these characteristics were directly related.^{289,321} Even so, Geiger did not discern a positive relation.²⁹²

Two further studies revealed significant associations of overbite and overjet with gingivitis in specific regions of the mouth, but the associations were either inconsistent when more than one sample was studied, or failed to be clearly positive or negative.^{320,323} The first study by Alexander and Tipnis included 200 dental students and staff, and 200 patients of a mean age of 30 years, whereas the second by Sanjana, Mehta, Doctor and Shroff was based on 307 Indian male subjects aged between 12 and 16 years.^{320,323}

Waerhaug has stated that indications of the associations of overbite and overjet with periodontal disease are inconsistent, and the present review supports this conclusion.³²⁴ If overbite and overjet are associated with crowding, then associations of the former characteristics with periodontal disease might be masked by the influences of crowding.

C. Associations of overbite and overjet with decay

Only one study was reviewed where the statistical

association between overbite and decay was reviewed.²⁹⁴ Adler surveyed 3,318 Hungarians aged from 16 to 18 years and concluded that those with a deep overbite and a class one jaw relationship had less decay than subjects with a normal occlusion.^{211,294}

Although no investigation was noticed which explored the association between overjet and decay, a positive association might exist. Overjet might relate to an absence of lip seal, which could predispose the upper anterior teeth to dryness and consequently to decay.

D. Associations of overbite and overjet with fractured teeth

No reviewed studies explored the relation of fractures to overbite, but six investigations were directed towards overjet or protrusion in this regard.^{308,312,325,326,327,328}

Eichenbaum found a direct association between the extent of injury to teeth and protrusion in an investigation of 206 subjects aged from six to 16 years.³²⁵ Glucksman concluded that teeth were especially prone to fracture when individuals possessed a class two occlusion of the division one variety.^{211,308} This conclusion was based on observations of 100 patients.³⁰⁸ Similarly, Hallett studied 670 patients with traumatized incisors and concluded that subjects with superior protrusion were substantially more predisposed to fractures.³²⁶ Hardwicke and Newman observed 608 fractures in 403 children.³²⁷ They concluded that 86 per cent of fractures were in

mouths with an excessive prominence of the affected teeth.³²⁷ They claimed that usually there was a lack of contact between the affected teeth and the opposing jaw.³²⁷ Lewis surveyed 343 subjects aged from eight to 13 years and found that fractures were directly related to the protrusion of teeth.³²⁸ Sweet concluded that fractured teeth were related to protrusion and a lack of coverage of the affected teeth by the lip.³¹²

Although it seemed that some of these investigations were not thorough and relied excessively upon casual observations and intuition, the conclusion that fractures and the protrusion of teeth were directly related was without exception.^{308,312,325,326,327,328}

3.2.2.2 Materials and methods

The sample already has been described and is presented in Table 114. Although most examination methods have been reviewed, the methods of measuring overbite and overjet and the reliability of these measurements require definition.

Overbite was defined as the extent to which the upper incisal edges overlapped the corresponding lower incisal edges in centric occlusion. The distance was measured in units of 0.8 millimetres with a graded ruler at right angles to the occlusal plane. The mean measurement for the upper central incisors was specified as the subject's score.

Overjet was interpreted as the extent to which the upper incisal edges overlapped the labial surfaces of the

corresponding lower teeth in the occlusal plane. The distance was measured in units of 0.8 millimetres with the teeth in centric occlusion, and the mean measurement for the upper central incisors was defined as the subject's score.

Independent duplicate scores were obtained for 65 subjects, and their reliability was tested by calculating Spearman's rank correlation coefficient.³⁰⁷ The coefficient was statistically significant for overbite (coefficient = 0.945 : $p < 0.001$) and overjet (coefficient = 0.897 : $p < 0.001$).

Associations between prevalence figures were undertaken as for crowding.^{167,170} Associations of overbite and overjet with debris and gingival disease were investigated by calculating linear regression coefficients.^{167,205} As for the corresponding coefficients for crowding, the accompanying p values should be interpreted cautiously.^{167,205}

It was anticipated that crowding might correlate with overbite and overjet. Therefore, coefficients for overbite and overjet on both debris and gingivitis also were calculated for each level of crowding. If homogeneous, these coefficients were pooled using standard covariance methods.³²⁹ That is, associations were studied after accounting for crowding.

When analysing the associations of overbite and overjet with debris and gingivitis, instances of anterior openbite (3.7 per cent) and of anterior crossbite (8.6

per cent) were excluded from overbite and overjet data respectively. It was considered that the excluded conditions might be pathological and therefore could have masked the statistical associations under investigation.

3.2.2.3 Results and comments (Overbite and overjet)

A. Prevalence

The percentages of subjects with overbites and overjets of four millimetres or more in the individual age-sex specific groups are presented in Table 122.

A tendency for these characteristics to become more pronounced during the transitional period from the primary to the permanent dentition was evident.

