DENTAL HEALTH OF CHILDREN BEFORE AND AFTER THE CESSATION OF WATER FLUORIDATION.

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DECLARATION

This thesis is the work of the author.

SUMMARY

Extensive research has established that dental caries experience can be reduced by adding optimum levels of fluoride to drinking water. However, it has been suggested that water fluoridation may be less effective where caries levels are falling, as in Britain and Europe. Earlier studies carried out before the period of temporal decline in caries prevalence, had shown increases in caries prevalence after fluoridation ended. The cessation of water fluoridation in Wigtown District in 1983 has provided the opportunity to study the effect of the cessation of water fluoridation in a period of declining caries incidence. Such a study will also throw some light on the benefit of introducing water fluoridation when caries experience is declining in the population.

A series of studies of dental health in 5, 10 and 15 year old children resident in Stranraer, the main town in Wigtown District, in comparison with a similar non-fluoridated town, Annan were carried out in 1980, 1986, 1988 and 1991. These studies have used the same methodology and examiner, allowing secular trends to be examined over time and the monitoring of any changes in caries prevalence which may have resulted from the ending of water fluoridation. The sample in each study was all life-time residents in the age group in each town.

The original data was analysed using the System for Planning and Epidemiological Evaluation of Dental Services (SPEED) suite of programmes on a main-frame computer. As this system did not provide surface data, it was felt that the programme should be revised to provide both DMFT and DMFS scores. With the widespread availability of micro computers, the opportunity was taken to change to a data analysis system operating on a micro computer. As a result a new Dental Analysis System (DAS) has been developed based on the modular concept of SPEED and utilising the Statistical Package for the Social Sciences (SPSS). DAS is a multi-module set of SPSS programmes, operating on both main-frame and micro computers, developed to process dental epidemiological data.

The final study was analysed utilising DAS. The DAS system has also been tested on a number of other epidemiological studies in Britain and abroad.

The 1980 study had demonstrated that caries prevalence in Stranraer children was up to 50 per cent lower than in the control town, Annan. In 1986, three years after fluoridation ceased, 5 year old children in Stranraer had a 65% lower mean dmft than the corresponding group in Annan. The 10 year old group were only 38% better than the Annan 10 year old children. Both age groups in Annan and the 5 year old groups showed a downward trend in keeping with the temporal decline in caries rates in Britain. However the 10 year old group in

Stranraer had a marginally higher mean DMFT score in 1986 compared with 1980. This was thought to be an early indication of an adverse trend in caries levels in Stranraer.

Five years after the cessation of fluoridation, the mean dmft/DMFT scores for 5 and 10 year olds had increased by 24% and 37% respectively ($p < 0.01$) by 1988, although the studies were carried out during a period when there has been a national reduction in caries prevalence. Over the same period, caries prevalence in Annan children has followed the national trend with a 23-27% fall in mean scores ($p < 0.01$). As a result, caries prevalence in the study groups in the two towns in 1988 showed a difference of only 0.1 and 0.28 respectively in mean dmft/DMFT scores. These differences are not statistically significant.

In 1991, caries levels in Stranraer 5 year olds were found to be slightly higher than in Annan, although the difference was not statistically significant. Caries prevalence in both towns was lower than the levels found in 1988. This appears to be in line with general trends in caries rates in Scotland.

The results of this series of studies have confirmed that cessation of water fluoridation still leads to increases in caries levels, during a period of temporal decline. The studies have confirmed that water fluoridation would be beneficial in Scotland. It is hoped that water fluoridation will be restarted in Wigtownshire and these studies will provide a basis for the monitoring of the effects on dental health following its re-introduction.

INTRODUCTION

Extensive research has established that dental caries can be safely and economically reduced by adjusting the fluoride content of public water supplies to the optimum level for a particular region depending on ambient temperature. In 1969 the World Health Organisation recommended that member states should introduce, where practicable, fluoridation of those community water supplies where the fluoride intake of the population from water and other sources is below optimum levels for the prevention of dental caries (1). A World Health Organisation report, published in 1970, stated that a level of one part per million fluoride in water in areas with a temperate climate had no harmful effects on the community (2).

Following the success of trials of community water fluoridation in North America, a Government mission from Britain visited the United States and Canada in 1952 to study the fluoridation programmes. The mission concluded that water fluoridation was a valuable health measure and recommended that trials be carried out in Britain (3). Clinical trials began in 4 areas with matched control areas in 1955-56. Despite a number of difficulties the trials proved successful (4,5) and water fluoridation was recommended as a dental preventive measure. By 1980, more than 10 per cent of the population of England and Wales were being supplied with fluoridated drinking water. This included a number of large urban fluoridation schemes, such as Birmingham and Newcastle.

Unfortunately, less than 1 per cent of the population in Scotland were benefiting from this public health measure. There were no major urban fluoridation schemes operating in Scotland, fluoridation projects being restricted to a few rural areas. The largest of these was the Wigtown County scheme which was introduced between 1967 and 1970. One other scheme which served the town of Wick in Caithness was terminated in 1979, as a result of a decision by Highland Regional Council.

The benefits of Fluoridation of the Public Water Supply were demonstrated by a study carried out in Stranraer, Wigtownshire in 1980 (6). A 44 per cent difference in caries prevalence was reported in the primary teeth of 5 year old children resident in Stranraer, in comparison with similar children in Annan, a town with negligible levels of fluoride in its water supply. A 50 per cent difference in caries prevalence in permanent teeth was also demonstrated in 10 year old children resident in the two towns. Substantial differences were also recorded in the related cost of providing dental treatment for the Stranraer and Annan school children (7).

In view of the proven benefits of fluoridation Strathclyde Regional Council agreed to a request from the Health Boards serving its area to introduce a programme of water fluoridation. This however prompted the raising of a civil action by Mrs Catherine McColl in the Court of Sessions claiming that the Council's decision would endanger the public, fluoride was ineffective and it was illegal to tamper with public water supplies. In July 1983, Lord Jauncey gave his judgement (8) that, although fluoride was beneficial in reducing dental caries incidence and was not harmful at optimum levels, it was technically not legal to fluoridate public water supplies in Scotland. As a result water fluoridation ceased in Scotland and, despite an amendment to the law legalising water fluoridation, this still remains the position in Scotland.

In 1986, a follow-up to the 1980 study was carried out in Stranraer and Annan to examine secular trends in caries prevalence to assess whether the reported falls in caries levels elsewhere in Britain and Europe were also occurring in Scotland. This study was also designed to provide a base-line for monitoring any changes in caries prevalence resulting from the loss of water fluoridation.

Comparison of the 1980 and 1986 studies confirmed that the trend of reducing caries prevalence had also occurred in Scotland, in common with other countries (9). There had been a decrease in caries prevalence and potential treatment costs in Annan (10). While there was still a benefit accruing in reduced caries prevalence and cost of treatment in both the 5 and 10 year old age groups in Stranraer in 1986 by comparison with the Annan children. Although caries prevalence was lower for the 5 year old group, the Stranraer 10 year old children unfortunately showed a slight non-significant increase in caries prevalence (11). This was considered to be an early indication of a possible adverse trend in caries levels resulting from the cessation of water fluoridation three and a half years earlier. This trend was emphasised by a greater than 100 per cent increase in the cost of restorations for caries in the 1986 group of 10 year old children in Stranraer when compared with the same 1980 age group (10). This change was thought to be due to an increase in the number of surfaces affected, leading to more complex and costlier restorations.

As a result of these findings, it was felt to be desirable to continue to monitor caries prevalence in the two towns to ascertain whether the cessation of fluoridation of the public water supply in Wigtown District had affected caries prevalence in children resident in the area as suggested by the results of the 1986 study.

Few studies have reported on the effects of ending water fluoridation. The majority of such studies were carried out some time ago when caries rates were higher. Only one study has been carried out since the downward trend in caries prevalence which appears to have resulted from the wide-spread use of fluoride toothpaste. This study found that caries experience in five year old children was higher after fluoridation ceased.

Since that study was completed in 1984, caries prevalence has continued to fall in Britain. It has been suggested that the potential benefits of the fluoridation of public water supplies may have fallen to a level which no longer justifies this use of fluoride as a public health measure (12). It is therefore important to continue to study changes in caries prevalence in Stranraer to provide up to date information on the benefits of fluoridation of water, particularly with regard to the effect of general falls in caries levels on these benefits. The series of studies also provides an opportunity to gain information relating to the pre- and post-eruptive effect of fluoride on developing and erupted teeth.

Further information would also be gained regarding secular trends in caries prevalence in Dumfries and Galloway.

The 1980 and 1986 studies had utilised the System for the Planning and Epidemiological Evaluation of Dental Service (SPEED) suite of programmes written for main-frame computers (13). As part of the investigation of the prevalence of caries before and after the cessation of fluoridation, it was decided to develop a method of obtaining additional information relating to the occurrence of caries in the first two studies. This was to be undertaken by using either the Statistical Package for the Social Sciences (SPSS) (14) or modifying the SPEED suite of programmes to provide extra information.

As micro-computers have become increasingly available, it was also deemed appropriate to investigate the use of micro-computers to analyse dental survey data, either by converting SPEED to operate on a micro-computer or by using an alternative system. This would enable future studies to be analysed without the need for access to a main-frame computer. This would enable clinicians to undertake locally based epidemiological studies and process the data without recourse to a main-frame computer.

The key objective of this thesis is to present data on the dental health of children in South West Scotland, which is a unique environment in which the present day value of water fluoridation can be assessed. As a result of the McColl court case, Stranraer and Annan have been placed in the fluoridation spotlight.

LITERATURE REVIEW

It is proposed to review the literature relating to four main topics:

1. Water Fluoridation and caries incidence
2. Changing Caries Prevalence
3. Dental Indices
4. Use Of Computers In Dentistry

Over the years a great deal of work has been undertaken investigating Fluoride and its beneficial effect of reducing dental caries. Due to the immense volume of published research, it can not all be covered here, and only key areas of the discovery of the caries preventive effect of fluoride and the development of water fluoridation will be reviewed.

1. Water Fluoridation and caries incidence.

This first topic of the literature review forms the major part of the chapter, and will be divided into the following sub-sections:-

1.1 Development of water fluoridation

1.2 Community Water Fluoridation

1.3 Fluoride in Britain

1.4 Fluoridation in Scotland

1.5 Fluoride studies in England & Wales

1.1 Development of Water Fluoridation

Although Fluoride tablets for stronger teeth were being advertised in Denmark in 1882, it is likely that the first referral to a prophylactic role for Fluoride was made by Erhade in 1874 (15). He reported that daily Potassium Fluoride pills were being used in England to give hardness and durability to tooth enamel, especially in children and during pregnancy. Sir James Chrighton-Browne in a speech in 1892 (16), suggested a specific cause of the increase in dental caries was the change to white bread, which had changed the amount of Fluoride in the diet. He thought "it was worthy of consideration whether the re-introduction of a supply of Fluoride in some suitable natural form into the diet of child-bearing women and children might not do something to fortify the teeth of the next generation".

The first reference relating to the presence of fluoride in water in Britain appears to be the report by Wilson of the presence of Calcium Fluoride in a well in Edinburgh (17). He also reported the presence of fluoride in sea water (18). In 1893, Hillebrand reported the fluoride concentration in water from a thermal spring in New Mexico as 5.2 parts per million Fluoride (19).

However the history of the fluoridation of water really begins in 1901, when Dr. Frederick McKay first noted that many of his patients in Colorado Springs had an apparently permanent stain on their teeth, known locally as the "Colorado Stain". McKay called this stain mottled enamel and was unable to find any reference to the condition in the available scientific literature. Although it was common among long-term residents of the area, McKay found that the stain was prevalent in the area around Colorado Springs and in a number of other districts in the region.

By 1908, he had decided that he needed help from a recognised dental research worker. He therefore sought the assistance of Dr. Greene Vardiman Black, a leading authority on dental enamel. Black agreed to visit Colorado Springs in June 1909, and in preparation for the visit, McKay and Dr. Isaac Binton examined the children attending public schools in Colorado Springs. They examined 2945 children and found that 87.5% of children native to the area had mottled teeth. This was the first statistical data showing the prevalence of the lesion in a community (20).

McKay continued his investigations and identified other areas where mottled teeth were endemic. In 1912, McKay read a paper written in 1902 (21) which reported that many of the migrants from Naples in Italy had a condition known locally as "Denti di Chiaie". A doctor from Colorado Springs, who was visiting Naples, confirmed that this was the same condition as "Colorado Stain". Investigations continued and in 1916, Black published a paper entitled "An endemic imperfection of enamel of the teeth heretofore unknown in the literature of Dentistry" (22).

The investigations carried out by McKay were designed to find the cause of the mottling, but throughout his investigations, McKay noticed, as did Black and others, that caries prevalence in patients with mottled teeth appeared lower than would be expected (23).

The investigations established that the occurrence of mottled enamel was localised in definite geographical areas, a very high proportion of children native to the area were affected, but children who had been born outside the area and brought to the district when two to three years old, were not affected. The condition was not affected by home or environmental factors, as all socio-economic groups were equally involved (24). This tended to eliminate the diet as an aetiological factor. Further evidence came from three cities in Arkansas, where mottling occurred (24). Although separated from each other, the cities all received their water from a common source, Fountain Creek. This and other evidence led McKay to wonder whether something in the water supply in the endemic areas was the cause of the mottled enamel.

Further evidence supporting the water supply hypothesis came from Britton, South Dakota. In 1898, Britton had changed its water supply from individual shallow wells to a single deep-drilled artesian well. McKay found that natives of Britton who were born after 1898 had mottled teeth, but all those who had been born and passed through childhood before the change in the water supply had normal teeth. McKay concluded that some mysterious element in the water was the cause of the mottled teeth (25).

In 1923, McKay persuaded the officials of Oakley, Idaho to change their water supply in an effort to overcome mottling. The new water source was opened in 1925 and in 1933 McKay reported no mottling in permanent teeth in children born since 1925 (26).

In 1928, at the request of the United States Public Health Service, McKay visited Bauxite where mottled teeth were reported to occur, although the children in the neighbouring town of Benton had normal teeth. A new deep well water supply had been introduced in Bauxite in 1909 and McKay found that no mottling had occurred in those who had grown up before 1909, but all native Bauxite children who used the deep well water had mottling. No mottling was recorded in Benton. A report was published which stated that "the standard water analysis of Bauxite water throws little light whatsoever on the possible causal agent" (27).

As the Aluminium Company of America (ALCOA) had established the town of Bauxite, they were interested in discovering the cause of mottling. The ALCOA laboratory was instructed to look for traces of rare elements not usually tested for in water analysis.

A spectrographic analysis revealed 13.7 parts per million of Fluoride in the Bauxite water. Samples of water were obtained from other endemic areas and subjected to the same tests. All the water samples contained Fluoride, varying between 2 parts per million in Colorado Springs and 13.7 parts per million in Bauxite (28). ALCOA emphasised the fact that no precise correlation between the Fluoride content of the water and the mottled enamel had been established.

Meanwhile, N.J. Ainsworth had noted cases of "Rocky Mountain Teeth" in Maldon, Essex and concluded, "that the cause of both mottling and stain, will be found in some quality of impurity of the drinking water not ascertainable by ordinary analytical methods" (29). After reading the ALCOA report, Ainsworth had the local water tested and found approximately 5 parts per million Fluoride present. Ainsworth also noted that caries experience in the fluoridated area was lower than average.

In 1931, the United States Public Health Service assigned Dr. H. Trendley Dean to full - time research on mottled enamel, giving new impetus to the study of the relationship between Fluoride concentration in drinking water, mottled enamel and dental caries. Dean began by establishing the extent and geographical distribution of mottled enamel in the United States. Dean developed a standard classification of mottling (30) to allow quantative recording of the severity of mottling in a community and to relate this to the concentration of Fluoride ions in the water supply.

He showed that the severity of mottling increased with increasing Fluoride ion concentration in the drinking water (31). He also found that at levels of one part per million and lower, there was no significant mottling (32). In 1938 Dean and McKay stated "that there was conclusive and direct proof that Fluoride in Domestic Water is the primary cause of human mottled teeth" (33).

Dean was aware of the reports that there may be a relationship between the level of mottling and the prevalence of caries in a community. During his studies to establish the minimum threshold of mottling, Dean had also examined some of the children for dental caries. He concluded, in 1938, that "as it appears that the mineral composition of drinking water may have an important bearing on the incidence of dental caries in a community, the possibility of partially controlling dental caries through the domestic water supply warrants thorough epidemiological-chemical study" (34).

To test the hypothesis that an inverse relationship existed between endemic dental fluorosis and dental caries, a survey of 4 cities in Illinois was carried out.

Two cities had water supplies containing 1.7 - 1.8 parts per million of Fluoride and two had 0.2 parts per million Fluoride in the water supply. 885 children (between 2 and 14 years old) were examined and caries experience was found to be twice as high in the low Fluoride cities (35). This study was followed by a larger study, involving 7257 children aged 12 to 14 from 21 cities in four states (28). The results clearly showed an association between increasing Fluoride concentration in the drinking water and decreasing caries experience.

In addition, this study demonstrated that near maximal reduction in caries prevalence occurred at a concentration of 1 part per million Fluoride ion, in the water. At this Fluoride concentration only slight mottling of no significance occurred (37).

As a result of this work, the U.S Public Health Service planned the crucial experiment to establish whether dental caries could be reduced in a community by adding Fluoride to a Fluoride deficient water supply. Extensive field and laboratory studies were undertaken to investigate the physiological effects of Fluoride ingestion. The work of Dean and other investigators into the relationship between caries experience and the fluoride content of the water supply to 21 cities in the United States of America showed that near minimal reductions in caries incidence occurred at Fluoride levels of 1-2 parts per million. Noticeable mottling was observed when the Fluoride content rose above 1.5 parts per million. It was therefore concluded that a Fluoride concentration of 1 part per million was the best for caries control and this was well within the limits of safety (38).

In 1944, the city officials of Grand Rapids and Muskegon in the Lake Michigan area agreed to participate in the trial. The trial was to be carried out by Dr. Dean in conjunction with the University of Michigan Dental School and the Michigan State Health Department. Grand Rapids was chosen as the experimental community and Muskegon as the control. In September 1944, Dean and his co-workers began the dental examination of children aged between 4 and 16 years old, who were continuous residents of the cities, to provide base-line data. Children in Aurora, naturally fluoridated at 1.4 parts per million, were also examined as an additional control. Caries prevalence was recorded as Decayed, Missing and Filled Teeth - the DMF Index (39).

On 25th January 1945, artificial fluoridation of the Grand Rapids Water supply commenced at a level of 1 part per million. After six and a half years of Water Fluoridation it was clear that caries prevalence in six year old children in Grand Rapids was half that of similar children in Muskegon (40). As a result, the city officials of Muskegon decided to fluoridate their water supply in July 1951. Further studies after ten and fifteen years of fluoridation, confirmed 50% lower levels of caries prevalence compared with base - line data (41,42).

This study gave experimental proof that the inverse relationship between fluoride levels in drinking water and the prevalence of dental caries was a casual relationship. Additionally two other fluoridation trials had been carried out in the United States (43,44) as well as a similar trial in Canada (45).

The strength of the experimental proof of the caries inhibitory property of fluoridated drinking water lies in the results of these four trials carried out by different investigators in different areas. The conclusion of each study was that the addition of Fluoride at a level of 1 part per million to drinking water reduces caries prevalence by approximately 50 per cent.

Studies by a number of other investigators have substantiated these results. Data from Sweden and Denmark (46) showed the same trend to lower caries levels as reported by Dean (36). Studies in Hungary, Austria, Spain, and the United Kingdom all demonstrated a decrease in caries experience with increasing fluoride content of public water supplies up to 2 parts per million Fluoride (47,48,49,50,51).

1.2 Community Water Fluoridation

Following these favourable results, many communities decided to fluoridate their water supplies to provide optimal fluoride levels. By 1978, approximately 155 million people world-wide were consuming fluoridated water, in addition to approximately 40 million who had naturally fluoridated water supplies (52).

In addition to the large number of communities with fluoridated water supplies in the United States of America, around 7 million people in Canada have fluoridated water. Fluoridation in South America has been fairly widespread with 10.3 per cent of the population with piped water supplies receiving fluoridated water supplies by 1968. All piped water supplies in Paraguay have been fluoridated, although this only supplies about 10 per cent of the population. Fluoridation has also been implemented in Chile, Panama, Nicaragua, and Brazil (52).

In Asia, water fluoridation has been introduced in Malaysia. Singapore had fluoridated all of its water supplies by 1958, serving about 2 million people. 3.6 million people receive fluoridated water in Hong Kong. In Japan the town of Yamashina began fluoridation in 1952, but this has now ceased. Water fluoridation has been widely introduced in both Australia and New Zealand.

In Europe fluoridation began in Belgium in 1956 with the town of Assesse with about 0.4 million people receiving fluoridated water by 1974, but artificial addition of fluoride to water is not allowed by law, and only natural and "contaminated" fluoride drinking water is now available (53).

By 1972, ten cities in East Germany had fluoridated water and further schemes have been introduced to cater for about half the population (52).

Sweden and West Germany both had pilot water fluoridation schemes in Norkapping and Kassel-Wahlerhausen respectively. However both of these schemes ceased at the end of the study period, despite proving successful. Holland began water fluoridation in Tiel in 1953 but in 1973, when 15 million or 38 per cent of the Dutch population had fluoridated public water supplies, fluoridation suddenly ceased in Holland following a judgement by the Supreme Court that there was no legal basis for fluoridation of drinking water (54).

In Finland, although fluoridation started in the town of Kuopia in 1959, public campaigns have prevented the introduction of any further fluoridation schemes (55). Water fluoridation began in Switzerland in 1960 with a scheme serving the community of Aigle. Since 1962 the town of Basel with a population of approximately a quarter of a million, has artificially fluoridated its public water supply. Fluoridated domestic salt is widely available in the rest of the country and accounts for 75 per cent of all salt used (56).

Fluoridation of public water supplies has advanced rapidly in Russia since the first scheme commenced in 1958. By 1977, 20 million of the population of the USSR had access to fluoridated water. Other Warsaw Pact countries have also introduced water fluoridation, including Poland, Czechoslovakia, Romania and Bulgaria (52).

Nearer to Britain, water fluoridation commenced in the Republic of Ireland in 1964, following the enactment of the Health (Fluoridation of Water Supplies) Act of 1960 (57), which provided for mandatory fluoridation of public water supplies. The Act was challenged in the Courts on constitutional grounds but, unlike Holland, the judiciary rejected this claim and declared the Act legal under the constitution. At the present time, about 68 per cent of the Irish population have public water supplies containing fluoride (58). Due to practical difficulties this proportion is unlikely to increase further.

Artificial fluoridation of water has been implemented in about 50 countries, benefiting an estimated 350 million people in the world (59).

Despite changes in caries prevalence, water fluoridation continued to be an effective strategy for caries prevention (58). It is the logical approach in countries with communal water supplies from the standpoints of cost-effectiveness and total caries-preventive impact (60).

1.3 Fluoride in Britain

Fluoride studies had continued in Britain. In 1941, children from South Shields, who had been evacuated to the Lake District due to the war, were noted to have much less caries than Lake District children. Following confirmation of the lower caries prevalence in South Shields children, the South Shields water supply was analysed and found to contain 2 parts per million Fluoride (61). In 1944, Weaver examined 1000 children in North Shields. North Shields is an industrial town very similar to South Shields situated on the opposite side of the river Tyne, but with a different water supply which contained Fluoride at less than 0.25 parts per million. The mean DMF teeth in 5 year old children was 6.6 in North Shields and 3.9 in South Shields. The figures for 12 year old children were 4.3 and 2.4 DMF teeth respectively (61).

Weaver repeated this study after the Second World War and also gave results for West Hartlepool, which had a water supply containing Fluoride at 3 parts per Million (62). Other workers studied caries prevalence in other natural Fluoride areas in England. Forrest et al compared 286 adults living in naturally high fluoridated areas in England with a similar group from low fluoride areas and found lower caries levels in the high fluoride adults equivalent to a ten year postponement of dental caries (63). Pre-school children in the same area also had significantly less dental caries. Forrest also compared four areas in South East England with levels between 0.9 and 5.8 parts per million Fluoride with two control areas. The results showed a markedly lower caries prevalence in the Fluoride areas than in the control areas (64). Enamel mottling was also recorded in this study.

In 1952, a Government Mission was sent from Britain to the United States and Canada to study the Fluoridation programmes. The mission concluded that Fluoridation of Water Supplies was a valuable health measure, but recommended that trials be carried out in selected communities before its general adoption (3).

Originally four areas agreed to add Fluoride to their water supplies at a rate of 1 part per million in 1955/56. They were Andover, Watford, Kilmarnock and part of Anglesey. However, because of opposition, the scheme in Andover was abandoned after two years. The control towns were Sutton, Ayr and the rest of Anglesey respectively. The results after 5 years of Fluoridation (4) showed that caries prevalence in 5 year old children was 50 per cent lower in the Fluoride areas than in the non Fluoride areas. Despite these good results, the Fluoridation scheme in Kilmarnock was discontinued in 1962 on the instruction of the local council. Further examinations were carried out in all areas and, after 11 years, (5) Watford and Anglesey still showed a 50 per cent reduction in caries prevalence in children who had been resident since birth. But the Kilmarnock results showed that caries levels had increased back to approximately the same levels as Ayr, the control town.

As a result of the early results, the whole of Anglesey was fluoridated in 1964, leaving the original fluoridated part of Anglesey without a control. However Jackson compared 15 year old children from Anglesey, who had received fluoridated water all their lives, with 15 year old children from the Bangor/Caernarvon area, just over the Menai Bridge from Anglesey (65). This study was carried out on a blind basis by conveying all the children to a central point for the examinations and ensuring that the children from the two groups were randomly mixed and wearing no identifying marks. The results showed mean caries prevalence to be 44 per cent lower in the Anglesey group.

As can be seen the British Fluoridation Trials were complicated by the loss of one of the trial areas after two years, another after seven years and the loss of a control area after nine years. However the trials clearly showed a reduction in caries prevalence in the fluoridated areas (4,5).

While the British Fluoridation trials and associated studies were being carried out studies were also continuing in natural fluoride areas. A study in

East Anglia compared secondary school children living in three areas. One with a continuous fluoride level of about 1.2 parts per million, an area with intermittent natural fluoridation and a low fluoride area (66). To introduce an element of blindness to the examiner, data from continuous and non-continuous residents were separated and compared after the examinations.

Children from the continuous fluoride area had significantly less dental caries. There was little difference in caries prevalence in the low and intermittent fluoride areas when the DMF teeth index was used. However the DMF surface rates were significantly lower in the intermittent fluoride district. Continuous residents of the high fluoride area had double the number of sound first permanent molars than the non-continuous residents. This study found that the first molars had benefited more from fluoride exposure than the incisor teeth, the opposite of Weaver's findings in South Shields (61).

Murray (67,68) carried out a study of the effect of continuous residence in Hartlepool, a high fluoride area, in relation to the dental condition of children and adults. 5 and 15 year old children resident in York, a low Fluoride area, were also examined to compare caries prevalence at the beginning and end of school attendance between natural high and low Fluoride areas. A difference of 64 per cent in mean caries prevalence was recorded in the 5 year olds and 44 per cent in 15 year olds.

A further study was carried out in the two towns during 1968-69 to investigate whether "Fluoridation benefits only children" (69). Examinations were performed on 5 age groups of adults in Hartlepool and York, to assess the life time effects of fluoride in water. The results confirmed that fluorides in drinking water have substantial life long benefits.

The first large community fluoridation scheme in Britain started in Birmingham in 1964. The next large scheme started in Newcastle upon Tyne in 1968. Since then a number of other communities, particularly in the Midlands and the North, have introduced fluoridation schemes in England.

By 1988, several of the 14 English Regional Health Authorities had some of their populations covered by water fluoridation schemes, although the proportion varies from region to region. The most extensive coverage is the West Midlands Region with 69% of the population receiving a fluoridated water supply, followed by Northern Region (39%) and Trent (17%). Natural fluoride water is found to various extents in Northern, Trent, East Anglian, North East, Thames and Western Regions (70). Artificial water fluoridation schemes are also found in Wales, the first area being Anglesey in the original British Fluoridation Trial (4).

A survey carried out in June 1988 by the British Fluoridation Society reported that overall 6.6 million people in England and Wales, residing in 49 Health Districts, have public water supplies with a fluoride level of over 0.7 parts per million fluoride content. A further 2.7 million have water with a fluoride level between 0.3 and 0.7 parts per million, which still provides some benefit (70).

Since that survey, the Huddersfield fluoridation scheme ceased in October 1989 due to water distribution changes. The Watford scheme in S.W. Herts has also ceased as the fluoride plant requires refurbishment. However refurbishment of the West Cumbria plant was completed in 1990 and a new scheme was implemented in S.E. Staffordshire at the beginning of 1990. Plans are well advanced for the introduction of water fluoridation throughout the North West Regional Health Authority area.

1.4 Fluoridation in Scotland

In Scotland Fluoridation of the public water supply, at a rate of 1 part per million, began in Wigtownshire in 1967. Also in Scotland, the towns of Lerwick and Wick fluoridated their water supplies and a small area of Argyllshire also received fluoridated water. Plans to commence a large scheme in Strathclyde Region were halted by legal action challenging fluoridation on the grounds of legality and health risk. After a lengthy action, Lord Jauncey delivered the verdict that fluoridation of Water Supplies was beneficial and carried no risk to health whatsoever (8).

However he found that water fluoridation was Ultra Vires and it was beyond the legal powers of Strathclyde Regional Council to add Fluoride to the public water supply. As a result, fluoridation of public water supplies ceased in Scotland in 1983. No legal action has been taken in England and Wales, so fluoridation continues there. A bill, legalising water fluoridation, received the Royal Assent in 1985 (71). However, although it is hoped that fluoridation of public water supplies will start again in Scotland, an indemnity and guide-lines had first to be agreed by the Scottish Office and the Confederation of Scottish Local Authorities (COSLA).

In May 1991, the Secretary of State reaffirmed the government commitment to supporting water fluoridation and indicated that circulars would shortly be issued to Health Boards and Local Authorities setting out the procedures for implementation of the Water Fluoridation Act (Appendix 1).

The guide-lines were published on 27th June 1991 (Appendix 2) giving guidance to the Scottish Health Boards on the consultation process to be followed. A model agreement and model indemnity were also provided. The guide-lines confirmed the government view that fluoridation of public water supplies was a safe and effective means of reducing tooth decay.

1.5 Fluoride Studies in England & Wales

Five and a half years after the fluoridation of Birmingham's water supply a study of caries prevalence in 5 year old children was carried out, with children in the Borough of Dudley as the control (72). The children were examined between 1967 and 1970 and caries levels were found to halve over the period in the fluoridated area, while caries prevalence remained fairly constant in Dudley.

Six years after water fluoridation began in part of Cumbria, examinations were conducted on primary school infants in 2 towns in the fluoridated area and 2 comparable low-fluoride towns (73). Caries experience in the fluoridated area was found to be 46 per cent less than in the non-fluoridated communities. These findings were in accord with those from naturally and artificially fluoridated communities with water supplies at 1 part per million and show water fluoridation to be highly effective in substantially reducing the incidence of dental caries.

A blind study was carried out of caries experience in 5 and 15 year old children in Anglesey who had a life-time exposure to fluoridated water (65). As the original fluoridation trial control area had also fluoridated its water supply in 1964. Two towns, Bangor and Caernavon, on the mainland side of the Menai Strait where negligible levels of fluoride were present in the water were selected as the control. To avoid bias during the examination, all children were brought to one central examination centre. Neither of the two examiners were aware of the area the children resided. The investigation found that fluoridation in Anglesey was having a marked and beneficial effect on the incidence of dental caries. Caries experience in the 15 year old children of Anglesey was almost half of that of mainland children. Caries experience in the 5 year old children was less than might have been expected, but this was thought to be due to interruptions and falls in the fluoride content during a two year period of their life. Incisor teeth were found to have particularly benefited from fluoridation. It was also reported that there was little community difference in the various grades of mottling.

A further fluoride survey was undertaken in fluoridated Birmingham, comparing the dental health and treatment needs of infant and secondary school pupils with similar children in non-fluoridated Salford (74). In Birmingham, the infants had 54 per cent less dmf teeth than in Salford, while 47 per cent had no caries experience compared with only 29 per cent in non-fluoridated Salford. Similar results were reported for the secondary group with particularly large differences in the permanent anterior teeth. This study also attempted to quantify the economic benefits of water fluoridation, utilising the Resource Related Index (75) which is based on the National Health Service item of service fee scale. It was found that fluoridation had halved the cost of treatment needed for caries.

Fluoridation commenced in the Newcastle Upon Tyne area in October 1968. In order to assess the effect of fluoridation on the dental health of children, a survey of caries prevalence in 5 year old children continuously resident in fluoridated and non-fluoridated urban and rural areas was carried out in 1974 (76). Dental caries experience was found to be 57 per cent lower in the urban fluoride area and 67 per cent lower in the rural fluoride area compared with the non-fluoride areas. A similar trend was seen in the mean decayed, extracted and filled surface results. With a score of 4.5 in the urban fluoridated area group compared with 11.6 in the non-fluoride urban area a percentage difference of 61 per cent. Comparing the rural communities a 74 per cent difference in mean dmfs was found, with mean scores of 3.1 and 11.7 respectively. The potential costs of treatment required were 61 per cent lower in the fluoridated urban area and 76 per cent lower in the rural fluoride area. Life-time experience of toothache and general anaesthesia was around one half lower in the fluoride groups. There was three times as many children with no caries experience in the fluoridated areas. No consistent relationship was found between white flecking of deciduous enamel and water fluoridation. This study, in agreement with Weaver (62) found no evidence to support claims that fluoridation delays the eruption of teeth. However the analyses demonstrated that early loss of deciduous molars leads to accelerated eruption of first permanent molars. As loss of deciduous molars is less likely in fluoridated areas, this may explain any apparent delay in eruption fluoridated areas.

Since 1968 the public water supplied to 4 districts of Leeds has been fluoridated and ten years after the commencement of the scheme, a survey was carried out comparing the caries experience of 5 year old life-time residents of these districts with two neighbouring low fluoride districts as comparison (77). Caries prevalence in the fluoride district was 62 per cent lower with a mean dmft score of 123 compared with 3.28 in the low-fluoride group. The number of caries free children in the fluoridated group was almost twice that of the low fluoride children. The caries experience of the children from the low fluoride districts was in accord with the apparent trend to reductions in caries experience in English 5 year old children (78). It was suggested that the factors responsible for this downward trend could have enhanced the effect of the water fluoridation.

The relationship between caries experience and social class has been investigated in a number of studies and age groups and it has been found that caries experience is higher in lower social classes. Rugg-Gunn et al. therefore studied what impact the introduction of water fluoridation might have upon relative caries experience of different social classes (79). Studying 5 year old children in fluoridated and non fluoridated areas they reported a greater effect from fluoridation in lower social classes with a 71 per cent difference in social classes IV & V compared with a 26% difference in classes I & II.

A study in 1978 of four communities in N E England with differing fluoride levels ranging from <0.1 to 1 part per million Fluoride found that caries experience varies immensely with water fluoride levels and that clinically important caries reductions are found in areas with less than optimal fluoride levels (80). In the four areas, mean dmf surface scores were 11.6 in the low fluoride area, 8.9 and 6.2 in the 0.2ppm and 0.5ppm Fluoride areas, and 4.1 in the optimal fluoride area. Differences between the adjacent pairs were statistically significant at the 5 per cent level. This study also found substantial differences between areas in the potential cost of treatment required.

In 1981, twelve years after water fluoridation was introduced in Newcastle Upon Tyne, a further study was conducted using the same criteria and methods as the 1976 study, although separation of rural and urban areas was omitted in 1981 (81). Similar results to the 1976 study were reported. However over the period covered by the two surveys, caries experience had fallen by over one third in both fluoridated and non fluoridated areas, but the percentage differences in mean dmft scores remained virtually unchanged at 59 per cent overall in 1976 and 58 per cent in 1981. As in 1976, a higher percentage difference was found between the mean dmf surface scores in the fluoridated and fluoride-low areas, mean dmfs being 2.14 in Newcastle and 5.70 in Northumberland, a 62 per cent difference in tooth surface caries experience. The relationship between this general fall in caries prevalence and fluoridation of water appears unclear, although the benefit of fluoride has remained constant.

In 1981, prior to expansion of fluoridation of public water supplies in the West Midlands, an investigation was designed to study the relative effects of fluoridation and social background on the caries experience of 5 year old children (82). As the Black report (83) has reported that a working class person is at a greater disadvantage when living in a socially mixed area, the sample was chosen from electoral wards stratified into predominantly high or low social class populations rather than utilising the individual children's social class. 393 children were examined in fluoride and non fluoride areas of Birmingham and the results showed that fluoridation reduced caries prevalence by almost 50 per cent, with a mean dmft score of 1.09 in the fluoride and 1.91 in the non fluoride areas. The children from the low social background were found to have caries prevalence three times higher than those from the high social background. This was at variance with the finding of the study of children in

Newcastle and Northumberland that fluoridation eliminated significant social differences (79).

This difference may be due to a combination of two factors. Carmichael (79) and his co-workers divided the children on the basis of individual social class rather than by social background. Additionally caries levels were higher in N.E. England than in the North Midlands and fluoride is normally more effective in areas of high caries levels. If there is little caries to reduce the power of any inhibitory agent will diminish. Bradnock concluded therefore that the incompatibility of the results of the two studies was only apparent and concluded differences between geographical locations made locally-based studies necessary (82).

A further study of the effects of water fluoridation in Anglesey was carried out in 1983 (84). Despite the steps taken in the 1974 study (72) to eliminate bias by providing blind examination facilities some opponents of fluoridation had argued that the control community was inadequately defined and that the study was not double blind. Although, unlike clinical trials, point-prevalence studies are rarely double blind, a large sample was chosen in each area to enable all children to be examined and then excluded later on the basis of non-life-time residence, use of fluoride supplements and type of water supply to provide a double blind study. Apart from this, change in the sampling method, the study method was similar to the 1974 methodology. Although there had been a secular fall in caries in children in both fluoridated and non fluoridated areas of Gwynedd between 1974 and 1983, the fall had occurred in both areas and the differences in caries prevalence between the two groups were largely maintained. 5 year old children in Anglesey had 55 per cent less caries experience than the control group with a mean dmft scores of 1.59 and 3.55 respectively, compared with 2.83 and 4.58 in 1974. Despite secular falls in 15 year old children from a mean DMFT of 6.37 in fluoridated and 11.44 in non-fluoridated areas in 1974 to 4.73 and 7.69 respectively, caries prevalence in the fluoride area was still 38 per cent lower in 1983. A 12 year old group was also studied in 1983 and a 43 per cent difference found in caries experience between the fluoride and non fluoride areas (84).

As the North West Regional Health Authority were planning the implementation of water fluoridation in the North West area, and caries prevalence had fallen in England and Wales (85) including the N W of England (86), a study was carried out to review the potential benefits of fluoridation. The aim of the study was to compare caries experience of 5 year old children in Newcastle (fluoridated) and North Manchester (non-fluoridated) against the changing levels of dental disease in 1985 (87). The results of the study were in line with previous studies, caries experience of 5 year old children was approximately 60 per cent lower in Newcastle with a mean dmft of 1.33 compared with 3.31 in North Manchester. The North Manchester children had suffered significantly more toothache and undergone more dental extractions. While 62 per cent of Newcastle children had no experience of caries compared with the 29 per cent in North Manchester, only 2 of the Newcastle children had a caries rate of at least dmft=10 compared with 24 in North Manchester. The investigators concluded that despite the general improvement in dental health in the past decade, there was still a significant difference between children living in fluoridated and non fluoridated districts in the North of England (87).

A further study in the North West Region was undertaken in 1987 to consider the benefits of fluoridation for 14 year old children in the Bolton Health District which has a water supply with less than 0.1 parts per million fluoride (88). The South Birmingham District, which had been fluoridated at 1 part per million since 1964 was the comparison area. Although the two districts have similar social class profiles, a statistically significant mean difference of 1.53 DMFT (40 per cent lower) was reported between South Birmingham (DMFT 2.26) and Bolton (DMFT 3.79). A difference which is important in both dental health and economic terms. Health Authorities in the North Western Region are currently promoting policies which it is hoped will lead to 90 per cent of the Region's 4 million population receiving fluoridated water by 1993.