Data for dental age one and two were omitted from comparisons by sex, because of insufficient numbers and erupting incisors respectively. Although differences in the prevalence of deep overbite (>4 mm) by sex were not significant in the age specific groups, collectively a significant difference was evident ($\chi_m^2 = 5.28 : df=1 : p<0.05$). More males were affected in each of the three age-sex specific groups (Table 122). At dental age five, males had a mean overbite of 2.92 millimetres, whereas the mean for females was 2.68 millimetres. Differences in the prevalence of extreme overjet (>4 mm) by sex were not significant in the age specific groups, although males always presented higher scores and the collective difference was significant ($\chi_m^2 = 5.90 : df=1 : p<0.05$). Details are evident in Table 122. At dental age five, males had a mean overjet of 2.71 millimetres, whereas the mean for females

was 2.63 millimetres.

B. Associations of overbite and overjet with oral debris and gingival disease scores

No definite association of overbite with debris or gingivitis was apparent in the upper jaw (Tables 123 and 124). Of the 20 coefficients for overbite on debris in the upper segment, 13 were positive: similarly, 12 of the 20 coefficients for overbite on gingival disease were positive (Tables 123 and 124). Although 16 of the 20 coefficients for overbite on debris were negative in the lower jaw, 12 of the 20 coefficients for overbite on gingivitis were positive (Tables 123 and 124). That is, a trend which suggested an association between overbite and gingival disease was not apparent. It appears that a negative association between deep overbite and oral debris, which cannot be attributed to concurrent crowding levels, existed in the lower jaw. Regression coefficients for overbite on debris in the lower jaw seemed homogeneous across the age-sex-crowding specific groups, and the pooled coefficient was -0.220 ± 0.101 .

A positive association of overjet with debris and gingivitis was evident in both jaws (Tables 125 and 126). Of the 40 coefficients for overjet on debris, 34 were positive, whereas this number was 33 for the 40 coefficients of overjet on gingival disease (Tables 125 and 126).

C. Associations of overbite and overjet with proximal decay

The prevalence of proximal decay in the upper

anterior segments of the 14 and 16-year-olds is classified by overbite and overjet in Tables 127 and 128 respectively. No consistent association was evident between these features of occlusion and the prevalence of decay. Collectively, neither association was statistically significant.

D. Associations of overbite and overjet with dental fractures

The prevalence of dental fractures in the upper anterior segments is classified by the degree of overbite in Table 129. A significant association was not evident between these features in the dental age-sex specific groups nor collectively (Table 129).

However, a significant positive association between dental fractures in these segments and overjet was evident from Table 130 both for females at dental age four ($\chi^2 = 6.33 : df=1 : p<0.05$) and collectively ($\chi_m^2 = 7.99 : df=1 : p<0.01$).

3.2.2.4 Discussion (Overbite and overjet)

Results supported the slight trends, which were apparent from the reviewed studies, for males to present more pronounced overbites and overjets. At dental age five, approximately one-third of the subjects possessed overbites of four millimetres or more, and this proportion approximated one quarter for overjets of this dimension.

The lack of a definite association between overbite and gingival disease was not surprising in the context of the reviewed studies. Perhaps an association might have

been disclosed had the palatal tissues been examined. For example, deep overbite might lead to an impingement of the lower incisors on the palate, so causing gingivitis. The apparent negative association between lower debris scores and overbite is difficult to rationalize. Perhaps the passage of food over these surfaces achieves a greater cleaning effect when overbites are pronounced. It seems that this association requires confirmation, particularly as a coexisting negative association between overbite and gingival disease was not apparent.

The slight trend which was apparent from the reviewed studies for extreme overjet to relate directly to periodontal disease was supported by the present results. Furthermore, it was apparent that the association could not be explained by concurrent crowding levels. Perhaps pronounced overjet is associated with an absence of lip seal and dryness with consequent poor oral hygiene and gingival disease.

As anticipated, pronounced overjet was directly associated with fractured upper anterior teeth. The present results support the claim that children with extreme overjet should wear mouth guards during contact sport and that ideally they should obtain corrective treatment.

Extreme overbite apparently was not associated with decay, nor with fractures in the upper anterior segment. Furthermore, extreme overjet apparently was not related to decay in this region.

3.2.3 Crossbite, openbite and proclination

3.2.3.1 Introduction

Although numerous studies have reviewed the associations of crowding, overbite and overjet with periodontal disease, few have investigated corresponding associations for crossbite, openbite or proclination.^{280,284,285,286,287,288,289,290,291,292,293,320,321,322,323,324}

In this section, the associations of crossbite and of proclination of the lower incisors with oral hygiene and periodontal disease are reported. The prevalence of openbite was too low to analyse its association with periodontal disease.

Although the associations of crowding, overbite and overjet with proximal decay and fractured teeth were undertaken and have been reported already, the numbers were insufficient to accomplish corresponding analyses for crossbite, openbite or the proclination of the lower incisors.