Although the percentage difference in fluoridated Newcastle had remained virtually unchanged at 58 per cent in 1981 (81) compared with 59 per cent in 1976 (76) there had been a decline in caries prevalence of 36 per cent in the Fluoridated area and 37 per cent in the non fluoridated area over this period. As this general fall in caries levels had reduced the absolute saving in dmft in 5 year old children, a further survey was carried out in 1987 to determine the current effectiveness of fluoridation in Newcastle and whether caries levels had continued to decline in North East England during the 1980's (89). The survey followed the same methodology as the previous studies and mean dmft of children in the fluoridated area was 1.8 compared with 3.9 in the non fluoride area, a difference of 2.1 teeth per child or 54 per cent less. The corresponding dmfs scores were 2.8 and 7.0 respectively, a difference of 60 per cent or 4.2 surfaces per child. 50 per cent of the children in the fluoridated area had no caries experience compared with 32 per cent in the control area. The difference in potential treatment costs was again examined based on the 1986 National Health Service fee scale and was found to be £9 - 91 per child greater in the non fluoridated area. Studying secular trends, the reduction of over one third in caries levels between 1976 and 1981 had not continued and there was, in fact, a non significant marginal increase in both areas. It was concluded that water fluoridation remained a cost effective public health measure in Newcastle (89).

1.6 Fluoride Studies in Scotland

Many studies have been carried out in England to assess the effect of fluoridation on caries prevalence. The results have all shown average caries prevalence to be 38 - 63 per cent lower in the fluoridated areas compared with the controls. The first study of the effects of fluoridation of public water supplies in Scotland was the Ayr/Kilmarnock study which was part of the British Fluoridation Trials (4,5). Five years after the introduction of water fluoridation, caries levels in 5 year old children in Kilmarnock were 50 per cent lower than in the control town of Ayr. Fluoridation ended at this time because Kilmarnock Town Council voted to withdraw from the trials. Monitoring continued and 11 years after the beginning of the trial, 5 years after fluoridation ceased, caries levels had increased in Kilmarnock to the same levels as in the Ayr children.

The next investigation of water fluoridation in Scotland was a study in 1976, comparing caries prevalence in three rural areas in Dumfries and Galloway (90). One area was in the fluoridated area of Wigtown District, where fluoridation had commenced in 1967, the other rural areas had water supplies with negligible levels of fluoride. This small study found that caries prevalence measured by mean dmft was 52 per cent lower in indigenous 6 year old children attending state schools in the fluoridated area compared with the two non fluoride areas. A fissure sealant study reported caries data for

5-6 year old children in fluoridated and non-fluoridated areas in Galloway in 1976 (91). This study found obvious benefits in caries inhibition in the fluoridated area.

In 1980, a study compared the dental health of children who were life-time residents of Stranraer, a fluoridated urban area in the Wigtown District, with similar children living in Annan, a non-fluoridated town in Dumfries and Galloway (6). A 44 per cent difference in mean dmf teeth was reported in 5 year old children attending state primary schools in Stranraer when compared with Annan. The mean dmft score for Stranraer was 2.48 and 4.39 in Annan, a difference of 1.94 teeth per child. Ten year old children were also examined and mean DMFT scores of 1.66 and 3.35 respectively were found, a 50 per cent lower score in Stranraer than Annan. This study also compared potential treatment costs in the two towns by means of the Resource Related Index (75), which is based on the National Health Service dental practice scale of fees. The differences in the potential cost of treatment for dental caries were 56 per cent in the 5 year old children and 76 per cent in the ten year old children in the fluoridated community (7).

In 1969, the small town of Wick in the far North of Scotland began to fluoridate its water supply at a level of 1 part per million Fluoride ion. Following local government changes in Scotland, Highland Regional Council became responsible for this water supply and the decision was taken in late 1977 that fluoridation should cease in

Wick " to bring it in line with the rest of the region ". As no caries prevalence data had been collected in Wick, a study was initiated in 1979 of caries experience in Primary 1 (5 year old) children in Wick (92). It was reported that the mean dmft score in children who were life-time residents of Wick was 2.63 in 1979, with a mean dmfs score of 7.80. A further study was carried out in 1984 to assess the effect of the ending of water fluoridation in Wick. This study will be reviewed later.

A follow up survey to identify secular trends in the dental health of schoolchildren resident in Stranraer, which had been fluoridated until July 1983, and Annan was carried out in 1986 (9). The same criteria and methods were used as in the previous study of 1980 and the examiner was one of the two examiners in the earlier study (4). A 15 year old age group was added to the 5 and 10 year old groups studied in 1980 to assess the effect of a longer period of fluoridation. In 1986, mean dmft for 5 year old children, who were life-time residents of formerly fluoridated Stranraer was 1.17, 53 per cent lower than the 1980 dmft figure of 2.48 giving a mean difference of 1.31 teeth per child between the two studies. The same comparison of Annan 5 year old children showed only a 13 per cent reduction in caries prevalence. Mean dmft in Annan 5 year old children was 3.82 in 1986, compared with a mean dmft of 1.17 in Stranraer, giving a percentage difference of 69 per cent. Although fluoridation had ceased in 1983, the children of

Stranraer still demonstrated a benefit from previous exposure to fluoridated water. As early as 1941, Dean and Arnold had reported that children who had been subjected to the effects of fluoride pre-eruptively had less caries even when fluoride ceased post-eruptively (36). In the 10 year old children, mean DMFT was 1.72 in Stranraer and 2.81 in Annan, a difference of 39 per cent. However while mean DMFT in Annan was 16 per cent lower than in 1980, in Stranraer it had increased by a non-significant 4 per cent over the period. It was suggested that, while there still appeared to be a residual benefit from fluoridation to the Stranraer 10 year old children, the lack of an improvement in caries levels over time might be the first indication of a detrimental effect from the cessation of water fluoridation (11). There was a 65 per cent difference between the mean DMFT score of 2.72 in formerly fluoridated Stranraer and the score of 7.95 in the 15 year old age group in Annan, with a mean difference of 5.03 teeth per child (9). There was therefore still a beneficial accruing in all three age groups from the previous fluoridation of Stranraer water supply. A study of potential treatment costs in the 3 age groups in Stranraer and Annan found similar reductions in costs calculated by the Resource Related Index (10).

1.7 Fluoride studies world-wide

The following illustration (Figure 1) by Naylor and Murray summarises the results of a review of 95 studies in 20 countries (52). For deciduous teeth percentage caries reductions have been reported in the range of 20 - 80 per cent (93). Figures for permanent teeth range from 20 - 90 per cent. However, as can be seen from the vast majority of studies reported a reduction of between 40 and 70 per cent (52).

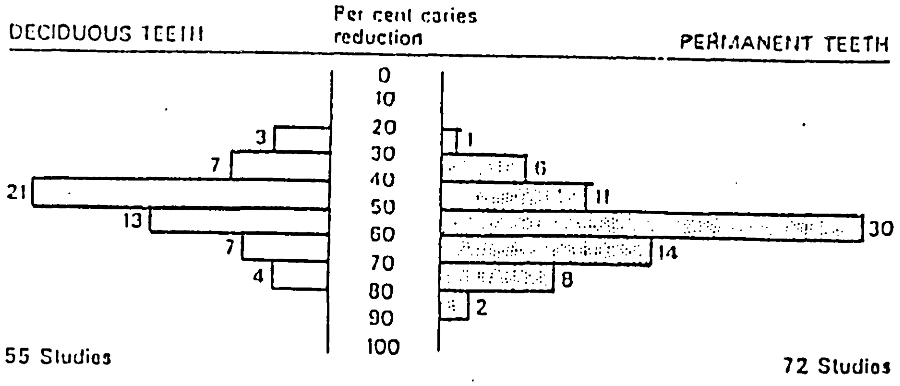

Figure 1. Summary of 95 fluoride studies (52).

A further review of a further 113 studies, including 59 from the United States of America, reported in the 1980's was carried out by using the same methods as the previous survey of world literature (94). The authors concluded that modal caries reductions for both deciduous and permanent dentitions are between 40 and 60 per cent, whether a historical or parallel control group was utilised, justifying the statement that fluoridation cuts caries by half.

Higher percentage caries reductions tended to be recorded in studies using historical controls, suggesting that when background caries levels are changing, historical control studies should be interpreted with caution. Table 3 illustrates the results of historical and parallel control studies (94).

However Sutton in 1974 (95) re-examined data from a small number of studies and claimed that there was no statistical basis for linking caries reduction with fluoride in water. This claim was refuted by several of the participants in the studies quoted.

This report was followed by an analysis by Ziegelbecher of 25 papers on dental caries and water fluoride content published between 1938 and 1976 (96). Ziegelbecher concluded that at the so-called "caries prophylactic level" of fluoride of 1 part per million, some signs of intoxication in the form of fluorosis must be expected but no caries prophylactic effect. However, Busse et al (97) analysed the same data, selecting only 12 - 14 year old groups as Ziegelbecher did, and reported that this contrary finding arose from three simultaneous methodological errors. These were the use of a uni-factorial instead of a multi-factorial model, the quoted data were only partly used and aggregated and the method of analysis applied by Ziegelbecher was inappropriate. They concluded that analysis of all relevant information in the published studies confirmed an inverse relationship between the fluoride content of drinking water and the prevalence of dental caries (97).

Thus a considerable weight of evidence, collected over a number of years shows that the addition of Fluoride to the public water supplies at the optimum level will substantially reduce new caries. The physiology and metabolism of Fluoride ingestion have been studied in great detail for many years and no harmful effects have been found when Fluoride is taken in the recommended dosage. The World Health Organisation and many national medical, dental and other health organisations have actively endorsed fluoridation as a significant factor in improving the dental health of communities (98,99,100).

1.8 Effects of Removal of Fluoride from Water Supplies

Most studies have investigated the effectiveness of fluoridation in communities where fluoride had been continuously present in the water supply once fluoridation started. The question therefore arises whether the beneficial effect of fluoride in the water supply continues or the caries inhibitory protective effect is lost when fluoride is withdrawn.

MacKay stated "that once acquired, the inhibitory effect of fluorine is permanent and is not diminished by later migrations" (101). Further studies indicated that people moving from fluoride communities to a non-fluoride area retained the protective effect of fluoride undiminished. Mackay concluded that the use of fluoridated water after calcification of the enamel was necessary (102). Other studies had reported that teeth with fluoride deposited in them during the development period appeared to retain their resistance to caries throughout life (103). In Bauxite, it was reported that children who had been exposed to fluoride during the formative pre-eruptive stage of their teeth had less dental decay even when they did not have continued post-eruptive fluoride exposure (104).

The literature has also shown that the ingestion of fluoridated water produces an increased resistance in teeth which had erupted prior to the availability of the fluoride. Klein reported that there was an increase up to 60 per cent in resistance to caries in non-carious teeth which had erupted before fluoridation commenced (105). The New Jersey and Brentford studies confirmed these findings (43,45).

However in 1959 the community of Galesburg, Illinois changed its water supply from three deep wells, which had water containing an average of 2 parts per million of fluoride, to the Mississippi with fluoride content of less than 0.1 part per million. Clinical observations appeared to indicate carious lesions were developing in previously caries free children as a result of this water supply change. Accordingly a study of 6, 10, and 14 year old children was undertaken in 1961 (106). Previous studies had taken place in 1938 (35) and 1958 (106) and no significant differences found over the 20 year period, for example mean DMFT of the 14 year old age group was 2.01 in 1938 and 2.02 in 1958. However in 1961 14 year old children who had received fluoride containing water for the first twelve years of life had an increased mean DMFT of 2.79. There was also a 10 per cent decrease in the population of 14 year old children with no caries experience and a 38 per cent increase in incremental carious lesions. Similar findings were also reported in the 6 and 10 year old children in 1961 when compared with the previous studies. It was concluded that the significant differences were the result of the change in water supply. There appeared to be a topical benefit from the presence of fluoride in the drinking water: The report of the study concluded that "to maintain the limited immunity that existed while ingesting the fluoridated communal water, the continued use of fluoride was essential for children of all age-groups" (106).

The first study of the dental consequences of ending controlled fluoridation of a public water supply was conducted in Austin, Minnesota. Water fluoridation commenced in Austin in 1952 at a level of 1.2 parts per million and was discontinued in 1956 after four years. Annual examinations provided information relating to dental health from 1952 to 1959. Jordan reported a progressive decrease in DMF rates from 1952 to 1956. However rates in 1958 and 1959 began to show an increase. Jordan concluded that " the trend now indicates the decay rate may return to its original rate of 1952 " (107).

Fluoridation of the city of Antigo's water supply began in June 1949 and the decision was taken to end fluoridation in November 1960. A dental examination of school children in 1960 showed that def/DMF rates compared favourably with those of other fluoridated areas in Wisconsin (108). A survey of the dental health of the children in the city school system was carried out in December 1964, four years after the controlled fluoridation was discontinued (109). As a result of the findings of this survey, a referendum was held and fluoridation restarted in October 1965. A third series of examinations was undertaken in May 1966 comparing the results of the 1964 survey with the 1960 findings it was found that mean def of kindergarten children showed a 92 per cent increase from 2.5 to 4.8 (109). Mean DMF scores for second and fourth grade children showed 183 per cent and 41 per cent increases respectively. Only children who were life-time residents of Antigo were included in the two studies. It was originally planned to follow the 1964 study with a further study two years later. However due to the reintroduction of water fluoridation, the second study was carried out after an 18 month interval, some six months after the restart. The findings of the 1966 study showed a further increase in caries prevalence and a comparable decrease in caries-free children (109). Kindergarten children showed an increase of 112 per cent in mean def to 5.3 when compared with 1960. Second grade children had mean DMFT counts of 0.6, 1.7 and 2.0 respectively, an overall increase of 233 per cent since 1960. Caries rates in fourth year children in 1966 had increased by 70 per cent from 1.7 in 1960 to 2.9. Sixth grade children were also examined in 1966 and a 91 per cent increase in the DMFT rate found when compared to the 1960 study. The numbers of Kindergarten children with no caries experience had fallen by 53 per cent in 1960. Proportions of children with no caries experience in permanent teeth had decreased between 63 and 67 per cent over the six year period. The findings of these studies had confirmed the hypotheses propounded by Russell regarding the caries inhibitory effect of fluoride (110):

a) Fluorides may be incorporated into tooth enamel either during the process of calcification or after eruption and when so incorporated are effective in the inhibition of dental caries

b) The inhibitory effect tends to persist so long as fluoride is continued, but tends to be slowly lost after fluoride exposure is discontinued

c) Periodic or continuous renewal of the fluoride content of tooth enamel is required for maintenance of the maximum caries-inhibitory effect.

After scanning the available data, Newbrun has concluded that the caries-protective effect of water-borne fluoride is diminished when fluoride intake is discontinued and the maximum inhibitory effect is not permanent but tends to be slowly lost (111). Maximum caries inhibition requires continued exposure of the enamel surface to fluoride. This suggests that fluoride acts systematically and topically in plaque and the enamel surface.

Although the mode of action of fluoride in reducing caries has not been fully clarified there are at least three mechanisms that appear to be important (112):

a) If fluoride is present in appropriate concentrations during tooth development it is incorporated into the enamel of the developing teeth prior to eruption. Fluoride rich enamel is more acid resistant than fluoride low enamel.

b) After eruption, fluoride ions counteract enamel dissolution and aid the remineralisation of very early carious lesions. This topical action appears to be the most important fluoride action

c) Fluoride ions may inhibit enzyme action in the plaque, and thus less acid is produced on the enamel surface.

Evidence supporting the systemic and topical effects of fluoride can be seen in the data collected in Kilmarnock as part of the British Fluoridation Trials (4). After 5 years, caries levels in deciduous teeth in Kilmarnock children had fallen compared with the control town of Ayr, but following the withdrawal of fluoridation, the topical effect was lost and caries levels increased to similar levels to those found in Ayr.

Fluoridation of the public water supply at 1 part per million Fluoride began in Kilmarnock in 1956, as part of the British Fluoridation Trials (4). After five years of fluoridation, caries prevalence had fallen by 42 per cent in Kilmarnock when compared with the control town of Ayr, mean dmft scores were 3.99 in Kilmarnock and 6.89 in Ayr. However the Town Council decided to withdraw Kilmarnock from the Trial and fluoridation was discontinued in 1962. Dental examinations continued in Kilmarnock and Ayr in conjunction with the other trial areas. Eleven years after, fluoridation began and five years after it had ceased, caries prevalence in deciduous teeth had risen to the same levels as in Ayr (5). The mean deft in the control town of Ayr in 1968 was not significantly different to the score of 5.81 in Kilmarnock.

After the decision to end the water fluoridation scheme serving Wick in late 1977, base-line examinations were carried out in early 1979 to measure the caries prevalence in 5 year old children who were born and raised in the town. Five years later, in May 1984, the same examiner repeated the examination of 5 year old life-time residents of Wick (92). The results of the studies showed that mean dmft had increased by 27 per cent from 3,14 in 1979 to 4.30 in 1984. Mean dmf surface counts were 8.42 and 13.93 respectively, a 39.6 per cent increment. A 60.9 per cent increase in the number of extracted teeth in 1984 was significant at the 1% level. There had also been a non-significant reduction of 10 per cent in the proportion of children who had no experience of caries. This increase in caries levels had occurred during a period when caries prevalence in the U.K. was showing a downward trend. Additionally the social class profile of Wick had altered during the study period with a significant reduction in the number of children from Social Class IV and V, with a matching increase in Social Class I and II. In the light of other studies, the 1984 sample would therefore be expected to have a lower level of caries experience than the 1979 sample. It was concluded that "defluoridation of Wick's water supply had been most detrimental to the dental health of children in that area" (92). The proven efficiency of water fluoridation from birth was again demonstrated. The suggestion that the caries pattern is improving to such an extent that water fluoridation policy might now be questioned (12) was not borne out by the Wick results, especially as the study period covers the time when fluoride dentifrices have been available to all (92).

The study of secular trends between 1980 and 1986 in schoolchildren resident in Stranraer, fluoridated from 1969 to 1983, and Annan with negligible levels of fluoride found that there was still a residual benefit from water fluoridation in 5, 10 and 15 year old children who were life-time residents of Stranraer by comparison with Annan (9). However in a period when caries prevalence in the population of the U.K. was falling (113), ten year old children in Stranraer did not show the improvement found in Annan children and mean DMFT was marginally but not significantly higher (11). Additionally, it was found that the potential cost of restorative treatment required in 1986 had increased by 115 per cent, due to an increase in the number of decayed surfaces (10). Although there was still a benefit accruing from the period of fluoridation of Stranraer's Water Supply, these results suggested that, three years after the cessation of fluoridation, the dental health of children had started to deteriorate.

A similar early adverse trend had also been reported in an East German Study which took place before the recent declines in dental caries rates were documented (114). Although the city of Karl-Marx-Stadt had fluoridated from 1952, due to technical problems the fluoride level was at sub-optional levels between 1970 and 1972. Caries levels in children between 3 and 15 years of age had been declining, but in 1974, caries scores increased. This increase was attributed to the period of sub-optimal water fluoridation (114). Caries levels began to fall once again once adequate fluoride concentrations were present in the water supply.

2. Changes in Caries Prevalence

In the past few decades, an increasing number of studies have examined the prevalence of dental caries in developed countries. More recently studies have examined caries prevalence in developing countries.

These many studies have revealed two distinct trends in caries prevalence. A general downward trend in caries levels, especially in children, has been reported in most industrialised or developed countries, with caries prevalence falling by 35 to 50 per cent since the 1970's (115). However during a similar period, caries levels have shown a steady increase in the developing countries. This increase is believed to be due to dietary changes resulting in large increases in sugar intake and consumption (116).

It is proposed to review studies reporting trends in caries prevalence in Europe and Britain under a number of headings as follows:-

2.1 Trends in Europe

2.2 Trends in Britain

2.3 Trends in Scotland

2.4 National Surveys

2.1 Trends in Europe

A number of publications have reviewed changes in caries prevalence in Western European countries (117,118) and have reported declining levels of caries experience in children from about 1970. However data relating to the then Federal Republic of Germany demonstrated little change during the 1970's, but several recent reports indicate a reduction in caries prevalence in children in recent years (119). The few studies carried out in Greece showed an apparent rise in caries prevalence in children which continued into the 1980's (120). However a recent study of children in Athens indicates that caries incidence may be starting to decline in Greece (121).

In Holland, numerous surveys were carried out from the 1950's onwards providing evidence of a decrease in caries prevalence among Dutch children (122).

Dental examinations were carried out every three years from 1969 to 1984 to monitor a long term Dental Health Education programme in the Hague (123). The data collected over a 15 year period showed a decreasing trend in caries prevalence in children in the Hague. This decrease was first noticed in 1975 and by 1984 a comparison with the 1969 data showed an 86 per cent reduction in dmfs in 5 year olds and a 76 per cent fall in DMFS in 7 year olds. Substantial increases in the population of children with no caries experience were also found. For example 65 per cent of 5 year olds had no experience of caries in 1984 compared with just 1 per cent in 1969. In 1984, 10 year old children had a DMFS score of 2.18, lower than the mean score of 3.94 reported for 9 year old schoolchildren in 1978 (124). However an inverse gradient was found to be present during the 15 year study period when comparing socio-economic status and caries experience. The cause of this trend to lower caries levels was thought to be multi-factorial. The decline was already apparent before fluoride dentifrices formed the majority of toothpaste sold in Holland.

A comparison of caries prevalence in studies of 14 year old children in Norway between 1959 and 1984 demonstrated a 78 per cent reduction in caries levels over the period (125). Mean Missing and Filled surfaces steadily reduced over the 4 studies from 34.1 in 1959 to 7.3 in 1984. Additionally mean DMFT of 12 year old children had fallen from 10.1 in 1971 to 4.4 by 1982, a 5.5 per cent change (126). However the same age group in Sweden showed a much lower percentage decline from a mean of 4.8 in 1972 to 3.4 in 1982 (127). A Finnish study investigated the occurrence of caries among 15 year old children in Helsinki from 1976 to 1986 (128). All indicators showed a significant improvement in dental health during the ten year period, with the percentage of intact teeth increasing markedly. The mean DMFT score fell from 12.5 to 5.1 over the time.

While the trend to lower caries levels was revealed in most studies in Western Europe, those countries with a higher base tended to show a steeper decline. Similar trends in caries levels have been reported in Scandinavia and throughout most of Europe.

Although, a comparative study in France showed no change between 1975 and 1982 (129), later studies have shown a fall in caries prevalence levels in 12 year old schoolchildren.

Although data from some countries of Western Europe is sparse, Oral Health Profiles for European countries show a general tendency to higher caries levels in Southern countries compared with Northern Europe (130). The majority of Northern Europe 12 year olds having a mean DMFT of around 3.0 in 1985 compared with an average of about 4.0 in the South. Although Malta reported a mean DMFT of 1.6 for 12 year old children.

A possible factor in this general difference is that fluoride toothpaste had been more recently introduced into Southern Europe and was less universal in use. There is little comparative data to demonstrate whether caries prevalence has changed with similar levels throughout Western Europe.

Many of the Eastern European countries have only recently started to collect data relating to caries prevalence. However, the limited data available appears to indicate a decrease in caries levels (117). Where data is available, mean DMFT of 12 year old children generally falls within the range 4.3 to 5.9 (130,117). The USSR reported caries levels varying between 6.7 in Latvia and 1.3 in Moldavia.

2.2 Secular Trends in Britain

In Britain, the majority of studies have been carried out in England. However many of the earlier studies were isolated prevalence studies or short term clinical trials and give little information regarding trends in caries prevalence.

While not directly comparable it is possible to establish a pattern of change in caries prevalence since the 1930's.

Mellanby demonstrated an improvement in the level of caries in 5 year old children between 1927 and 1947 (131). Studies by the Department of Health and other workers (132) showed a deterioration in caries prevalence levels during the 1950's, followed by a slight reduction in caries prevalence in 5 year olds in the early 1960's (133).

Studies of the epidemiology of other diseases indicate that they often have incidence and prevalence rates which vary with time, often following what appear to be rhythmic, cyclical patterns. It could be that dental caries is no exception to this pattern and that the prevalence levels vary with time. This would explain the changes found in Britain. This suggestion is supported by a Finnish study, (134) which demonstrates that between 1934 and 1970, the levels of caries prevalence in Finnish children have improved, deteriorated and then improved again. Each period of change has lasted about the same length of time and the maximum and minimum levels were approximately the same, as were the rates of change.

Jackson analysed 15 studies of caries prevalence in 15 year old English children carried out between 1950 and 1977 to establish whether de-rationing of sugar and sugar products in 1953 had led to a substantial increase in dental caries. Caries levels had remained fairly static over the period and he concluded that there was no evidence of any genuine increase in caries (135).

In the last 15 years, however, studies in Great Britain, Ireland, the United States, Holland, New Zealand and Scandinavia, including Finland have demonstrated a marked fall in the levels of caries prevalence (117).

As a result of this fall in caries prevalence, the British Association for the study of Community Dentistry (BASCD) organised a workshop in March 1981 to consider the changes in dental caries prevalence (113). The workshop agreed that from the evidence there did appear to be a reduction in dental caries prevalence, which had taken place over the last 10 to 15 years.

Although the reduction appeared to have occurred throughout the country, the meeting agreed that absolute caries prevalence levels were not the same throughout the country. There was evidence to suggest that caries prevalence was higher in inner city areas than rural areas. Similar reductions in caries prevalence levels had been reported in most studies from fluoridated areas. The workshop found that the reasons for this reduction in the prevalence of caries are not easy to ascertain and will only be established by regular and continuing dental epidemiological investigation. The workshop also felt that anyone who had collected epidemiological data during the past decade should be encouraged to re-visit the same areas or schools to observe whether there had been any change in those locations.

Following the BASCD Workshop a number of studies reviewed trends in caries incidence. Repeated studies in South West Avon found that caries prevalence levels in 5 and 13-14 year old children had fallen in 1981 and were about 40 per cent lower than levels found in similar age groups in England and Wales in 1973 (12,136). As surveys of 5 year old children in the South West region of England had shown that caries experience was considerably lower than reported in the 1973 National Survey (136), dental health of 11 and 14 year old children in Bristol was reviewed. There had been a 36 per cent reduction in mean DMFT of 11 year olds from 1970 to 1979, and a 30 per cent fall in caries levels in 14 year old children, comparing studies in 1973 and 1979 (137).

Examination of representative samples of 3 year old Hertfordshire children, carried out eight years apart, showed that mean deft had fallen from 1.37 to 0.52, a 62 per cent reduction (138). It was also found that social class difference in caries prevalence were occurring in other parts of England. A series of six clinical trials were carried out in the North West between 1968 and 1981. Although not directly comparable because of varying examiners, percent caries reductions in DMFT up to 33 per cent were found. As the greatest reductions were on smooth and approximal surfaces, particularly in the anterior teeth, it was felt that fluoride may have played a role in these reductions (86).

A review of the prevalence of dental caries in English Children found large reductions ranging from 32 to 57 per cent in caries prevalence in 5 and 12 year old children over a period of 10 to 15 years (139). These changes had occurred in urban and rural areas and in all tooth types. Children in two schools in Somerset were examined in 1963, 1978 and 1982 and mean DMFT in 12 year old children was found to be 5.36, 3.44 and 2.77 respectively (140). This was a 48 per cent reduction over the 19 years from 1963 to 1982, and there was a reduction of 19 per cent between 1978 and 1982. There were corresponding changes in the average cost of restorative treatment required from £5.20 to £0.62 in 1982 an 88 per cent change.

There was also discussion at the Workshop regarding the importance of common protocol for criteria and indices, so that results from varying studies could be compared. One such method is the System for Planning and Epidemiological Evaluation of Dental Services - SPEED (13), which has been utilised in several studies in different areas of the country. Field testing of this computerised information system in 1975 provided a base-line for a study of trends in dental health of first and third year Secondary School children in Salford. After 6 years, the first year children demonstrated a 20 per cent lower DMFT of 3.16. There was a corresponding fall in the 13-14 year old children from a mean DMFT of 6.57 to 4.96, a 25 per cent fall in caries levels (141). Costings for restorative treatment, utilising the Resource Related Index (75), showed reductions of 26 per cent and 59 per cent respectively.

Other studies utilising SPEED include a comparison of fluoridated Birmingham and non-fluoridated Salford children (74), patterns of dental caries in Irish schoolchildren between 1961 and 1981 (142), caries experience in Secondary School and Nursery School children (143,144) comparisons between Finnish and Scottish children (145) and the fluoridation study comparing Stranraer and Annan (6).

The first International Conference on the Declining Prevalence of Dental Caries was held in Boston, Massachusetts in June 1982 (146). Included among the many speakers from most parts of the World, Dr. R. J. Anderson emphasised the difficulties and constraints of epidemiological research over long periods of time. He then reported on studies on children in England which showed decreases between 32 and 57 per cent in areas with and without fluoridated water. During a similar period, repeated national dental surveys of adults had demonstrated an improvement in the dental health of adults in Britain (147).

2.3 Trends in Scotland

Dr. M.C.Downer (then the Chief Dental Officer for Scotland) evaluated the dental health of Scottish school children in 1970 and 1980 and compared the levels of caries found with English school children (148). He reported that average caries prevalence in 4 to 12 year olds in Scotland had declined between 14 and 36 per cent. A comparative study in Stranraer, situated in one of the four fluoridated areas in Scotland, had shown a reduction of 44 per cent in mean caries prevalence (6).

Scotland has generally been considered to have experienced poorer dental health than England (148). Findings of recent epidemiological surveys of children in the two countries, utilising similar data collection methods, indicate that this difference still persists (148).

A review has interpreted data derived from unpublished surveys in Edinburgh, Orkney and Shetland, base - line data from clinical trials and cross - sectional epidemiological surveys of fluoridated and non - fluoridated water areas (148). Two different methods of clinical examinations for caries were employed in the collection of these data. One method utilises a predominantly tactile method using sharp probes (149).

The second method depended primarily on visual diagnosis with the use of standardised blunt probes to confirm or reject doubtful lesions (150). Analysis of this available data indicated reductions in the prevalence of caries of 14 to 36 per cent in the non - fluoridated areas over the period of the time considered (148).

The changes in caries prevalence in specific areas are likely to be real, within the range of error introduced by possible shifts in diagnostic procedures. Less reliance can be placed on direct comparisons between the various localities, where different investigators were involved. The examiners were not necessarily calibrated with one another and the methods and criteria varied in some instances. The best comparative data will obviously be obtained where the examiners are the same, utilising the same criteria and the same sampling method.

Dental epidemiological studies were carried out in Kirkwall, Orkney between 1970 and 1973, 1977 and 1982, and in 1984 using the same methods and criteria. A retrospective analysis was undertaken to provide information on trends in caries prevalence (151). The same pattern of reduction in dental caries experience as reported in English studies was found in all age groups in Orkney. Comparison of a series of studies over a period of 47 years of children living on the Isle of Lewis revealed a marked increase in caries from 1937 to 1971 followed by a marked decrease during the 1970's

(152). However there was a modest increase in caries prevalence between 1981 and 1984.

2.4 National Surveys

In 1983, the Office of Population Census and Surveys (OPCS) Social Survey Division organised a national survey to establish the level of dental health among children aged 5 to 15 years in the United Kingdom (85). As a previous national survey of school children had been carried out in England and Wales in 1973 (135), comparison was also made between the 1983 results and the position in 1973. Levels of caries were reported to be significantly lower than in 1973. This was so for both primary and permanent dentitions and all ages, although the biggest differences were to be found in 5 year olds and the smallest in fifteen year olds.

This comparison was unfortunately not possible for Scotland and Northern Ireland, as they were not included in the 1973 survey and a proposed Scottish national survey never took place. However Northern Ireland and Scotland both showed much higher levels of caries prevalence than England or Wales. In the majority of age groups, children in Northern Ireland were in a slightly less favourable position than Scotland (85).

Without direct comparison it is impossible to know whether, despite the much higher levels of caries prevalence found in Scotland in 1983, there has in fact been improvements in dental health similar to those found in England and Wales. However BASCD are co-ordinating regular Regional studies of 5, 12 and 14 year old children in England and Wales. In Scotland, the Scottish Health Boards Dental Epidemiological Programme is also examining the same age groups, using the same criteria and methodology. These co-ordinated studies will provide on-going monitoring of trends in caries prevalence.

A series of reports have been produced from these epidemiological programme (153,154,155,156). Although a modication to the criteria relating to arrested caries has led to an increase in caries levels in four regions in the latest survey, an overall mean reduction in dmft of 0.04 was reported (155). However Dowell and Evans concluded that the trend in falling caries rates previously observed in five year old children (153) is beginning to level off and the level of untreated disease among this age group remains unacceptably high (155). Sixty per cent of Scottish 5 year old children had experienced caries and 49 per cent had active decay present.

The view of Dowell and Evans is supported by the latest study of children in the Isle of Lewis. Changes in dental caries have been followed by the same examiners since 1971. Following a marked decrease in caries prevalence during the 1970's a small increase in caries prevalence, measured by the DMF index, was reported between 1981 and 1984. The latest study in 1987 (157) showed that, while there had been a further small decline in caries rates, it was not occurring as rapidly as in the 1970's. The researchers felt that the decline was linked to the availability of fluoride dentifrices (157).

3. Dental Indices

Dental Indices are included in this review of the literature as, it is necessary for computerised analysis of dental data to be able to readily utilise different measures of oral health where these are appropriate. It is also necessary to be able to select the appropriate measure and not be constrained by an inflexible system in these times of much change in oral health.

Dental indices will be reviewed as follows:-

3.1 Decayed, missing and filled index

3.2 Other caries measures

3.2.1 Caries Intensity

3.2.2 Knutson's formula

3.2.3 Care Index

3.2.4 Oral Health Status indices

3.2.5 Dental needs measures

3.3 Other indices

3.1 Decayed, missing and filled index

The Decayed, Missing and Filled Index in its various forms is still employed in the majority of dental caries incidence studies, although preventive and treatment methods are causing the DMF Index to be a less satisfactory measure.

First suggested by Klein in 1938 (158), the DMF Index is the commonest of the current methods of measuring dental caries and has been used in the great majority of Fluoridation studies. Each permanent tooth is considered individually and if it is decayed(D), Missing due to caries(M) or Filled(F) it scores one. The total of affected teeth is an expression of an individual's caries experience. The mean number is found by dividing the total number of affected teeth by the number of affected individuals in the group.

Gruebbel (159), in 1944, introduced the def Index for the deciduous dentition. As originally described it recorded teeth decayed(d), teeth requiring extraction(e), and filled(f) deciduous teeth. Missing teeth were not recorded, therefore it may be regarded as a measure of observable dental caries prevalence. Frequently the Index is scored in the same way as the DMF Index and may then be regarded as a measure of past and present dental caries experience. When used in this way, it is generally known as the dmf index. Exfoliating teeth are a complicating factor and modifications are sometimes made to allow for this natural loss of teeth. It is normal practice to only count the deciduous molars after the age of six. The World Health Organisation recommend the use of the dmf index for deciduous dentitions (160).

One disadvantage of the DMF Index is that a tooth scores exactly the same despite extreme differences in the clinical condition. A tooth with a small restoration scores the same as a grossly carious or extracted tooth. As a result a finer measurement may be required for clinical trials and similar studies, than the comparatively crude DMF Index.

In these cases the DMFS and dmfs indices may be utilised. These indices are calculated in the same way as described for the DMF Index, but the unit of measurement is not the tooth but each tooth surface. It has been found that the surface index provides little or no additional information in studies where the prevalence of caries is being compared between groups (161).

There are four disadvantages:

1) The problem of allocating a surface score to extracted teeth.
2) The scoring of multiple surface restorations where the filling may have been extended onto a surface for technical reasons rather than caries.
3) There is a wider range of possible values and hence a larger standard deviation and standard error.
4) Finally there is the problem of the saturation of the index in older age groups, thus preventing the accurate registration of further caries attack. However this is not usually a problem in children.

Despite these difficulties no better method has yet been reported for public health investigations and it is widely used by research workers. The World Health Organisation recommends its use for caries studies (160)

3.2 Other Caries Measures

3.2.1 Caries Intensity

Caries intensity can be expressed as a proportion of decayed, missing or filled teeth per 100 teeth at risk, providing a partial correction for differences in eruption dates of teeth (162). As all teeth are exposed to the same environment, it is necessary to base the calculation on the individual and not the group. The individual DMF per 100 teeth for each individual is first calculated using the following formula; -

$$\text{DMF per 100 teeth at risk} = \frac{\text{Individual DMF} \times 100}{\text{Number of teeth at risk}}$$

The individual values are then aggregated to find the group mean. Caries intensity has little advantage over the DMF Index, unless the groups have widely differing numbers of teeth.

3.2.2 Knutson's Formula

The prevalence of dental caries is usually determined by a full mouth examination for each subject in a study population. As limitations of manpower or time may preclude such an approach, Knutson suggested that a cusory examination method could be used to estimate age-specific mean DMF teeth (163,164). The estimate was based on the percentage of individuals in an age group with a minimum of one decayed, missing or filled tooth. Knutson suggested that the relation between the mean DMFT of a specific age group and the percentage of individuals within the group with a DMFT of 1 or higher could be described by the formula; -

$K - Y = K(x)B$
x = age-specific mean DMFT
Y = age-specific percentage of individuals with DMFT > 1
$B + K$ are constants for all age groups & populations.

Knutson estimated $K = 97$ and $B = 0.524$ on the basis of data collected in one town (163). A review of data from a further nine studies, confirmed his opinion that the value of these constants gave a good correlation with age-specific caries rates (164).

Lilienthal and Andrews (165) suggested that Knutson's formula might be inaccurate for age groups with a high proportion of individuals with a DMFT of 1 or more. It was also suggested that the method might be more appropriate for younger age groups. In response to these suggestions a review of the formula was carried out using data from 149 age-specific data sets from low-fluoride areas in America, to determine the age groups and range of Y values for which Knutson's Formula can be accurately used (166). The review also examined the best values for the constants K and B. The analysis showed that the formula gave accurate estimates of age-specific DMFT scores for age-groups from 5 to 11 years old, provided the percentage of individuals with a DMFT score of 1 or more was less than or equal to 70 per cent (I4). It was also concluded that the most appropriate values for the constants K and B were respectively 100 and 0.542.

3.2.3 Care Index

To provide an objective assessment of dental care, Walsh proposed the Care Index (167). The Care Index expresses Filled Teeth as a percentage of DMFT.

$$\text{Care Index} = \frac{FT \times 100}{DMFT}$$

Thus giving an assessment of the level of dental care within the population under study.

3.2.4 Oral Health Status Indices

More recently work has been undertaken to produce indices which will provide an objective measure of dental care. This type of cost-benefit analysis involving process and outcomes is necessary for the planning and evaluation of dental services. Nikias et al proposed an oral health index in 1979 based on oral health rankings by panels of dentists (168). Similar work was carried out in Canada, using a panel of dental surgeons to review and assess pairs of cases from full mouth records. The mean scores of the 12 dentists were used to construct an empirically derived index of oral health status for adult populations (169). It was claimed that this outcome measure met an important need of the dental community by providing an assessment of the level of dental care required (170).

Following the development of the Adult Oral Health Status Index, similar methods were employed to produce an Oral Health Status Index for children based on dentists' judgements (171). The paired preference method of assessing subjective measurement was again utilised to analyse the judgement of equal numbers of general dentists and paedodontists to empirically select four variables appropriate for the comparison of children's oral health. These easily measured variables were carious teeth, occlusion, abnormal tooth position and missing teeth which had not been exfoliated. Testing of this outcome measure indicated that it was suitable for survey use and cost-effectiveness analysis of the dental care of children.

However both the Adult and Children's Oral Health Status Indices have been little used outside the United States of America, so there is a lack of evidence to indicate whether these outcome measures are appropriate for general use in the world. It may be that local versions would need to be developed for each country to reflect local attitudes to treatment and oral health.

3.2.5 Dental Needs

The need for dental care has usually been measured in terms of the prevalence and severity of dental disease. However, the established indices of dental disease such as the DMF and Periodontal Indices are not adequate for assessing dental needs, as the type and extent of treatment cannot be ascertained from the index, as a decayed tooth may require periodontal treatment.

Beck devised the Dental Services Index (172) to provide an assessment of the amount of dental treatment required by an individual or group. It is based on a standardised scale of fees to allow comparisons to be made between groups. The magnitude of the index is directly proportional to the amount of dental treatment required to produce dental fitness. This concept was further developed to a system based on the Relative Value Unit (172), an expression of the time and cost of any dental procedure based on the General Dental Service Fee Scale. The Statistical Package for Epidemiological Evaluation of Dental Services (SPEED) further developed the principle of converting dental treatment needs into costs (13). This utilises a treatment need system based on the treatment of caries and periodontal disease, taking into account malocclusion and prosthetic requirements. The treatment needs were then converted into costs by means of the Resource Related Index (75) which quantifies costs of treatment by means of the relativities used to produce the National Health Service Scale of Fees. While still being appropriate for Adults, the recent changes in the General Dental Service Contract based on a capitation system for children makes the Resource Related Index less valid for use in children, but it is still an excellent method for showing differences in the relative cost of dental care between groups.

The problems with most measures of dental caries and treatment costs is the necessity for careful examiner training so that the reliability and reproducibility of data recorded remains constant during all examinations carried out by an examiner. If more than one examiner is taking part it is also necessary to ensure by careful training and testing during the study by means of replicate examinations, that all examiners are achieving a high degree of reproducibility and reliability.

3.3 Other indices

Indices are also required to assess and measure oral cleanliness and periodontal status, enamel opacities and fluorosis, and malocclusions.

3.3.1 Oral Cleanliness

Loe & Silness developed a Plaque Index (174) which provides a measure of oral cleanliness. Six index teeth are utilised for the index, each surface being visually examined and then tested with a probe to measure the presence and extent of soft debris or plaque. The mean of the four surface scores forms the score for each tooth. The tooth means are added and divided by the number of teeth examined to provide the individual's plaque score.

A similar index was introduced by Greene and Vermilion to measure the extent of debris and calculus, again using index teeth (175). This measure was again based on a visual and tactile examination with a probe to quantify the type and present of plaque and calculus. This index was modified by Lennon and Davies to produce a screening procedure for periodontal disease, based on oral cleanliness, calculus and gingivitis (176). This method was utilised by the SPEED survey system.

A further measure of oral cleanliness is the Tooth Cleanliness Index (177). Following the use of a disclosing agent, the extent of plaque in each of the six segments of the mouth is assessed visually and scored on a ten-point scale. Ten being a perfect oral hygiene score.

3.2.2. Gingivitis

The PMA Index devised by Schour and Massler was one of the earliest and widely used gingivitis measures (178). This index assesses visually the status of the gingival and oral mucosa, by scoring the papilla, gingival margin and adjacent soft tissue of each tooth.

Loe and Silness (174) also developed a Gingival Index, utilising numerical scoring of six index teeth. As in the Plaque Index, the scores for each surface are scored on a 0 - 3 scale and averaged. The individual score is obtained by summing the teeth scores and dividing by the number of teeth examined.

3.2.3 Periodontal Status

The main measure of periodontal status is the Community Periodontal Index of Treatment Needs (CPITN) which was developed by the World Health Organisation to provide information relating to population periodontal needs (179). It is now also used to assess individual periodontal status as an aid to treatment planning.

The CPITN index measures three indicators of periodontal status with the aid of a specially designed lightweight probe with a 0.5mm ball tip. For adults the mouth is either divided into sextants or 10 index teeth are used.

The measures are:-

1) Presence or absence of gingival bleeding
2) Presence of calculus - sub or supra-gingival
3) Periodontal pocketing - subdivided by depth.

The highest score in each sextant is recorded for that sextant within a range of 0 - 4, after careful probing around the gingivae of each tooth. The scoring system is designed to give an indication of the type of treatment and the level of professional intervention required.

The method is modified for use in adolescents when only six index teeth are examined (180). Pocketing should not be measured in children under 15 to avoid confusion caused by the "false pockets" which occur due to tooth eruption.

Because of its widespread adoption, it is important that any computer based survey analysis system can process the CPITN index. The development of the SPEED suite of programmes unfortunately preceded the introduction of this periodontal index, so only oral cleanliness the presence of gingivitis and sub-gingival calculus is measured by the SPEED system. However the SPEED analysis does attempt to divide the patients by means of a threshold for professional intervention.

Other measures of periodontal status, include Russell's Periodontal Index (181) examining all teeth and Ramfjord's Method (182) a partial recording system based on six typical teeth. The Ramfjord method requires very careful and technical measurement of gingivitis, calculus, pocketing and attrition which are recorded on a schematised data collection chart. As a result the Ramfjord PDI is not very suitable for population screening although useful for assessing individual treatment need.

A modified version of Russell's Periodontal Index using six index teeth (183) provided a simple survey measure of periodontal status prior to the widespread use of the CPITN Index.

3.3.4. Malocclusions

Numerous methods have been introduced to record the prevalence and degree of malocclusion, however many are only suitable for use with individuals rather than as part of a dental public health survey. As a result, many surveys including the British National Dental Surveys and those using SPEED record the presence or otherwise of a range of specific malocclusions in addition to measuring overjet and overbite.

The Index of Orthodontic Treatment Needs (IOTN) was developed to provide a measure of the level of need for orthodontic treatment as part of a screening process (184). A lengthy range of criteria are assessed and scored on a five point scale. The highest score found being the individuals IOTN score. The frequency distribution of individual scores gives an indication of population treatment need. Unfortunately, the index does not give a measure of population demand.

Richmond has attempted to simplify the scoring process by developing a plastic measure to provide a quick scoring method (185). However, its use on Scottish surveys has indicated difficulties with reproducibility when used by a number of examiners. The World Health Organisation are still to agree a survey index relating to malocclusion.

3.3.5. Enamel opacities and Fluorosis

A number of indices have been introduced since Dean's Classification system for Dental Fluorosis, which could be used to calculate a Community Fluorosis Index (186). However there are a number of drawbacks with this classification. Clarkson (187) summarised the problems as follows:-

1) The index is based on the two most severely affected teeth and does not allow measurement of the extent of other defects.

2) No indication is given of the location of defects.

3) The use of the term "Questionable" is vague.

4) The index is not sufficiently sensitive to distinguish between degrees of fluorosis in high-fluoride areas.

5) As the classification is based on an ordinal scale, the use of the arithmetic mean to calculate the CFI score is of doubtful validity.

6) The CFI may not give a true reflection of the level of fluorosis within a population.

Concern has also been expressed regarding the presumption of fluorosis, when enamel defects are caused by many factors. This has led to a number of descriptive measures being used on surveys, including that of Al-Alousi et al (188) which is a simple index which records the presence of various enamel opacities but does not attempt to categorise them as fluorosis. The Al-Alousi method assessed fluorosis by comparing samples from fluoridated and low-fluoride areas.

As opposed to the descriptive approach, Thylstrup and Fejerskov developed the TF Index (189), a 10 point classification measuring the degree and type of fluorosis affecting buccal, lingual and occlusal surfaces. Thylstrup and Fejerskov attempted to validate the visual appearance with the histological appearance using extracted teeth. However the TF Index could be affected by the period for which the tooth was dried prior to the examination.

Another alternative to Dean's Classification was the Tooth Surface Index of Fluorosis (TSIF) developed by Horowitz et al (190). A separate score is given for each tooth surface and the teeth are examined wet with saliva in their natural state, as drying accentuates any existing fluorosis (191).

However, the FDI through a Working Group (192) proposed a descriptive index should be adopted to reduce the confusion and lack of comparability of studies of enamel defects. The Developmental Defects of Enamel Index (DDE) records the type, number and location of defects on the buccal and lingual surfaces of the teeth. However the multiplicity of data generated has caused difficulties in presenting results in a meaningful fashion, although the DDE Index gives information relating to a wide range of defects, their distribution and location.

Clarkson and O'Mullane proposed a modification of the DDE Index to simplify the data collection (193). Two modified versions were described. One comprehensive, recording sub-divisions and combinations of the types of defects and their extent and the other for simple screening surveys recording the three basic defects plus an other defects category (193). It was also proposed that the teeth should be examined wet with the aid of a glare-free light. Data can be recorded on a whole mouth basis or only for 10 index teeth, including upper anteriors where the majority of defects tend to occur.

A version of the screening DDE Index, the "Scots" Index (194) was utilised in the Scottish Health Boards Survey in 1990/91.

Following minor changes, the modified DDE Index has been recommended by the FDI and WHO for studying enamel defects.

4. Use of Computers in Dentistry

This section will review the development of the computer in relation to its use in the field of dentistry to collate and analyse data. Sub-section headings are:-

4.1 Historical background

4.2 Punch card systems

4.3 Computer development

4.4 Computers in dental epidemiology

4.5 Dental analysis systems

4.6 Data input methods

4.7 Data storage and analysis

4.8 SPEED

4.9 Micro-computer systems

4.10 Statistical analysis

4.11 Surveyplus

4.12 Other systems

Dental Services require to be planned, operated and evaluated to achieve maximum effectiveness. Epidemiology provides the necessary information in all three stages and should be part of the administrative mechanism of any dental service. However the object of a dental epidemiological study is generally to examine fairly large numbers of subjects giving rise to large volumes of data. Fortunately, in the last few decades, the development of the computer has greatly assisted the analysis of these data.

4.1 Historical Background

The history of computers began about 150 years ago, when Charles Babbage devised the Analytical Engine, a mechanical computer. Unfortunately Babbage was unable to build the complete engine, although the Science Museum has recently built a working model. The Analytical Engine based on cogs and wheels would have been a large machine, as were the first computers. The Analytical Engine was designed to use a similar system to the binary mathematics of computers to carry out its calculations.

Before the development of the first electronic computer in 1946, the only machinery available for data processing were the mechanical calculators and the Hollerith punch Card System. Punch card systems are limited to sorting, counting and very simple mathematical operations. Unfortunately analysing a large amount of data generated by most dental studies was time consuming. Once the data has been collected it is normally necessary to analyse it in several ways to obtain the information required. If data analysis has to be undertaken by hand, apart from very small studies, it can take several months to obtain even interim results. As a result, few large scale dental surveys were carried out in the past.

4.2 Punch card systems

The Dental Division of the Metropolitan Life Insurance Company developed a dental statistics system during the 1920's (195). It was designed to gather, organise and tabulate the data, and by proper statistical technique to draw correct conclusions regarding the frequency of caries in different tooth surfaces. Data was collected on a primary record card, then following coding it was hand punched onto 80 column cards. Each card was punched twice to allow comparison for punching errors. Finally the punched cards were sorted with a mechanical sorter to give counts and tabulations.

A study was carried out in the United States of America in 1936 to examine dental caries in urban communities (196). Klein and Palmer described the development of a data recording and analysis system for this project (197). The design of the record system had to provide detailed observations of the 260 coronal surfaces of the deciduous and permanent teeth. The sheer volume of data thus produced necessitated the use of punched card methods for data analysis and interpretation. The data collection form designed for the study provided paired boxes for each tooth in the mouth where multiple coding described the status of each surface. Space was also provided on the form for the collection of additional data relating to congenitally absent teeth, abscesses, and gum infections.

Coding boxes were also provided for use in the first stage of data analysis. Sixteen summary codings were inserted in these boxes to provide individual decayed, missing and filled teeth information. After this manual intermediate coding, the data was transferred onto

Hollerith 80 column punched cards. The 80 columns were arranged as follows, 5 columns for personal data, 56 columns for tooth data, and 16 columns for the summary data with three columns spare. Tooth data for the third molars was not entered although it was included in the summary data. Punch card reading machines were then used to produce tabulations and frequency results from the data.

The system described was used over a three year period during which data from almost 14,000 examinations were processed. It was proved to be generally adequate for studies on the epidemiology of dental caries (196).

During the decade that followed, the Hagerstaun Dental Examination Form (197) was used in a number of surveys and studies (198,199,200). While the use of codes by the dental examiner, which are recoded by his clerical assistant, had eliminated much of the manual manipulation of dental examination forms, hand punching for all the data was still required. The development of mark sensing allowed the system to be further simplified (201). The principle of mark sensing is based on marking a special form with an electrophobic pencil with a high graphite content. The completed forms are fed into an IBM Mark Sense Reproducer where an electric current flows through the graphite mark causing holes to be punched at the selected points.

The design of a dental mark sense record form allowed mechanical punching of the dental data, thereby eliminating the intermediate coding and hand punching originally required. If a mark sense reproducer is unavailable, the form can still be used for hand punching of the data.

However, it is important that extreme care is taken in the physical handling of the cards due to the complicated and delicate balance of the electrically activated machines (201).

4.3 Computer development

In 1946, the first electronic computer (ENIAC) was developed at the Moore School of Engineering in Pennsylvania. It was capable of carrying out the basic functions available via punch card and other methods, but it could also make more complex calculations. It was able to carry out these functions around 1000 times faster than existing mechanical calculators. Unfortunately it contained 18,000 valves which led to reliability problems.

By the early 1950's, the first generation of computers were in use. Although capable of high speed calculation, they were physically large and expensive and required purpose-built accommodation to provide a controlled environment. These computers were mainly used for scientific purposes to carry out large and complex calculations.

The development of the transistor to replace the valve led to the appearance of the second-generation of computers in 1960. The smaller transistor which replaced the valve allowed the size of the computers to be reduced, increased their reliability and allowed higher calculation speeds. As a result computers began to be used for many applications including commercial uses. By the mid 1960's, there was a third generation of computers manufactured for a wide range of purposes. These computers were working more than a thousand times faster than the original ENIAC. They were also able to carry out several functions at the same time.

The next change in computer technology was the development of complex integrated circuits on silicon wafers. These integrated circuits or "chips" contained multiple transistors and electronic gates. On-going development led to smaller and cheaper chips providing increased computing power. This allowed the development of "mini computers" which were much smaller in size and did not require the same purpose-built environment.

Although achieving the same computing speeds as the third generation computers, now known as "main-frame computers", they did not have the same computing capacity. However, continuing development of integrated circuits rapidly provided equal computing power to the existing main-frame computers. The smaller sizes and much lower prices of mini computers led to a rapid expansion in the number of computer users and the applications for which computers were used.

Continuing development of "chips" and micro processors, with the developments in memory storage facilities led to another range of computers. These "micro-computers" were desk top machines with similar abilities to main-frame and mini computers. The initial micro-computers introduced at the end of the seventies were much cheaper and made computing available to all, including home use. They were however limited in computing ability by the size of memory that it was possible to build into them.

Further rapid developments during the 1980's has led to increasingly powerful micro-computers which can carry out the same functions as a minicomputer. The latest micro-computers have memory chips and hard drives capable of storing and processing large amounts of data. Processing speed has also been steadily increased during the past decade. The ability to link micro-computers into multi-terminal networks has also expanded the possibilities in their use.

Once computers became reliable and generally available, dental studies and surveys began to utilise their data processing abilities to speed up analysis of the collected data. Developments in "software" programmes mean that it is possible to carry out data analysis of quite large amounts of dental data on a desk top micro-computer.

4.4 Computers in Dental Epidemiology

Computers have been described as a fortuitous union of the principle of the electric switch, the formal logic that all propositions are true or false and the binary system of numbers (202). Binary arithmetic represents numbers or letters by a combination of one or zero. The computer interprets the ones and zeros by having switches either set on or off. This simple mathematical method allows the computer to make logical decisions at high speed. A more valuable capability of computers for dental use is their ability to store large amounts of information and instructions.

In the earlier use of computers for dental data analysis, the data was usually input to the computer by means of a punch card reader, utilising the 80 column cards of the Hollerith system. Stacks of cards were read into the computer where the data was stored on magnetic tape or a magnetic disc unit. A batch of several rotating discs coated with magnetic material capable of storing millions of item of data were known as Winchesters. Tapes and Winchesters are normally removable from the computer for storage.

The transcription of data was further developed by the introduction of paper tape readers which input the dental data from continuous strips of paper punched with the coded information in patterns based in several positions on the tape. The first Australian Symposium on the use of computers in Medicine & Biology was held in 1965 (203) and topics discussed indicated many areas where computer data processing would assist dental research. Following the symposium an introductory guide was published in the Australian Dental Journal (204). It compared the use of computers or punched card sorters in the processing of dental data. While the card sorter can be used in surveys to provide counts of data in multiple runs, if the punched cards are used for computer input, the computer can read, store and manipulate large quantities of data at high speed and be programmed to execute long and involved sequences of operations entirely automatically. The authors suggested that computers should provide research workers with accurate results and the leisure to think (204).

Christopher (205) reviewed the role of computers in dentistry and reported that computers were being used in 14 different projects in 1965, ranging from mortality in dentists to the epidemiology of dental caries. Studies had also been carried out into caries-inhibitory dentifrices and the benefits of fluoridated drinking water.

The computer was described at the Fifth Canadian Conference on Dental Research as enabling projects to be undertaken that would have been inconceivable previously because of the large numbers of time-consuming calculations required (206). The computer aids statistical analyses and data processing. Statistical procedures suitable for computer application were grouped into three categories;

1) Reducing and summarising data
2) Testing hypotheses
3) Investigating relationships or making predictions

Marthaler (207) suggested that records should be planned for greater ease of use and automatic checks of the evaluation. Studies evaluated by electronic computers should provide for all steps except the diagnosis proper to be automated. As an alternative to the use of mark sense cards, a hand operated device had been developed to punch data directly onto special 40 column cards at the time of the examination. Where 40 columns were insufficient, two cards could be transformed by a machine punching onto a standard 80 column card. This method eliminated the need for hand punching or mechanised punching of mark sense cards thereby facilitating data input onto the computer.

A further refinement was the introduction of optical scanning equipment to allow machine processing of the original dental data (208). This optical scanning allowed greater flexibility and detail than was possible with mark sense forms for mechanical punching. Glass et al (1969) developed a system based on optical scanning equipment to provide computer generated treatment plans (208). The aim of the project was to develop an automated system which would be applicable to surveys of large numbers of subjects. Summary cards could be produced by the system for statistical analysis of data relating to DMF, and treatment needs and costs.

A specialised form was developed, with a separate sheet for each quadrant of the mouth. A box containing the range of codes is provided for each tooth surface plus a further box to record mobility, prosthesis etc. A pencil mark was placed next to the appropriate code. The absence of a pencil mark indicating normality. The completed sheets were then read by an optical scanning device which processed the data onto punch cards or magnetic tape which formed the computer data base.

After the data was input into the computer, it was checked for errors and completeness. Some recoding and re-formatting of information was then performed by the computer to facilitate data analysis. The computer programme was written in the Fortran high level computer language. A series of 1348 Fortran statements and decision tables processed the input data and provided the required output. The output was printed onto paper utilising a line printer. Other output methods which could have been used are punch cards and punched paper tape for translating in punch readers.

Moore reviewed the use of computers in North American Hospital and Dental School in 1969 (209). IBM had developed Hospital Information Systems (HIS) which were being used in the Oral Surgery Department of the two hospitals. The systems also provided for computer storage of patient master records. Computers were being used for research at Harvard Dental School, New York University Dental School, and Toronto University. A computer was also being installed at the new Michigan University Dental School. The Toronto installation consisted of an IBM 1130 Computer with card reader punch card sorter and line printer. Programmes were compiled on punch cards using the Fortran IV language. At Tufts Dental School a punch card based system was being used to monitor student marks and mark sense multiple choice answer papers allowed computerised marking of examinations. Computers were also being used for research, based on punch card or mark sense data collection methods. Finally the Medical Literature Analysis and Retrieval System (MEDLAR) was being utilised to computerise the Index Medicus and the Index of Dental Literature (210).

In Britain computers were used to assess the efficiency of an oral hygiene programme and to investigate a hospital record system (211).

Computers are invaluable in dental epidemiology for the speedy analysis of large surveys, with detailed results available in a matter of days. However the speed at which results can be produced depends to a large extent on the speed on which data can be prepared and input onto the computer. In order to reduce the time-consuming process of collecting dental data, then coding and punching cards, Anderson and Beal designed a special set of five punch cards (212). The first card is for the collection of general information and the other four for collecting the individuals dental data on a tooth surface basis, a quadrant per card. The cards were designed so that for each item there is a series of boxes with a label to identify the correct position for entering information on the card and a space to identify the position where the data is to be punched.

The cards are colour-coded and arranged in a booklet. However time was still being lost at the card punching stage. To further speed up the data entry process a mark sense set of cards which only recorded tooth, not surface data, was developed for studies where surface information was unnecessary. The mark sense cards allowed mechanised punching of the cards. The computer analysed the data using programmes written in Fortran and also produced abstract cards for further analysis and sorting. Sorting was carried out with a card sorter as the disc sorting process on the computer was found to be extremely slow and time-consuming. Over 50,000 records had been successfully analysed by the system at that time, involving a variety of staff. The system was designed for an IBM 1440 computer but has been adapted for the IBM 360 and ICL 1900 series.

As epidemiological studies of dental health gained importance in research and dental public health planning, an increasing number of studies used computers to process the collected data. Studies included clinical trials of preventive agents and evaluation of dental health programmes. As previously described (Section 3) a number of commissions and expert groups had worked to standardise criteria for the diagnosis of dental caries incidence and prevalence. The standardisation of criteria for generalised epidemiology studies and clinical trials was important as it allowed comparisons to be made between studies.

Moller and Poulson (213) described a standardised system for recording and analysing dental caries data, based on standardised diagnostic criteria. The basis for development of the system was to produce a flexible computerised system which could be utilised in different situations. Punch cards were still used to transfer the data to the computer. Two 80 column cards were used, one for each jaw, to record data for each tooth surface. The data were collected on standardised record forms and, after manual decoding, were transferred onto the punch cards for input into the system. The record form was designed to act as a punch guide. A number of computer programmes were developed to provide a library of dental caries analysis programmes. The programmes were written in Fortran IV.

The library of programmes consisted of two main groups, plus a single programme (CHECK) to test the data for errors. The first group consisted of programmes suitable for analysis of studies of dental caries prevalence, while the second group was utilised for studies of the incidence of caries. A programme (DOBB) was also provided to analyse replicate examinations for inter and intra-examiner reliability.

Two programmes were available for the computation of caries indices in prevalence studies. These computed either surface or tooth based decayed, missing , or filled scores for the primary and permanent dentition. For clinical trials where the incidence of dental caries was studied, two programmes based on the DMF and def indices were available. The incidence of dental caries was computed on the basis of new caries in teeth or surfaces which had originally been recorded as sound. Different computations were available which included or ignored D1 early caries lesions. The purpose of this system based on a library of programmes was to provide flexibility in meeting the varying needs of different types of dental caries studies. However, statistical tests, other than summary statistics, were not available in the programme library. Statistical testing had to be performed by means of a standard statistical package or simple hand computations.

As computers expanded the possibilities for data analysis available to the dental epidemiologist, ever-increasing piles of computer printout were produced with only a few pertinent figures appearing in each printout. There was also a need for repeated computer runs to look at the data in slightly differing ways. In 1975, Poulsen et al attempted to overcome these problems by developing a computer programme which would yield exactly the output the user required, no more and no less (214). A data structure was designed which defined each tooth surface within a multidimensional co-ordinate system. This enabled the basic process of the programme to be a count of the numbers of locations which fulfilled pre-defined criteria.

The programme (214) as developed, consisted of one small main programme and a number of sub-routines. The main programmes function was to call a number of sub-routines. The sub-routines were divided into three groups. The first group of sub-routines read and converted the data into the multidimensional structure. The second group provided sub-routines to assign the individuals to different groups, such as Sex and Age or a number of permanent teeth etc. Finally group three provided tabulations, with or without cumulative distributions. The only statistic provided was the mean number of counts per individual. The sub-routine RED also provided a computer file for further statistical analysis using standard statistical computer programmes. The sub-routine (RED) also initiates the counts and edits the scores in one or more of the co-ordinates.

As well as being a more complex system to use, it was necessary to have a fairly large working area available in the main-frame computer. The experience of the authors was that the full application of this principle had proved rewarding (214).

4.6 Data input methods

The continuing development of electronic computers had made possible the rapid analysis of the large quantities of data collected in dental epidemiological surveys. As a result the problem of transferring the data from survey records into the computer system for analysis began to be addressed. It was at this input stage that most delays and errors occurred (215).

Two main methods of preparing data for the computer were in use. Either the information was collected on standard charts or specially designed survey sheets and subsequently coded for computer input or the examiner memorised the coding system and called "codes" directly to the recorder or scribe. Neither method is free from error and each requires training prior to the study. Once coded the data can be input onto the computer.

Pennell and Herman reported in 1952 that the use of mark sense records was advantageous in reducing clerical and punching work (216). Information is obtained at source and "punching" is in effect performed on the job. Using an automatic reproducer, data on 7,329 mark sense cards were punched in under two working days. However a disadvantage is the need for great care in handling mark sense forms. Clerical personnel also must be thoroughly trained to reduce marking errors.

Fairpo suggested that the use of keyboard entry either directly via an on-line terminal or indirectly through punch cards or paper tape was slow and prone to error (215). Further delay also occurs while the input is checked and corrected.

A new method of direct computer entry of dental data was therefore suggested using an X-Y digitiser (215). An X-Y digitiser is an input device which can be linked to a computer. It detects and records the position of a button-activated cursor on a digitising table. When the button is pressed, the position of the cursor cross-wires is input as a pair of numbers, the X and Y co-ordinates. The X and Y co-ordinates may be input directly onto the computer or onto punched paper tape for later analysis. As described, the system used a Hewlett-Packard 9830A calculator linked to a printer, cassette tape memory, floppy disk unit and a Talas digitiser.

A menu overlay sheet was attached to the digitiser board to provide selection of the required function during digitising to allow greater versatility. The initial test of the system was to input data from survey abstract sheets originally designed for keyboard entry of seven summary records. The data was stored on magnetic tape and later transferred by means of a further programme into a fixed-format record stored on a floppy disk. It was found that data could be transcribed four times faster using the digitiser, with about one-tenth of the number of errors, than was possible with keyboard entry.

Further development of the digitising method allowed the use of grid charts provided up to nine anatomical sites per tooth. Each tooth is first recorded as present, then information relating to the status of anatomical sites recorded with the aid of the menu functions. Moving to another tooth, ended data entry for the previous tooth. The menu also provided for the entry of personal data with an end of record cell provided to show that all information for that chart has been entered. Additional refinement was the combination of the two original programmes into a single programme which stored the input data on a floppy disk. A printout of each entry could also be produced as an immediate check. The operator was able to input about 50 records per hour with an error rate of 5 to 6 errors per 50 charts. It was suggested that many of these errors were due to the operator trying to enter data at too fast a rate for the system. A faster processor might therefore have reduced the rate of error. The digitiser system provided for speedy data entry direct from the original record charts, using a charting system similar to a method already in widespread use. The low error rate claimed made error checking more straightforward, although it was still necessary to give almost error free computer records.

While being an alternative method of data input which eliminated the coding of data, it was still necessary to record the data accurately on a survey chart prior to the digitising of information into a data file which could then be analysed by means of a computer analysis programme. Obviously errors in the use of the menu functions could lead to data entry errors which could only be detected by manual checking of the printout with the original chart. As it did not automate the data input process, this interesting method failed to find widespread use. However, orthodontists and others make full use of digitisers in recoding and storing radiographic information.

In 1962 a revised but rather complicated use of mark sense cards was described which it was claimed gave greater flexibility and detail for data analysis (217). To cope with the amount of information desired, the system utilised a master card for patient identification and a separate card for each tooth. For each examination, the recorder had a file of master cards and a stock of prepunched tooth cards in packs of 28, arranged in the examination order. Following marking with a special electrographic pencil, the cards for each subject were bundled together and held with a rubber band. All further data input was accomplished by machines. The master card was used to "gang-punch" personal details onto the tooth cards and then discarded. This method was reported to provide efficient recording and detailed analysis (217).

A system was also developed utilising a card reader rather than a general purpose optical scanner (218). This was based on a binary image representation of the standard 80-Column computer card. As a result instead of reading Hollerith punched code, binary code related to markings in each of the column fields was input on to the computer. A reader invisible overlay was printed onto each card to guide the recorder in marking the cards. Data processing was achieved by means of a calculator card reader and a desktop computer. Automatic data entry from schematised computer readable cards reduces sources of error and the costs and delays associated with manual entry. This system, being simpler than optical reading systems, makes automatic data entry available to small research organisations. The on-going development of computer analysis of dental epidemiological data enabled the results of the 1983 National Survey of Children's Dental Health to be provided within six months of the completion of the survey (219).

A 1980 review of the use of computers in Preventive Dentistry (220) noted the astonishingly rapid development of computers in the previous twenty years, which had allowed the electronic processing of information to be speedily and cheaply carried out. The importance of error checking on the enormous amounts of data that had been generated was stressed. Errors may be of the illogical type, such as an extracted tooth being recorded as unerupted at a later examination, or the finding may be very improbable, eg. a 51 year old schoolchild. A good error detection programme should uncover the majority of such mistakes.

As the importance of epidemiological studies of oral health has been recognised and the number of such studies increased, the importance of accurate data collection and input has increased. Inter-examiner and intra-examiner variability can be reduced by training and standardisation of diagnostic criteria and recording methods. Thus data validation has become an essential part of data input.

The development of micro-computer systems has allowed methods of direct data input to be used at the examination site, allowing error checking to be carried out while the subject is still present. One such system was described in 1981 by Pieper et al (221).

A portable data recording system based on a CBM 3040 micro-computer was developed. Following the input of a subject's personal data, a series of screen displays, each representing a quadrant of teeth, prompted the operator to enter surface caries data. The system provided immediate checks for illogical and contradictory entries, allowing for correction of recording errors. The collected data was stored on a floppy disk and transferred to the main-frame computer system with a special transfer program. It was reported that this method excludes human error during data transfer (221).

Both data input and transfer programmes were written in the BASIC programming language, allowing easy transfer to other computer hardware. The advantages of the system were a tenfold improvement in the detection and correction of examiner's errors and a greater reduction in errors by recording personnel (221).

Other data input methods have been tried with the aim of increasing the efficiency and accuracy of data entry. These systems include the use of a touch screen system and user-defined keyboards in the first half of the 1980's (223) (224). As well as the voice input dental system described by Baumgarten in 1988 (224), voice recognition has been tested in a number of medical applications, including radiology reporting, laboratory data input and to assist motor impaired patients (225).

A pilot study was funded in 1986 to develop a dental charting system utilising voice recognition in a clinical environment (225). The keyboard of an IBM PC computer was replaced with a Keytronics keyboard, which was attached to a telephone operator's style headset and a foot switch. The DMFS charting system was programmed in "C" high level language to be operated by the Keytronics Voice Recognition software. The system was then tested on 20 patients, comparing the time taken and the number of errors against the traditional examiner/recorder method. Only un-corrected errors were counted in the analysis.

There was a significant difference in the mean time per examination, with the traditional method proving a third faster at 2.69 minutes compared with 3.72 for the voice recognition method. The error rate using the traditional method was also lower, at 0.1 and 0.6 respectively, although this was not significant. A questionnaire completed by the subjects indicated a higher degree of discomfort with the dentist talking to a computer rather than an assistant. However 95 per cent indicated that they would still attend a dentist who used a computerized voice recognition charting system.

The results suggested that computerized voice recognition clinical charting systems could be a viable alternative to more traditional methods, although larger scale trials needed to be carried out (225).

4.7 Data storage

The traditional way of storing data was in the form of punch cards, which provided a compact and reliable means of storage, and was the original form of computer input. Apart from variations of punch card and paper tape, data can be read into the computer directly by optical character readers or direct keyboard entry. However for large quantities of examination data, storage is more likely to be on magnetic tapes or disks which can be used with a large computer system. Magnetic tapes are a good means of long-term storage as large quantities of data can be stored in a small space and data management and processing can be carried out from a computer terminal without the need for a punch card reader. However magnetic disks are more suitable during the active analysis stage as data can be retrieved and manipulated very rapidly without the need to wind a tape backwards or forwards to locate the appropriate data.

Many computer systems have standard programme suites available which can be used to analyse data from various sources. SPSS (14) for example can be used to find all records with errors by means of a validation programme. Following the checking runs, a corrected set of data can be analysed and evaluated providing results such as DMF scores and statistical comparisons. In many cases, the dental researchers use specific locally written programmes for data analysis, even though the same diagnostic criteria and data collection methods are utilised in several different studies.

When a large amount of data is collected in a standardised way, especially over a period of years, it is probably advantageous for the analysis to be carried out by a centralised computer and staff. The World Health Organisation provide such a facility and also maintain a global data bank (226). Many studies from a number of countries use the WHO computer facility and its standard data collection chart (227). The National Institute for Dental Research at Bethesda in the United States of America also provides facilities for the analysis of many different studies.

While relatively slow, desk-top computers available in 1980 were capable of simple tasks such as DMF counts and practically all types of statistical evaluation (220). These procedures can obviously also be carried out on main-frame or minicomputer systems. Large systems were only really necessary for studying complex problems or processing very large data masses.

The mathematical power of modern computers has facilitated the development and use of complex statistical procedures, allowing stepwise analysis and other methods. Additionally the use of students t-test and similar statistical tests based on normal distribution was questionable due to the skewed nature of dental caries, but analysis of many studies has shown that, even in the presence of extreme skewness and kurtosis, analysis of variance tests are sufficiently robust, given the general age of sample used in caries studies, as to give accurate statistical results unless the sample size was very small (228). The two sample t-test has been shown to be robust at the levels of skewness and kurtosis normally found in DMFT datasets (229).

4.8 SPEED

The System for Planning and Epidemiological Evaluation of Dental Services - SPEED is a suite of programmes written in Fortran for use on main-frame computers developed jointly by Salford Area Health

Authority and the University of Manchester Dental Health Unit (230). SPEED (13) provided a comprehensive method for collecting and analysing dental data relating to dental disease, and treatment needs. As it was also developed as an aid in the planning and evaluation of dental care services, data is also collected relating to the use of dental services and related personnel data.

The SPEED system was designed to provide information to management to aid the planning of dental services and for use in epidemiological surveys. A standard data collection chart is used to record numerical codes relating to dental caries, oral cleanliness and gingivitis, malocclusions, prosthetic requirements and trauma. Data can also be collected regarding treatment need, this data providing potential treatment costs utilising the Resource Related Index (75).

The first section of the chart records personal data including sex, age, residential district, ethnic and social classification and dental attendance history.

After manual data checking, in the original version of the system, data was transferred to Hollerith punch cards. Each record consisting of four punch cards. However it is also possible to key the data directly to magnetic tape or other computer storage material.

The Validation programme Validate is then used to check the data for a series of range and error checks.

Once errors have been corrected a validated datafile is produced. The main suite of Fortran programmes are used to analyse the validated file. The computer operations are implemented by means of control cards or a control file which enable the various options to be selected.

The Treatment programme provides a list of each subjects' data and treatment needs. Tabulation is the main programme providing tables and cross-tabulations for dental caries and other conditions. The data can be classified by sex, age, district and other variables. Tabulation will also provide frequency tables of clinical measurements. These programmes normally provide line printer output, rather than on-screen output. Tabulation can also provide a summary data-file suitable for use with the Statistical Package for the Social Sciences - SPSS (14) to provide advanced statistical analysis, although other statistical packages may also be utilised.

The Tabulation tables include the appropriate statistical information to allow hypotheses of differences between groups to be tested.

The final programme in the SPEED suite is Reliability which analyses replicate examination data to provide a measure of inter and intra-examiner diagnostic reliability.

The various programmes are selected and controlled by means of control cards, which were originally punch cards but can now be a batch or command file. The control cards provide for the selection of up to 33 items. The tables produced contain the necessary statistical information to enable hypotheses to be tested by common statistical methods, such as Student's t-test and analysis of variance (ANOVA).

SPEED has been designed to provide information on population groups or representative samples. The system can indicate differences in levels of dental disease and treatment need allowing dental care services to be evaluated. The output provides measures of outcome, such as DMFT, or the means of measuring the care process by means of various indices and formulas. Information gained from the data can be utilised to measure appropriateness, effectiveness and efficiency of services.

The SPEED suite of programmes were used to collect and analyse the data in the original 1980 fluoridation study. The use and effectiveness of the SPEED suite will be further discussed later in the thesis.

4.9 Micro-computer systems

The development of micro-computers allowed new methods to be developed for data input. The use of mechanical and manual punching of data or optical reading of special forms tends to lead to time-consuming errors. A study was therefore carried out utilising an Apple II micro-computer for direct data entry at the time of the examination (231). A computer programme was developed which displayed an image of a dental form on the monitor screen. Data was entered from the keyboard and stored on floppy disc. As the data was entered, the programme validated the data and gave a warning if an entry was outside the valid range for that item. Comparison with the punch card method showed that while there was an 8 per cent error rate with the old method, the new keyboard entry technique gave an almost zero error rate.

The entered data was transferred directly from the Apple micro-processor to the main-frame computer for analysis. This transfer was completed in hours, rather than the two weeks it normally took to convert forms onto punch cards and input the data into the main-frame. It was suggested at the end of this trial, that voice input data would have further advantages for speeding up data input into the computer (231).

As small desktop computers became readily available it became possible to develop epidemiological systems based on micro-computers to carry out the data processing for most investigations. Such a system was developed for use in the South West Region of England (232). The system was based on a CBM computer, which had a 32K memory. The computer weighed 44 lbs and was considered sufficiently portable to be transported to the examination site where data was entered and stored on a cassette tape. The stored data was analysed at a central point with a computer equipped with a disk unit and a printer. The data analysis system was known as Dentanplus. After a 12 month trial in the South West Region of England it was concluded that the system had facilitated the collection of epidemiological data required for the evaluation and planning of dental services (232). Many dental research centres had their own computer systems operating programs that had been developed over a period of years (232). However they were not interchangeable and were designed for specific tasks. Further development of the Dentanplus programme led to the introduction of a dental module for a commercial program called Surveyplus (234) which was designed for the collection and analysis of research data. This system had been developed to run on a Commodore micro-computer. Dental data was directly input utilising an on screen schematised display. Once entered the data can be tabulated and subjected to statistical analysis. A review of Dental Surveyplus reported that the program provided the means to process most research information (233). The constantly changing technology and proliferation of computers has led to newer more sophisticated programmes which allow the collection, processing and analysis of very large data bases.

Brunelle (235) reviewing the use of computers in dental studies felt that direct data entry from the keyboard, aided by a forms image including some data checks on the monitor was certainly a more direct way of inputting information. However, while being a successful method for small studies, this type of system had two possible draw-backs for large scale clinical trials. A well trained person would be required to enter the data rapidly and a failure of the storage device would lose the data as there would be no hard copy back-up available.

At that time, the National Institute of Dental Research operated a system which processed a large number of clinical studies and epidemiological surveys. Data input to the main-frame computer was by means of optical mark readers to disk or computer tape, including the provision of back-up copies. Validation and analysis were performed by a range of programmes written in higher level languages, such as Fortran or PL/1 (235), This system provided many variations in data analysis and also allowed data entry via direct data transmission lines.

Additionally, a number of standard computer packages for almost any computer system, were available to perform a myriad of statistical procedures.

4.10 Statistical analysis packages

Three of the most widely-used statistical program sets are the Statistical Analysis System (SAS), (236) Biomedical Computer Programs (BMDP) (237) and the Statistical Package for the Social Sciences (SPSS) (14). However, these packages lack uniformity in their data definition format, which can lead to the need to re-format data to allow a specific package to be used, a time-consuming process. Unfortunately the ease of obtaining a large variety of statistical analysis can lead the unwary into the use of inappropriate and misleading methods.

While geographic divisions and Social Class can be used as independent variables in data analysis to indicate differences between population groups, the broad brush approach of these methods can in itself create difficulties. It is difficult, for example, to satisfactorily combine geographic boundaries with social class groupings. However the availability and use of computer data-bases can overcome these problems. A system such as ACORN - A classification of Residential Neighbourhood can reasonably accurately group subjects within a geographic district by socio-economic grouping (238). ACORN is based on census statistics and by means of cluster analysis comparing census enumeration districts by 40 key variables covering demographic, socio-economic and housing characteristics. The system identifies 36 types of Residential Neighbourhood which are generally aggregated into 11 Neighbourhood Groups.

A study comparing the use of ACORN and geographic districts as a basis for analysis of dental data found data collection was simpler and the ethical problems of the use of Social Class were avoided by the ACORN method (239). The study also showed that the planning of dental services using geographic districts may fail to take into account inequalities of dental health within the district. ACORN assigns subjects to their appropriate group by means of a database based on Post Codes (238).

The Korner Report (248) on information requirements in the National Health Service recommended minimum data sets for health service management. Post codes were recommended as an item in the minimum data set for hospital patients, and that post codes should become a standard data item for most groups, including dental.

A questionnaire survey in 1984 examined the use of computer applications in the Community Health Services in the U.K. (241). A literature review carried out as part of the study found little published information. Despite achieving a 95 per cent response rate from Health Authorities the survey only reported one use of computers relating to dental workload. It would appear that a number of Health Authorities may have failed to report the use of programs such as Surveyplus to collect and monitor dental health statistics in their area.