3.2.3.2 Review of the literature

A. Prevalence

Comparisons of absolute prevalence data between different studies did not seem justified, because common indices were not employed.

Nine studies compared the prevalences of crossbites in males and females.^{277,278,281,313,315,316,330,331,332} Females had significantly more crossbites in Rostock children.²⁷⁷ Helm found no significant difference between data for the sexes in the anterior region, although there were higher scores for females.²⁷⁸ Nevertheless, females presented significantly more transverse crossbites.²⁷⁸

Although Fisk concluded that posterior lingual cross-bites usually were more prevalent in females, posterior buccal crossbite scores were significantly higher for males.³¹⁶ A tendency for females to have more cross-bites was evident from data provided by Mills and Davies which already have been reported.^{313,315} Gravely surveyed 1,287 children from three to eight years of age and found more canine and molar crossbites in females, and Kutin and Hawes obtained similar results from a study of 277 seven to nine-year-olds.^{330,332} Although a trend for higher crossbite prevalences in females is evident, Horowitz and Doyle found equivalent prevalences in the sexes in a study of 321 caucasian and 397 negroid 10 to 12-year-olds, and Grewe, Cervenka, Shapiro and Witkop discerned more anterior crossbites for males in a study already reported.^{281,331}

Although Mills did not discover a significant difference between the prevalences of posterior openbites in the sexes, anterior openbites were more common in females.³¹³ Conversely, Helm found more anterior and posterior openbites in males, although the differences were not statistically significant.²⁷⁸ It is apparent from Fisk's results that males had more anterior openbites than females in the age range from three to six years, and also at 21 years of age.³¹⁶ Nevertheless, Grewe, Cervenka, Shapiro and Witkop found more anterior and posterior openbites in females, although the numbers were small and possibly misleading.²⁸¹ An overall trend for one sex to

have more openbites was not evident.^{278,281,313,316}

No reviewed studies investigated inter-sex differences between the degree of proclination of the lower incisors, as analysed in this investigation.

B. Associations of crossbite, openbite and proclination with oral hygiene and periodontal disease

Sakuda and Matsumoto considered that gingivitis was directly associated with anterior crossbite in 44 orthodontic patients.²⁹⁰ Moreover, a positive association between crossbite and localized periodontal pockets was apparent to Geiger.²⁹² Even so, neither McCombie and Stothard nor Gould and Picton found a significant association between crossbite and periodontal disease.^{288,293} A definite trend for positive associations between crossbite and periodontal disease was not evident from these investigations.^{288,290,292,293}

Stiefel surveyed 402 high and junior high school students and found no apparent association between openbite and gingivitis.³³³ Similar findings were obtained by Geiger, whereas Sakuda and Matsumoto considered that their observations demonstrated a positive association.^{290,292} The nature of the association seems inconclusive.^{290,292,333}

Geiger measured the angle of the long axis of the lower incisors to the occlusal plane.²⁹² Where the angle was most acute and the teeth therefore were regarded as most proclined, less periodontal disease was evident, but the association was not statistically significant.²⁹²

3.2.3.3 Materials and methods

The sample has been described and is presented in Table 114. Most examination methods have been reviewed already, but the methods of measuring crossbite, openbite and proclination require description.

Crossbite was classified separately for the anterior and the two posterior regions, and was interpreted as the number of lower teeth in centric occlusion with either

- (i) the incisal edges or cusps occluding labially or buccally to the upper teeth, or
- (ii) the buccal cusps occluding lingually to the palatal cusps of the upper teeth.

Openbite also was scored separately for the anterior and the two posterior regions. In the anterior region, negative overbite of all incisors was required. Posteriorly, at least two teeth in a segment were required to be out of contact with their antagonists in centric occlusion.

Measurements of proclination were restricted to the lower anterior segment and were made with an adaptation of the instrument described by Geiger.²⁹² The angle of each lower incisor to the occlusal plane was determined and the mean was calculated as the score for the subject. The measurements were made so that scores would increase with the degree of proclination. Measurements were made for the dental ages three to five only, that is, only where the permanent incisors were fully erupted.

Crossbites and openbites were too rare for assessments of examiner consistency from the independent dupli-

cate recordings for 65 subjects. However, Spearman's rank correlation coefficient was 0.934 ($p < 0.001$) for the duplicate proclination scores.³⁰⁷

The validity of the proclination scores was investigated by relating them to a subjective classification. A total of 106 study casts was categorized into four groups according to the perceived extent of proclination of the lower incisors. The mean proclination score for each group agreed with the subjective classification (Table 131). The association between corresponding scores, which were obtained independently through the two methods, was tested by calculating Spearman's rank correlation coefficient and was found to be significant (coefficient = 0.766 : $p < 0.001$).³⁰⁷ Therefore the proclination scores evidently were valid.

Associations between prevalence data were undertaken as for crowding, overbite and overjet.^{167,170} Also, associations of crossbite and proclination with debris and gingival disease were investigated by calculating linear regression coefficients.^{167,205} As for the coefficients relating to crowding, overbite and overjet, the corresponding p values should be interpreted cautiously.^{167,205}

As it seemed that crowding might correlate with crossbite and proclination, coefficients for the latter features on oral hygiene and gingivitis also were calculated for each level of crowding. If homogeneous, these coefficients were pooled using standard covariance

methods.³³¹ That is, associations were studied after accounting for crowding.

Overjet scores of at least four millimetres (23.1 per cent) were excluded from analyses of associations of anterior crossbite with oral hygiene and gingivitis, because it seemed that extreme overjet might be pathological and therefore could mask the statistical association under investigation.

3.2.3.4 Results and comments (Crossbite, openbite and proclination)

A. Prevalence

The percentages of subjects with anterior and posterior crossbites are presented in Table 132. A tendency for posterior crossbites to become more prevalent with increasing dental age was apparent.

When analysing crossbite prevalences by sex, dental ages one and three were excluded because of small numbers. Dental ages two and four were disregarded when analysing anterior and posterior crossbites respectively, because of the large numbers of erupting teeth in the relevant segments. No significant differences were evident between the prevalences of anterior crossbites in the sexes. Females had significantly more posterior crossbites in the mixed dentition ($X^2 = 15.68 : df=1 : p<0.001$), but collectively no significant difference was apparent (Table 132).

The percentages of subjects with anterior and posterior openbites are presented in Table 133. An analysis of the prevalence of anterior openbite by sex was limited to dental age five, because of the small numbers

and the inappropriateness of dental age two with erupting incisors. The prevalences of anterior openbites were not found to differ significantly between the sexes. Insufficient numbers prevented analyses of the relative prevalences of posterior openbites by sex, although it seems from Table 133 that there was no consistent difference.

The percentages of subjects with proclination scores of eight units or more are presented in Table 134. Subjects were included whenever a measurement could be achieved. Occasionally a score was not obtained because there were no posterior teeth or because of obstruction from the tongue, which prevented the proclination gauge from being positioned. In each age group, males had higher proclination scores and the collective difference was statistically significant ($\chi^2_m = 5.02 : df=1 : p<0.05$).

B. Associations of crossbite and proclination with oral debris and gingival disease scores

Associations of crossbites with debris scores by segment, dental age and sex are presented in Tables 135, 136, and 137. Collectively, no association was evident in the upper jaw. Irrespective of whether crowding was taken into account, seven coefficients were positive and 11 were negative in the upper posterior segments, and an equal number was positive and negative anteriorly. A positive association was evident between crossbite and debris scores in the lower jaw. Irrespective of whether crowding was taken into account, 22 coefficients were

positive and six were negative. This trend was least apparent anteriorly.

Associations of crossbites with gingival disease scores by segment, dental age and sex are presented in Tables 138, 139 and 140. Collectively, no association was evident in the upper jaw. When crowding was disregarded, 13 coefficients were positive and 15 were negative. Whereas when crowding was taken into account, 12 coefficients were positive and 16 were negative. A positive association was evident between crossbite and gingival disease scores in the lower jaw. Irrespective of whether crowding was taken into account, 22 coefficients were positive and six were negative (Tables 138, 139 and 140).

Equal numbers of regression coefficients for proclination on debris in the lower anterior segment were positive and negative, irrespective of whether crowding was taken into account (Table 141). Even so, after accounting for crowding, regression coefficients for proclination on gingival disease were suggestive of a weak positive association (Table 141).

3.2.3.5 Discussion (Crossbite, openbite and proclination)

A somewhat high prevalence of crossbites, as defined in this study, was evident at dental age five. Approximately one in 13 subjects had anterior crossbites at this age, and the corresponding ratio was one in six for the posterior crossbites.

Direct associations of crossbite with debris and

gingival disease were evident in the lower jaw. It seems plausible that the buccal or labial positioning of the lower teeth might predispose them to poor oral hygiene by reducing the access of toothbrushes and cleansing foods.

If the degree of proclination of the lower incisors and the extent of overjet are directly related, then the weak trend for a positive association between periodontal disease and proclination is consistent with the positive association of this disease with overjet. The suggestion of a weak negative association between proclination and periodontal disease, which was reported by Geiger, might have resulted from a lower prevalence of crowding in instances of overt proclination.²⁹² That is, a direct association might have been masked by the effects of crowding.

Although the collective prevalences of crossbites in males and females were similar in this study, females presented significantly more posterior crossbites in the mixed dentition. This finding is consistent with the slight trend, which was apparent from the reviewed studies, for females to have more crossbites.

3.2.4 Discussion

Regression coefficients of occlusal features on debris and gingival disease were homogeneous across the crowding levels, except for the most isolated instances. Therefore, these rare instances of heterogeneity were considered to have arisen by chance, and pooling nevertheless was undertaken.