4.11 Surveyplus

Surveyplus and its dental module became widely used by District Dental Officers in England, providing a wealth of epidemiological data which formed the basis of the surveys co-ordinated by the British Association for the Study of Community Dentistry (153,155,242,143).

Smaller, more powerful and cheaper computers have proliferated following the launch of the IBM PC micro computer which has led to the development of many clones based initially on the Intel 8086 processor chip and the DOS operating system. These PC clones have been followed by versions using faster and more powerful central processor chips such as the Intel 80286 and 80386. As a result, Surveyplus has been further developed to operate on the PC compatible range of machines while retaining all the original features, Surveyplus has been extended to provide a comprehensive menu driven programme giving database and statistical facilities (244).

The Dental Module has also been expanded to take advantage of the greater power available on PC computers compared with the original CBM Commodore version. Access to the dental chart has been made easier and indices can be calculated automatically during data entry. The more recent versions of Surveyplus will be discussed more fully in later sections of this thesis.

4.12 Other systems

While Surveyplus and a number of other specially developed software packages can be used for direct keyboard entry at the examination site, the weight and size of portable and micro-computers have limited this use in the past. The fragility of floppy disks, and sensitivity to magnetic fields and damage in transit have also been limiting factors. However the introduction of the Psion Organiser, a hand-held computer of similar size to a calculator, offered another option. (245). The Psion Organiser is a battery-operated computer available with various memory sizes. It is an EPROM writer, enabling the storage of data on removable micro-chips or datapaks. The datapaks can either store data or hold pre-programmed software. As a result the Organiser is not sensitive to dust and has no moving parts, it also requires no external power source.

The Psion Organiser has been used by some Health Districts to collect Korner Statistics and also by researchers for epidemiological studies (245). A large number of programs are available including the data collection and analysis programme NUMBASE (246).

Numbase, allows datasets to be created with up to 254 fixed length fields. A data-collection format similar to paper-based forms have been developed for NUMBASE (244). This enables dental and related data to be keyed in directly and stored in a datapak. Range limitations can be used to reduce erroneous entries.

Once the data has been collected, it can be analysed using the statistical options of NUMBASE to produce DMFT and other scores or a communications link (Commslink) can be used to transfer data to PC compatible computers and other software packages. The largest datapak (128k) will hold 1200 records each of which can contain 100 items of information. If transferred to other programmes, including SAS, SPSS, dBASE and Surveyplus the data can be merged into larger datasets prior to analysis. A further facility, if a printer is available, is a printout of each examination at the time of data entry to provide a hard copy of the data as a backup.

Continued development of computer hardware has resulted in the availability of lap top and so-called pocket-book computers. These small portable computers with built-in screens are available with hard disks for data storage and are readily portable. As a result it is now possible to have available a reliable readily transportable computer system giving comprehensive data collection facilities using direct keyboard entry at the examination site.

Surveyplus can, for example, be used in this manner as can "DCT" developed for the Dental Health Research Unit at Manchester University. This is a customised database programme developed within DATAFLEX (247) a programme which designs custom data-bases. "DCT" has been used in clinical trials for keyboard entry at the time of examination, installed in a Compaq portable computer (248).

A further development in direct data entry is Simplesoft; a data collection programme which enters data directly through a voice recognition module. This was developed for the Colgate Palmolive Company in America and has been tested at the Dental Health Research Unit, University of Manchester on a recent clinical trial (249).

During the use of the Simplesoft system on the clinical trial, a number of problems were encountered. Although the system was installed on a portable computer, it took time to set it up at each examination location. There were initial problems in achieving accurate voice recognition from the system, as the software was designed to reject any input which did not fall within the restricted number of allowable codes. Compared with keyboard input by a recorder, it took longer per examination and was no more accurate (249). Further development of the system with a faster micro-processor could possible overcome the problems and produce a viable portable voice recognition input system.

As alternative data entry systems are still not fully developed, the two main methods in use on most epidemiological trials are either direct keyboard entry at the time of the examination or manual recording on data collection charts for later computer input, usually by keyboard entry. The rapid increases in power and memory size of portable or laptop computers, combined with reductions in size and weight will facilitate greater use of direct data entry at the time of the examination.

The British Association for the Study of Community Dentistry (BASCD) has stated that most surveys will require computing facilities. These should be as inexpensive as possible, readily accessible and provide the flexibility to undertake whatever analysis is required (250). The analysis should be under the control of the investigator and statistics should be provided by the computer package.

5. Summary

As can be seen from Section 1 of the review, Fluoride tablets were being recommended to strengthen teeth in the last century, but it was the 1930's before a link between fluoride in water and reductions in dental caries was established, in conjunction with an investigation into the cause of mottled teeth.

After further investigations to establish that a fluoride concentration of 1 part Fluoride per million was the best for caries control without side effects, the first of a number of clinical trials began in 1944 investigating the results of fluoridating the public water supply of Grand Rapids, Michigan.

Following the North American trials, a British Fluoridation trial began in Andover, Watford, Anglesey and Kilmarnock. The Andover scheme was abandoned after only two years. However after five years, caries prevalence was 50 per cent lower in the fluoridated areas compared with their controls. At that point fluoridation ended in Kilmarnock and, five years later, caries levels in 5 year old children in Kilmarnock had returned to parity with the control town of Ayr.

This was one of the few studies, outlined in the literature review, which examined changes in caries prevalence after the ending of fluoridation of public water supplies have all reported increases in caries rates in children within a few years of the change.

However, apart from the investigations in Wick, all the studies were conducted some time ago when there were higher general levels of caries. Although the Wick Study was carried out in 1979 and 1984, following the arbitrary ending of fluoridation in 1977, when declining caries rates in children were being reported in Europe and developed countries. It was the early part of the period of temporal decline. The decline has been attributed to a number of factors, the principal one being fluoride toothpaste. It is likely that the majority of children in the Wick Study were using fluoride toothpaste as it became readily available at the beginning of the Eighties, but it is not possible to definitely ascertain what proportion of toothpaste sold in Wick contained fluoride at that particular time. However in the second half of the decade, 97 per cent of toothpaste sold in Britain, contained fluoride.

A study of trends in dental health in the formerly fluoridated area of Wigtown District would therefore provide information relating to the effect of the cessation of water fluoridation when fluoride toothpaste is almost universal and during a period of temporal decline.

Section 2 reviews changes in caries prevalence with particular reference to the decline in caries levels in developed countries, which has continued since the 1970's. This continuing fall in the incidence of caries has led to a need to review the traditional measures of caries incidence and oral health status. The DMF index provides a cumulative life-time measure of caries experience rather than the current caries rate of the individual or population. Because of the efforts to develop new measures, it is necessary for computer based dental analysis systems to be flexible and able to produce a variety of indices from dental data collected in a standard manner.

Accordingly programmes such as SPEED, which has been used in the studies of dental health in Stranraer and Annan, need to be modified or developed to provide other indices and status measures from the data collected. A further need is for easy modification of the programme to accommodate any new measures which may be developed.

It therefore seems to be most appropriate to carry out research into secular trends in the formerly fluoridated area of Dumfries and Galloway while developing the computer system to provide additional information from the original and new data, which may give a greater insight into the changes happening following the cessation of water fluoridation during a period of temporal decline of caries experience.

The published data relating to changes in caries prevalence following the ending of water fluoridation is mostly old and limited in its scope. Therefore the cessation of water fluoridation in Wigtownshire in 1983, after 15 years, provides a fairly unique opportunity to study any resulting changes which may occur. A series of comparable studies also allows an analysis of secular trends in dental health and related treatment costs in formerly fluoridated and negligible fluoride areas in Scotland. Further development of the computer analysis system in conjunction with these studies would provide the opportunity to examine the old and new data in greater detail.

AIMS AND OBJECTIVES

The study of secular trends in the dental health of schoolchildren carried out in 1986, almost three years after fluoridation ceased in Stranraer, had shown a residual benefit from fluoridation, but there was an indication of a possible adverse trend in 10 year old children. It therefore appeared important to study in greater depth the changes in caries prevalence in children in Stranraer and Annan between 1980 and 1986 to further investigate the trends found.

As the Kilmarnock and Wick Studies were carried out over a 5 year period, it was appropriate to conduct further studies to compare caries prevalence in Stranraer and Annan and examine trends over time. The first of these should be conducted in 1988, five years after the cessation of water fluoridation.

A number of objectives can be formulated for these new investigations:-

a) To assess whether the previous fluoridation of the public water supplies in Stranraer had conferred a continuing benefit in terms of lower caries incidence when compared with non-fluoridated Annan.
b) To study changes in caries prevalence in Stranraer and Annan since 1980.
c) To assess differences in the potential cost of treatment required at the time of the examination between Annan and Stranraer schoolchildren.

d) To examine changes in the potential cost of treatment in the two towns since 1980.

The extended dataset, which will be made available from these studies, will provide a solid basis for on-going monitoring of changes in caries prevalence, particularly if water fluoridation should recommence in Wigtown District. The fluoridation plant has been in care and maintenance since the legal judgement, so Dumfries and Galloway Health Board may well re-introduce fluoridation at an early date following the appropriate consultation process.

The System for Planning and Epidemiological Evaluation of Dental Services suite of programme only provides DMFT and its component scores as caries prevalence information; but it was felt to be advantageous to obtain additional information relating to tooth surfaces rather than just individual teeth.

To achieve this, the SPEED programmes would require modification to provide surface data in the latest study as well as giving additional information from the original data. It would also be advantageous to enable data processing to take place on readily available micro-computers rather than a main-frame. Such a development would also allow the system to be adapted for direct data entry at the time of examinations.

Three further objectives were therefore included as part of this research project:-

1) To modify and develop the SPEED suite of programmes to enable tooth surface data to be analysed to provide further information relating to caries incidence.
2) To devise methods of obtaining additional information from the data collected in 1980 and 1986 using the standard SPEED data collection system.
3) To modify the SPEED suite to operate on a micro-computer.

A number of null hypotheses to be tested have been developed from these objectives.

1) That there is still a reduction in caries prevalence in formerly fluoridated Stranraer compared with non-fluoridated Annan.

2) That there has been no change over time in the levels of caries prevalence in children in Stranraer and Annan since 1980.

3) That there is no difference in the patterns of caries incidence found in Stranraer and Annan in the studies.
4) That there has been no change in the relative cost of treatment required in Stranraer and Annan by comparison with the 1980 study.

Although the development of the computerised analysis program forms part of the objectives of the research project, it is not planned to produce quantitative comparisons with the original suite of programmes. Comparisons and changes to the programmes to increase the detail available from the data and to enable the program set to operate on a micro-computer will be considered qualitatively rather than attempting any statistical comparison. Therefore no null hypotheses have been formulated in relation to the computer work in this project.

METHODS

Following the literature review, it was possible to develop a series of null hypotheses to be tested in this thesis. Thus it is necessary to develop a study outline and methodology which will meet the aims and objectives and provide the appropriate information to test the null hypotheses.

In addition to further analysis of the data available from the 1980 and 1986 studies, it is necessary to plan further studies to provide up to date data relating to caries experience and treatment costs in the formerly fluoridated town of Stranraer and its control town Annan.

To enable a comparison to be made with previous investigations into the effect of ending water fluoridation, a study was planned to examine caries prevalence five years after the closure of the fluoridation scheme in Wigtown District. A study was therefore planned to be carried out in 1988 using a similar sample of 5 and 10 year old children in the two towns, Stranraer and Annan.

A further study was also planned to investigate caries experience in 1991, five years after the 1986 study, when an apparent early adverse trend was found. As well as continuing to monitor 5 year old children in the two towns, it is hoped to re-examine the 10 year old cohort in the 1986 study to establish whether the apparent trend revealed in 1986 has continued or was a statistical artefact.

As more detail will be required from both old and new studies than provided by the original System for Planning and Epidemiological Evaluation of Dental Services - SPEED suite of programmes, it will be necessary to develop the programme to provide surface data in addition to the DMF tooth data normally available. To aid this process and move away from the constraints of access to a main-frame computer, the SPEED programme was transferred to a micro-computer system. SPSS, which is used in conjunction with SPEED for statistical analysis, is also available on micro-computers. The literature review has also indicated that the data analysis programmes should be able to provide a variety of indices of oral health status as well as the DMF indices. Accordingly development of the data analysis programme will include provision of flexibility in the system of data collection and analysis to meet this need.

Further detailed description of the methodology will be given under the following sub-headings:-

4.1 Caries Studies

4.2 Data collection

4.3 Data processing

4.4 Computer methodology

4.1 Caries Studies

The 1980 study was a cross - sectional survey of children in two towns, Stranraer and Annan, which recorded the prevalence of dental caries. The mean caries prevalence figures were compared to assess the percentage reduction in caries prevalence for Stranraer in comparison with Annan. Stranraer's public water supply has been fluoridated at a rate of 1 part fluoride per million since 1967 and the significant difference found in caries prevalence was attributed to this factor.

The 1986 investigation was a descriptive cross - sectional survey of three groups of schoolchildren in Stranraer and Annan. The study was a repeat of the 1980 study, to allow comparisons to be made over a period of time. The study had been planned to provide information for the testing of hypotheses relating to fluoridation of the public water supply in Stranraer and the secular trends in caries prevalence in the two towns.

The sampling method used in the 1980 study was adopted. Data has been collected by the same examination method, using the same criteria and standardised data collection charts. An additional age group was included to assess the effect of a longer period of water fluoridation in Stranraer. The prevalence of dental caries was recorded using the DMF and dmf teeth indices. These indices are a measure of past and present caries experience to give the prevalence of caries at the time of the examinations. These indices were also used in the 1980 study.

As a result of the early indications of an adverse trend in caries prevalence in Stranraer found in the 1986 study, the 1988 study was a repeat of the 1980 study, five and a half years after fluoridation ceased. The same criteria and indices methods were employed to measure caries levels and provide an assessment in changes of prevalence over a period of time. The same methodology and criteria were also employed in 1991.

4.1.2 Study Areas

The towns chosen for the 1980 and 1986 studies were Stranraer (fluoridated) and Annan (non - fluoridated) and these towns were again selected for the later studies. The approximate population sizes are 13,800 and 11,150 respectively. There has been a small increase in the size of each of the populations since 1980, due to a drift from rural to urban areas. Both towns are small ports supporting some light industry and services for the surrounding farming areas. Stranraer is also a ferry terminal. Both towns lie on the A75 Euroroute. The social class composition of the towns is similar. Dentist/population ratios are approximately equal in the two towns, split between the General Dental Service and the Community Dental Service. Hospital Dental services are provided by the same consultants, based in Dumfries. Peripheral clinics are held in the Garrick Hospital, Stranraer, but patients from Annan have to travel to Dumfries for Hospital Dental Services. There has been a small increase in the level of dental services available in the two towns since 1980, due to an increase in the number of General Dental Practitioners. Both towns have relatively stable, indigenous populations.

4.1.3 Sample

All children in three age groups attending all maintained non - denominational schools in Stranraer and Annan were included in the surveys. The schools participating in the studies were:-

STRANRAER	ANNAN
Park Primary	Newington Primary
Belmont Primary	Hecklegirth Primary
Sheuchan Primary	Elmvale Primary
Rephad Primary	Annan Academy
Stranraer Academy	

Belmont School was known as Dalrymple School in 1980. Elmvale is a new school, built since 1980, its pupils were drawn from the other schools in Annan. The two Academies are additions in the 1986 study to provide the older age group. Each town has one parochial (catholic) school. These schools have a different catchment area and were not included in the interests of homogeneity of the sample. All children in the specified age groups were examined , apart from those absent at the time of the examinations. Only life - time residents were include in the analysis.

The three age groups were as follows:-

1) All children in Primary 1 classes (mean age approximately 5.0 at the beginning of the Autumn term).

2) All children in Primary 6 Classes (mean age

approximately 10.0 at the start of the Autumn term).

3) Children in Secondary 4 forms, resident in Annan or Stranraer (mean age approximately 15.0 at the start of the Autumn term).

The first two age groups are the same as the age groups studied in the 1980 survey. The third group was included in 1986 as life-time residents of Stranraer, this group had received artificially fluoridated public water since birth up until the summer of 1983 when fluoridation had to cease as a result of the Strathclyde Fluoridation verdict. The 15 year old group were not included in the 1988 study, although it is planned to examine the 15 year old children in 1991, five years after the 1986 study.

The numbers in the sample are similar to those in the 1980 study, although there is a small reduction in the numbers due to falling school rolls. (Table 1).

Calculations, based on the results of the 1980 survey, indicate that the sample size in the 5 and 10 year old age group will give the study a power of 0.99 at the 5 per cent level. At a power of 0.9, the smallest significant difference in mean DMF which will be detected is estimated at 0.72.

4.1.4 Examination Environment

The 1986 examinations were carried out at each school by the examiner and scribe, using portable equipment, comprising a portable reclining chair, operating light and compressed air syringe. Although a mobile examination unit was used in the 1980 study, the operating light and air syringe utilised in 1986 were of identical type, the same equipment was used in the later surveys. The mobile examination unit used in 1980 is no longer in existence.

The examiner in the later studies was one of the two examiners involved in the 1980 study. The examiner attended a training and calibration course to re - standardise for the SPEED system and the criteria used prior to each survey. A reproducibility exercise was carried out at the end of each of the training courses. During the study examinations, replicate examinations of a random 10 per cent of the sample were performed to allow calculation of the reliability coefficient for the examiner. The coefficient calculated by the SPEED program is equivalent to Pearson's r. The two scribes who recorded the data in 1980 and 1986 also recorded the data for the later studies.

The diagnostic examination employed is based largely on visual criteria. A blunt 0.5 diameter probe was used as an aid in the caries and periodontal examinations, being available for cleaning the fissures and free smooth surfaces to improve observation. Specially modified Sickle probes were used in 1980 and 1986, while CPITN probes, which have a 0.5mm ball end, were used in the other studies.

All teeth were examined and caries recorded where there was a visible breakdown of the enamel resulting in cavitation or an unquestionable shadow or opacity beneath the enamel. When doubt existed, the lesion was gently tested with the blunt probe and, unless the tip entered the lesion, the site was recorded as sound. The validity of this examination method has been confirmed in previous studies (65,66).

The type of treatment need, recorded for each tooth, was confined to items allowed under the National Health Service Regulations. A denture was prescribed if permanent tooth loss caused spacing of more than half a tooth unit in the upper anterior segment or at least three units elsewhere in the mouth, or to replace an existing unsatisfactory denture.

The periodontal examination method was based on the partial recording method of Lennon and Davies (176). The presence or absence of soft or calcified supragingival accretions, frank gingival inflammation and subgingival calculus deposits were recorded. Full details of the caries and periodontal examinations and criteria are in Appendix 3 and 4.

The criteria used are designed to reflect stages in the disease processes which call unequivocally for particular types of intervention. The probability of recording disease when it has not reached a stage calling for a specific intervention is thus minimised. The validity of the method of caries diagnosis has been confirmed and the periodontal disease screening procedure evaluated. The diagnostic technique is based on established systems (150, 176, 254).

4.2 Data Collection

A standardised method of data collection was employed to collect and record data on dental diseases oral cleanliness and need for dental treatment, together with relevant personal information. Data was recorded in numerical code on schematised data collection charts (Appendix 5). One chart was used for each subject and it contained all the data recorded for one subject. The charts provide for the collection of data on dental caries, oral hygiene, the presence of gingivitis and calculus, denture requirements, dental trauma and personal information. There is also a provision for the recording of malocclusions, but these were not recorded in this study. Data relating to identified treatment need was also recorded.

Each chart is identified by a unique four digit identification number, commencing at 0001. In the personal information section, the following boxes were completed. Exam Type, Sex, Age (years and months), Age Group, School District, School Number, Social Class and Period of Residence. Additional information was also collected for the 15 year old age group, boxes 17 to 19 relating to dental attendance and treatment and box 27 relating to future educational plans were completed. A single digit code was used to indicate social class, based on the Registrar General's Classification (70). Each school was allocated a specific code (range 1 to 9) and districts an individual code prior to the start of the examinations. These codes were recorded under school number and school district.

To shorten the time required per examination, as much as possible was pre-coded on the charts prior to the field examinations. Information to allow this was obtained from the Community Dental Record cards and the schools. Coding was as specified on the data collection chart, except where stated.

Following completion of the personal information section, the periodontal examination was performed.

The principal aim of this examination is to establish the need for treatment of periodontal conditions and the level of oral hygiene. The 5 year old age group did not receive periodontal examinations.

The periodontal examination is restricted to 12 sites in the mouth. These sites are the mesio - buccal aspects of each of the permanent incisors. The gingival third of the tooth surface and the papillary and marginal gingival associated with it, are regarded as one unit for evaluation purposes. Second molars were substituted if the corresponding first molar was absent, But no other substitution was used. Boxes 37 to 72 were completed in accordance with the criteria and coding (Appendices 3 & 4).

The final stage was the examination for caries, trauma and prosthetic requirements. The aim of data collection in this section was to record the presence or absence of teeth, treated or untreated caries and trauma and any prosthetic requirements. The chart provides for recording the findings for 32 permanent teeth and 20 deciduous teeth. Only deciduous teeth data was recorded for the 5 year old age group, both permanent and deciduous tooth descriptors were completed for the 10 year old age group and permanent teeth only recorded for the 15 year old age group. If a tooth was recorded as requiring treatment in the tooth descriptor section, the corresponding box was completed in the tooth treatment section. Codes and criteria were as shown in Appendices 3 & 4. Supernumerary teeth were not recorded in this study.

To provide additional information and to facilitate the comparison of micro - computer based dental survey systems, caries surface data was also recorded on a separate form utilising the same diagnostic criteria (Appendix 6). The SPEED data collection chart does not provide for the recording of caries surface data.

4.3 Data Processing

Data has been processed in the first instance on a main-frame computer, using the standard suite of programmes developed for the System for Planning and Epidemiological Evaluation of Dental Services - SPEED (13). Analysis also required the use of the Statistical Package for the Social Sciences - SPSSx (14). With the agreement of the authors of the SPEED suite of programmes, a copy of these programmes written in Fortran high level language for the VME operating system was obtained from the Scottish Office Computer Services in 1986 and installed on the Glasgow University Main Frame computer.

Data processing consisted of three stages: data preparation, data validation, and data analysis. Prior to data preparation, the completed charts were hand-checked for obvious errors and omissions, including completion of the mandatory boxes 1 to 4, 8 and 13. The replicate charts were then separated from the routine examination charts. The charts were arranged in numerical order and passed to data preparation for input into the raw data file.

The raw data file was then checked for errors by the programme Validate, which provides a list of identity numbers and appropriate error messages. When all errors have been corrected, the Validate programme outputs the reformatted data as a validated file onto magnetic tape, ready for analysis. It was also necessary to input the Title and Costs File. This file provided the necessary information regarding the scale of the fees required for calculation of treatment costs. The Title and Costs File is based on the Resource Related Index developed by Hill and modified by Downer et al (75) (Appendix 7). The fee scale information uses the latest fees related to the British National Health Service Statement of Dental Remuneration, adjusted to reflect relativities agreed by the Dental Rates Study Group following the

Sunningdale Conference of general dental practitioners on the timing of dental procedures.

The data from the 1980 survey was stored at Edinburgh University on magnetic tape as an unvalidated file. A copy was obtained , validated and analysed by the same methods. The same data processing procedure was followed in 1986 and the data stored onto the University of Glasgow main - frame computer with the 1980 data. This permitted additional analysis and comparison with the data sets for the three studies. The same data input methodology has been employed for the later studies.

Data analysis is provided by the programmes Treatment, Tabulation and Reliability. These programmes utilise the validated data file and the Title and Costs file. The treatment programme calculates the decayed, missing, filled indices for permanent and deciduous teeth for each subject and estimates the treatment requirements.

Tabulation is the largest programme, designed to produce a variety of tables and analyse the data in various subsets. As originally written the programme was controlled by means of a set of 80 column punched cards. Each control card provides the necessary data for one run. An automatic re - run facility is provided, allowing the use of a series of control cards. Following the installation of the SPEED suite of programmes in Glasgow, the opportunity was taken to modify the control arrangements. The programme is now controlled by a job or batch file which utilises a control command file containing the necessary selection instructions for each run, avoiding the need for punched cards.

Tabulation provides three main types of tables, which can be further sub - divided. Disease tables are divided into two types. Type 1 provides tabulations related to decayed, missing filled, permanent and deciduous teeth. The main type 1 analyses used tabulated DMFT and dmft by District. It also tabulated by sex and by the subsets Decayed, Missing and Filled. Type 2 gives information regarding dental attendance, oral hygiene, gingival condition and prosthesis. These categories were analysed by District, School and Sex.

Costings Tables produce a variety of treatment cost tabulations. This set of tables were used to tabulate Restorative treatment, Extractions, General Anaesthetics, Periodontal treatment and Total treatment cost by District, School and Sex. Analysis of General Anaesthetic need, while expected to be small in quantity, was felt to be important as this procedure has the risk factor associated with it.

The final group of tables available are Frequency Distribution Tables. These fall into three groups. Type 1 produce decayed, missing, filled and DMFT for the permanent dentition. Type 2 give the corresponding frequencies for the deciduous dentition. Type 3 provides the frequency calculations for plaque, gingivitis and calculus. All three types can be analysed by sub - groups. Basic statistical data, such as mean and standard deviations are also provided with these tabulations.

The tabulation programme provides the additional option of Summary Data Output. This was utilised to produce a data file for use with SPSSx. Analysis of Variance, Multiple Regression, Chi - square, Student's t and Mann - Whitney U tests were calculated utilising SPSSx. 95% Confidence intervals were also calculated (251). The statistical analysis was used to assess the significance of the results, expressed as a p value. The reliability programme estimates the reliability coefficient between duplicate examinations of the same subjects to ascertain intra - examiner reliability. This programme was used in the 1980 study to calculate the inter - examiner and the intra - examiner correlation. In 1980, correlation was found to be very good, with scores between 0.94 and 0.98 between examiners and replicate reliability of 0.99.

Reliability calculates a reliability coefficient for decayed teeth, DMFT, Plaque, Gingivitis and Subgingival calculus and treatment prescription.

Comparison was made between the mean DMF/dmf and treatment cost figures for Stranraer and Annan to assess the effect of water fluoridation on dental health in the different age groups. These results were also compared with the results of the 1980 study to identify any change. Additionally DMF/dmf and treatment cost results for Annan were compared with the results for Annan in 1980 to identify any change or trend. A similar comparison was made between the 1980 study and present results for Stranraer.

4.4 Reliability

A random 10 per cent of the sample examined in each study were recalled for replicate examinations to assess intra-examiner reliability. The replicate examinations were not carried out as a block, but were distributed among the routine examinations. The examiner was not aware whether the subject was having a routine or replicate examination, as selection of the replicate subjects was carried out by the recorders

The replicate examinations were compared with the routine examination for each subject. Analysis was carried out by the Reliability programme of the SPEED suite, which calculates a reliability coefficient for 17 variables equivalent to Pearson's r (251). This method was also employed in the 1980 study. A similar analysis was also carried out of the replicates in the 1991 study. Intra-examiner reliability was also measured for decayed and filled surfaces by means of Dice's Coincidence Index (252).

4.5 Computer Methodology

To allow transfer of the SPEED programme and to analyse dental survey data on a micro - computer, an IBM PS2 Model 50z. micro - computer was installed and set-up. A database package, graphics programme, Fortran compiler and the Statistical Package for the Social Sciences for PC compatible computers (SPSS.PC) were installed on the 60 Mb hard disk. The computer has 5.5 and 3.5 floppy disk drives to facilitate data transfer and input. The PS2 Model 50z has an 80286 processor running at 12Mhz and the optional 80287 maths co - processor chip has been fitted to provide faster calculation times.

The System for Planning and Epidemiological Evaluation of Dental Services (SPEED) suite of programmes were transferred onto floppy discs from the main-frame using the University of Glasgow Kermit Programme. The programmes were then loaded into the IBM PS2 micro-computer. Following some minor amendments, the programme modules were ready for use. Printouts of the various programmes were produced to allow modifications to be planned to enable dental surface data to be collected and analysed on the micro-computer. An SPSS.PC command file was also produced to facilitate the analysis of data with the SPEED system.

It became apparent at an early stage that major modifications would be required to the existing Fortran programmes to enable Surface data to be analysed, particularly to provide both DMFT and DMFS scores. An alternative was the provision of an additional module to provide DMFS analyses of data. This would have required a further section to be added to the standard SPEED data collection chart. To assess which, if either, of these options should be pursued, it was decided to obtain copies of available software for the analysis of dental data on micro-computers.

The majority of dental software programmes available are Practice Administration programmes. While able to handle clinical data, they are mainly tailored to handling appointment lists, invoicing and other business aspects. Therefore only programmes designed to handle survey or clinical trials data were considered. Copies of the small number of such programmes were obtained for assessment relating to facilities provided by this software and the SPEED suite of programmes. Comparison was made with both the main-frame installation of SPEED and the converted version on the IBM micro-computer with the additional SPSS command file.

Data collected in the following studies was analysed on the IBM micro - computer utilising various programme sets:-

a) Athens - 12 year old children
b) Glasgow - studies of 5, 12, & 15 year old children
c) 1988 Stranraer & Annan survey of 5 - 10 year old children
d) Abu - Dhabi - 5 & 12 year old children
e) Greater Glasgow - Children in special need schools

f) Caries and Enamel Hypoplasia in Tuberous Sclerosis Patients

The data in the first three studies was initially input and analysed with SPEED on the University of Glasgow main frame to provide the survey results.

Following their initial analysis, the datasets from the 1986 and 1988 Stranraer-Annan studies, the 1987 Glasgow study and the survey of 12 year old children in Athens were utilised to assess the SPEED, Numbase and Surveyplus analysis systems.

The data was input into the micro-computer using each programme and then the various programmes were assessed and compared for their ability to perform various functions and the ease with which these could be performed.

The later studies were used to field test and develop the Dental Analysis System, which was written as a modular set of SPSS command files. The study data were input directly to the micro-computer using either the database programme or the data entry module of SPSS.PC. Both of these programmes allow the creation of an on-screen form which corresponds to the data collection chart utilised on each study, facilitating data input. Datasets were also input directly into the software which was being assessed.

RESULTS

The data collected from four studies provides a large amount of information to be reported in this chapter. The results have therefore been sub-divided into a number of sections to aid the reader. The sections are as follows:-

1. Population
2. Caries
3. Secular Trends
4. Periodontal Results
5. Treatment Costs
6. Social Class
7. Dental Attendance
8. 10 Year Old Cohort
9. Reproducibility
10. Computer Analysis Systems

1. Population

The target population for all of the studies involving Stranraer and Annan was the total available population of children attending state schools in Primary 1, Primary 6 and Secondary 4 classes. Tables 1 to 4 give details of the target population, number examined and life-time residents for Stranraer and Annan in each study.

1.1 The Samples

1980 Sample: In 1980, 95.9 per cent of the target population in Stranraer were examined and 95.4 per cent of the Annan target group (Table 1). Two age groups were included in 1980, namely Primary 1 and 6 pupils. The results will be presented for life-time residents only. There were 101 life-time residents in Primary 1 in Annan, 86.3 per cent of the target population, and 129 life-time residents in Stranraer, 81.6 per cent of the target population. The average age of the Primary 1 life-time residents included in the analysis was 5 years 4 months in both towns.

In the 10 year old group, Primary 6 children, 141 life-time residents were included in the study analysis, comprising 82.9 per cent of the target population in Annan (Table 1). The average age of this group was 10 years 4 months. Of those examined in Stranraer, 147 were life-time residents, 77.4 per cent of the target population. The Stranraer subjects had an average age of 10 years 5 months. One child refused the examination, the remainder of those who were not examined were absent from school at the time of the examinations. Apart from the 10 year old group in Annan, there were more girls than boys in each group.

1986 Sample: Three age groups were examined in 1986, the target population being all pupils in Primary 1, Primary 6 and Secondary 4 classes in each town. The total available population in the two towns was 274 in Primary 1 (5 years old), 326 in Primary 6 (10 years old) and 353 in Secondary 4 (15 years old). Examinations were carried out on 248 (90.5%) of the sample population of Primary 1 children, 301 (92.3%) of Primary 6 and 315 (89.2%) of the Secondary 4 pupils.

After elimination of non life-time residents, 210 (76.6%) in Primary 1, 323 (71.2%) in Primary 6 and 224 (63.4%) in Secondary 4 were include in the analysis. Table 2 shows the division between Stranraer and Annan. The average ages at the time of the examination were 5 years 5 months in Stranraer and 5 years 7 months in Annan for the 5 year old groups. Mean ages for Primary 6 were 10 years 6 months and 10 years 7 months respectively. Average age of the Secondary 4 children in Stranraer was 15 years 8 months and 15 years 7 months in Annan.

A total of 170 boys and 194 girls were life-time residents of Stranraer and 149 boys and 155 girls were life-time residents of Annan. Apart from the 15 year old group in Annan, there were more girls than boys in each group.

1988 Sample: The 1988 study had two age groups as in 1980, Primary 1 and 6. Table 3 shows the target population in the Primary 1 group was 266 and 319 in the Primary 6 classes. 138 (91.4%) Primary 1 children were examined in Stranraer of which 121 (80.1%) were life-time residents and therefore included in the analysis. Examinations were carried out on 109 (94.8%) of the 5 year old children in Annan and 96 (83.8%) of these were life-time residents. As the target population of 10 year old children was larger, 161 (94.7%) were examined in Stranraer and 125 (73.5%) were life-time residents. The corresponding figure for Annan were 135 (90.6%) examined, of which 114 (76.5%) were recorded as life-time residents (Table 3).

1991 Sample: In 1991, it was only possible to examine children in the 5 year old age group in the primary schools in Stranraer and Annan. However examinations were also carried out in the Secondary School on the cohort of children who formed the 10 year old age group in Stranraer in 1986. These children were examined five years later in 1991. Of the 115 life-time residents examined in 1986, 83 (72%) subjects were available for examination in 1991. The average age of the group was 15 years 10 months at the time of the examination. It was not possible to obtain access to the Annan Secondary School in 1991 to re-examine the 1986 Primary 6 cohort.

Table 4 shows the target population and life-time residents included in the analysis for the Primary 1 groups in the two towns in 1991. School number have remained fairly steady since 1988, following the previous falls in school rolls.

2. Social class distribution

Unfortunately Social Class data was not collected in the 1980 study, although the standard SPEED data collection form has provision for this information. For the 1986 and 1988 studies, subjects were allocated to social class by means of the father's occupation or the mother's occupation if she was a single parent, using the Registrar General's Classification of Occupation (253). Social Classes I to V were recorded. If the father was in the armed forces or unemployed, the subject was recorded as unclassified.

Table 5 illustrates the social class distribution found in 5 year old children in the study towns in 1986 and 1988. All social classes were represented, with a similar pattern in each town. There were slightly more Social Class I and II children in Stranraer than in Annan and slightly fewer Social Class IV and V among life-time residents in both study years. Unclassified subjects had increased from around 9 per cent to approximately 10.5 per cent in 1988, with a marginally higher proportion in Stranraer. This was due to higher levels of unemployment. The social class pattern in the two towns is similar to the Scottish pattern.

The social class distribution for the 10 year olds is shown in Table 6. Again there were slightly more Social Class I and II children in Stranraer compared with Annan. However in 1986, there was a significant difference ($p < 0.05$) between the Social Class IV groups in Stranraer and Annan. There were 21 (16.5%) subjects in Stranraer and 10 (9.5%) subjects in Annan in this category. This difference is probably due to the variation in the proportions of unclassified children in the study towns in that year, with 6.3 per cent in Stranraer compared with 11.4 per cent in Annan. In 1988, when unclassified subjects had increased from 6.3 per cent to 10.4 per cent in Stranraer, the Social Class IV groups were almost identical in the two towns.

2. Caries

Dental caries prevalence in the two towns was compared using the dmf and DMF indices for each age group. DMF teeth and dmf teeth were utilised for the 1980 and 1986 studies. In addition to the teeth based indices, decayed, missing and filled surfaces scores were also calculated from the 1988 and 1991 study data.
An estimate of decayed surfaces for the 1980 and 1986 studies, was obtained by means of additional analysis of the original data.

2.1 Prevalence

The results for the four studies are tabulated in Tables 7 to 12.

1980 Study: In 1980, mean dmft in Stranraer for 5 year old children was 2.48, compared with a mean dmft of 4.38 in Annan (Table 7). The difference between the means is 1.91, a percentage difference of 43.4 per cent by comparison with Annan. The difference of 21.3 per cent in missing teeth was not significant, but there was a statistically significant difference between all other scores for the two towns. Mean DMFT for 10 year olds in Stranraer was 1.66 compared with 3.35 in Annan, a difference of 1.69 and a percentage difference of 50.5 per cent. There was a significant difference between the individual components in the two towns.

The results were statistically analysed using SPSSx, the same statistical methods being employed for all studies. The methods used included Chi-square and Student's t-test with separate estimates of variance (251). 95% Confidence Intervals for the differences between the means were also calculated (251). As the data showed a Skewed frequency distribution and could not be satisfactorily transformed, the results were also analysed by non-parametric analysis of variance and significant differences between the groups identified by Mann-Whitney U-tests. The Mann-Whitney calculations produced similar results to the t-test, confirming the suitability and robustness of that test for dental caries data (229). Analysis of the data by school showed minor variations but no statistical differences.

1986 Study: Table 8 presents the decayed, missing and filled teeth data for the three age groups examined in 1986. Mean dmft of 5 year old children in Stranraer was 1.17 compared with a mean dmft of 3.82 for Annan. The difference between the mean scores was 2.65 or 69.4 per cent lower in Stranraer compared with Annan. This percentage difference was larger than the 3.4 per cent difference found in the 1980 survey.

For the 10 year old age group, mean DMFT in Stranraer was 1.72 and the corresponding figure for Annan was 2.81. A percentage difference of 38.8 per cent, which is lower than the difference of 50.5 per cent found in 1980. The 15 year old children had mean DMFT scores of 2.72 and 7.75 respectively. The difference between the means being 5.03, giving a percentage difference of 64.9 per cent by comparison with Annan.

Statistically significant differences between the two towns were shown to be present in all but two categories; MT and FT in Primary 6. Although these component scores were still lower in Stranraer than Annan. The percentage difference between the Filled Teeth scores for the 10 year old groups was lower at 22.4

per cent. While there was a 66.6 per cent difference between the Missing Teeth scores, the number of missing teeth in 10 year olds in the two towns was so low that no statistical significance could be detected.

Analysis by school showed no significant difference between schools within each district for DMFT and dmft indices, although there was some variation. All schools in Stranraer were better than the schools in Annan, with lower mean scores.

1988 Study: In 1988, mean dmft for the 5 year old children in Stranraer had increased to 3.08, only 3.1 per cent lower than the mean score of 3.18 for the Annan group (Table 9). The mean filled primary teeth score in Stranraer was 1.06. Compared with 0.64 for the Annan 5 year old children, this was 39.6 per cent higher. This was balanced by the mean decayed teeth score being 1.64 in Stranraer, 25 per cent lower than the Annan score of 2.19. The difference between the mean dt scores was significant at the 5% level.

A slightly different pattern of decayed, missing and filled teeth was found in the 10 year old groups in 1988. Mean DMFT in Stranraer was 2.28 compared with 2.56 in Annan, a non-significant 10.9 per cent difference. In this age group, mean DT was slightly higher and mean FT slightly lower in Stranraer than the corresponding scores for the Annan children. However none of the differences in component scores were statistically significant.

Analysis of the data by school in each town showed slight variations, but no significant differences between schools.

1991 Study: Table 10 presents the comparative data for 5 year old children in the two towns in 1991. Mean dmft in Stranraer was now about 15 per cent higher at 2.39 than the mean dmft score of 2.08 for the Annan group. The mean dt and ft scores were 15.9 per cent and 29 per cent higher in Stranraer at 1.82 and 0.40 respectively, compared with the Annan scores of 1.57 and 0.31. Mean missing teeth in Stranraer were marginally lower at 0.18 compared with 0.20 in Annan. None of these differences were statistically significant.

2.2. Caries by Sex

A comparison of decayed, missing and filled teeth scores by sex for 5 year old children in the four studies is presented in Tables 11 and 12. While boys tended to have slightly more decayed and missing teeth and less filled teeth than the girls, there was no definite pattern. None of the differences found between the sexes were statistically significant.