The credibility of the employed statistical methods was enhanced by the confirmation of the predictable associations between

- (i) oral debris and gingival disease;
- (ii) crowding and oral debris;
- (iii) crowding and gingival disease, and
- (iv) overjet and fractured upper anterior teeth.

Investigations of the associations of openbite with other conditions would require a modified sampling procedure whereby more instances of openbite would be included. The employed sample had the disadvantages of not incorporating advanced stages of periodontal disease and of not being based on a State-wide random selection.

The oral debris and gingival disease scores were not related to the proximal, lingual nor palatal aspects, and so a comprehensive analysis was not possible. A total review of the importance of occlusion also would require a consideration of effects on the temporo-mandibular joint, and on psychological and social characteristics.

Despite these limitations, the positive associations of

- (i) crowding with debris, gingival disease and proximal decay;
- (ii) overjet with debris, gingival disease and fractured teeth, and
- (iii) crossbite with debris and gingival disease,

suggest that occlusal conditions can have more than esthetic consequences. Associations do not prove causal relationships, but the associations disclosed in this

study support hypotheses of cause and effect. It does not seem that the occlusal features would have been effects of the correlates, nor effects of a cause common to these correlates.

Considerable emphasis has been placed on this study because there seemed to be a common attitude outside dentistry that orthodontic care was a cosmetic service only, and therefore should be assigned a low priority. In fact, the Australian Society of Orthodontists regarded the study to be sufficiently important to offer funds for the data processing.

Although the study demonstrated that certain arbitrarily defined occlusal features were prevalent, and therefore might constitute a public health problem because of their statistical association with pathology, it is evident that the prevalence of detrimental occlusions was not defined. The challenge of determining this prevalence seems immense when the variable impact of single occlusions on different individuals is considered in the biological, social and psychological dimensions. It seems that the sociological aspects are difficult to assess, but nevertheless are particularly important. Whereas a single occlusion might not impose destructive influences on an individual at one point in time, these influences could develop with age following changes in biological, psychological or social characteristics. The difficulty of defining occlusions which should be treated is a particularly daunting public health problem in view of the

expense of care and the seemingly high prevalence of potentially detrimental occlusions. In a previous section, the proportion of primary school children with Angle's normal occlusions was rated as 23.2 per cent by therapists and as 31.3 per cent by the regional dentists (Table 79).²¹¹ It seems unlikely that every other child would have required orthodontic treatment.

From Appendix 5.10, it is evident that school dental staff are considering the orthodontic requirements of patients. Of the primary teeth extracted by field staff in 1975, 4,456 (42.3 per cent) were removed for orthodontic reasons, whereas the corresponding figure was 1,953 (58.7 per cent) for permanent teeth. Minor orthodontic appliances were placed in 1,034 (2.8 per cent) of the patients treated. If it is assumed that individual children were never treated with appliances in more than one year, and that the total number of patients was distributed evenly across the seven school grades, then it seems that 19.8 per cent ($1,034 \times 7 \times 100/36,514$) would be treated with minor orthodontic appliances in the School Dental Programme during the primary school years.

Although the South Australian School Dental Programme has made provisions for assistance from orthodontic technicians and from a specialist orthodontic adviser, the scope of care is limited to so-called minor orthodontic care, and this care is considered a peripheral function of the organization. In instances where specialist orthodontic care would be more effective and would be obtain-

able, it seems particularly important that the limitations of minor care be stressed so that this care does not constitute an undesirable barrier to the acquisition of specialist services.

With school dental staff emphasizing the need for orthodontic care, it is important that any increases in demand are accommodated by an appropriate availability of specialist services. In fact, a considerable increase in the number of private orthodontic specialists has occurred in South Australia. Whereas the number of these specialists was one in 1950, five in 1960, and nine in 1970, the figure had increased to 19 by 1975.³³⁴ Three additional orthodontists are expected to graduate from a recently-established postgraduate course at The University of Adelaide in 1976.³³⁴ All the major country towns are visited frequently by private specialists and so sophisticated care is readily available in all but the remote rural areas of the State.³³⁴

3.3 Summary

A survey of the prevalences of various occlusal features was undertaken and their statistical associations with oral hygiene, periodontal disease, decay and fractured teeth were investigated. Considerable emphasis was placed on this study because a common attitude was apparent outside dentistry that orthodontic care was a cosmetic service only, and therefore should be assigned a low priority. It was anticipated that the results might be used to demonstrate the need for appropriate specialist services for the management of orthodontic referrals from the School Dental Programme.

The investigation was based on the fluoridation baseline sample together with an additional 31 subjects with histories of fluoride therapy. The prevalences of occlusal features and their associations with pathology were analysed by dental age, sex and segment of the dental arch, in order to account for extraneous variables. Associations of occlusal features with oral hygiene and periodontal disease were analysed after accounting for crowding.