Table 13 presents the same comparison for the 10 year old boys and girls in each study. A similar pattern of dmf component distribution is found in this age group. Although there was a whole tooth difference in mean DMFT scores for the Annan boys and girls in 1986, there were no statistically significant differences between caries prevalence in the male and female groups in any of the three studies.

2.3. Caries by surfaces

An SPSSx procedure was utilised to estimate the mean number of decayed surfaces in the 1980 and 1986 studies, based on information available from the Treatment module. Table 14 presents the results of this analysis.

In 1980, estimated mean decayed surfaces in Stranraer 5 year olds was 1.98 compared with 5.31 in Annan, a percentage difference of 62.7 per cent. The corresponding figures for 10 year old children were 0.45 and 2.51 respectively , an 82.1 per cent difference. These percentage differences were higher than the differences between the decayed teeth scores.

In 1986, there was a 70 per cent difference between Stranraer and Annan, with mean dmfs scores of 1.25 and 4.18 in 5 year old subjects. The 10 year old group in Stranraer had a mean estimated DS score of 0.86 compared with 2.72 in Annan, 68.3 per cent lower. the 15 year old mean figures were 0.79 and 2.55 respectively, a 69 per cent difference. There was, in fact, a lower percentage difference in decayed scores in the 5 and 15 year old groups in the two towns, than the difference found between the decayed teeth scores. This reflects an increase in the average number of surfaces per restoration required in Stranraer in 1986. All of the differences found were statistically significant.

In 1988, an additional chart was used in conjunction with the SPEED data collection chart to record surface data (Appendix 6). Missing teeth were arbitrarily assigned a surface value of three for dmfs/DMFS calculations.

Mean ds was 3.38 in Stranraer and 4.28 in Annan 5 year old children (Table 15). There was a percentage difference of 11.6 per cent between the mean dmfs scores of 5.92 and 6.36 respectively. This percentage difference was higher than the 3.1 per cent difference between the dmft scores (Table 9).

In the 10 year old groups, there was only a 4.1 per cent difference between the mean decayed surface figures, as opposed to a 13.5 per cent difference in the mean decayed teeth scores. However, the proportion of filled teeth was 31.1 per cent higher in Annan than Stranraer, almost twice the difference found when analysed by teeth rather than surfaces. Mean DMFS was 4.79 in Stranraer and 6.23 in Annan, a 23.1 per cent difference which was more than double the percentage difference between the DMFT scores.

Table 16 presents the surface results from the 1991 examinations of 5 year old children. The 1991 data was collected using the Dental Analysis System (Appendix 9 and 10), which provides tooth and surfaces scores. The mean ds score was 22.4 per cent higher in Stranraer at 3.76 compared with 3.07 in Annan. Over-all mean dmfs was 4.83, 16.1 per cent higher than the figure of 4.16 reported for Annan. However none of these differences were statistically significant.

Comparison of the estimated surface scores and ds scores over the four studies shows that decayed surfaces in Annan fell from a mean of 5.31 in 1980 to 3.07 in 1991 in the 5 year old age group. The marginal increase between 1986 and 1988 may be due to an under-estimate in the 1986 calculation. Over the same period in Stranraer, after a fall in 1986, the decayed surface score had risen to 3.76 in 1991 compared with an estimate of 1.98 in 1980.

In the 10 year old children, the decayed surface score increased from an estimated 0.45 in 1980 to a mean score of 2.02 in 1988 in Stranraer. Meanwhile in Annan, the decayed surface score had fallen from 2.51 to 1.94 over the same period.

2.4. Frequency distribution

Frequency distributions for dmf components for each study and age group are illustrated in Figures 4 to 11.

In the 5 year old group in 1980, Stranraer children had a much higher proportion with dt or dmft = 0, otherwise the distributions were similar. A similar pattern was found in the 10 year old age group.

In 1988, similar differences in the frequency distribution were found in the 5 and 10 year old age groups, with Stranraer having much higher proportions with a zero score.

The differences were even more marked in the 15 year old groups. To aid the drawing of the charts, two outliers with a DMFT score of 21 and one with a score of 24 were omitted. Children in Annan in this group had much more treated and untreated caries than their Stranraer counterparts. The frequency pattern for DMFT was particularly different with a concentration of subjects between scores of 6 and 9, compared with the main group falling within the range of 0 to 5 in Stranraer.

In the last two studies, very similar frequency distributions are found for all components, reflecting the similarity of caries levels in the two study towns.

2.5. Caries-free children

1980 Study: Table 17 presents information relating to the number of children with no caries experience or untreated caries in 1980. 42.6 per cent of 5 year old children in Stranraer had no experience of caries (dmft = 0), as opposed to 15.8 per cent in Annan. In the 10 year old children, 34.7 per cent in Stranraer and only 9.9 per cent in Annan had no caries experience in 1980. Similar, but smaller, differences were also present in the proportions of children with no untreated caries. The differences found in the two towns were statistically significant ($p < 0.01$) when compared by the Chi-square method.

1986 Study: A similar pattern was found in all three age groups in the 1986 study (Table 18). 54.2 per cent of the 5 year old children in Stranraer had no caries experience compared with 27.8 per cent in Annan. Proportions for the 10 year old children were 33.9 per cent and 19.0 per cent respectively. Only 3.7 per cent or four of the 15 year old children in Annan had no caries experience in 1986, although 43 per cent had no untreated caries.

The figure of 3.7 per cent for Annan 15 year olds approximates to the figure for this age group in Scotland in the 1983 National Survey (85). Conversely, 21.7 per cent of this age group in Stranraer had no caries experience. All differences were statistically significant.

1988 Study: A different picture is found in the same comparison for the 1988 study groups (table 19). The proportion of 5 year old children with no experience of caries was approximately the same in the two towns, with 48.7 per cent in Stranraer and 45.8 per cent in Annan falling in to this category. There was a higher proportion with no untreated caries in this age group in Stranraer (67.7%) compared with Annan (55.2%). In 1988, the proportion of 10 year old children in the two towns with no caries experience were 38.4 per cent in Stranraer and 35.9 per cent in Annan. The figures for no untreated caries were almost identical at 60 per cent and 60.4 per cent respectively. None of these small differences were significant.

1991 Study: Table 20 shows a further change compared with the previous studies. The 5 year old children in Annan had fared better than the same group in Stranraer. While 39.5 per cent of children in Stranraer had no caries experience in 1991, 43.3 per cent had not experienced caries in Annan. A similar difference was found in the proportions with no untreated caries, 50 per cent in Stranraer compared with 53.4 per cent in Annan. These differences were not statistically significant however.

2.6. Caries in Anterior teeth

As the majority of caries is usually recorded in the posterior teeth, an analysis was carried out to establish the levels of caries in anterior teeth only. Table 21 presents the results of this analysis. The percentage differences were higher when only anterior teeth were compared in both the 1980 and 1986 studies.

In 1980 there was a 65.4 per cent difference in decayed and dmf anterior teeth compared with 59.0 and 43.4 per cent for the whole mouth in five year old children. A similar variation was found in the 10 year old groups with a percentage difference of 80.8 per cent, substantially greater than the 50.5 per cent difference for the whole mouth.

The 1986 results also showed the same pattern, the differences in mean dt and dmft scores for anterior deciduous teeth was 84.7 and 80.6 per cent respectively in the five year old groups. The same analysis for permanent anterior teeth in the 10 year old children found lower percentage differences of 77.8 per cent for decayed teeth and 58.7 per cent in DMFT scores. However the differences between the whole mouth and anterior teeth scores were less wide in 1986 than in 1980. All differences were statistically significant.

Comparing decayed and decayed, missing and filled anterior teeth in 1988 found percentage differences similar to the whole mouth differences with the percentage differences in mean dmf anterior teeth being only 5 per cent, compared with 3.1 per cent. The 10 year old result was similar, with a 16.6 per cent difference in DMF anterior teeth and 10.9 per cent. However the percentage difference in decayed anterior teeth was in fact slightly lower than the whole mouth percentage difference. These findings were not statistically significant.

Finally in the 5 year old children in 1991, the percentage difference between mean scores for anterior teeth in Stranraer and Annan was substantially higher than the difference found in all teeth. The percentage differences found were more than twice the differences for the whole mouth, at over 30 per cent instead of around 15 per cent. The differences were however not statistically significant.

3. Secular trends

3.1 Caries prevalence

The results of each study for the two towns were also compared and analysed by the same statistical tests to establish secular trends in caries prevalence. Tables 22 to 29 present the results of this analysis. Comparing the 1980 and 1986 results for Stranraer, reductions of up to 69.5 per cent were found in the mean dmft scores of Stranraer 5 year old children (Table 22). These were all statistically significant reductions, apart from the mean filled teeth score, where a non-significant 35.8 per cent reduction was demonstrated.

There were no significant changes between 1980 and 1986 in the 10 year old age group in Stranraer. Mean DT was unchanged at 0.35 and mean DMFT was marginally increased by 0.06 or 3.6 per cent.

Table 23 presents the same comparison for Annan, reductions being found in all components of the DMF index in both age groups in Annan, excluding the filled and missing teeth components in the 5 year old group. Filled deciduous teeth moved from 0.31 in 1980 to 0.68 in 1986, a 119 per cent increase. The mean dmft score in 5 year olds fell by 12.8 per cent to 3.82 in 1986 from 4.82 in 1980, however this was not significant. Mean DMFT in Annan 10 year old children also showed a 16.1 per cent decrease to 2.81 in 1986 compared with 3.35 in 1980.

There were further changes in caries prevalence in the study towns between 1986 and 1988. In the 5 year old age group in Stranraer, mean dmft increased by 163.3 per cent between 1986 and 1988, a highly significant change (Table 24). All dmf components showed increases over 100 per cent, but due to low actual scores, the change in the mean missing teeth score over the period was not statistically significant.

In the 10 year old groups in Stranraer, only the increases in the decayed and DMFT scores were significant. There was, in fact, a fractional fall in the number of filled teeth, which was more than counter-balanced by a 163 per cent increase in decayed permanent teeth, comparing 1986 and 1988.

Table 25 presents an entirely different pattern of change in the same age groups in Annan. Although there was a reduction in the mean dmft score for 5 year old children of 16.8 per cent, from 3.82 in 1986 to 3.18 in 1988, this change was not significant. All components of the dmft index were lower in 1988, but the only significant change was the 57.3 per cent difference in missing teeth.

Falls of up to 10 per cent were found in the DMF component scores for 10 year olds in Annan, with an 8.9 per cent fall in mean DMFT from 2.81 to 2.56. However, none of these changes were statistically significant.

Comparing caries prevalence in Stranraer children between 1980 (fluoridated) and 1988, revealed increases in dmft and DMFT scores, other than the missing deciduous and permanent teeth scores (Table 26). The mean dmft score for the 5 year old age group was 2.48 in 1980, but this was 24.1 per cent higher in 1988 at 3.08. An even larger increase in mean DMFT scores was found in the Stranraer 10 year old children, five years after water fluoridation ceased. Mean DMFT was 1.66 in 1980 and 2.28 in 1988, an increase of 37.4 per cent. Both missing teeth scores were lower in 1988, but this was offset by increases in decayed and filled teeth in each age group. The only statistically significant change was the 100 per cent increase in filled teeth in the 5 year old group in 1988, all other differences were not significant.

Table 27 presents the corresponding figures for the 5 and 10 year old age groups in Annan in 1980 and 1988. Although not statistically significant, the mean deciduous filled teeth score was 106.5 per cent higher in 1988 compared with 1980. The other components of the index were lower in 1988 than 1980, with an over-all change of 27.4 per cent in the mean dmft score, from 4.38 in 1980 to 3.18 in 1988. Only the mean dt and dmft scores were significantly different in this age group.

All components showed lower scores in 1988 in the 10 year old children in Annan, compared with 1980 results. Mean DMFT was 2.56 in 1988, compared with 3.35 in 1980, a 23.6 per cent difference (Table 27). Again, only the changes in DT and DMFT scores were statistically significant.

The comparison of secular trends in caries prevalence in 5 year old children in both towns between 1988 and 1991 is presented in Table 28. Apart from a 10.9 per cent increase in decayed deciduous teeth in

Stranraer, all dmf components showed a fall during the 3 year period with mean dmft in Annan being 34.6 per cent lower at 2.08 compared with 3.18 in 1988. There was a 22.4 per cent reduction in Stranraer with mean dmft of 3.08 in 1988 being lower at 2.31 in 1991.

In Table 29, the comparison shows different trends in Stranraer and Annan between 1986 and 1991. Mean dmft had fallen by 45.6 per cent in Annan from 3.82 to 2.08 in 1991, with substantial reductions in all components. All changes were statistically significant. However in Stranraer, there was a 184.4 per cent increase in decayed teeth with mean dmft rising to 2.39 in 1991 from 1.17 in 1986, a 104.3 per cent difference. The missing teeth score was identical in both studies, with only a small increase in filled teeth. Only the changes in dt and dmft were significant. The final comparison giving secular trends over an eleven year period from 1980 to 1991 is illustrated in Table 30. The children studied in 1980 had received fluoride during their lifetime, whereas the 1991 study was eight years after fluoridation ceased. While decayed teeth in the Stranraer groups had increased by 33.8 per cent, falls in missing and filled teeth meant there was only a non-significant fall of 3.6 per cent in mean dmft over the period. A very different picture is found in the trends in Annan. Mean dmft has fallen from 4.38 in 1980 to 2.08 in 1991, a 52.5 percentage difference. Apart from the unchanged filled teeth score, the large changes found in Annan were statistically significant.

Figure 2 illustrates the changes in caries prevalence which have occurred in 5 year old children in the two towns over the period of the studies. Figure 3 presents the same data for the 10 year old age group, illustrating the continued fall in caries rates in Annan, against the increase in caries levels found in Stranraer.

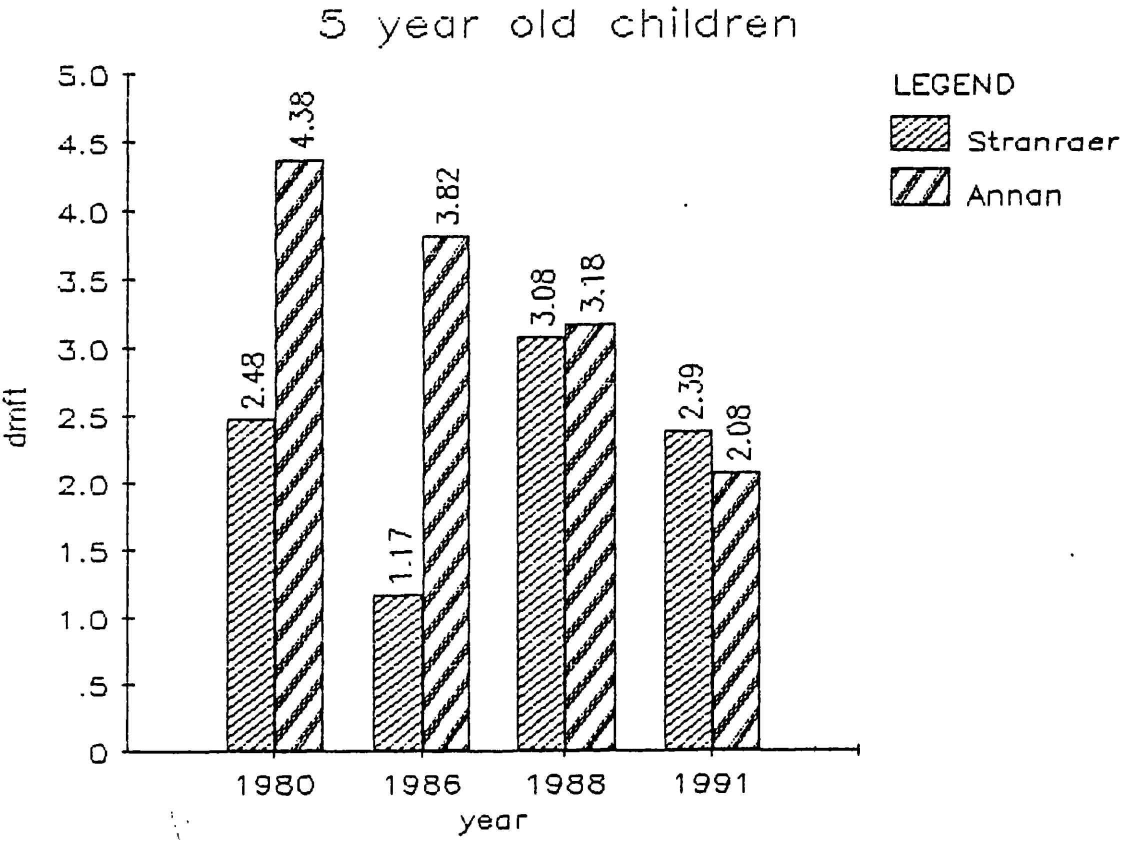

Figure 2. dmft by year in study towns

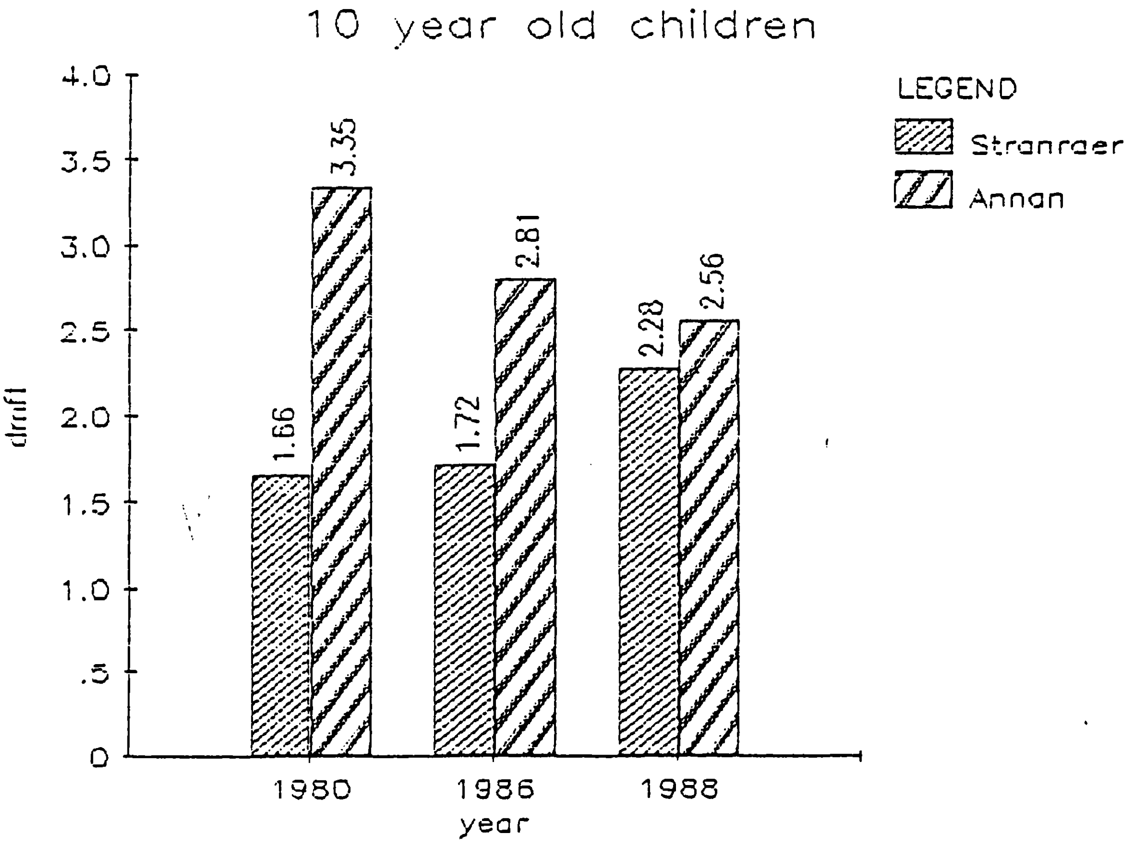

Figure 3. DMFT by year in study towns

3.2. Compound Annual Changes

Table 31 tabulates the Compound Annual Changes in caries prevalence between each study for the 5 year old children in Stranraer and Annan. Between 1980 and 1986, there was a fall of 11.8 per cent in mean dmft scores for the 5 year old Stranraer children, with falls in all the components on the dmf index. During the same period, there was an annual fall of only 2.3 per cent in the same group in Annan, with increases in missing and filled teeth.

Between 1986 and 1988, the changes in caries prevalence in Annan were equivalent to an annual fall of 8.8 per cent. All dmf components showed a fall, including a 34.6 per cent per annum reduction in missing teeth between the two studies. However, a totally opposite change occurred in Stranraer 5 year old children over the same time period. There was an annual increase of 74.4 per cent in the mean dmft score, with a 60 per cent increase in decayed teeth and 45.3 per cent and 76.6 per cent annual increases in missing and filled teeth.

These differing patterns are confirmed by looking at the compound annual rate of change between the 1980 and 1988 studies. While there was a 2.9 per cent annual increase in caries prevalence in the Stranraer groups, with only missing teeth showing a decrease, the change in mean dmft in Annan was equivalent to a reduction of 3.9

per cent per annum. Decayed and missing teeth showed annual falls of 5.1 per cent and 9.1 per cent, although filled teeth in Annan had increased by 9.5 per cent annually between 1980 and 1988.

Comparing the first three studies with the 1991 study of 5 year old children again reveals differing patterns of change between the Stranraer and Annan groups. While there has only been a Compound Annual Rate of Change in mean dmft of minus 6.5 per cent in Annan between 1980 and 1991, comparison with the intervening studies shows a steadily rising annual rate of decrease in mean dmf scores. Coincidentally, the mean filled teeth score in 1991 was identical to that found in 1980, although falls were recorded between 1986-91 and 1988-91. This reflects increases in filled teeth as a proportion of the over-all score in previous years.

A different pattern of change has again occurred in Stranraer. Between 1986 and 1991, the annual rate of change in mean dmft was an increase of 15.4 per cent, which included an annual rise of 23.2 per cent in decayed deciduous teeth and only a slight increase in filled teeth. These increases are much lower than the changes found between 1986 and 1988, as a result of the reversal in the trend found between 1988 and 1991. Mean dmft showed a compound annual decrease of 8.1 per cent in that three year period, with annual reductions of over 20 per cent in missing and filled teeth.

The final comparison of the 1980 and 1991 studies shows that, after the pattern of increase and decrease in Compound Annual Changes in caries levels, there has been only a 0.3 per cent annual increase in mean dmft taken over the eleven year period in Stranraer.

A comparison of the Compound Annual rates of change in caries prevalence in 10 year old children in the two study towns is presented in Table 32. There was an annual increase in mean DMFT between the 1980, 1986 and 1988 studies in Stranraer, while there was an annual decrease in mean DMFT in Annan.

Although there was no change in mean decayed teeth between the 1980 and 1986 studies, mean DMFT had increased by an annual figure of 0.6 per cent over the period. During the same time span, mean DMFT in Annan 10 year olds showed a compound annual reduction of 2.9 per cent, with a 6 per cent fall in both decayed and missing permanent teeth.

Between 1986 and 1988, mean decayed teeth showed an annual increase of 62.1 per cent, giving an over-all annual rate of change in the mean DMFT of 15.1 per cent in Stranraer. Caries levels in the Annan group continued to fall during the same period, with all DMF components showing reductions up to 5.1 per cent per annum, with an over-all annual change in mean DMFT of 4.6 per cent.

As a result of these trends over time, the compound annual change in caries prevalence in 10 year old children between 1980 and 1988 was an increase of 4.1 per cent in Stranraer, compared with a 3.3 per cent fall in Annan. All the DMF components fell over time in Annan, while only the numbers of missing teeth reduced in Stranraer. The DT and FT results for Stranraer showed annual increases of 12.8 per cent and 0.9 per cent respectively between 1980 and 1988.

4. Periodontal Examinations

Although the suite of computer programmes now available allows for the study of periodontal and oral hygiene status by means of the CPITN Index (179), for consistency, the same oral cleanliness and gingivitis measuring methods adopted by the SPEED system and used in the earlier studies were also used in the 1988 study. The authors of the SPEED suite of programmes had concluded that oral cleanliness should be divided as debris present at 11 or more sites and less than 11 sites. If 11 or more sites are affected there is normally a need for professional treatment.

Periodontal examinations recording oral cleanliness, the presence of gingivitis and sub-gingival calculus were carried out on the 10 year old age groups in 1980, 1986 and 1988 and also the 15 year old children in 1986.

4.1. Oral cleanliness

The results of the oral cleanliness examinations for the three studies are presented in Tables 33 to 36. In 1980, 92.7 per cent of Annan 10 year old children had soft debris or supra-gingival calculus present at less than 11 examination sites (Table 33). In Stranraer, 93.2 per cent of the children scored less than 11 sites, however boys were slightly poorer than girls for oral cleanliness. Conversely, a slightly higher proportion of boys than girls were recorded as having debris present at less than 11 sites in Annan. There were no statistically significant differences between oral cleanliness in the 10 year old children in the two towns and for each sex in 1980.

In 1986, the proportion of the Annan Primary 6 group who scored fewer than 11 sites was 90.5 per cent, with 15.9 per cent of boys and 4.9 per cent of girls having debris or calculus recorded at 11 or more sites (Table 34). In the same age group in Stranraer, 95.3 per cent scored less than 11 sites and 4.7 per cent had 11 or more sites affected. There was only a slight difference between the 10 year old girls and boys in Stranraer, with the girls marginally better. There was again no significant difference between the oral cleanliness scores.

The Secondary 4 or 15 year old groups in 1986 had oral cleanliness results around 3 per cent poorer than the 10 year old children in both towns (Table 35). The proportions in Stranraer were 92.2 per cent with under 11 sites and 7.8 per cent with 11 or more sites. The respective proportions in Annan were 87.2 per cent and 12.8 per cent. While oral cleanliness was slightly poorer in Annan compared with Stranraer, none of the differences were significant when analysed by the Chi-square method. Oral cleanliness was again slightly poorer in the boys in the two towns by comparison with the girls. The Stranraer boys had 90.7 per cent with fewer than 11 sites, while 93.4 per cent of the girls had under 11 affected sites. In Annan the proportions were 85.3 per cent of the boys and 89.6 per cent of the girls with less than 11 sites. There was again no significant difference.

Table 36 details the oral cleanliness results for the 10 year old children in 1988. Oral cleanliness was again marginally better in the Stranraer group than in the Annan children. 95.2 per cent of the Stranraer group had debris recorded at less than 11 sites examined compared with 94.6 per cent of the Annan children. Oral cleanliness was slightly better in the girls in Stranraer than in the boys, with proportions of 96.8 per cent and 93.5 per cent respectively. In Annan, almost identical proportions were recorded in the boys and girls. None of the differences found in 1988 were statistically significant however.

Over the studies, the oral cleanliness in the Stranraer children had improved slightly in 1986 to 95 per cent from 93 per cent in 1980. The 1980 results were similar to the 1986 proportions. The Annan children demonstrated more variation, with a fall from 92.7 per cent in 1980 to 90.5 per cent in 1986, followed by an improvement to 94.7 per cent with fewer than 11 sites affected in 1988. None of these changes over time were statistically significant.

4.2. Gingivitis Prevalence

The SPEED system included a division at 5 sites where gingivitis was recorded, again on the basis of the need for professional intervention. In 1980, gingivitis was recorded at fewer than five sites in 86.2 per cent of the 10 year old children in Annan and 98 per cent of Stranraer life-time residents (Table 37). While the boys in Annan had slightly better oral cleanliness than the girls in 1980, a different picture was found when comparing the prevalence of gingivitis by sex. 18.4 per cent of the Annan boys had gingivitis present at 5 or more sites, compared with 8.1 per cent of the girls. This difference between the sexes was significant at the 5 per cent level. The girls in Stranraer were marginally better than the boys at 97.2 per cent and 98.7 per cent respectively. There was a significant difference ($p < 0.05$) between the over-all figure for Stranraer of 98 per cent with fewer than 5 sites affected by gingivitis, compared with the 86.2 per cent figure for Annan in 1980. No children in the two towns had sub-gingival calculus recorded at 2 or more sites.

Table 38 presents the comparison of gingivitis prevalence in 10 year old children in Stranraer and Annan in 1986. In Stranraer, only 2 children or 1.6 per cent had gingivitis recorded at 5 or more examination sites. These two subjects were a boy and a girl attending the same school. None of the 10 year old children in Annan had gingivitis recorded at 5 or more sites in 1986.

Much higher levels of gingivitis were found in the 15 year old age group in 1986 (Table 39). Among the Stranraer children, 15 or 13 per cent of the group had gingivitis recorded at 5 or more sites. Gingivitis was slightly less prevalent in the Stranraer boys with 88.9 per cent having the presence of gingivitis recorded at less than 5 sites compared with 85.3 per cent of the 15 year old girls.

However, 36 or 33 per cent of the Annan 15 year old group had gingivitis present at 5 or more sites in 1986 (Table 39). This 20 per cent difference between the proportions of gingivitis sites in Stranraer and Annan were significant at the 1 per cent level. There was also a significant difference ($p < 0.01$) between the number of gingivitis sites recorded in boys and girls in Annan. Only 57.4 per cent of the 15 year old boys had gingivitis scored at fewer than 5 sites compared with 79.2 per cent of the girls.

Despite the high levels of gingivitis recorded, no children in either age group in the two towns had sub-gingival calculus recorded at 2 or more sites, which was deemed to be the significant level for treatment.

Gingivitis prevalence had shown a small increase in the 10 year old children in 1988 in both towns (Table 40). In the Stranraer group, 96.8 per cent had gingivitis at less than 5 sites compared with 97.4 per cent of the Annan children, a non-significant difference. The girls in both towns had lower levels of gingivitis than the boys, but the small differences found were not statistically significant.

Gingivitis levels showed little change over the period of the three studies in Stranraer, over-all results in the first two studies were almost identical with a slight deterioration in the 1988 study. There was again more variation in Annan in the three studies, although the changes followed a different pattern to the oral cleanliness results. There was a significant change ($p < 0.05$) from the 86.2 per cent with fewer than 5 sites affected to 100 per cent in 1986. This was followed by a slight increase in the prevalence of gingivitis in 1988.

5. Treatment Costs

Treatment costs were calculated by means of the Resource Related Index (75) using the same index values for the 1980, 1986 and 1988 studies to provide a direct comparison of potential treatment costs between the three studies.

Tables 41 to 43 compare the treatment costs by age group in the two study towns. All values given are in Resource Related Units, based on time costings for the National Health Service General Dental Practice fee scale. The SPEED suite of programmes includes this analysis. Mean costs were calculated for restorations and extractions for caries, general anaesthetics and total treatment costs for all groups. Periodontal treatment costings were also calculated for the older age groups.

A need for General Anaesthesia is included when extractions are required in more than two sextants of the mouth, otherwise extractions are assumed to be carried out under local anaesthesia. Although the need for general anaesthesia was small in the 1980 study, it was still analysed separately because of the attached risk.

5.1 1980 Study

Mean total treatment costs for Primary 1 in 1980 in Stranraer was 7.40 units compared to 14.05 units in Annan, a 47.3 per cent difference of 6.65 units. In the Primary 6 group, mean total costs were 3.99 units in Stranraer and 7.97 units in Annan, a difference of 3.98 units or 49.9 per cent (Table 41).

Mean costs for restorations in the 5 year old children were 4.65 units in Stranraer and 9.30 units in Annan. A difference between the means of 4.64 or percentage difference of 50.0 per cent. Mean costs of restorations for caries in the 10 year old age group were 1.08 in Stranraer compared with 4.65 units in Annan, a percentage difference of 76.8 per cent or 3.57 units lower in Stranraer.

These differences in potential costs were statistically significant, when analysed by Student's t-test and Mann Whitney U-test. 95% Confidence Intervals were also calculated for the differences between the means.

Total treatment costs include items such as treatment relating to trauma, examination and advice and periodontal treatment which are not related to caries and therefore unlikely to be affected by water fluoridation.

These items are, however, necessary for an over-all comparison.

The number of children requiring treatment in 1980 was significantly higher in Annan ($p<0.05$) than Stranraer and the individual amount of treatment required was also higher.

5.2 1986 Study

Mean total treatment costs for Primary 1 (5 years old) in Stranraer in 1986 was 4.75 compared with 11.03 in Annan, a difference of 6.28 units and a percentage difference of 56.9 per cent(Table 42). In the Primary 6 groups in the study towns, mean costs for Stranraer were 4.84 compared with 7.63 for Annan, a difference of 2.79 units or a percentage difference of 36.5 per cent.

The Secondary 4 or 15 year old group had a mean total treatment cost of 4.27 in Stranraer and 11.47 in Annan, a difference of 7.20 and 62.7 per cent less in Stranraer than in Annan. The main component in the treatment costs was restorations, with a low requirement for extractions leading to low mean costs for extractions for caries and need for general anaesthesia.

Student's t-test, confidence intervals for the difference between the means and the non parametric Mann whitney U test were again used to test the results for statistical significance. All differences in costs between Stranraer and Annan were significant, apart from those for extractions required for caries and periodontal treatment.

Comparing numbers requiring treatment rather than potential costs, 54 or 60 per cent of 5 year old children who were life-time residents of Annan were recorded as requiring treatment in 1986. Of these, 52 required restorations and 10 required extractions as a result of caries. In the same age group in Stranraer, 38 children (31.7%) required treatment, all of whom needed restorations and 3 also required extractions for caries.

A similar, although smaller, difference was also found in the 10 year old group. In Annan, 66 or 62.9 per cent required treatment, including 63 who required restorations for caries, 4 needed extractions and 10 met the criteria for prescribing scalings. In the corresponding group in Stranraer, 54 or 42.5 per cent were recorded as requiring treatment. Of which, 51 needed restorations, 3 extractions for caries and 7 children needed scalings. The majority of restorations required in both towns were recorded in the first permanent molars.

Among the Secondary 4 group who were included in 1986, 74 or 67.9 per cent of Annan residents were recorded as requiring treatment. This included 61 who needed restorations, 13 requiring extractions and 10 who required a scaling. Two partial dentures were also required by Annan children.

However in 1986, only 38 or 32.0 per cent of 15 year old life-time residents were charted as requiring treatment, including 31 who were noted as needing restorations and 2 requiring extractions for caries. There were also 7 subjects requiring scalings.

In 1986, as in 1980, there was a significant difference in the cost of treatment required when the Stranraer groups are compared with Annan. The proportion of subjects requiring treatment is higher in Annan than in Stranraer in all three age groups. This includes a higher level of need for scalings in Annan, compared with Stranraer.

5.3 1988 Study

The mean total potential treatment cost for 5 year old children in Stranraer in 1988 was 8.69 units, 1.3 units less than the mean cost for Annan of 10.06, a percentage difference of 13.6 per cent (Table 43). A similar percentage difference was found in the mean cost of restoration for caries. There was however a 70.6 per cent higher cost for extractions for caries in Annan.

A similar pattern was found when comparing the treatment costs for the 10 year old groups. Mean total cost in Stranraer was 6.01 Resource Related Units compared with 6.41 units in Annan, a 6.3 per cent difference. The cost of restorations was 10.4 per cent higher in Annan, with mean costs of 2.83 units in Stranraer and 3.16 in Annan. The cost of periodontal treatment needed was 0.26 units in Stranraer and 0.46 units in Annan, a 43.5 per cent difference. However, there was a higher mean cost for extractions required in the Stranraer 10 year old children of 0.21 compared with a mean cost of 0.1 units in Annan. None of these differences were statistically significant, apart from the cost of extractions for caries in the 5 year old children.

The numbers recorded as requiring treatment were 43 or 44.8 per cent of 5 year olds in Annan, of which 40 required restorations and 9 were recorded as needing extractions. The corresponding figures for Stranraer were 39 or 32.2 per cent, with 38 and 6, requiring restorations and extractions.

In the 10 year old groups, 45 or 39.4 per cent of the Annan lifetime residents required treatment and 50 or 40.0 per cent in Stranraer. All in Annan required at least one restoration and 4 also needed extractions, with 5 requiring periodontal treatment. In Stranraer, 50 or 40.0 per cent were classified as requiring treatment, of whom 50 required restorations and 3 were charted for extractions. Only 6 met the criteria for scalings.

As in 1986, the majority of restorations required were recorded in molar teeth.

5.4 Costs by Sex

Tables 44 to 46 present the costs of treatment required by sex in each study. There were only small differences between mean costs for treatment required by male and female subjects in most categories. However in 5 year olds in both towns, the mean cost of restorations required for caries was higher in boys than in girls. The respective scores for 5 year olds were 11.08 and 8.54 units in Annan and 5.34 units and 4.64 units in Stranraer (Table 44). This resulted in similar differences in the mean total costs for male and female subjects in each town.

However in the 10 year old group, while Stranraer boys had a mean cost of restorations of 1.60 units compared with 0.79 units for girls, in Annan, the cost of restorations was almost identical with a difference of only 0.03 units. As a result, mean total cost was almost equal in Annan but was higher for boys in Stranraer than in girls with respective scores of 4.62 and 3.39 units.

In all three age groups in Annan in 1986, the mean total cost was higher in boys than girls by around 3 Resource Related Units (Table 45). Mean total costs for 5 year olds were 12.43 units for boys and 9.64 for girls, the corresponding figures for 10 year olds were 9.29

units and 6.43 units respectively, with scores of 13.49 and 8.89 in the 15 year old group. These differences were largely due to corresponding differences in the mean costs of restorations for boys and girls.

Much smaller differences between the sexes were found in Stranraer. Mean costs and the cost of restorations were lower in boys in the 5 and 15 year old groups than in girls, although the differences were not large. However due to a higher cost for restorations required by 10 year old boys of 2.91 units compared with 2.00 units for girls, the mean total cost was higher for boys at 5.36 as opposed to 4.43 units for girls.

Table 46 shows that costs were higher for male subjects in all but two categories in both age groups in the study towns in 1988. However most of the differences were small, apart from the costs of restorations in Stranraer boys which were 6.23 units compared with 5.32 units in girls, giving a similar difference in mean total costs.

The mean cost of periodontal treatment required in Annan 10 year old boys and the mean cost of restorations in Stranraer boys was marginally lower than the corresponding scores for girls.

There were no statistically significant differences between the two sexes.

6. Social Class

Caries prevalence, and health and treatment costs were also analysed by Social Class. Social class was recorded in 1986 and 1988 by means of the father's occupation. Tables 47 to 49 present the analysis for the three age groups in 1986.

Table 47 shows that there was a social class gradient in caries prevalence in the 5 year old children in Annan from a mean dmft of 3.14 for Social Class I to 5.00 for Social Class V. However the mean dmft scores for Class II to IV were virtually identical. A similar pattern was also present in the mean costs for restorations and total costs, although, interestingly, the Social Class IV had lower treatment costs than Social Class III. This finding may have resulted from the much smaller numbers in Social Class IV compared with Social Class III which included almost half of the subjects.

There were no 5 year old children recorded as Social Class V in Stranraer in 1986. An inverse relationship was again found between caries and treatment and social class. None of the 7 subjects categorised as Social Class I had a need for restorations recorded. The range of mean dmft scores was 0.99 to 1.34 with a similar pattern for the mean total cost of treatment. Again, Social Class III was found to have a higher mean cost of restorations at 3.45 units compared with the 2.63 units for Social Class IV. None of the differences were found to be statistically significant when analysed by ANOVA (251).

The analysis by Social Class for the 10 and 15 year old group also includes oral cleanliness and gingivitis. Table 48 presents the results for the 10 year old lifetime residents in both towns. There was again an inverse relationship between Social Class and caries prevalence in the two towns. The range of mean DMFT scores was 1.99 to 4.85 in the Annan subjects and 1.01 to 2.35 in Stranraer. The cost of all treatment and restorations was much higher in Social Class V than the other classes. The range covering Social Classes I to IV was 3.01 units for restorations and 5.37 units for all costs to 4.42 and 6.78 units in Social Class III. Social Class IV again had lower mean costs. There were no differences in gingivitis, but Social Class III was the worst for oral cleanliness at 89.7 per cent while both classes I and V had no children with debris at 11 or more sites.

In the Stranraer group, there was a social gradient from Social Class I to V in both caries prevalence and costs, with class V only being slightly the worst. Again, Social Class IV fared better than Social Class III in the costs of treatment required. There was a steady fall in the percentage with fewer than 11 sites affected by plaque in Stranraer, with the range being 100 per cent in Social Class I to 66.6 per cent in Social Class V. None of the differences were however statistically significant.

A broadly similar pattern was found in the 15 year old groups in 1986, with Social Class V being an outlier in the range of mean DMFT scores in both towns, the mean score being 4.37 in Stranraer while the other classes fell within the range 2.33 to 2.69 (Table 49). In Annan there was not a clear gradient as in the other age groups, mean DMFT scores being 7.0, 8.5, 7.18, 6.27 and 11.0 for Social Classes I to V respectively. This pattern was repeated in the mean cost of treatment required.

The pattern of the other age groups was repeated in Stranraer when costs were analysed by Social Class, with Social Class IV requiring less treatment than Social Classes II and III. As in the 5 year old group, none of the Social Class I subjects required a restoration.

While there was a gradient for oral cleanliness in Annan from 100 per cent to 70 per cent, the differences were much more marked when analysed for gingivitis. While all of the Social Class I subjects has gingivitis recorded at less than 5 sites, only 30 per cent of the Social Class V subjects had gingivitis at less than 5 sites. This was reflected in the total cost of treatment for Social Class V as the 70 per cent with gingivitis at

5 or more sites would be categorised as requiring periodontal treatment.

In Stranraer, while 11.7 per cent of the Social Class III subjects had plaque at 11 or more sites, worse than all other classes apart from Social Class V, only 8.8 per cent had gingivitis at 5 or more sites which was better than all but Social Class I. Social Class II did worse in both periodontal measures than Social Class IV. None of these differences were significant apart from gingivitis in Annan which was significant at the 5 per cent level.

The corresponding figures for Social Class groups in 1988 are presented in Tables 50 and 51. Table 50 shows that in both Annan and Stranraer 5 year old children, Social Classes II to IV have fairly closely grouped mean dmft scores. The range being 2.93 for Social Class I to 4.8 for Social Class V in Annan and 2.96 and 5.3 respectively in Stranraer. As a result in both towns the main gradient is between classes I and II and classes IV and V. A similar pattern is found in the cost of restorations and total costs when analysed by Social Class (Table 50). There is a steady increase in the Stranraer groups but in Annan, Social Class III is again higher than Social Class IV for treatment costs. There are no statistically significant differences in either town however.

There is an inverse relationship between mean caries scores and social class in the 10 year old children in both towns (Table 51). Again Social Class II, III and IV show only slight differences with the other two forming the outliers, especially social class V. Mean costs of restorations for caries and the total cost of treatment required also show a social class gradient. In Annan, mean total costs are within the range of 6.04 units to 9.96 units and for the mean cost of restorations, the range is 3.98 to 6.89 units. The corresponding figures for Stranraer are 1.98 units to 4.99 units for mean restoration costs and 3.74 units to 7.01 units for total costs.

There is also a weaker gradient between oral cleanliness and gingivitis and the subject's social class. Social Class I having no subjects in either town requiring professional intervention, while only one subject in Social Class V in each town does not require periodontal treatment.

There were again no statistically significant differences between the Social Classes in 1988.

7. Dental Attendance

Information was collected from the 10 year old children in 1980, 1986 and 1988 and the 15 year old children in 1986 relating to their claimed dental attendance pattern and reported source of dental treatment. The results of analysis of this information is given in Tables 52 to 55.

In 1980, 77 per cent of 10 year old children in both Annan and Stranraer claimed to be regular attenders, visiting the dentist at least once a year (Table 52). The reported source of treatment in Stranraer was the General Dental Service 68.7 per cent and Community Dental Service 17 per cent, the remainder were unable to answer this question. The corresponding figures for Annan were 80.8 per cent and 8.5 per cent with 10.6 per cent classified as "Don't Knows".

Table 53 shows a slight increase in regular attendance in 1986 to 79.5 per cent in Stranraer and 80.9 per cent in Annan. The majority who indicated a source of treatment again attended the General Dental Service.

In 1988, Table 54 shows that there had been minor changes in claimed dental attendance compared with 1986, with slightly more Stranraer subjects claiming to be regular attenders (81.6 per cent) than Annan children (79.8 per cent). 75 per cent in both towns indicated that the General Dental Service was the source of their dental treatment.

There was a bigger difference between the proportions of regular attenders in the two towns in the 15 year old age group in 1986 (Table 55). While 86.1 per cent claimed to be regular attenders in Stranraer, only

76.2 per cent claimed regular dental attendance in Annan. The difference however was not statistically significant. Compared with the 10 year subjects, a slightly higher proportion reported that the Community Dental Service was the source of their dental treatment, 20.9 per cent in Stranraer and 15.6 per cent in Annan.

8. 10 year old cohort

The children who comprised the 10 year old group of life-time residents in Stranraer in 1986 were examined again in 1991. Of the 115 included in the study in 1986, it was possible to re-examine 81 in 1991. Table 56 presents the decayed, missing and filled teeth data for the cohort, aged 15 years in 1991 and compares it with the 15 year old group in 1986.

Mean DT was 0.68 in 1991 compared with 0.45 in 1986, a 33.8 per cent increase. Missing teeth had increased by 55.5 per cent from 0.20 in 1986 to 0.45 in 1991. The main component of the DMF score in both groups was filled teeth, which had risen to 2.72 in 1991 from 2.06, a 24.3 per cent difference. The DMFT score had increased by 29.4 per cent to a mean of 3.85 in 1991 compared with 2.72 for the 15 year old group in 1986. This increase had taken place during a time of temporal decline in caries levels in the United Kingdom.

9. Reproducibility

Tables 57 to 59 present the results of the replicate examinations. Examinations were carried out on 27 Primary 1, 30 Primary 6 and 31 Secondary 4 subjects in 1986. In 1988, 25 of the 5 year old and 30 of the 10 year old children were re-examined. In 1991, 24 of the 5 year olds in the two towns had replicate examinations, 10 of the 15 year old cohort were also re-examined.

The reliability coefficients (Pearson's r) in the three studies ranged from 0.98 to 1.00 and Dice index scores were 0.99 or 1.00. A score of 1.00 indicates complete agreement.

In the 1980 study, inter-examiner reliability was 0.97 for the 5 year old children. For the 10 year old groups, the reliability coefficients were 0.84 for decayed teeth and 0.94 for filled teeth (6).

None of the differences between mean scores in any of the studies were statistically significant using paired sample tests. There was a high degree of correlation in the studies.

10. Computer Analysis Systems

This section reports the comparison of the three dental epidemiology analysis systems and the facilities provided by each of them. The design and operation of each software package will be described. Any problems or advantages with the systems are also reported. The final sub-section analyses the results of these comparisons and the decisions resulting from these tests.

10.1 Speed

The System for Planning and Epidemiological Evaluation of Dental Services (SPEED) was developed in the late seventies to provide an epidemiological tool to aid the evaluation and planning of dental care services.

The SPEED Package consists of a suite of programmes written in Fortran and operating on main-frame computers, originally at the University of Manchester. Minor amendments were made to the programmes and a revised manual was published in 1984. A copy of the programme suite was installed on the University of Glasgow ICL main-frame in 1986.

The programme was originally designed to have data input by means of punched cards, with the operations of the programme controlled by punched Kontrol cards. However data can also be keyed into the main-frame directly and the programmes run by means of a command file.

There is a SPEED data collection chart which is divided into four 80-column sections (Appendix 5). The chart provides sections for personal data, oral cleanliness, calculus and gingivitis data, malocclusions, trauma, caries prevalence, treatment need and costs of treatment required.

Caries prevalence is recorded for deciduous and permanent teeth by means of the DMF teeth index (158). The Oral cleanliness and gingivitis measures are based on the partial recording method of Lennon and Davies (176). Treatment need is recorded by the examiner, but certain conventions are employed in the criteria to restrict over-all treatment choice. The potential cost of treatment required is calculated by means of the Resource Related Index (75).

Four main sections of the programme are available for the computer analysis. The unvalidated data-file is examined by the module Validate, which checks that the recorded data for each subject falls within the ranges specified by the SPEED criteria and that there are no inconsistencies, such as a sound tooth also being recorded as needing a restoration. A printout is produced indicating the location of errors detected. Correction of errors was originally carried out by producing an amended punch card, but can also be performed by direct editing of the data-file with the ECCE file editor available on the Glasgow University main-frame. During the process of validation, a validated data-file is produced with an amended layout of the recorded data. This validated datafile is used as the data source for all other operations of the SPEED suite.

The other programme modules are Tabulation, Reliability and Treatment. Tabulation is the main programme module. It is controlled by a Kontrol Card or Command file which provides 38 columns which allow the selection of the whole datafile or individual subsets of data (Appendix 7). The card also selects from three types of tabulation, namely caries and periodontal treatment, costs and frequencies.

The prevalence calculations are the most used tabulation, each table being accompanied by summary descriptive statistics which allow the calculation of statistics such as Crosstabs and provide an estimate of significance. As well as analysing the whole dataset or subset selected, each run also analyses the data by district, school, sex and examiner. The output is sent direct to a printer or is output onto punched card or paper, or magnetic storage.

Variable labels are provided for the output by means of a title file, which is set up with appropriate variable labels before the first run of the data. The title file also provides the costing information of the Resource Related Index (Appendix 8).

A printout of the potential costs of treatment recorded as required by the examiner can be produced, which includes the provision of periodontal treatment where the SPEED criteria indicate its necessity. A useful facility is the provision of the total cost of treatment, if carried out by a dental therapist as well as by a dentist, providing helpful planning information.

The final option of the Tabulation module is frequency distribution tables of DMFT, dmft and plaque, gingivitis and subgingival calculus. Each table shows the number and individual percentages of each score.

To provide a means of carrying out more complex statistical analysis, the last column of the Kontrol card or file allows for the selection of two forms of summary data output, that allow the use of statistical packages such as SPSS, SAS (236) or BMDP (237).

The Reliability module measures the reliability coefficient for replicate examinations of the same subject to establish inter-examiner or intra-examiner reliability. Reliability calculates Pearson's r coefficient for 17 items covering caries scores, periodontal scores and costs.

The final programme module is Treatment which calculates DMF components for each subject and estimates the treatment requirements. A separate page of output is produced for each subject giving a treatment prescription.

The SPEED suite of programmes is a comprehensive data analysis system providing detailed information relating to caries prevalence, oral health, treatment need and treatment costings. The control card operating method provides a simple selection system for the varied analyses available. Unfortunately it can only handle DMF tooth data, which provides less sensitivity to changes in caries incidence, as caries prevalence falls, than DMF surface scores. While the partial recording system for periodontal data can give an indication of the need for professional treatment, the CPITN Index gives more comprehensive data for measuring periodontal disease and planning care services. CPITN has also been recommended by the World Health Organisation for recording periodontal data. While there is a facility for recording option data, there is no direct method for recording enamel defects which are assuming increasing importance.

10.2 Numbase

This programme is designed to operate on the Psion hand-held computer to allow data entry at the time of the examination. The Psion computer has a rather limiting 2 or 4 line Liquid Crystal Display. There is provision for the installation of 2 EPROM modules, one of which holds the Numbase programme while the other contains the datafiles. The Psion Organiser computer was originally designed as a portable diary and databank with limited computing figures.

The programme provides facilities to record data relating to malocclusions, CPITN Index, tooth status, treatment need and Fluorosis. A ready set-up format allows the recording of information relating to the WHO Oral Health Survey standard dataform. After data is input relating to the caries status of each tooth, Numbase calculates DT, MT, FT and DMFT. Again there is no standard provision for DMF surface scores.

Statistics provided are, Mean, Standard Deviation, Confidence Intervals, Skewness, Frequencies, t-test, Chi-square and linear regression. The programme will also automatically calculate the significance and degrees of freedom for t-tests and chi-square at 1% or 5% level.

Through the Psion Computer RS232 link the data can be exported to other computers to enable analysis of the data to be carried out using dBase, Surveyplus and other programmes.

Unfortunately the small screen display and little keys of the computer make data entry fiddly and rather imprecise, although corrections can be made fairly easily. The major drawback found in testing Numbase was the number of occasions on which the datafile became incompatible with the programme file requiring data entry to be repeated. Numbase does not provide the comprehensive information provided by SPEED, particularly the provision of treatment costs, although fluorosis and CPITN measures are available.

10.3 Surveyplus

Surveyplus is a suite of programmes for the editing, cross-tabulation and statistical analysis of most forms of data. It is a database programme with statistical facilities, which can be used for the analysis of questionnaires or survey data. It provides for the compilation of routine statistics and analysis of parametric and non-parametric data.

The optional dental epidemiology module provides for a full dental surface record with 3 additional fields (X, Y, and Z) per tooth for other data, such as periodontal data, treatment need, maloclussion or mottling.

The special, pre-programmed Dental Format screen provides simple entry of the surface and X, Y, Z data for each tooth. It is arranged so that entries appropriate to a whole tooth are completed for all surfaces of the tooth with one key stroke. The dental format can be pre-coded for various details if required. Through a series of process files it will automatically calculate individual DMFT and DMFS scores at the time of data entry. The Dental Format is used in conjunction with the normal format which has to be produced in the normal manner of database programming. The DMF component scores are stored as variables in the normal format.

Periodontal or CPITN data can be collected using the X, Y, Z boxes or by setting up variables in the normal format. The most convenient method is to use the X, Y and Z boxes with a process to calculate the individual score. However, if periodontal, treatment need, fluorosis and other data are being collected for each individual the dental format is inadequate and the majority of the additional data has to be collected using the normal format.

Validation of data entry is performed by means of range checks of data. Statistics available are summary statistics, Mann-Whitney paired significance tests, Chi-square and correlation and multiple regression. Graph and Plot facilities are available if the system is linked to a HP Plotter.

Unfortunately once the format has been set up and data entry has started, there is no simple method for amending the variables of that format. If changed, the data-file is no longer compatible with that format. It is possible to overcome this by a series of copying and renaming of datafiles, but most databases now available will allow amendments to variables without complex actions. There is no readily available method of treatment costing. The X, Y and Z boxes can be used to record treatment need codings, which can be interpreted by a 'process' to produce costings. But it is necessary for the programme user to write a long process file to carry out this task. If the basic Surveyplus database was modernised and brought up to the standards of the commonly used databases, its use with the dental format would give a most useful dental epidemiology tool. However its rather outmoded design does not make for "user-friendly" operation. The ease of use is not helped by the manual which has a dental module chapter which carries a multiplicity of cross-references to the main manual which is laid out in an illogical order.

While it is possible to use Surveyplus to carry out most measures and indices required in dental epidemiology, the programme requires a lot of effort by the user to achieve the desired output.

10.4 Other Programmes

Other programmes available such as DCT or the Simplesoft voice activated system, are either specialised clinical trial programmes or have problems of reliability with data collection.

10.5 Dental Analysis System (DAS)

While the programmes available provide a wide variety of dental input, the simplest in use is the SPEED suite of programmes. However it has the drawback of the lack of surface data processing and the inability to collect fluorosis or CPITN data. The comprehensive set of modules provide a model for a satisfactory dental epidemiology tool. Unfortunately, to modify the programmes to deal with the additional measures which are felt to be desirable would entail a major rewrite of the Fortran programmes and the production of a new data collection method.

The provision of the facility of summary data files for use with SPSS indicated a simpler approach to updating the facilities available. The Statistical Package for the Social Sciences (SPSS) is available in both main-frame and micro-computer forms. It is possible to produce a series of modules based on SPSS command files which will carry out all the functions provided by SPEED with the addition of CPITN, DMFS, Enamel defects and other indices and measures. Data entry is facilitated by the Data Entry module available for SPSS which corresponds to a database style entry format. Being a statistical package, a wide variety of statistics is readily available for data analysis.

A Dental Analysis System based on the modular principle of SPEED, but written in the SPSS command language has been produced. The first modules to be written provided analysis of DMFT or DMFS data. The modules were developed and tested using the datasets which were utilised to assess the available programmes.

The DAS modules were found to produce the same results and statistics as the previous programmes. However running on both main-frame and micro computers, they provided ready accessibility for survey analysis. The simple modular nature also provided flexibility in use.

Following the successful testing of the principle of the Dental Analysis System, further modules were developed to deal with periodontal data, treatment need and enamel defects. These were also successfully tested with appropriate datasets from previous studies.

The Dental Analysis System was then field tested on the Abu Dhabi studies carried out by a post-graduate student. Following training and calibration with the criteria (Appendix 9), a small pilot study was conducted to test the data collection and analysis in the field. This pilot study also provided additional training and experience to the student. When the pilot study proved successful, the main study of the dental health of three randomly sampled groups of 5 year old children was carried out and the data analysed by means of the Dental Analysis System.

The system consists of a series of modules which provide analysis of caries prevalence, periodontal status including CPITN, the DDE Index and treatment need. A module is also available to quantify potential treatment costs. While codings vary the criteria used are in line with the BASCD/SHBDEP criteria and the SPEED criteria (Appendices 3, 4 & 9). The DAS modules provide summary descriptive statistics, crosstabulations and other statistical analysis. Statistical tests are readily available within SPSS by means of minor modifications of the command modules.

The data collection chart developed for use with DAS is also based on a series of modules, which are assembled to produce a chart. Layout can be varied to suit the design of an individual study. An example is shown in Appendix 10. The chart can also be produced on-screen using the SPSS Data Entry package, allowing direct input of data.

The Dental Analysis System has been used for the analysis of a number of studies following the initial testing in comparison with other programmes. The publications reporting the results of these studies and the Stranraer-Annan studies are included in Volume Two.

DISCUSSION

The original Stranraer-Annan study in 1980 was commissioned by Dr M C Downer, Chief Dental Officer for Scotland, in collaboration with Dr A S Blinkhorn, dental adviser to the Scottish Health Education Group. It was carried out to monitor the effects of water fluoridation in Scotland, where caries levels have traditionally been higher than in England and Wales. The study provided an assessment of the likely benefits of fluoridation of public water supplies in Scotland, providing information for planning and was utilised by the Scottish Health Education Group for educational purposes. Funding for this study came from the Scottish Health Education Group.

It is likely that the organisers of this straightforward comparison study did not fully realize the potential importance of their research at the time of the study. An extremely costly legal challenge, funded by the Legal Aid Board, was made to water fluoridation in Scotland in the Court of Sessions. The results of the 1980 study were used in the court proceedings.

However no one could have foreseen that the judgement delivered in 1983, whilst supporting the efficacy and safety of the fluoridation of public water supplies, would find that under the terms of the Water

Scotland Act fluoridation was Ultra Vires. As there was no legal basis for the addition of fluoride to water in Scotland, fluoridation plants in Scotland were closed without any real preparation for monitoring.

Thus the 1980 study suddenly achieved considerable importance, as it provided a benchmark for the effectiveness of water fluoridation in Scotland. It also provided base-line data which would allow secular trends to be monitored in the South West of Scotland.

The author was one of the two examiners in the 1980 study with an interest in epidemiology. Prompted by the original study, the decision was taken to undertake a further study in 1986 to assess secular trends in Stranraer and Annan. The 1986 study also gave information relating to the effect of water fluoridation and its ending in 1983, the results of which were reported in the Lancet in 1988 (11). This indication of possible changes in caries prevalence relating to the cessation of water fluoridation, showed that the dental health of children in the towns of Annan and Stranraer was worthy of more detailed investigation. This project was therefore undertaken to provide a detailed assessment of changes in caries prevalence in the two towns with particular reference to the ending of water fluoridation.

To this end, a further analysis was carried out of the data collected in the 1980 study and compared with studies in 1986, 1988 and 1991. These were follow up studies utilising the same methodology and criteria as the 1980 investigation and the same examiner. Additional caries data was also collected in the later studies. This thesis owes a debt to the foresight of the planners of the 1980 study, without which this project would not have been possible

This chapter will discuss the results of these studies and the factors which may influence the results. The following factors will be discussed as follows:-

1. The sample
2. Caries prevalence
3. 15 year old children
4. Trends in Ireland
5. Trends after ending of fluoridation
6. Factors affecting oral health
7. Treatment costs
8. Computer analysis systems

1. The sample

In each study the target population was all children in Primary 1 and Primary 6 classes in non-denominational schools in Stranraer and Annan. Pupils in Secondary 4 classes in each town were also included in the 1986 study.

The denominational school in each town was not included in the studies as pupils are drawn from a wide area. There are no denominational secondary schools in the study towns. As both primary schools are small, the number of children excluded was only a very small percentage of the total school population for each age range. Therefore the non-denominational schools can be considered to provide a representative sample of school children in the two towns. No attempt was made to draw a random sample from the target population as it was more practical to examine all the children. As the target populations in the study towns were small, this gave a manageable, but truly representative sample.

As can be seen, the target population and sampling were decided by the framework of the original study. However this has provided a representative sample, which is unaffected by minor changes over time.

2. Caries prevalence

The follow up studies were carried out after the withdrawal of water fluoridation in July 1983. Although the Water Scotland Act, which legalised the fluoridation of public water supplies, received the Royal Assent in 1986 (71), Health Boards only received the new Indemnity and Guide-lines from the Scottish Office in 1991 (Appendix 2). As a result it has not yet been possible to begin the procedures to restart water fluoridation in Wigtownshire.

The studies therefore provide information on levels of caries experience in Annan and Stranraer since fluoridation ceased. Comparison with the 1980 study where the children had life-time fluoride exposure allows changes over time to be assessed. The later studies provide an assessment of caries levels after varying periods of fluoride exposure.

The 1980 study compared dental health and need for treatment among 5 and 10 year old schoolchildren in the towns of Stranraer and Annan. At that time fluoridation of the public water supplies of Stranraer at the optimum level of 1 part per million Fluoride had been carried out for more than ten years.

Comparison of children who were life-time residents of Stranraer in 1980, with similar children in Annan which has no significant fluoride in the water supply, showed a difference of 44 per cent in the mean dmft score for 5 year olds in Primary 1 and 50 per cent in the mean DMFT score for 10 year olds in Primary 6.

Significantly lower levels of decay, missing an filled teeth were recorded in both age groups in Stranraer. Similar differences in the level of cost of treatment were also found.

In 1976 a small study of 6 year olds in three rural areas of Dumfries and Galloway reported a 52 per cent difference in caries prevalence in the fluoridated area compared with the non-fluoridated areas (90). A fissure sealant study also reported that children's teeth were benefiting from fluoridation in 1976 (91).

These three studies were in agreement with a summary of 95 studies by Murray and Naylor comparing fluoride and non-fluoride areas throughout the world which showed differences in dmf/DMF of 29-82 per cent in the fluoride areas. The majority of these studies fell between 40 and 70 per cent (52).

Although fluoridation of Stranraer's water supply stopped in July 1983, comparison of dental health and treatment need in 1986 of 5, 10 and 15 year old life-time residents in Stranraer demonstrated lower mean levels of decayed, missing and filled teeth and lower potential treatment costs when compared with the town of Annan, which had no history of fluoridation. For example, the mean decayed, missing and filled deciduous teeth score was 69.4 per cent lower in five year olds in Stranraer; a dmft of 1.17 compared with 3.82 in Annan.

A similar study in 1981 by French et al comparing 5 year old children in Newcastle, after 12 years of fluoridation, with a low fluoride area found dmft of 1.41 and 3.37 respectively, a 58 per cent difference (81). As the level of fluoridation in Newcastle had fallen below the optimum level for some of the period, it was surmised that the difference would have been larger if the optimum level had been maintained.

Other English studies of that period have reported similar results to Newcastle. In 1979, a study comparing Birmingham with Salford reported a 54 per cent difference

(74) and, in 1980, a 62 per cent difference was observed in Leeds (77). The 1980 Scottish study reported a lower difference of 44 per cent in Stranraer.

A previous study of 5 year olds in 1976 in Newcastle found a 59 per cent difference and dmft of 2.2 in Newcastle and 5.4 in the control area (76). The 1980 Stranraer and Annan dmft figures were 2.48 and 4.38 respectively for 5 year olds.

In both areas, a reduction in over-all dmft scores has occurred in the period covered by the studies a similar pattern having been reported in other studies. However, whereas in the Newcastle studies the percentage difference has remained almost constant at 58 per cent, there has been a marked change in the percentage difference in Stranraer, namely from 44 per cent to 69 per cent.

Comparing the 1986 study with the one undertaken in 1980 there has been a decrease of 52.8 per cent in the mean dmft in Stranraer 5 year olds over the period, while the Newcastle study only reported a 36 per cent difference over a similar 5 year period. However, the low fluoride area in the Newcastle study showed a 37 per cent difference in mean dmft over the 5 years, while in Annan the mean dmft has only changed from 4.38 in 1980 to 3.82 in 1986, a non-significant difference of 12.8 per cent. This is largely due to an increase of 54.4 per cent in filled deciduous teeth with mean dt's of 0.31 and

0.68 for 1980 and 1986 respectively in Annan. There was also a 9.3 per cent increase in missing teeth in 5 year olds. At the same time there was a 30.1 per cent difference in the mean decayed teeth score in 1986 compared with 1980.

These results may be attributable to changes among the dental practitioners serving Annan. Although the dentist-patient ratio in Annan was unchanged, a new dental practice had opened its doors. This practice placed particular emphasis on the dental care of children, which may well have led to more caries being treated in this age group. There may also be an increased level of dental attendance leading to more caries being treated. Unfortunately dental attendance details were not recorded for this age group, because of the difficulty of collecting this type of information from younger subjects. Unfortunately, published figures from the Information Services Division do not provide sufficient local breakdown to quantify any changes in attendance patterns in the town.

As different dental practitioners tend to make different treatment decisions relating to the same lesion, the changes in personnel may also have affected the dmf components. The new younger dentists may well have had a different approach to the treatment of deciduous caries than their older predecessors.

However, this swing from 43 per cent to 69 per cent difference when comparing Annan and Stranraer is probably mainly due to variation in the sample groups. Both percentage differences fall within the range reported for the majority of studies by Murray and Naylor. Comparison of the 95 per cent Confidence Interval for the difference in means in the two studies shows an overlap with the 1980 difference of 1.9 falling just outside the 1986 Confidence Interval of 1.91. Accordingly it is likely that a major part of the swing in percentage difference is due to the two cohorts being outliers in the normal range of results.

40 per cent of the Annan 5 year olds had no untreated caries in 1986 compared with 22 per cent in 1980. Whilst 27.8 per cent of life-time residents had no caries experience compared with 16 per cent in 1980, an 82 per cent improvement. In Stranraer, the proportion with no untreated caries increased from 53 per cent to 68.3 per cent and those with no caries experience from 43 per cent to 54.2 per cent, only a 26 per cent improvement.

The 1983 Children's Dental Health Survey (85) reported that 26 per cent of the 5 year olds examined in Scotland had no experience of caries and 34 per cent had no untreated caries. While these figures are comparable with the Annan results, they emphasise the advantage Stranraer children enjoyed. The 1983 National Survey does not report mean dmft for 5 year olds, but the mean decayed, filled teeth (dft) score was 3.2 for Scottish 5 year olds.

The first Scottish Health Board's Dental Epidemiological Programme Survey (154) was carried out in late 1987. Weighted dmft scores for the 5 year old sample in this survey were dt = 1.76, mt = 0.5 and ft = 0.46 with a mean dmft score for Scotland of 2.72, with 42.4 per cent having no caries experience (dmft = 0). The 5 year old sample in Dumfries and Galloway Health Board Region, which included children in both Stranraer and Annan, had a mean dmft score of 2.25 with a similar spread of dmft component scores. The proportion with no caries experience was 46.5 per cent for the region. Both of these results fall just below halfway between the results for children in Stranraer and Annan. Although there is apparently a small improvement during the year between the 1986 study and the Scottish Health Boards Survey, it may well just reflect the proportionate balance in the sample between the children from the formerly fluoridated area and the non-fluoride portion of Dumfries and Galloway.

A number of studies of 10 year old children in fluoride and non-fluoride areas around the world have reported differences in mean DMFT of 42 - 67 per cent (52). The 1980 study observed a difference of 50 per cent between Stranraer and Annan, with mean DMFT scores of 1.66 and 3.35 respectively. No other British studies have reported on this age group, although a study of 12 year olds in Birmingham recorded a difference in DMFT of 45 per cent (74).

With hindsight it might have been better to have selected 12 year old children for the Stranraer-Annan study to aid comparison with the many studies of this age group which have been undertaken. However the Primary 6 group was selected in 1980 as the oldest cohort who had received fluoridated water from birth. It was not therefore possible to use 12 year old children in the 1980 fluoridation study.

The 1986 study revealed a difference of only 38.8 per cent in mean DMFT in Stranraer compared with Annan, with scores of 1.72 and 2.81 respectively. The 1983 National Survey (85) reported a mean DMFT of 2.7 for Scottish 10 year olds, with 60 per cent of the subjects having no untreated caries and 39 per cent having no experience of caries. While there has been a reduction of 16 per cent in mean DMFT in 10 year olds in Annan between 1980 and 1986 there has been a 3.6 per cent increase in DMFT in Stranraer (tables 22 & 23)

There is no obvious reason why there should have been a marginal increase in the mean DMFT in Stranraer between 1980 and 1986. The period of exposure to caries risk after eruption, particularly of the first permanent molars coincides approximately with the period when fluoridation ceased in Stranraer. This would remove any benefit from the topical post-eruptive effect of fluoridated water. Studies have indicated that remineralisation of the early carious lesion in the presence of fluoride leads to the formation of a more resistant enamel. Fluoride in the drinking water is likely to increase the opportunity for this effect to occur. Fluoride was available in this manner to the 10 year olds in 1980 but the 1986 group were without fluoride in the water during the crucial early years after eruption. Thylstrup and Fejerskov et al have reported that maximum period of risk for caries attack is the first year following eruption (255). This coincides with the period in Stranraer when post-eruptive fluoride was no longer available to the first permanent molars in which most of the caries was recorded. No change was found in the deciduous teeth of the five year old children in Stranraer, as the majority of these teeth would have erupted prior to the ending of fluoridation in 1983 and would therefore have benefited from the pre-eruptive fluoride mechanism and the topical post-eruptive effect during the crucial early eruption period. As the caries risk became lower with time, the use of fluoride toothpaste was probably sufficient to support the pre-eruptive inhibitory effect of the fluoridated water.

Other possible changes may have contributed to the reduction in caries in the younger children as opposed to the older age group.

Although the number of practices had remained the same, there had been changes in the personnel in General

Dental Practice in Stranraer between the two studies and this may have had an effect on the pattern of prevalence found. It has been reported in a number of studies that a dentist seeing a patient for the first time is more likely to prescribe treatment. An 11 per cent increase in the filled permanent component was observed in the 10 year old Stranraer children between 1980 and 1986. The younger age group appeared to have had less dental care, as would be expected, as the filled component was less than the decayed teeth component. This was directly opposite to the pattern of decay and fillings in the 10 year old children. However many dentists fail to restore primary teeth due to poorer cooperation and tend to leave them until extraction is necessary. By the age of ten, most children are reasonably cooperative and are more likely to have restorative care of their permanent teeth.

There is a possibility that early carious lesions, which would not be recorded as caries under the study criteria, may be regarded as requiring treatment by some dental practitioners, particularly as fissure sealants are not available from the General Dental Service under item of service. Practitioners may also have been worried by a number of reports of large areas of occult caries in dentine with only minor cavitation or staining of the enamel, and may therefore have investigated suspicious lesions and placed restorations. Interestingly there is little scientific evidence to support this concern.

Despite the increase in filled teeth, fluoridation still benefited the children of Stranraer in 1986, 75.9 per cent of the Stranraer 10 year olds had no untreated caries compared with 50.5 per cent in Annan. 43 (33.9 per cent) children had no caries experience compared with 20 (19 per cent) in Annan, a difference of 78 per cent (Table 18) The respective 1980 figures were 35 per cent and 10 per cent, so there was again a marginal increase in Stranraer and a significant improvement in Annan (table 17). The non-fluoride area showed the general fall in caries which has been recorded elsewhere in the U.K. It may be that the caries levels in Stranraer had reached the lowest feasible level, leaving little room for further improvements.

However many of the other studies in England and Wales have reported much lower levels of caries in fluoridated areas, including older groups of children who would have additional age increments of caries. So it is not reasonable to assume that caries prevalence in Stranraer 10 year olds was at its lowest possible level.

3. 15 year old children

The 1983 Children's Dental Health Survey recorded a mean DMFT for 15 year olds in Scotland of 8.4. The mean DMFT in the 1986 study was marginally lower in Annan at 7.75, but is similar to the mean DMFT recorded in a study of 15 year olds in five districts in Greater Glasgow (143). A lower mean DMFT of 6.81 was reported in a study of Edinburgh 15 year olds (145). Both of these studies used the SPEED system employed in the Stranraer-Annan studies. The comparable DMFT for 15 year olds in England is 5.6. In contrast, the mean DMFT for 15 year old life-time residents in Stranraer was 2.72, a difference of 5.03 and a difference of 64.9 per cent compared with Annan, 65.8 per cent with Glasgow and 60 per cent with Edinburgh.

The Children's Dental Health Survey observed that 96 per cent of 15 year olds in Scotland had experienced caries. Only 4 of the Annan subjects had not experienced caries, equivalent to 3.7 per cent, similar to the national survey and the Glasgow study. More than 55 per cent of the Annan 15 year olds had untreated caries and this accounted for 21.4 per cent of the overall DMFT score in Annan. The Glasgow study had a slightly higher level of untreated decay at 26 per cent of the overall DMFT.

Fluoridated Stranraer had 25 subjects (21.7 per cent) who had no caries experience and 73 per cent of the sample had no untreated caries.

4. Trends in Ireland

A series of studies in Ireland since the original base-line pre-fluoridation study in 1961 have measured caries prevalence in four age groups of children. One of the selected groups was 5 year old children, who had a mean dmft score of 5.6 in the base-line study (142). By

1981 the studies had shown a 50 per cent decrease in the prevalence of caries in the fluoridated areas and a 10-30 per cent difference in areas without fluoride (142). The proportion of children with no caries experience has increased to over 50 per cent in the fluoridated areas and between 20-40 per cent in the non-fluoridated. This decline in caries has been attributed to water fluoridation and the widespread use of fluoride toothpastes.

By 1984 the mean dmft of children who were life-time residents in areas with fluoridated water supplies had fallen to 1.8, with children from non-fluoridated areas having an over-all mean dmft score of 3.0 (256). On a national basis, there had been, by 1984, a 68 per cent reduction in caries prevalence in 5 year old life-time residents of fluoridated areas, compared with 46 per cent in non-fluoride areas. There was however, considerable variation between the different Health Board areas, both in the original and later studies.

In 1984, there was a 40 per cent difference between the mean dmft scores of 5 year old life-time residents in fluoridated areas and the non-fluoride areas. On a surface basis, the difference was 42 per cent with mean dmft scores of 3.6 and 6.2 respectively. Although these are significant, higher differences have been found in most similar studies in the United Kingdom. The authors suggested that this apparent reduction in effectiveness was mainly due to the difficulties of obtaining a true control group in the Irish Republic. Many of the children living in the non-fluoridated areas spend some of the year in fluoridated areas and food and drink is moved from area to area, leading to some level of fluoride exposure for all children. Comparison of the results of studies of older children in Ireland with the results of a study in Northern Ireland, where this is no water fluoridation indicate differences of over 50 per cent between the two countries. Much of this difference in caries rates can be attributed to water fluoridation.

5. Trends after ending of fluoridation

In 1988, there was significantly less untreated caries in Stranraer 5 year olds ($p < 0.05$) than Annan, with a 25 per cent difference in the mean dt scores, but there was also 39 per cent more filled teeth in Stranraer compared with Annan (Table 9). As a result of this, the difference in mean dmft scores was a non-significant 3.1 per cent or 0.1 dmft. So five years after fluoridation ceased, caries levels in the two towns had moved to almost parity in the 5 year old age group.

The 10 year old age group showed a different pattern, with more decayed teeth and less filled teeth in Stranraer when compared with Annan. Although there was a 10.9 per cent lower DMFT score in Stranraer, none of the differences found in decayed, missing and filled components were statistically significant.

Similarly, when looking at dental health, the large differences found in the proportions of children with no caries experience in 1980 had been eliminated over time, until no significant difference existed between the two towns.

Although there was a 52.8 per cent fall in caries levels in 5 year old children in Stranraer in 1986 compared with the 1980 study, a 163 per cent higher mean dmft score was recorded in 1988 compared with 1986. As a result caries prevalence in Stranraer 5 year old children had increased by 24 per cent between 1980 and 1988.

In Annan, after the 12.8 per cent decrease in caries levels found in 1986, there was a further 16.8 per cent decrease in mean dmft score during the next two years, giving an over-all decrease of 27.4 per cent over the period since the original study.

Unlike the 1986 cohort, who had the benefit of water fluoridation during the development and eruption of the deciduous teeth, the 1988 group of 5 year old children in Stranraer had no exposure to water fluoridation. It would appear that the benefit of the pre-eruptive mechanism of fluoride, aided by the topical or post-eruptive effect during the critical eruption period gave a continued benefit from water fluoridation in 1986.

As the 1988 children had neither post or pre-eruptive water fluoridation to help their teeth resist dental caries, they were on a par with Annan children for caries risk.

The study of 5 year old children in Wick after water fluoridation ceased in 1978, revealed a similar increase in the mean dmft score (92). All of the Stranraer and Wick studies were carried out during a period of temporal decline in caries prevalence in Britain, with fluoride toothpaste readily available.

The 27.4 per cent decline in caries in Annan is in line with the falls in caries prevalence reported in the United Kingdom in the late seventies and nineteen eighties. A fall of 23.6 per cent was also found in the mean caries levels in the 10 year old children when comparing the 1980 and 1988 studies.

However, the 10 year old children in Stranraer showed a marginal increase in caries prevalence in 1986, which was followed by a 32.6 per cent increase in caries levels between 1986 and 1988. There was a 37 per cent increase over the eight year period. So once again, an increase in caries prevalence had occurred in Stranraer during a period when there had been a significant decrease in caries rates in Annan. As can be seen from Table 31, the major increase in caries rates occurred between 1986 and 1988 in Stranraer. There was a compound annual rate of change in 5 year olds of 74 per cent during that two year period, following a compound fall of 11.8 per cent per annum in the previous 6 year period, This substantial increase after a period of decline resulted in a 2.8 per cent annual increase over the full eight year period. During the same time period, reductions in caries levels found in each study led to a 3.9 per cent compound decrease per annum in Annan.

The pattern of change found in Stranraer repeats that found in the small number of earlier studies which monitored caries where water fluoridation had ceased. Caries rates in these studies increased to similar levels to those in non-fluoride groups (5, 92, 106-109). These studies mainly took place prior to the general decline in caries prevalence. It is noteworthy that the latest studies took place during a period of temporal decline and there was still an increase in caries levels in Stranraer to parity with Annan.

The changes in Annan follow the pattern of declining caries prevalence reported in many studies in Britain and Europe during the same period.

A similar pattern of change was also found in the 10 year old children in the two study towns, with steadily increasing caries rates in Stranraer giving rise to a 4.1 per cent Compound annual rate of increase over the period. The largest rate of change was again between 1986 and 1988.

This increase in Stranraer was mirrored in Annan by a compound rate of decrease of 3.3 per cent over the eight year period of the 3 studies (Table 32).

These findings in Stranraer are in line with the changes reported in areas where water fluoridation has been discontinued, whilst the changes in Annan follow the general temporal decline in caries reported in many studies in both Britain and Europe.

The 1991 study of five year old children in the two towns, eleven years after the original study showed that caries levels were continuing to fall in Annan. There had been a further fall of 34.6 per cent, with a 13.2 per cent annual rate of change during the three year period between the 1988 and 1991 studies.

The SHBDEP report of the 1989/90 survey of 5 year olds in Scotland had suggested that the falls in caries levels may have reached a "Plateau" at a level above that achieved in England or there may have been a pause in the temporal decline (156). While caries levels had continued to decline in Annan, the mean dmft of 3.18 found in 1986 was higher than the figure of 2.18 reported in the 1987/88 Scottish survey. So it could be said that the continuing fall in Annan was just bringing caries levels in that town in line with average levels in Scotland. The latest figure of a mean dmft of 2.28 for Scotland (156) is similar to the scores of 2.08 and 2.39 found in Annan and Stranraer in 1991.

As any benefit from water fluoridation was denied to the 1988 cohort of 5 year old children in Stranraer, it is interesting to see that caries levels fell between

1988 and 1991. the mean dmft of 3.08 reported in 1988 had fallen to a mean score of 2.31 in 1991, a 22.4 percentage difference or 0.77 dmft giving an 8.1 per cent annual decline over the period. This fall also brought caries levels in Stranraer down towards the average caries prevalence in Scottish children

Although there is not a statistically significant difference between the two towns, it is interesting to note that caries levels are now higher in 5 year old children in Stranraer than in Annan. The proportion of children with no caries experience is also slightly lower in Stranraer compared with Annan. However both towns require further improvements in dental health to achieve the Global Goal of 50 per cent with no caries experience.