Crowding apparently increased during the transition from the primary to the permanent dentition to affect almost 75 per cent of the subjects of the most advanced dental age, as defined in this study. The condition was more pronounced in the lower jaw and was directly associated with oral debris, gingival disease, and with proximal decay in the upper anterior teeth.

At the most advanced dental age, approximately one-third of the subjects had overbites of four millimetres or more, and the proportion approximated a quarter for overjets of this dimension. Extensive overbites and overjets seemed to be more prevalent in males. Overbite apparently was not associated with gingival disease, but gingivitis was examined on the labial aspects only. Overjet was directly related to oral debris, gingival disease and fractured upper anterior teeth.

At the most advanced dental age, anterior openbites affected only about four per cent of the subjects, and the corresponding proportion was lower for posterior

openbites. However, the proportion of occlusions with crossbites at this age was about one in 13 for the anterior segments, and about one in six for the posterior regions. Crossbites apparently were directly related to oral debris and gingival disease on the labial and buccal aspects of the lower jaw.

A comprehensive review of the importance of occlusion would require State-wide samples which included adults, and a consideration of the effects of occlusion on the following:

- (i) oral debris and periodontal disease on the proximal, lingual and palatal aspects of the teeth;
- (ii) the temporo-mandibular joint, and
- (iii) the psychological and social dimensions.

The problem of defining the occlusions which should be treated is a particularly serious public health problem in view of the expense of care and the seemingly high prevalence of potentially detrimental conditions. The psychological and social significance of a single occlusal syndrome in specified individuals seems especially difficult to assess.

It appears that approximately 20 per cent of patients in the School Dental Programme might receive so-called minor orthodontic care with appliances. It is important that this care does not constitute an undesirable barrier to the acquisition of more effective specialist services.

With school dental staff emphasizing the importance of orthodontic care, it is important that any increase in

demand is accommodated by an appropriate availability of specialist services. Between 1970 and 1975, it seems that the number of private orthodontists in the State increased from nine to 19. Three additional practitioners are expected to complete a recently-established postgraduate orthodontic course at The University of Adelaide in 1976.

VII GENERAL DISCUSSION

The dental research unit's cost for salaries, estimated capital depreciation, and for data processing and computer programming, has varied between one and $1\frac{1}{2}$ per cent of the South Australian School Dental Programme's budget. This investment seems small when its relevance to planning and evaluation is considered. School dental personnel can account to administrators, politicians, health professionals and the community by demonstrating dental health needs, the effect of school dental care and the associated costs. Individual methods of care can be evaluated scientifically and superior alternatives chosen according to effectiveness and efficiency. It is anticipated that the South Australian Health Commission will be established in 1977 and that a regionalization of the health administration will ensue. Existing provisions for data collection and central evaluation should enable a system of accountable management to develop, whereby maximum authority for decision-making can be delegated to the regions and to the lowest organizational levels without a loss of the appropriate central oversight and control. It is anticipated that "scientific management" will be augmented by regionalization, the increasing size and complexity of the health system, the rapid changes in health technology, an increased sophistication in health administration and in government, and a greater competition for resources.

Perceived limitations in performance have resulted from the organizational fragmentation of the dental system. Although the School Dental Programme has devoted considerable attention to manpower planning and apparently has established schools of dental therapy of an appropriate capacity, the education of dentists is undertaken by The University of Adelaide and hygienists are trained by a separate government department. It seems necessary that there be a planning body with a clear responsibility to advise on the appropriate dimensions of training programmes for all dental personnel. This need seems paramount when there is an attempt to offer comprehensive care to entire community groups and when available manpower therefore must match existing requirements. If the capacities of training programmes were excessive, anxiety and industrial problems could develop amongst dental health providers, and resources would be wasted. Alternatively, insufficient training would result in a short-fall of health care. Comprehensive manpower planning must rely on assumptions concerning the potential character and performance of the dental system and the associated future demands and needs for care. In an environment of rapid social and technological change, manpower planning must be tentative and be reviewed continuously.

The South Australian School Dental Programme's research unit is the first dental development of its kind in an Australian State, and represents a more intensive attention to planning and evaluation than is apparent in

most areas of the health system. Accordingly, it has been necessary to search for supportive expertise, and performance has been handicapped until recently by a limited availability of statistical advice and of data processing facilities. Hopefully, a comprehensive health planning bureau will be established within the forthcoming Health Commission so that planning competence can be consolidated and the development of the total health system integrated.

It is evident that decision-making in health cannot be based entirely upon scientifically established facts, and so there always will be a combination of pragmatic and scientific factors in management. As the capacity for "scientific management" increases through developments in planning and evaluation, so the need for pragmatic methods will be reduced. Nevertheless, it appears that habit might prompt administrators to persist unnecessarily with intuition as a basis for decision-making. It has been evident that the dental research unit's full value has not been realized because most dentists were not trained in public health nor health administration, and have found it difficult to think in quantitative terms. Accordingly, an on-going programme of staff education seems essential to gain the full value of scientific planning and evaluation. Planners must not become isolated by using incomprehensible terminology and mathematical formulae in their communications. It seems that planners should work with health providers, politicians and health consumers if plans are to be appropriate.