Unfortunately it was not possible to examine the 10 year old children in Stranraer and Annan in 1991. However the 1986 10 year olds from Stranraer were re-examined in 1991, when they were aged 15 years old. In 1986, although caries levels were declining in general, there was no improvement in caries prevalence in Stranraer 10 year old children. This was thought to be a result of a possible early adverse trend resulting from the loss of water fluoridation. Although the permanent teeth of this group had benefitted from the pre-eruptive mode of fluoride action, there was no topical effect present when the teeth erupted. This is a possible cause of the lack of improvement in caries rates.

Comparing the decayed missing and filled scores for this cohort in 1991 with the 15 year old children in 1986, caries levels are substantially higher in the 1991 study. Mean DMFT had increased by almost 30 per cent to 3,85 compared with 2.72 in 1986. The 1986 group had been exposed to water fluoridation for more than 10 years at the time fluoridation ceased in 1983. The first molar teeth in this group, where most caries was recorded, would have benefitted from both pre and post-eruptive fluoride during development and the period of maximum caries risk after eruption. Whereas the 1991 group had only been exposed to pre-eruptive fluoride without any reinforcing topical action apart from fluoride toothpaste. This higher caries rate appears to have resulted from this lack of post-eruptive fluoride exposure.

6. Factors affecting oral health

However other factors could have been responsible for the differences found between the Stranraer and Annan children in the four studies and the secular trends identified in each study town

Dental Attendance was recorded for the 15 year olds and 76 per cent claimed to be regular attenders in Annan and 86 per cent in Stranraer. A 1984 study showed that the average claimed regular attendance for Glasgow was 76 per cent (143), ranging from 71 to 81 per cent in the districts studied. Although the majority of 15 year olds in Glasgow, Annan and Stranraer were recorded as regular attenders, it appears that only in the fluoridated area were the dentists able to cope with their clinical needs.

However these figures may be an over-estimation of regular attendance as a result of the self-reporting method used. Annual figures from the then Scottish Dental Estimates Board, now Dental Practice Board, indicate that slightly more than 50 per cent of children were regular attenders during the period covered by these studies. Similar levels of dental attendance were also claimed by the 10 year old subjects in each town. None of the variations in attendance between the age groups in Stranraer and Annan was statistically significant. It is therefore unlikely that dental attendance patterns had any link with the differences in DMFT scores found in these studies.

15 year olds in Annan appeared to have similar patterns of dental health to the rest of Scotland, but Stranraer did better than average in 1986. Whether the better oral hygiene levels in Stranraer compared with Annan or Glasgow (143) are attributable to better dental attendance is doubtful. Water fluoridation does not improve oral hygiene. However the differences were not statistically significant. However the dental attendance figures and the results of the periodontal examination may be an indication of the level of dental awareness among 15 year olds in the two towns.

Oral cleanliness was variable in the 10 year old groups in the 1980, 1986 and 1988 studies. In all studies, the majority were recorded as having plaque or debris at less than 11 sites. In 1980, there was little difference in oral cleanliness levels in the two towns, but in the other studies, around 5 per cent more subjects in Stranraer were categorised as having plaque at less than 11 sites.

Apart from the girls in the 10 year old age group in Annan in 1980, the boys had marginally poorer oral hygiene than the girls. However none of the differences found were statistically significant.

A similar pattern is found in the over-all prevalence of gingivitis in the two communities. The Stranraer 10 year old group having slightly less gingivitis than their Annan counterparts in 1980 and 1988. In 1986, none of the Annan children had gingivitis recorded at 5 or more sites and only 2 children were in this category in Stranraer.

There were no statistical differences between the boys and girls in the 10 or 15 year old groups in Stranraer. But in 1980, 10 year old boys in Annan had significantly higher levels of gingivitis than the girls ($p < 0.05$). Additionally, in 1986 15 year old boys in Annan had more gingivitis recorded than the girls, again a statistically significant difference($p < 0.01$).

However this was not reflected by differences in caries levels between these boys and girls. It appears therefore that oral cleanliness and periodontal health in the study towns has no link with the differences in caries levels found in the studies.

Studies have also shown that there is an apparent relationship between Social Class and dental awareness. Many studies have been carried out into the relationship between caries experience and social class and the majority have shown that there is an inverse relationship between social class and caries experience. These studies had also observed a trend towards a gradient of increasing caries experience with lower social class. However the numbers available in the study population were insufficient to produce any significant difference. In both areas social class IV has shown a level of caries experience slightly better than would be expected. There is no obvious explanation for this result, other than the small numbers involved.

The similarity in social class composition of the samples in the two towns and the lack of any statistical difference when caries prevalence is analysed by social class, appears to exclude social class as a factor in explaining the differences in caries prevalence which have been found.

7. Treatment Costs

While the benefits of water fluoridation in reducing dental caries experience have been demonstrated in many studies, there have been relatively few studies showing the benefits in terms of reduced cost of treatment in fluoridated areas. Those studies which have examined treatment costs in fluoride and non-fluoride areas have, in general, found that the differences in mean treatment cost are of a similar order to those reported in caries studies. A study of Birmingham and Salford 5 year olds observed a difference in the cost of treatment needed for caries of 49 per cent in fluoridated Birmingham (74). The lower cost was attributed to fewer lesions and a reduced need for multiple surface restorations in the Birmingham children.

The 1986 study found a 69.4 per cent difference in the mean cost of restorations for caries with a mean cost of 2.35 in Stranraer 5 year olds and 7.96 in Annan. Analysing the mean total cost of treatment found a 56.9 per cent difference for Stranraer compared with Annan. Total cost calculations include the cost of examination and advice and, in the older age groups, periodontal treatment as well as treatment for trauma. These costs are, of course, not affected by fluoridation of the water unlike treatment for caries.

In 1980 a difference of 50 per cent was reported in the cost of restorations for caries in Stranraer. Over the period covered by the studies there has been a 49.2 per cent decrease in restoration costs and 42.8 per cent in total costs in Stranraer 5 year olds, compared with differences of 12.8 per cent and 21.4 per cent respectively in Annan, reflecting the improvements in caries levels in both areas (tables 26 & 27).

The 10 year old group in Stranraer showed an increase in the mean cost of restorations and total cost by comparison with 1980. An increase was a possibility, in view of the slight increase in DMFT which was observed. However the mean cost of restorations had risen by over 100 per cent, while the mean decayed teeth figure has remained constant at 0.35. It would appear that the smaller numbers who required restorations in 1986 compared with 1980 also required more complex and expensive restorations. A further indication of a decline in resistance to caries in this group.

There was also a 9 per cent increase in the cost of restorations in Annan 10 year olds, but a 4.3 per cent decrease was found in mean total cost. However a reduction in restoration costs might have been expected, as there had been an increase of 14 per cent in the number with no untreated caries. There were reductions in the costs of extractions in both areas.

Comparing Stranraer with Annan showed a 52.9 per cent difference in mean restoration costs and 36.5 per cent in mean total costs in the fluoridated group. No

General Anaesthetic costs were incurred in this age group or in the 5 year old groups. A 44.4 per cent difference was observed in the cost of periodontal treatment in Stranraer compared with Annan, but very low levels of periodontal treatment were recorded.

The 15 year old group showed a difference in the mean cost of restorations for caries of 5.74 units or 78.6 per cent when comparing fluoridated Stranraer with Annan. The mean total cost figures showed a difference of 7.20 or 62.7 per cent. The largest difference was of 87 per cent in the cost of extractions for caries. The Annan 15 year old group contained the only subjects who required general anaesthesia according to the SPEED criteria.

There was a 49.3 per cent difference in the mean cost of periodontal treatment in Stranraer by comparison with Annan. This is probably due to the poorer oral cleanliness and gingivitis prevalence recorded for Annan. The poorer scores reflect the lower reported levels of regular dental attendance in Annan compared with Stranraer.

Analysis of treatment costs in the 1988 study showed that the potential costs of providing restorations and extractions for caries were 14.3 per cent and 70.6 per cent higher in Annan than Stranraer, reflecting the 25 per cent difference found in decayed teeth in 5 year olds. While decayed permanent teeth were slightly higher in 10 year olds in Stranraer, the mean DMFT figure was almost 11 per cent lower in Stranraer than Annan, although this difference was not statistically significant. However the cost of restorations for caries in the Annan subjects was 10.4 per cent higher and although the cost of extractions was lower, a greater need for periodontal treatment resulted in total treatment costs being significantly higher in Annan by comparison with Stranraer ($p < 0.05$).

The results for treatment costs in the studies are similar to other studies of treatment cost. However these savings will only apply if the children in both areas actually receive treatment from the General Dental Service. Approximately 20 per cent of the 15 year olds stated that treatment was received from the Community Dental Service.

The Resource Related Index is based on the General Dental Service fee scale. The fee for any item is based on the average number of time units that dentists take to complete that particular operation and the price per unit of time. The time units per item were agreed at the Sunningdale conference. As the fee scale takes into account average practice expenses, it is realistic and comprehensive.

Unfortunately it is not possible to estimate costs of treatment in the Community Dental Service, as costs vary from one Health Board to another and detailed breakdowns are not available.

A further factor affecting the potential savings in the fluoridated area, is that the SPEED programme does not analyse the cost of treatment already received, only the treatment which is actually required at the time of the examination. The higher numbers with no experience of caries and the lower mean decayed, missing and filled scores for Stranraer indicate that there would probably still be a cost saving if past treatment was included.

The high levels of claimed regular dental attendance would seem to indicate that most subjects would have the recorded treatment carried out. However, it is likely that this will not be the case, as probably only slightly more that 50 per cent of children attend regularly. Unfortunately it is not possible to assess the likelihood of treatment being obtained from the data in the Scottish Health Statistics (257) published each year as they only record national totals and do not divide the data into age groups.

Finally there may have been an under-estimation of the amount of treatment required. The epidemiological criteria employed require that any doubtful lesion should be recorded as sound. However dental practitioners often prescribe treatment for early lesions, which would be recorded as sound in the study. This is often based on worries regarding undetected dentine caries. As studies have shown that the early carious lesion can remineralise, with especial benefit if fluoride is present in the month, it would appear that cost savings in fluoridated areas could be maximised by caries diagnostic standards which did not prescribe treatment until cavitation had occurred. This should have no adverse effects provided regular screening examinations are carried out with the use of radiographs where necessary.

Changes in the NHS Contract may have spelt the end for studies examining treatment costs. However in my view they perform a useful function as subjects requiring specific restorative care can be identified and the examination of relativities between the different groups is helpful to decision making.

So in the three studies, treatment costs have been calculated based on the Resource Related Index fixed on the fee scale of 1988.

As can be seen. there do not appear to be any factors, such as oral hygiene, dental attendance, social class or other variations between the two towns, that can be used to explain the changes in caries prevalence in Stranraer and Annan. However the hypotheses of Russell and the further conclusions by Newbrun provide an explanation for the pattern of change in Stranraer.

In 1980, the children of Stranraer were benefiting from both the post and pre eruptive mechanism of fluoride leading to caries prevalence levels around half the levels found in the control town of Annan with no water fluoridation. Following the cessation of fluoridation in 1983, the 5 year old children in 1986 continued to show a benefit from fluoride which had increased by comparison with the Annan subjects. The deciduous teeth of these children had fluoride available during their development and fluoride was still present in the water to reinforce its protective effect during the eruption phase of these teeth.

However the first permanent molars of the 10 year old children in Stranraer only had the benefits of the pre-eruptive mode of action of fluoride. As a result the apparent beginning of an adverse trend can be explained by the loss of the maximum inhibitory effect due to the end of water fluoridation and its topical effect. The ready availability of fluoride toothpaste was insufficient to maintain the maximum level of fluoride inhibition of caries.

By the time of the 1988 study, the 5 year old children had no exposure to fluoridation while some of the teeth of the 10 year olds would have benefitted from the presence of fluoride during development. However these teeth had no topical or post eruptive fluoride available to maintain the caries inhibitory action of fluoride. As a result, caries increased in both age groups in Stranraer.

Finally in 1991, following the substantial increase in caries levels found in 1988, caries levels had begun to fall again in Stranraer. While there was no benefit available from fluoridation to the teeth of the 5 year old children, the decline in caries prevalence was probably associated with the widespread use of fluoride toothpaste, which has been suggested as the main cause of the temporal decline in caries in Britain and Europe.

However the evidence from the Stranraer-Annan studies shows that fluoride toothpaste alone can not produce the benefits on lower caries levels obtained with water fluoridation. It was only after caries levels in Stranraer had risen to parity with Annan and other areas of Scotland, that caries rates began to follow the general downward trend.

The continuous decline in caries levels in Annan is also associated with the general decline in caries prevalence. The trend in both towns is in line with the continued but smaller decline reported in children in the Isle of Lewis between 1987 and 1990 (258). Despite the temporal decline, there would still be a substantial benefit available from the re-introduction of water fluoridation in Wigtownshire and other parts of Scotland. Particularly in areas such as Glasgow where high levels of caries are still found and one major water source serves the majority of the population.

8. Computer Analysis Systems

The comparison of the computer software for the analysis of dental epidemiology data has shown that while the three main programmes assessed can all produce dmf/DMF information readily, their ability to analyse other indices is more varied. While Numbase can process the WHO dataset, its operation on a hand-held Psion computer places a number of limitations on its use. The size of the available datapaks limit the amount of data which can be simultaneously analysed. The small LCD screen also limits the amount of data which can be displayed at any one time, making it necessary to scroll through the data entry screen to complete the caries charting.

Surveyplus displays a complete charting on the screen, but being based on rather out-dated database software, its ease of use and manipulation of data is not up to expectations. While it can deal with a number of different indices if the appropriate process macros are written by the user, it is difficult to collect a range of dental indices in the dental format alone and several indices have to be tabulated and processed in the standard format section. The programme and its manual requires improvements to produce a convenient user-friendly software package.

The System for Planning and Epidemiological Evaluation of Dental Services provides a modular suite of programmes which can be readily selected to provide a series of different analyses, covering caries, periodontal data, malocclusions and treatment need and related costs. The combination of a standardised chart and analysis modules make it a straightforward and easy to use programme suite. It operates very effectively on main-frame computers. However while it has been possible to transfer SPEED to a micro-computer, limitations of available memory and workspace restrict the size of data sets which can be readily handled on such a system. It is possible to improve this by means of using an SPSS PC programme to carry out some of the Fortran based SPEED suites functions.

Unfortunately, because it was developed in the late seventies and despite the convenient modular design of the software, SPEED has the problem of its inability to deal with CPITN data, the DDE Index and also DMF Surface data. Caries surface data and root caries are becoming of greater importance as caries levels fall in the general population and the proportion of edentulous people in the general population decreases. While it would be possible to write a Fortran programme to analyse surface data, which could be collected on a modified data form, the programme operates most effectively on a main-frame computer due to the space limitations which occur when it is used on the average micro-computer.

Because this problem can be partially overcome by means of carrying out some of the SPEED functions via an

SPSS command file, it seems logical to consider the development of an analysis programme using SPSS command files. SPSS is available in both mainframe and micro-computer forms and data can be readily swapped between the two formats, freeing the analysis of epidemiological data from the main frame strait-jacket of old. Utilising an SPSS based system provides a comprehensive statistics package as well as data handling. Data entry is particularly facilitated in the PC version by the SPSS Data Entry Module which allows an on-screen form to be used to make the input process simple, data being either copied from a chart or keyed direct at the time of collection.

As the SPEED modular system had been found to be the best available from the point of ease of use and flexibility within its limitations, the new Dental Analysis System was developed as a modular system based on SPSS. Modules are available to carry out data analysis for the main indices currently used, DMFT/DMFS, DDE index and CPITN. Other modules are available to produce treatment need information and other requirements.

Following testing on the datasets used for the original assessments, the DAS programmes were successfully field tested in the Abu Dhabi study carried out by a postgraduate student in Paediatric Dentistry. It has since been used in other studies including the Glasgow/Dublin study and the 1991 Stranraer/Annan study.

It is proposed that the DAS system will be made available on disc. A manual will be produced for use in conjunction with the discs. As SPSS is now available for the Apple Macintosh, the programme could be readily adapted for use on that computer hardware. It is believed that the Dental Analysis System has taken the modular concept of SPEED and developed it to produce an analysis system which can meet the needs of epidemiology today and which will be readily adaptable in the future.

CONCLUSIONS

1) The hypothesis that there is still a reduction in caries prevalence in formerly fluoridated Stranraer compared with non-fluoridated Annan is rejected.

Although there was still a significant difference in caries levels at the time of the 1986 study, in 1988 there was no statistically significant difference between caries levels in the two towns in either age group. In 1998, caries prevalence was actually higher in Stranraer 5 year old children than the same group in Annan, although the difference was not statistically significant.

2) The hypothesis that there has been no change over time in the levels of caries prevalence in children in Stranraer and Annan since 1980 has also been rejected.

While there was no change in caries levels in the 10 year old group in Stranraer in 1986, caries prevalence was substantially lower in the 5 year old group. There was no statistical difference in 5 year old children in Annan between 1980 and 1986, but caries levels fell in the 10 year old age group. In 1988, caries rates had increased in both age groups in Stranraer, while caries prevalence had declined in the Annan subjects. Finally, in 1991, there was a further decline in caries levels in Annan to an over-all decrease of 52.5 per cent over the period of the studies. Due to a fall in caries rates after 1988, the mean dmft score in 5 year old children in Stranraer showed a non-significant difference of 3.6 per cent when compared with the 1980 results.

3) The hypothesis that there is no difference in the patterns of caries incidence found in Stranraer and Annan in the studies has been rejected.

While caries prevalence in Annan has steadily declined over the 11 year period of the studies, caries rates have risen and begun to fall again over the same period in Stranraer.

4) The hypothesis that there has been no change in the relative cost of treatment required in Stranraer and Annan by comparison with the 1980 study is rejected.

Treatment costs have decreased over the period between 1980 and 1988 in both 5 and 10 year old age-groups in Annan. A different pattern of change occurred in Stranraer with a decrease in treatment costs for the 5 year olds in 1986 and an increase in costs in the 10 year old group. This increase featured a substantial increase in the cost of restorations for caries, although the decayed teeth score was unchanged. In 1988, there was a increase in costs relative to 1980 in both study groups in Stranraer.

Following assessment of a variety of computer software for dental analysis, the Dental Analysis System was written utilising the facilities of the Statistical Package for the Social Sciences. It was based on the modular system of the System for Epidemiological Evaluation of Dental Services. After testing on the data collected for this and other SPEED studies, it had been successfully used for data analysis on a number of dental surveys.

This series of repeated studies, comparing children in a formerly fluoridated town with a control town, has provided useful information relating to the effects of stopping water fluoridation in a time of temporal decline in caries prevalence. The pattern of change in caries prevalence in Stranraer had provided evidence in support of the theories of the pre and post eruptive action of fluoride. Now that Health Boards in Scotland can begin the process to introduce water fluoridation, the results of the studies provide information which can be used to support the need for water fluoridation, as has already been done in the United States of America. The databank also provides base-line information should water fluoridation be restarted in South West Scotland.

Fluoridation was beneficial to Stranraer children in reducing caries levels and treatment need. Since fluoridation ceased, caries levels have risen to the same levels as non-fluoride areas, despite the widespread use of fluoride toothpastes and falling caries rates in general.

It is hoped that the benefits of water fluoridation will soon be restored to the children of Stranraer.

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DENTAL HEALTH OF CHILDREN BEFORE AND AFTER THE CESSATION OF WATER FLUORIDATION.

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VOLUME TWO

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Age Group (years)	Total Population 5	10	Number Examined 5	10	Life-time Residents 5	10
Stranraer (fluoridated)	158	190	151	183	129	147
Annan (non-fluoride)	117	170	111	163	101	141
Total	275	360	262	346	230	288

Table 1.Study population in Stranraer and Annan by age group in 1980.

Age Group (years)	Total Population 5	10	15	Number Examined 5	10	15	Life-time Residents 5	10	15
Stranraer (fluoridated)	156	175	189	150	161	166	120	127	115
Annan (non-fluoride)	118	151	164	98	143	149	90	105	109
Total	274	326	353	248	304	315	210	232	224

Table 2. Study population in Stranraer and Annan by age group in 1986.

Age Group (years)	Total Population 5	10	Number Examined 5	10	Life-time Residents 5	10
Stranraer (fluoridated)	151	170	138	161	121	125
Annan (non-fluoride)	115	149	109	135	96	114
Total	266	319	247	296	217	239

Table 3. Study population in Stranraer and Annan by age group in 1988.

Age Group (years)	Total Population 5	15	Number Examined 5	15	Life-time Residents 5	15
Stranraer (fluoridated)	145	-	128	-	112	83
Annan (non-fluoride)	115	n/a	105	n/a	90	n/a
Total	260		233		204	83

Table 4. Study population in Stranraer and Annan by age group in 1991.

Social Class	1986 Stranraer n	%	Annan n	%	1988 Stranraer n	%	Annan n	%
I	7	5.9	6	6.6	8	6.6	6	6.3
II	22	18.3	12	13.4	20	16.5	14	14.6
III	54	45.0	44	48.9	56	46.8	46	47.9
IV	26	21.6	19	21.1	23	19.0	19	19.8
V	0	0	1	1.1	1	0.8	1	1.0
Unclassified	11	9.2	8	8.9	13	10.7	10	10.4

Table 5. Social Class distribution of 5 year old children in 1986 and 1988

Social Class	1986 Stranraer n	1986 Stranraer %	1986 Annan n	1986 Annan %	1988 Stranraer n	1988 Stranraer %	1988 Annan n	1988 Annan %
I	8	6.3	5	4.8	7	5.6	7	6.1
II	20	15.8	17	16.2	22	17.6	17	14.9
III	67	52.7	58	55.2	63	50.4	55	48.2
IV	21	16.5	10	9.5	18	14.4	17	14.9
V	3	2.3	3	2.8	2	1.6	3	2.6
Unclassified	8	6.3	12	11.4	13	10.4	15	13.2

Table 6. Social Class distribution of 10 year old children in 1986 and 1988

5 year old group

	STRANRAER mean	STRANRAER SD	ANNAN mean	ANNAN SD	Difference	% difference	95% Confidence Interval	
dt	1.36	2.08	3.32	3.38	1.96	59.0	1.26 to 2.67	
mt	0.59	1.46	0.75	1.77	0.16	21.3	-0.26 to 0.57	NS
ft	0.53	1.08	0.31	0.90	-0.22	-70.9	-0.40 to -0.04	*
dmft	2.48	3.16	4.38	4.31	1.90	43.4	1.41 to 2.39	
	n = 129		n = 101					

10 year old group

	STRANRAER mean	STRANRAER SD	ANNAN mean	ANNAN SD	Difference	% difference	95% Confidence Interval	
DT	0.35	0.74	1.34	1.48	0.99	73.8	0.65 to 1.33	
MT	0.16	0.55	0.40	1.01	0.24	60.0	0.05 to 0.43	*
FT	1.16	1.35	1.61	1.85	0.45	28.0	0.08 to 0.82	*
DMFT	1.66	1.63	3.35	2.30	1.69	50.5	1.26 to 2.10	
	n = 147		n = 141					

$p < 0.001$ (t test and Mann-Whitney U test)
* = $p < 0.05$ NS = Not significant

Table 7. Caries prevalence by age group in fluoridated Stranraer and non-fluoridated Annan in 1980.

5 year old group

	STRANRAER mean	SD	ANNAN mean	SD	Difference	% difference	95% Confidence Interval	
dt	0.64	1.19	2.32	2.91	1.68	72.4	1.10 to 2.25	
mt	0.18	0.82	0.64	1.50	0.64	78.0	0.32 to 0.96	
ft	0.34	0.68	0.68	1.44	0.34	50.0	0.05 to 0.63	*
dmft	1.17	1.76	3.82	3.63	2.65	69.4	1.91 to 3.39	
	n = 120		n = 90					

10 year old group

	STRANRAER mean	SD	ANNAN mean	SD	Difference	% difference	95% Confidence Interval	
DT	0.35	0.74	0.90	1.13	0.55	61.1	0.30 to 0.79	
MT	0.09	0.37	0.27	0.95	0.18	66.6	0.00 to 0.36	NS
FT	1.28	1.37	1.65	1.61	0.37	22.4	-0.01 to 0.75	NS
DMFT	1.72	1.56	2.81	2.22	1.09	38.8	0.60 to 1.58	
	n = 127		n = 105					

15 year old group

	STRANRAER mean	SD	ANNAN mean	SD	Difference	% difference	95% Confidence Interval
DT	0.45	0.85	1.70	2.37	1.25	73.5	0.79 to 1.71
MT	0.20	0.61	1.15	2.04	0.95	82.6	0.56 to 1.34
FT	2.06	2.25	4.91	3.58	2.85	58.0	2.07 to 3.63
DMFT	2.72	2.38	7.75	4.74	5.03	64.9	4.06 to 6.00
	n = 115		n = 109				

$p < 0.001$ (t test and Mann-Whitney U test)
* = $p < 0.05$ NS = Not significant

Table 8. Caries prevalence by age group in Stranraer and Annan in 1986.

5 year old group

	STRANRAER mean	STRANRAER SD	ANNAN mean	ANNAN SD	Difference	% difference	95% Confidence Interval	
dt	1.64	1.82	2.19	2.32	0.55	-25.1	0.01 to 1.1	*
mt	0.38	0.81	0.35	0.64	-0.03	+8.5	-0.23 to 0.32	
ft	1.06	1.46	0.64	1.35	-0.44	+39.6	-0.80 to 0.04	
dmft	3.08	3.56	3.18	3.29	0.1	-3.1	-0.82 to 1.02	
	n = 121		n = 96					

10 year old group

	STRANRAER mean	STRANRAER SD	ANNAN mean	ANNAN SD	Difference	% difference	95% Confidence Interval
DT	0.92	1.12	0.81	1.21	-0.11	+13.5	-0.41 to 0.19
MT	0.11	0.43	0.25	0.95	0.14	56.0	-0.04 to 0.32
FT	1.25	1.34	1.51	1.72	0.26	17.2	-0.13 to 0.65
DMFT	2.28	2.04	2.56	2.23	0.28	10.9	-0.26 to 0.82
	n = 125		n = 114				

Not Significant, except * = $p < 0.05$

Table 9. Caries prevalence by age group in Stranraer and Annan in 1988.

5 year old group

	STRANRAER mean	STRANRAER SD	ANNAN mean	ANNAN SD	Difference	% difference	95% Confidence Interval
dt	1.82	3.1	1.57	2.31	0.25	+15.9	-0.51 to 1.02
mt	0.18	0.38	0.20	0.41	-0.02	-10	-0.09 to 0.13
ft	0.40	0.85	0.31	0.80	0.09	+29	-0.14 to 0.32
dmft	2.39	3.12	2.08	2.70	0.31	+14.9	-0.33 to 1.23
	n = 114		n = 90				

Not significant

Table 10 Caries prevalence in Stranraer and Annan in 1991

1980 STUDY

	STRANRAER		ANNAN	
	MALE	FEMALE	MALE	FEMALE
dt	1.46	1.28	3.64	3.05
mt	0.77	0.45	0.71	0.79
ft	0.64	0.45	0.29	0.32
dmft	2.87	2.18	4.64	4.16
n	56	73	40	61

1986 STUDY

	STRANRAER		ANNAN	
	MALE	FEMALE	MALE	FEMALE
dt	0.56	0.72	2.58	2.07
mt	0.19	0.18	0.60	1.04
ft	0.39	0.30	0.49	0.87
dmft	1.14	1.20	3.67	3.98
n	59	61	45	45

Table 11. Comparison of caries prevalence by sex in 5 year old children in the study towns in 1980 and 1986.

1988 STUDY

	STRANRAER		ANNAN	
	MALE	FEMALE	MALE	FEMALE
dt	1.62	1.66	2.28	2.10
mt	0.39	0.38	0.36	0.35
ft	1.05	1.06	0.61	0.66
dmft	3.06	3.09	3.25	3.11
n	58	63	47	49

1991 STUDY

	STRANRAER		ANNAN	
	MALE	FEMALE	MALE	FEMALE
dt	1.84	1.81	1.58	1.56
mt	0.39	0.38	0.36	0.35
ft	0.19	0.17	0.20	0.20
dmft	2.42	2.39	2.07	2.08
n	55	59	44	46

Table 12. Comparison of caries prevalence by sex in 5 year old children in the study towns in 1988 and 1991

1980 STUDY

	STRANRAER		ANNAN	
	MALE	FEMALE	MALE	FEMALE
DT	0.44	0.25	1.26	1.44
MT	0.07	0.24	0.36	0.44
FT	1.03	1.28	1.73	1.47
DMFT	1.54	1.77	3.35	3.34
n	72	75	77	64

1986 STUDY

	STRANRAER		ANNAN	
	MALE	FEMALE	MALE	FEMALE
DT	0.35	0.35	1.07	0.77
MT	0.09	0.08	0.41	0.16
FT	1.22	1.33	1.91	1.46
DMFT	1.65	1.76	3.39	2.39
n	55	72	44	61

1988 STUDY

	STRANRAER		ANNAN	
	MALE	FEMALE	MALE	FEMALE
DT	0.92	0.91	0.81	0.82
MT	0.12	0.11	0.25	0.25
FT	1.24	1.26	1.51	1.48
DMFT	2.28	2.28	2.57	2.55
n	62	63	55	59

Table 13. Comparison of caries prevalence by sex in 10 year old children in the two towns in 1980, 1986 and 1988.

1980 STUDY

		Stranraer	Annan	% difference
5 years old	ds	1.98	5.31	62.7%
10 years old	DS	0.45	2.51	82.1%

1986 STUDY

		Stranraer	Annan	% difference
5 years old	ds	1.25	4.18	70.0%
10 years old	DS	0.86	2.72	68.3%
15 years old	DS	0.79	2.5	69.0%

Table 14. Estimated decayed surfaces in Stranraer and Annan in 1980 and 1986

5 years old

	Stranraer		Annan		% difference
	Mean	SD	Mean	SD	
ds	3.38	7.05	4.28	7.98	21.0%
ms	1.14	2.01	1.05	2.23	8.5%
fs	1.40	3.14	1.03	2.99	35.9%
dmfs	5.92	8.91	6.36	9.11	11.6%
	n = 121		n = 96		

10 years old

	Stranraer		Annan		% difference
	Mean	SD	Mean	SD	
DS	2.02	3.99	1.94	3.88	4.1%
MS	0.33	1.22	0.75	2.17	56%
FS	2.44	4.18	3.54	4.11	31.1%
DMFS	4.79	8.12	6.23	9.75	23.1%
	n = 125		n = 114		

Table 15. Caries prevalence by surface in Stranraer and Annan in 1988

	Stranraer		Annan		% difference
	Mean	SD	Mean	SD	
ds	3.76	8.45	3.07	6.12	+22.4%
ms	0.54	0.93	0.60	0.98	-10.0%
fs	0.53	1.22	0.49	1.16	+8.2%
dmfs	4.83	8.93	4.16	6.15	+16.1%
	n = 114		n = 90		

Not significant

Table 16. Caries prevalence by surface in Stranraer and Annan in 1991

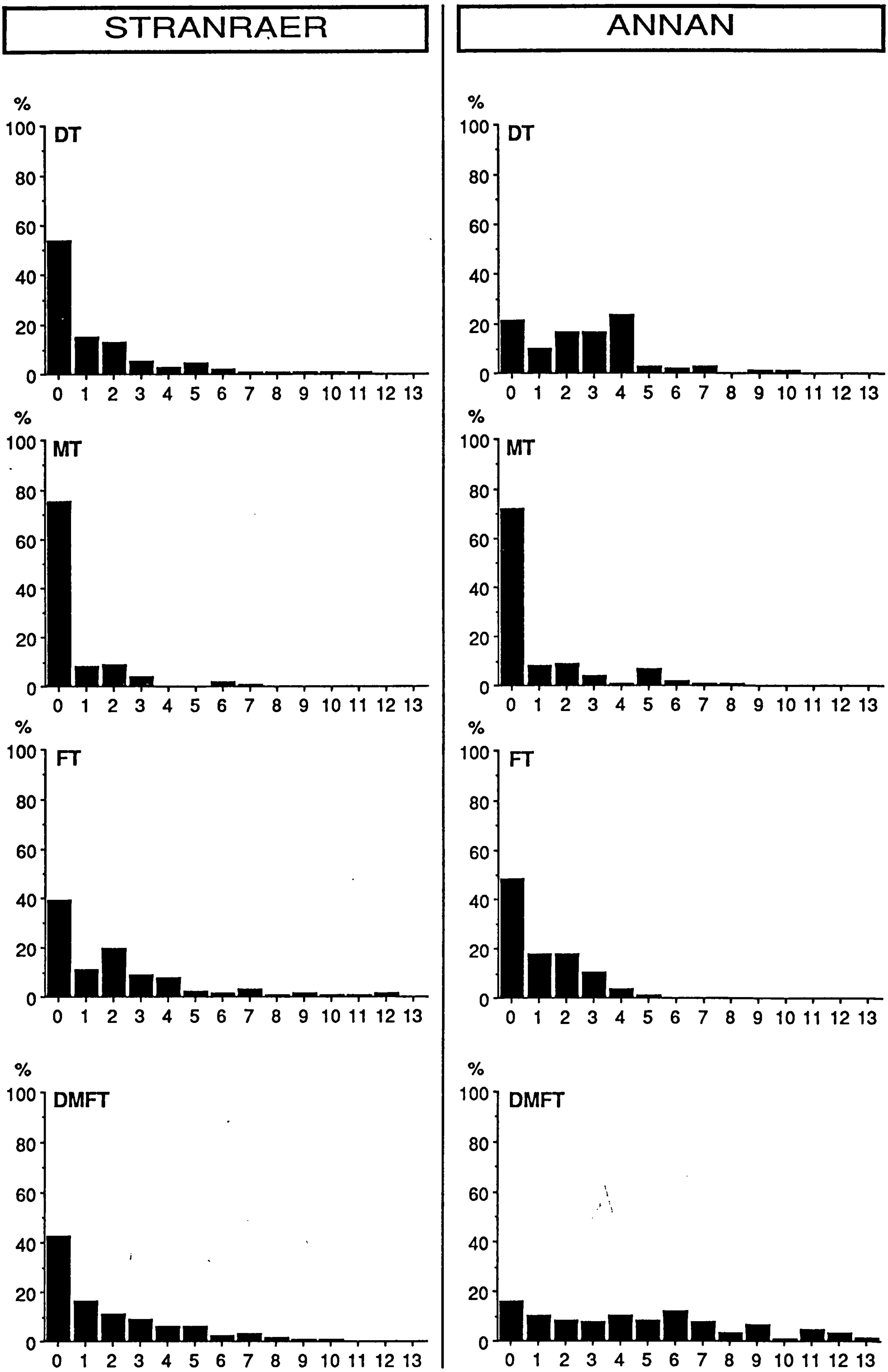

Figure 4
Percentage frequency distribution of decayed, missing and filled teeth in 5 year old children in 1980.

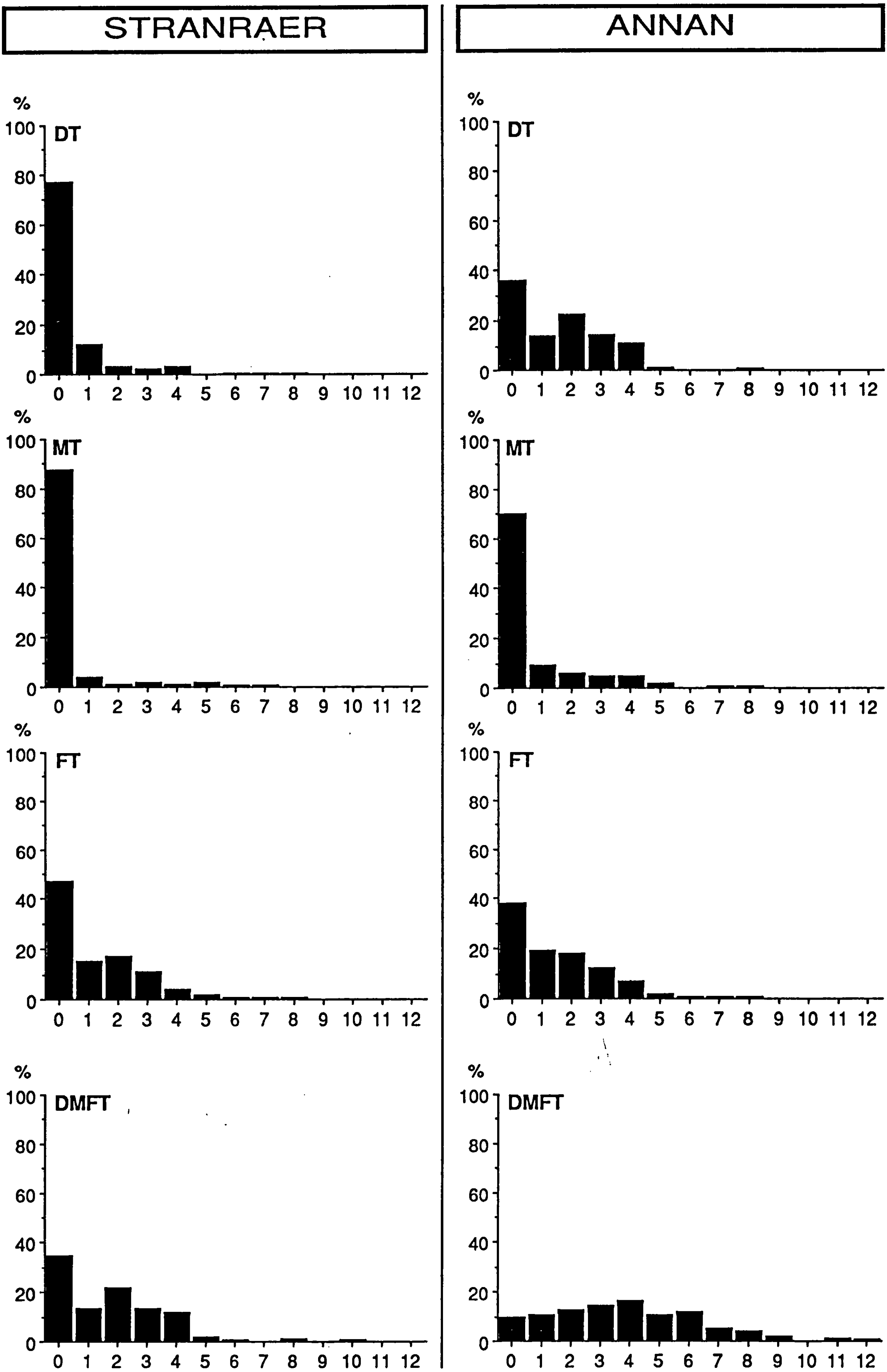

Figure 5

Percentage frequency distribution of decayed, missing and filled permanent teeth in 10 year old children in 1980.