It is apparent that dental personnel have been preoccupied more with the technical process of care than with health considerations. Possibly this has resulted from the tangible nature of care when compared with the more elusive characteristics of health. Private practitioners have been remunerated for units of care rather than for units of health. With developments in methods of evaluating health changes, it seems appropriate that there be an increased emphasis on health achievements and costs in evaluation, rather than on services delivered and costs. It appears that practitioners have concepts of quality care which are instilled in them during their training. These concepts often have become part of the dental socialization process and have a dubious relevance to effectiveness and efficiency. For example, sometimes the notion of quality in the polish of a restoration seems more relevant to the evidence of technical skill and peer respect than to the interests of the patient and cost. Many dental health providers have been conditioned to regard a six-monthly interval between successive courses of dental care as "the ideal". The persistence of this recall interval might be reinforced by community expectations, which have been developed by the profession. Ideally, there should be a flexible School Dental Programme where staff continually question the characteristics of quality care in the perspective of health needs and efficiency. For example, it seems that the desirability of topical fluoride therapy and of six-monthly intervals between

dental examinations would vary with the patient's needs and with fluoridation. Perhaps recall intervals should be extended more where dental examinations are particularly thorough. Such a Programme would have few State-wide standards. With greater reliance on local decision-making, it seems that there would be an increased scope for professional freedom. This system would require sophisticated evaluation and continual communication between the central and regional staff, if appropriate central controls were to be retained.

It is apparent that a disproportionate emphasis has been placed on the number of treated patients as an index of a dental programme's merit. It seems that additional attention should be given to short and long-term effects on health, utilization, social acceptability, the capacity to accommodate to changing requirements, and the inherent potential of the system to improve its effectiveness and efficiency. Possibly a concentration on health rather than on care would encourage a more earnest consideration of techniques which are not within the traditional scope of care: for example, improving menus in school canteens, developing programmes of self-application of fluoride, organizing systems for the referral of patients to private dentists after they leave the School Dental Programme, and developing health education schemes where health providers largely are replaced by school teachers and senior children as educators.

It appears that pilot projects are particularly im-

portant. New procedures can be tested without disrupting the entire Programme by introducing methods which possibly are inappropriate. Without pilot projects, an aversion towards major disruptions might hinder progress.

One undefined aspect of the School Dental Programme is the value of minor orthodontic care. Regional dentists devote considerable time to this treatment and no provision has been made for assessments of the long-term benefits. As regional dentists are restricted almost entirely to pedodontics, and as most routine pedodontic care is delivered by the therapists, the provision of minor orthodontic care apparently has facilitated the dentists' job satisfaction. Even so, the long-term effects of this care should be evaluated. Perhaps some of the associated resources should be redirected towards indigent adult populations.

It is evident that a national dental survey of a representative sample of Australians would be desirable. A calibrated group of examiners and interviewers could be used to obtain data for general planning and evaluation. The employment of data from isolated samples and from general clinical records offers an indication of needs and of the effects of programmes, but lacks the breadth, reliability and sophistication which could be expected from a national survey.

The rapid growth of school dental programmes throughout Australia is a major development, and reflects a concern of Government for the dental needs of all children.

It appears that dentistry traditionally has attracted individuals with an interest in the technical aspects of care, and that this interest has been fostered in dental training without an adequate concurrent emphasis on public health. It is important that schools for dental auxiliaries do not embrace the traditional emphasis on care rather than on health.

VIII CONCLUSIONS

The following conclusions are presented to identify South Australian dental health needs, and the effects and characteristics of the School Dental Programme and of related health schemes.

1. For children without histories of school dental care, the mean number of permanent and primary teeth with untreated decay ranged with age from approximately $6\frac{1}{3}$ to $7\frac{1}{2}$. The number seemed higher in the lower socio-economic areas.
2. Mid-way between courses of school dental care, primary school children had a mean of about $1\frac{1}{2}$ or fewer teeth with untreated decay.
3. It appears that decay rates were lower in subjects from the upper socio-economic areas and possibly in the permanent teeth of primary school children who had received the most courses of school dental care.
4. Approximately 50 per cent of primary school children presented with "poor" or "very poor" oral hygiene, and about 40 per cent had "moderate" or "severe" gingivitis in some schools. Females and subjects with histories of school dental care apparently had cleaner teeth.
5. Primary school children practised poor dental habits with regard to diet, toothbrushing, professional dental care, and the use of fluoride tablets and toothpaste, but an increased use of recommended toothbrushes seemed to follow school dental care.

6. Primary school children usually acknowledged the desirability of dental practices which were recommended by dentists, but many children apparently
 - (i) considered that they would know if they had dental disease;
 - (ii) overrated the cosmetic and functional qualities of artificial teeth, and
 - (iii) thought that natural teeth only should be retained for shorter periods than a life-time.
7. Research based on x-ray and clinical findings indicated that secondary school students averaged about seven or eight teeth with untreated decay, but dental needs were substantially lower in fluoridated areas and amongst students with histories of school dental care.
8. Decay rates in second-year students at secondary schools were similar, irrespective of whether there was a history of school dental care, but certain improvements in oral hygiene practices and in dental knowledge apparently followed this care.
9. As only about 40 per cent of second-year students at secondary schools reported a dental visit since leaving the School Dental Programme, remedial action should be taken in this regard.
10. Too few South Australian adults would have received school dental care for ready assessments of the long-term effects. It seemed that approximately 26 per cent of the population aged 15 years or more

- was edentulous, and this percentage was higher outside the State capital and amongst females, the aged, lower socio-economic groups and those born in Australia. Surveys should be undertaken in the future to assess the long-term effects of school dental care and of other dental influences in the State.
11. The eventual mean annual cost of school dental care per child, after excluding the training costs of dentists and the travelling and accommodation expenses in remote rural areas, was estimated in 1975 dollar values at \$27 for the State. This estimate related to primary school children and seemed reasonable when compared with specified "fee-for-service" standards.
 12. Projections indicated that in a fully developed primary school dental programme in a non-fluoridated area, school dental operators would provide a mean of 580 courses of treatment annually to a mean of 480 patients. Higher figures were evident when only 1974 and 1975 data were considered.
 13. In the context of the more limited availability of chairside assistants for therapists than for dentists, the therapists' restorative productivity seemed reasonable.
 14. It was evident that therapists could recognize decay, poor oral hygiene and chronic marginal gingivitis, and generally could plan appropriate treatment for decay. As therapists would not have referred many

children whom their supervising dentists would have wished to examine, it seemed that dentists should maintain a periodic surveillance of each child.

15. School dental records of the treatment of permanent

first molars indicated that

(i) in non-fluoridated areas, fissure sealants could reduce the need to restore many occlusal surfaces more than once, and

(ii) in fluoridated areas, fissure sealants could reduce the need to restore occlusal surfaces appreciably.

The retention rate of sealant placed by dental therapists approximated 25 to 31 per cent only, and decay rates were reduced by about 24 per cent on the test surfaces. It seems that therapists should not place sealants routinely until a more effective technique is established.

16. A pilot dental health education project in which 15 to 17-year-old secondary school students assisted at the chairside, explored various aspects of dental care, and provided dental health education to primary school children, apparently improved the former students' oral hygiene, gingival health and dental habits. The programme should be adopted for general use as it also seems a potentially effective and efficient method of providing health education to primary school students.

17. Insofar as available data are relevant to appraisals of the therapists' performance, cost of employment and acceptance by the community, there is support for the contention that they should be employed.
18. A formalized survey of the attitudes of school dental staff provided useful information for administrators and should be repeated periodically. Responses indicated that the dentists who directed therapists sometimes were critical of their own narrow clinical scope, and felt a need for more training in orthodontics, dental health education, administration and public health dentistry, in order to discharge their responsibilities more effectively.
19. Data indicated that x-rays increased the diagnostic sensitivity for proximal lesions. If bite-wing x-rays can introduce economies by increasing the intervals possible between routine examinations, and by reducing the need for multiple restorations of one tooth, their use should be encouraged unless there are overriding disadvantages.
20. It has been customary for school canteens to provide sweets, and investigations indicated that decay rates were directly associated with this practice. Canteen menus were more desirable in schools with dental clinics.
21. After three years of fluoridation in the State capital, DMF(T) scores were reduced by approximately
 - (i) 19 per cent for six-year-olds, and
 - (ii) 15 per cent for eight and 10-year-olds.

The greatest reduction apparent was 60 per cent, which applied to the incisors of 10-year-olds. The need for school dental manpower should be reduced markedly following the full effects of fluoridation.

22. Arbitrarily defined occlusal conditions were found to be prevalent in six to 16-year-olds, and positive associations of

- (i) crowding with oral debris, gingival disease, and proximal decay;
- (ii) overjet with oral debris, gingival disease and fractured teeth, and
- (iii) crossbite with oral debris and gingival disease,

were apparent. In view of the cost of specialist orthodontic care and the apparent high prevalence of potentially detrimental occlusions, research is required to define the conditions which should be treated.

23. The dental research unit's costs seem reasonable when the unit's relevance to "scientific management" is considered. However, there is a need for a planning body with a clear responsibility to advise on the requirements for all categories of dental health personnel.

24. A need for school dentists to be trained in public health and health administration is apparent to further performance.

25. Dental health personnel should concentrate primarily

on health rather than on the care process, and should continually review their techniques in this context.

26. A national dental survey of a representative sample of Australians by calibrated examiners and interviewers could enable the acquisition of more reliable and sophisticated data for planning and evaluation than seems possible from general clinical records and isolated surveys.