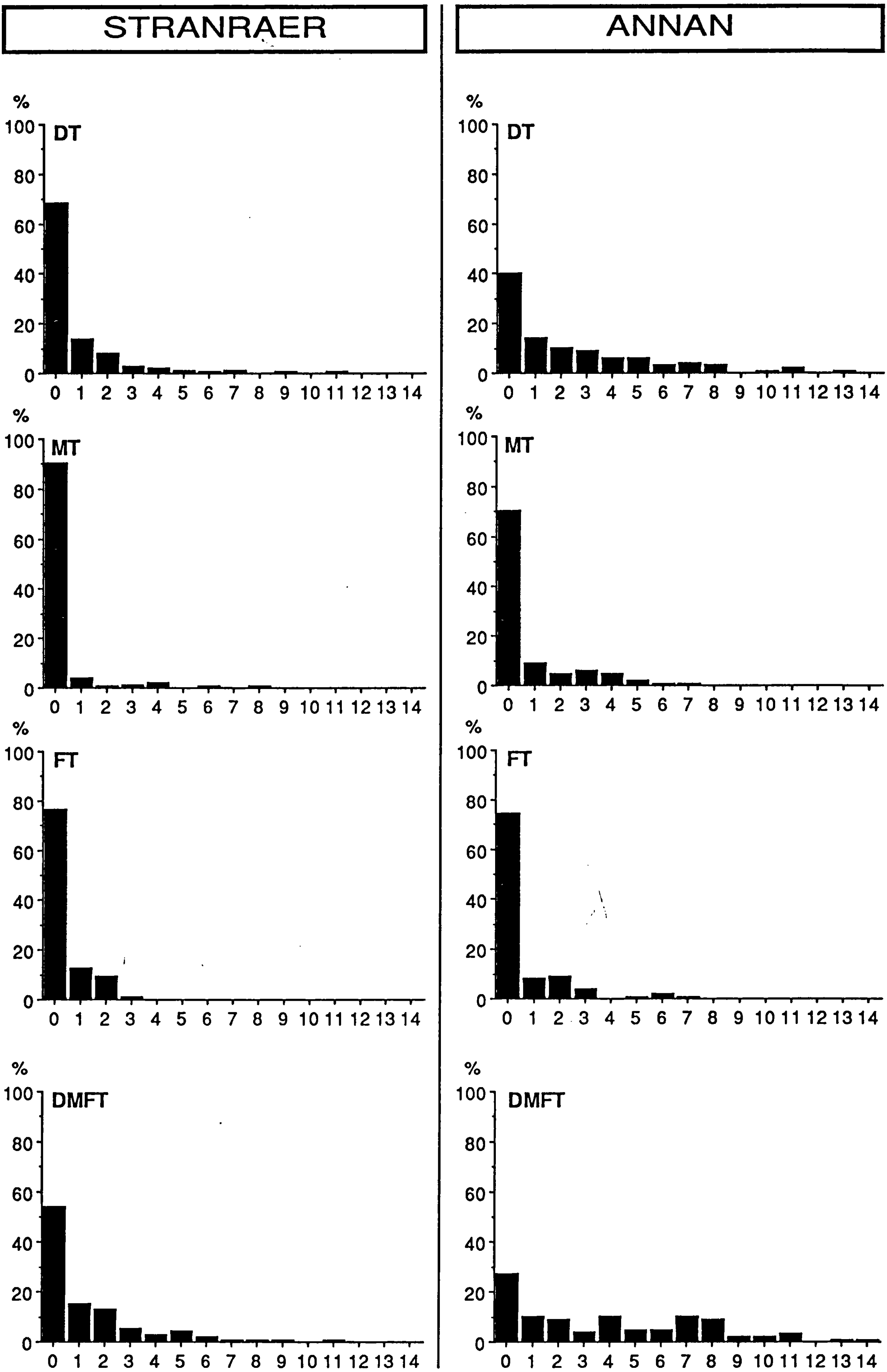

Figure 6
Percentage frequency distribution of decayed, missing and filled deciduous teeth in 5 year old children in 1986.

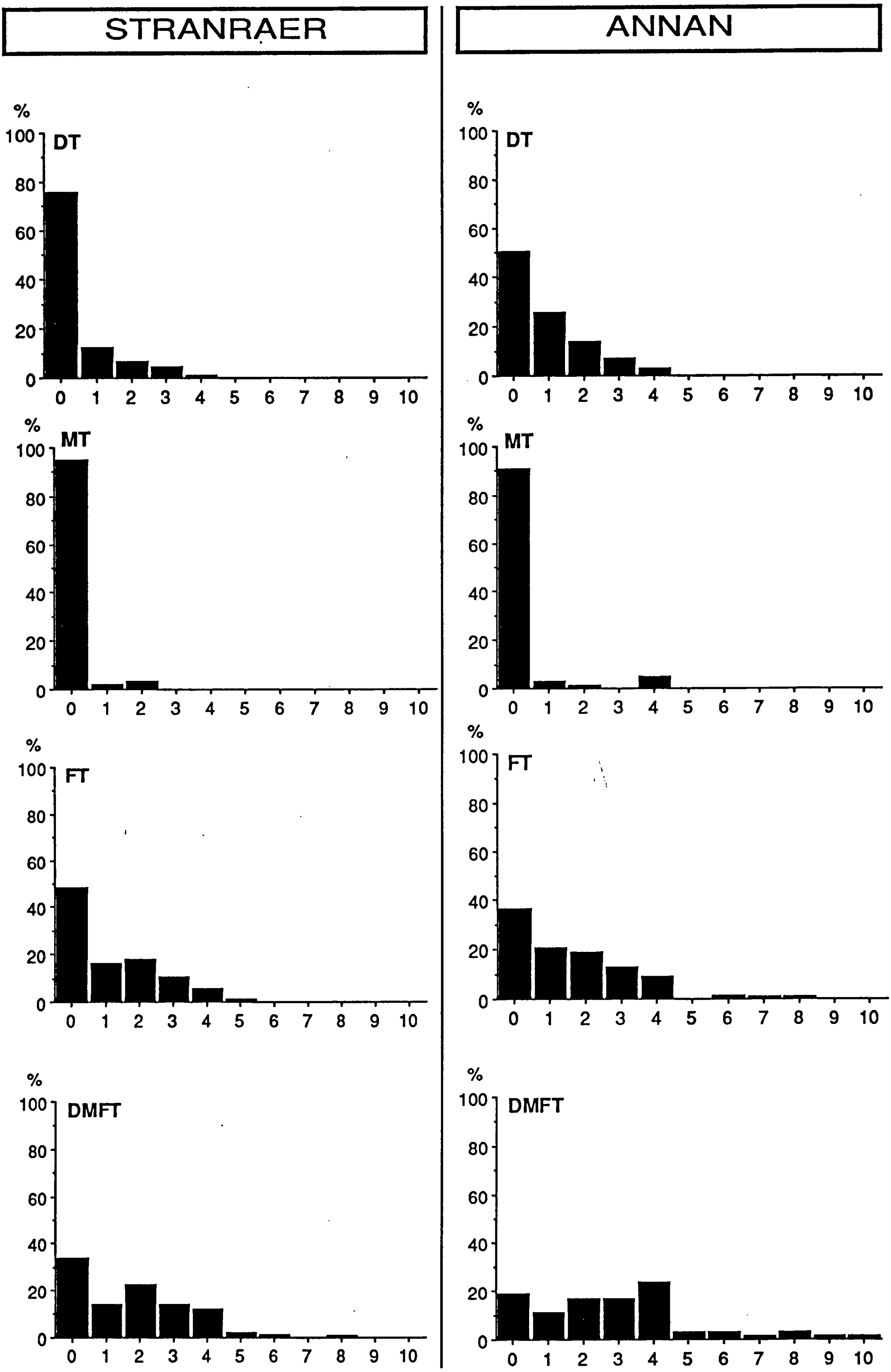

Figure 7
Percentage frequency distribution of decayed, missing and filled permanent teeth in 10 year old children in 1986.

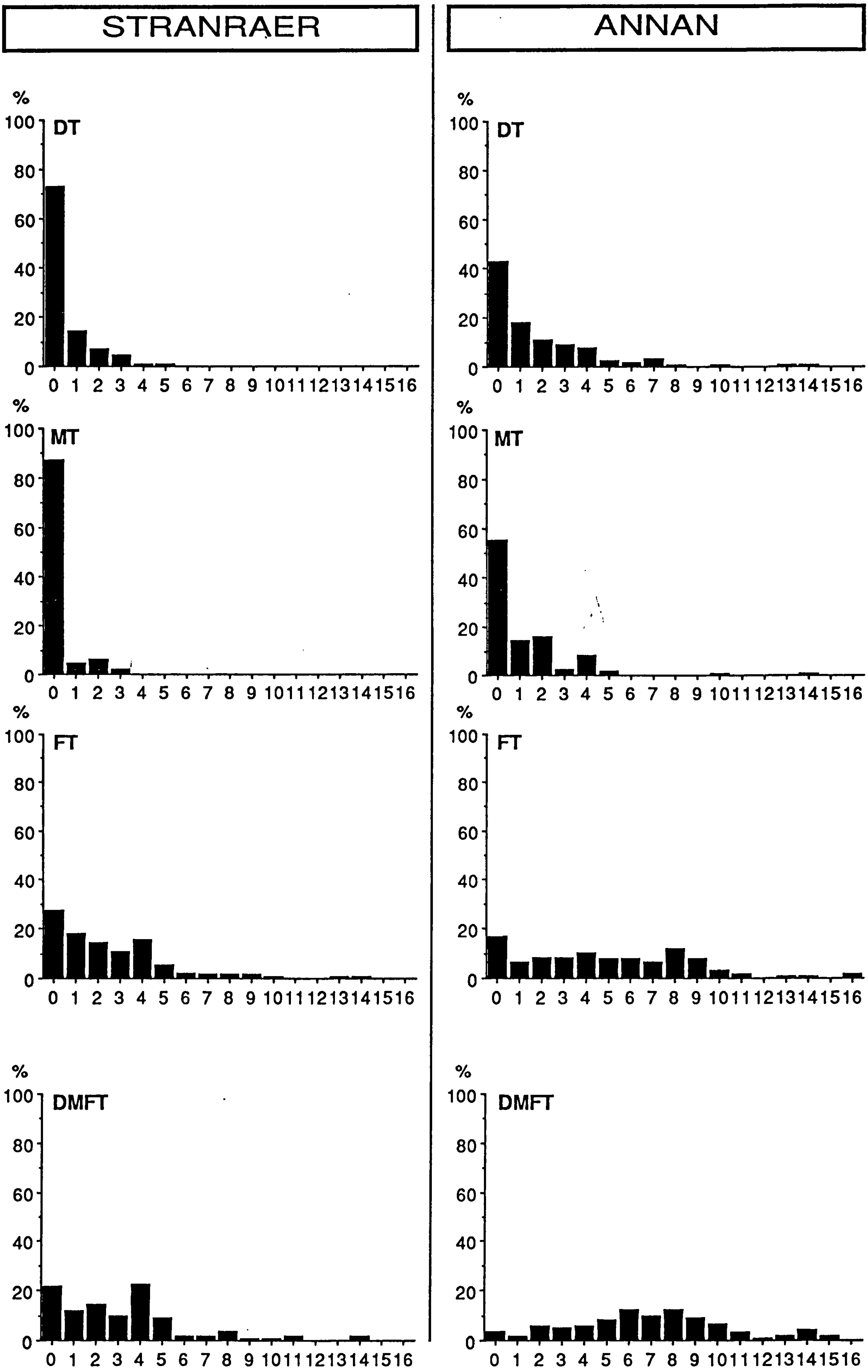

Figure 8

Percentage frequency distribution of decayed, missing and filled permanent teeth in 15 year old children in 1986.

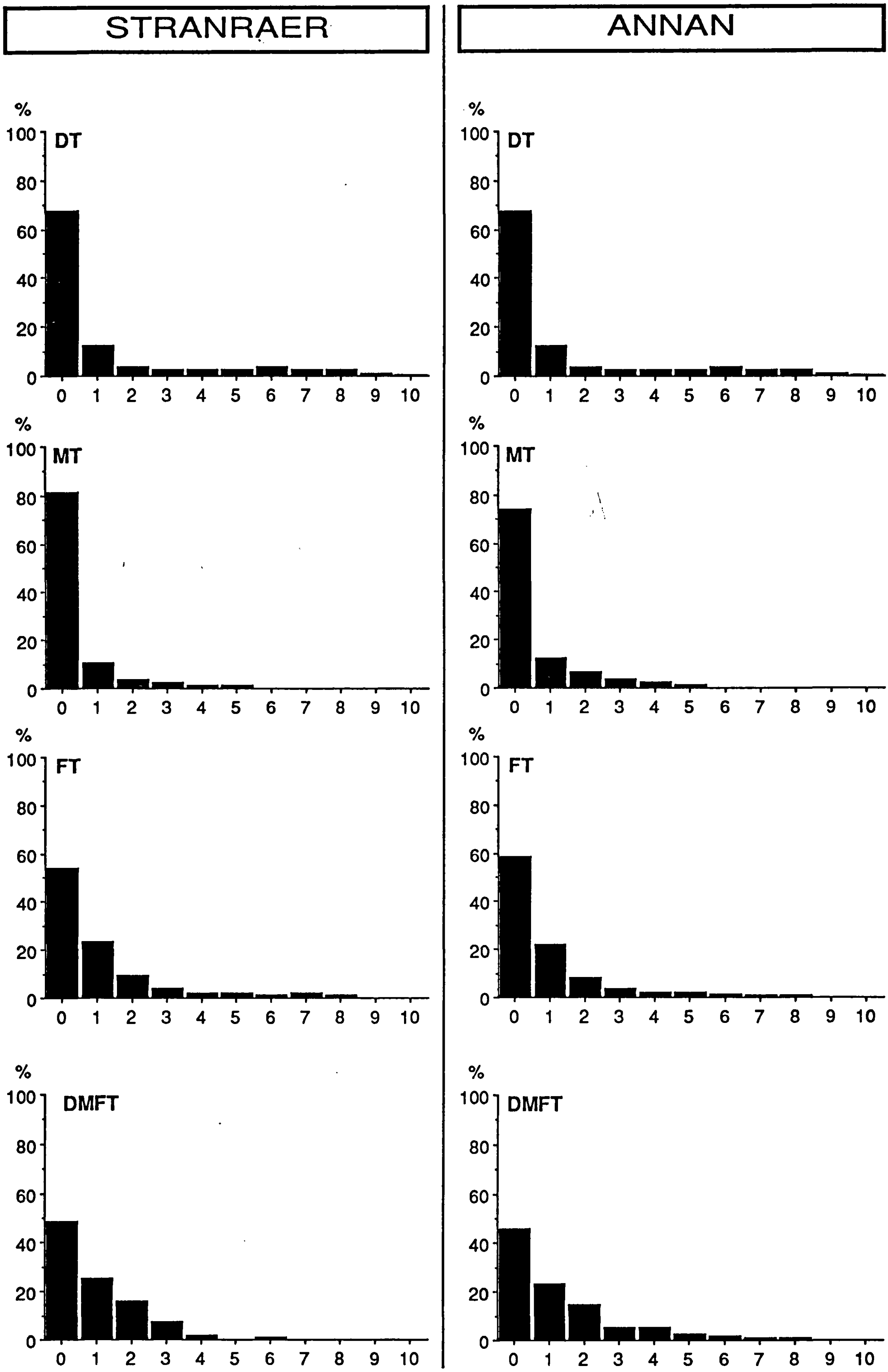

Figure 9

Percentage frequency distribution of decayed, missing and filled deciduous teeth in 5 year old children in 1988.

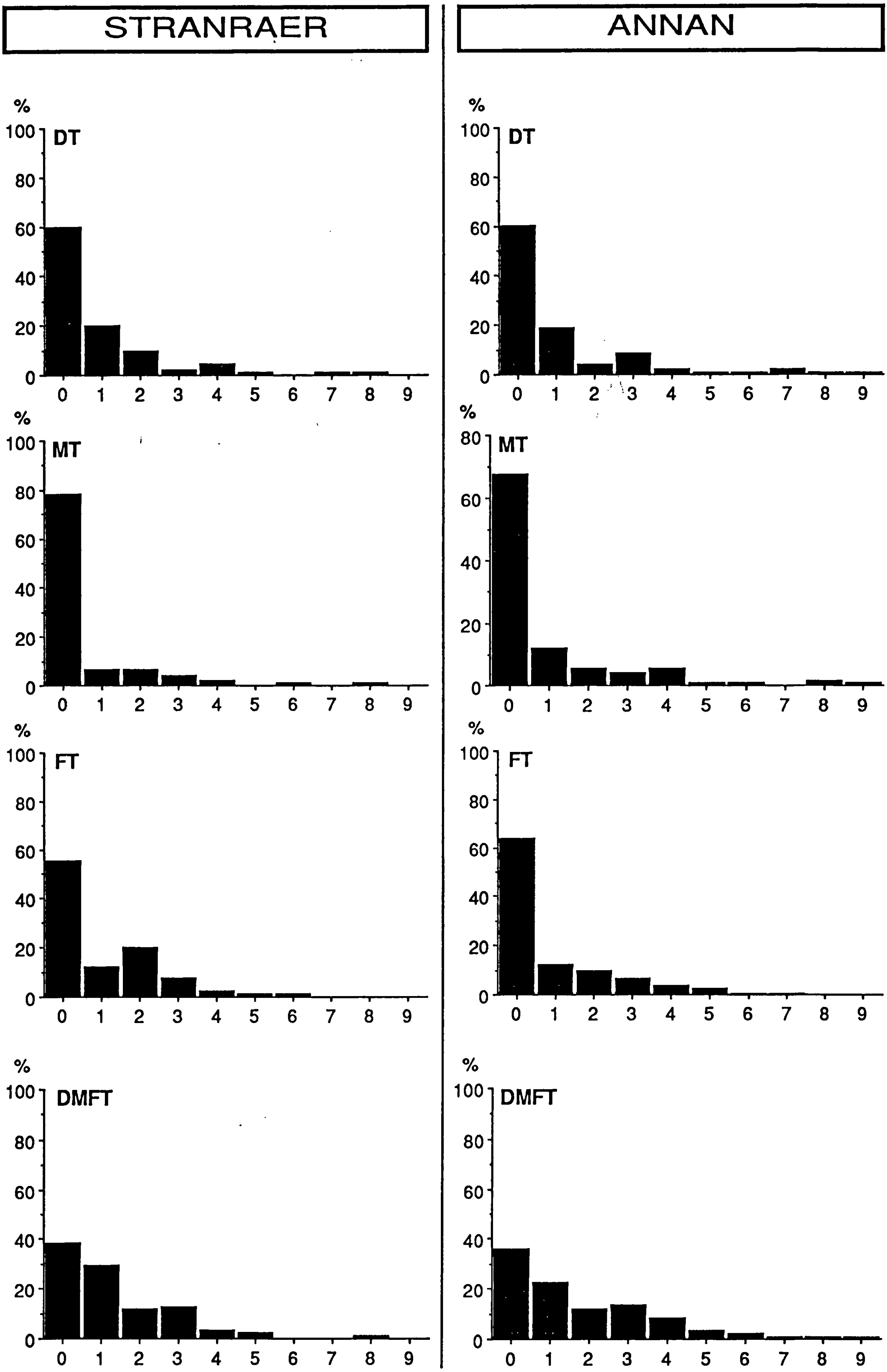

Figure 10
Percentage frequency distribution of decayed, missing and filled permanent teeth in 10 year old children in 1988.

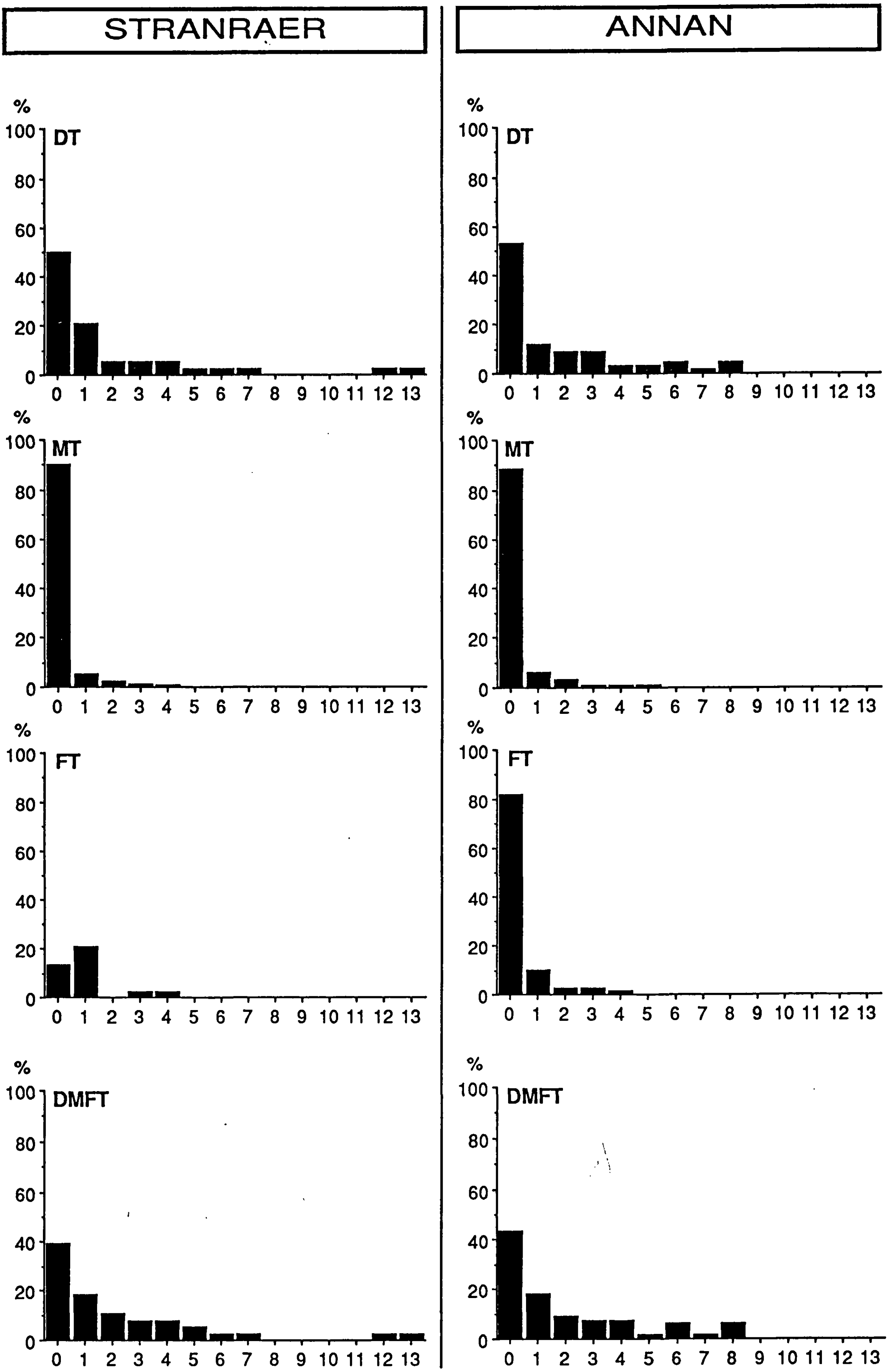

Figure 11
Percentage frequency distribution of decayed, missing and filled deciduous teeth in 5 year old children in 1991.

	Stranraer		Annan	
	Number	Per cent	Number	Per cent
5 year old group				
No caries experience dmft = 0	55	42.6%	16	15.8%
No untreated caries dt = 0	69	53.5%	22	21.8%
	n = 129		n = 101	
10 year old group				
No caries experience DMFT = 0	51	34.7%	14	9.9%
No untreated caries DT = 0	113	76.9%	51	36.2%
	n = 147		n = 141	

$p < 0.01$ (Chi-square)

Table 17. Dental Health in fluoridated Stranraer and non-fluoridated Annan by age group in 1980

	Stranraer		Annan	
	Number	Per cent	Number	Per cent
5 year old group				
No caries experience dmft = 0	65	54.2%	25	27.8%
No untreated caries dt = 0	82	68.3%	36	40.0%
	n = 120		n = 90	
10 year old group				
No caries experience DMFT = 0	43	33.9%	20	19.0%
No untreated caries DT = 0	96	75.9%	53	50.5%
	n = 127		n = 105	
15 year old group				
No caries experience DMFT = 0	25	21.7%	4	3.7%
No untreated caries DT = 0	84	73.0%	47	43.1%
	n = 115		n = 109	

$p < 0.01$ (Chi-square)

Table 18. Dental Health in Stranraer and Annan by age group in 1986

	Stranraer		Annan	
	Number	Per cent	Number	Per cent
5 year old group				
No caries experience dmft = 0	59	48.7%	44	45.8%
No untreated caries dt = 0	82	67.7%	53	55.2%
	n = 121		n = 96	
10 year old group				
No caries experience DMFT = 0	48	38.4%	41	35.9%
No untreated caries DT = 0	75	60.0%	69	60.4%
	n = 125		n = 114	

Not significant

Table 19. Dental Health in Stranraer and Annan by age group in 1988

	Stranraer		Annan	
	Number	Per Cent	Number	Per Cent
No caries experience dmft = 0	45	39.5%	39	43.4%
No untreated caries dt = 0	57	50.0%	48	53.4%

Table 20. Dental Health in 5 year old children in Stranraer and Annan in 1991

	STRANRAER mean	STRANRAER SD	ANNAN mean	ANNAN SD	Difference	% difference	95% Confidence Interval
1980 Study							
dt	0.27	0.91	0.78	1.96	0.51	65.4%	0.13 to 0.89 *
dmft	0.30	1.10	0.86	2.02	0.56	65.4%	0.15 to 0.97 *
DT	0.04	0.23	0.26	0.78	0.22	84.6%	0.09 to 0.35 *
DMFT	0.10	0.46	0.52	1.50	0.42	80.8%	0.17 to 0.67 *
1986 Study							
dt	0.07	0.42	0.46	1.16	0.39	84.7%	0.17 to 0.61 *
dmft	0.13	0.78	0.67	1.74	0.54	80.6%	0.19 to 0.89 *
DT	0.04	0.27	0.18	0.43	0.14	77.8%	0.05 to 0.23 **
DMFT	0.19	1.15	0.46	1.19	0.27	58.7%	-0.03 to 0.57 NS
1988 Study							
dt	0.20	0.99	0.27	1.36	0.07	25.9%	-0.24 to 0.38 NS
dmft	0.38	1.52	0.40	1.48	0.02	5.0%	-0.38 to 0.42 NS
DT	0.11	0.49	0.10	0.46	0.01	10.0%	-0.11 to 0.13 NS
DMFT	0.25	1.14	0.30	1.17	0.05	16.6%	-0.24 to 0.34 NS
1991 Study							
dt	0.26	0.98	0.19	0.80	0.07	36.8%	-0.05 to 0.19 NS
dmft	0.30	1.05	0.23	0.92	0.07	30.4%	-0.31 to 0.45 NS

* = p < 0.01; ** = p < 0.05.

Table 21 Caries in Anterior Teeth in Stranraer and Annan in the four studies.

5 year old children

	1980 mean	1980 SD	1986 mean	1986 SD	1980-86 difference	1980 -86 % change	95% Confidence Interval
dt	1.36	2.08	0.64	1.19	0.72	-52.8	0.42 to 1.15 *
mt	0.59	1.46	0.18	0.82	0.41	-69.5	0.11 to 0.70 *
ft	0.53	1.08	0.34	0.68	0.19	-35.8	-0.04 to 0.42 NS
dmft	2.48	3.16	1.17	1.76	1.31	-52.8	1.10 to 1.52 *
	n = 129		n = 120				

10 year old children

	1980 mean	1980 SD	1986 mean	1986 SD	1980-86 difference	1980-86 % change	95% Confidence Interval
DT	0.35	0.74	0.35	0.74	0	0	-
MT	0.16	0.55	0.09	0.37	0.07	-43.7	-0.04 to 0.18 NS
FT	1.16	1.35	1.28	1.37	+0.12	+10.3	-0.20 to 0.44 NS
DMFT	1.66	1.63	1.72	1.56	+0.06	+3.6	-0.31 to 0.43 NS
	n = 147		n = 127				

* = $p < 0.01$

<u>Table 22. Caries experience by age group in Stranraer children in 1980 and 1986</u>

5 year old children

	1980 mean	1980 SD	1986 mean	1986 SD	1980-86 difference	1980 -86 % change	95% Confidence Interval
dt	3.32	3.38	2.32	2.91	1.0	-30.1	0.10 to 1.90 *
mt	0.75	1.77	0.82	1.50	+0.07	+9.3	-0.04 to 0.54 NS
ft	0.31	0.90	0.68	1.44	+0.37	+119	0.03 to 0.71 *
dmft	4.38	4.31	3.82	3.63	0.56	-12.8	-0.50 to 1.62 NS
	n = 101		n = 90				

10 year old children

	1980 mean	1980 SD	1986 mean	1986 SD	1980-86 difference	1980-86 % change	95% Confidence Interval
DT	1.34	1.48	0.90	1.13	0.44	-32.8	0.10 to 0.78 *
MT	0.40	1.01	0.27	0.95	0.13	-32.5	-0.11 to 0.37 NS
FT	1.61	1.85	1.65	1.61	+0.04	+2.5	-0.40 to 0.48 NS
DMFT	3.35	2.20	2.81	2.22	0.54	-16.1	0.01 to 1.07 *
	n = 141		n = 105				

* = $p < 0.05$

Table 23. Caries experience by age group in Annan children in 1980 and 1986

5 year old children

	1986 mean	1986 SD	1988 mean	1988 SD	1986-88 difference	1986-88 % change	95% Confidence Interval	
dt	0.64	1.19	1.64	1.82	1.0	+156.3	0.61 to 1.39	*
mt	0.18	0.82	0.38	0.81	0.2	+111.1	-0.01 to 0.41	NS
ft	0.34	0.68	1.06	1.46	0.72	+211.8	0.43 to 1.00	*
dmft	1.17	1.76	3.08	3.56	1.91	+163.3	1.25 to 2.62	*
	n = 120		n = 121					

10 year old children

	1986 mean	1986 SD	1988 mean	1988 SD	1986-88 difference	1986-88 % change	95% Confidence Interval	
DT	0.35	0.74	0.92	1.12	0.57	+162.8	0.34 to 0.80	*
MT	0.09	0.37	0.11	0.43	0.02	+22.2	-0.08 to 0.12	NS
FT	1.28	1.37	1.25	1.34	0.03	-2.3	-0.30 to 0.36	NS
DMFT	1.72	1.56	2.28	2.04	0.56	+32.6	0.11 to 1.00	*
	n = 127		n = 125					

* = $p < 0.01$ NS = Not significant

Table 24. Caries experience by age group in Stranraer children in 1986 and 1988

5 year old children

	1986 mean	1986 SD	1988 mean	1988 SD	1986-88 difference	1986 -88 % change	95% Confidence Interval
dt	2.32	2.91	2.19	2.32	0.13	-5.6	-0.63 to 0.88 NS
mt	0.82	1.50	0.35	0.64	0.47	-57.3	0.14 to 0.79 *
ft	0.68	1.44	0.64	1.35	0.04	-5.9	-0.36 to 0.44 NS
dmft	3.82	3.63	3.18	3.29	0.64	-16.8	-0.35 to 1.63 NS
	n = 90		n = 96				

10 year old children

	1986 mean	1986 SD	1988 mean	1988 SD	1986-88 difference	1986-88 % change	95% Confidence Interval
DT	0.90	1.13	0.81	1.21	0.09	-10.0	-0.22 to 0.40 NS
MT	0.27	0.95	0.25	0.95	0.02	-7.4	-0.23 to 0.27 NS
FT	1.65	1.61	1.51	1.72	0.14	-8.5	-0.30 to 0.58 NS
DMFT	2.81	2.22	2.56	2.23	0.25	-8.9	-0.33 to 0.83 NS
	n = 105		n = 114				

* = $p < 0.05$

Table 25. Caries experience by age group in Annan children in 1986 and 1988

5 year old children

	1980 mean	1980 SD	1988 mean	1988 SD	1980-88 difference	1980 -88 % change	95% Confidence Interval
dt	1.36	2.08	1.64	1.82	0.28	+20.5	-0.27 to 0.21 NS
mt	0.59	1.46	0.38	0.81	0.21	-35.6	-0.08 to 0.50 NS
ft	0.53	1.08	1.06	1.46	0.53	+100.0	0.21 to 0.84 *
dmft	2.48	3.16	3.08	3.56	0.6	+24.1	-1.43 to 0.23 NS
	n = 129		n = 121				

10 year old children

	1980 mean	1980 SD	1988 mean	1988 SD	1980-88 difference	1980-88 % change	95% Confidence Interval
DT	0.35	0.74	0.92	1.12	0.57	+162.8	-0.79 to -0.35 NS
MT	0.16	0.55	0.11	0.43	0.05	-31.3	-0.06 to 0.16 NS
FT	1.16	1.35	1.25	1.34	0.09	+7.8	-0.23 to 0.41 NS
DMFT	1.66	1.63	2.28	2.04	0.62	+37.4	-1.06 to -0.16 NS
	n = 147		n = 125				

* = $p < 0.01$

Table 26. Comparison of caries prevalence in Stranraer children in 1980 and 1988

5 year old children

	1980 mean	1980 SD	1988 mean	1988 SD	1980-88 difference	1980 -88 % change	95% Confidence Interval
dt	3.32	3.38	2.19	2.32	1.13	-34.0	0.32 to 1.94 *
mt	0.75	1.77	0.35	0.64	0.4	-53.3	-0.11 to 0.91 NS
ft	0.31	0.90	0.64	1.35	+0.33	+106.5	-1.93 to 2.59 NS
dmft	4.38	4.31	3.18	3.29	1.2	-27.4	0.13 to 1.35 *
	n = 101		n = 96				

10 year old children

	1980 mean	1980 SD	1988 mean	1988 SD	1980-88 difference	1980-88 % change	95% Confidence Interval
DT	1.34	1.48	0.81	1.21	0.53	-39.5	0.19 to 0.86 *
MT	0.40	1.01	0.25	0.95	0.15	-37.5	-0.09 to 0.39 NS
FT	1.61	1.85	1.51	1.72	0.1	-6.2	-0.34 to 0.54 NS
DMFT	3.35	2.30	2.56	2.23	0.79	-23.6	0.23 to 1.35 *
	n = 141		n = 114				

*$p < 0.01$

Table 27. Comparison of caries prevalence in Annan children in 1980 and 1988

ANNAN

	1988 Mean	1988 SD	1991 Mean	1991 SD	1988-91 Difference	1988-91 % Change	95% Confidence Interval
dt	2.19	2.32	1.57	2.31	0.62	-28.3%	-0.05 to 1.19 NS
mt	0.35	0.64	0.20	0.41	0.15	-42.8%	-0.01 to 0.31 NS
ft	0.64	1.35	0.31	0.80	0.33	-51.6%	0.01 to 0.65 **
dmft	3.18	3.29	2.08	2.70	1.1	-34.6%	0.23 to 1.97 *
	n = 96		n = 90				

STRANRAER

	1988 Mean	1988 SD	1991 Mean	1991 SD	1988-91 Difference	1988-91 % Change	95% Confidence Interval
dt	1.64	1.82	1.82	3.1	+0.18	+10.9%	-0.67 to 1.03 NS
mt	0.38	0.81	0.18	0.38	0.2	-52.6%	-0.02 to 0.24 NS
ft	1.06	1.46	0.40	0.85	0.66	-62.3%	0.22 to 1.10 *
dmft	3.08	3.56	2.31	3.12	0.69	-22.4%	0.02 to 1.35 **
	n = 121		n = 114				

* = $p < 0.01$; ** = $p < 0.05$

Table 28. Comparison of caries prevalence in Stranraer and Annan 5 year old children in 1988 and 1991.

ANNAN

	1986 Mean	1986 SD	1991 Mean	1991 SD	1986-91 Difference	1986-91 % Change	95% Confidence Interval
dt	2.32	2.91	1.57	2.31	0.75	-32.3%	-0.07 to 1.57 NS
mt	0.82	1.50	0.20	0.41	0.62	-75.6%	0.30 to 0.94 *
ft	0.68	1.44	0.31	0.80	0.37	-54.5%	0.03 to 0.71 **
dmft	3.82	3.63	2.08	2.70	1.74	-45.6%	0.81 to 2.67 *
	n = 90		n = 90				

STRANRAER

	1986 Mean	1986 SD	1991 Mean	1991 SD	1986-91 Difference	1986-91 % Change	95% Confidence Interval
dt	0.64	1.19	1.82	3.1	-1.18	+184.4%	0.39 to 1.97 *
mt	0.18	0.82	0.18	0.38	0	0%	
ft	0.34	0.68	0.40	0.85	-0.06	+17.6%	-0.20 to 0.32 NS
dmft	1.17	1.76	2.39	3.12	-1.22	+104.3%	-0.29 to 2.73 NS
	n = 120		n = 114				

* = $p < 0.01$; ** = $p < 0.05$

Table 29. Comparison of caries prevalence in Stranraer and Annan 5 year old children in 1986 and 1991.

ANNAN

	1980 Mean	SD	1991 Mean	SD	1980-91 Difference	1980-91 % Change	95% Confidence Interval
dt	3.32	3.38	1.57	2.31	1.75	-52.7%	1.12 to 2.38 *
mt	0.75	1.77	1.20	0.41	0.55	-73.3%	0.22 to 0.88 *
ft	0.31	0.90	0.31	0.80	0	0%	
dmft	4.38	4.13	2.08	2.70	2.3	-52.5%	1.86 to 2.74 *
	n = 101		n = 114				

STRANRAER

	1980 Mean	SD	1991 Mean	SD	1980-91 Difference	1980-91 % Change	95% Confidence Interval
dt	1.36	2.08	1.82	3.1	-0.46	+33.8%	-0.33 to 1.25 NS
mt	0.59	1.46	0.18	0.38	0.41	-69.5%	0.08 to 0.74 **
ft	0.53	1.08	0.40	0.85	0.13	-24.5%	-0.17 to 0.43 NS
dmft	2.48	3.16	2.39	3.12	0.09	-3.6%	-0.37 to 0.56 NS
	n = 129		n = 114				

* = p < 0.01; ** = p < 0.05

Table 30. Comparison of caries prevalence in Stranraer and Annan 5 year old children in 1980 and 1991.

5 YEAR OLD CHILDREN

		1980-86	1986-88	1980-88
Stranraer				
	dt	-11.8%	+60.1%	+2.4%
	mt	-17.9%	+45.3%	-5.4%
	ft	-7.1%	+76.6%	+9.1%
	dmft	-11.8%	+74.4%	+2.8%
Annan				
	dt	-5.8%	-2.8%	-5.1%
	mt	+1.5%	-34.6%	-9.1%
	ft	+14.0%	-3.0%	+9.5%
	dmft	-2.3%	-8.8%	-3.9%

		1986-91	1988-91	1980-91
Stranraer				
	dt	+23.2%	+3.5%	+2.7%
	mt	0%	-22.0%	-10.2%
	ft	+3.3%	-27.7%	-2.5%
	dmft	+15.4%	-8.1%	-0.3%
Annan				
	dt	-7.5%	-10.5%	-6.6%
	mt	-20.7%	-17.0%	-11.3%
	ft	-14.5%	21.4%	0%
	dmft	-11.4%	-13.2%	-6.5%

Table 31. Compound annual changes in caries levels in 5 year old children in Stranraer and Annan

10 YEAR OLD CHILDREN

		1980-86	1986-88	1980-88
Stranraer				
	DT	0	+62.1%	+12.8%
	MT	-9.1%	+10.6%	-4.6%
	FT	+1.7%	-1.2%	+0.9%
	DMFT	+0.6%	+15.1%	+4.1%
Annan				
	DT	-6.4%	-5.1%	-6.1%
	MT	-6.3%	-3.8%	-5.7%
	FT	+0.4%	-4.3%	-0.8%
	DMFT	-2.9%	-4.6%	-3.3%

Table 32. Comparison of Compound Annual Change in Caries levels in 10 year old children in Stranraer and Annan

10 YEAR OLD CHILDREN

		fewer than 11 sites		11 or more sites	
Stranraer		n	%	n	%
	male	66	91.7%	6	8.3%
	female	71	94.7%	4	5.3%
	all	137	93.2%	10	6.8%
Annan					
	male	72	94.7%	4	5.3%
	female	56	90.3%	6	9.6%
	all	128	92.7%	10	7.3%

Not significant (Chi-square)

Table 33 Oral cleanliness in 10 year olds in Stranraer and Annan in 1980.

10 YEAR OLD CHILDREN

		fewer than 11 sites		11 or more sites		
Stranraer						
	male	52	94.6%	3	5.4%	NS
	female	69	95.8%	3	4.2%	
	all	121	95.3%	6	4.7%	
Annan						
	male	37	84.1%	7	15.9%	$p<0.05$
	female	58	95.1%	3	4.9%	
	all	95	90.5%	10	9.5%	

Table 34. Oral cleanliness in 10 year olds in Stranraer and Annan in 1986.

15 YEAR OLD CHILDREN

	fewer than 11 sites		11 or more sites	
Stranraer				
male	49	90.7%	5	9.3%
female	57	93.4%	4	6.6%
all	106	92.2%	9	7.8%
Annan				
male	52	85.3%	9	14.7%
female	43	89.6%	5	10.4%
all	95	87.2%	14	12.8%

Not significant (Chi-square)

Table 35. Oral cleanliness in 15 year olds in Stranraer and Annan in 1986

10 YEAR OLD CHILDREN

		fewer than 11 sites		11 or more sites	
Stranraer					
	male	58	93.5%	4	6.5%
	female	61	96.8%	2	3.2%
	all	119	95.2%	6	4.8%
Annan					
	male	52	94.5%	3	5.5%
	female	56	94.9%	3	5.1%
	all	108	94.6%	6	5.3%

Not significant (Chi-square)

Table 36. Oral cleanliness in 10 year old groups in Stranraer and Annan in 1988

10 YEAR OLD CHILDREN

		fewer than 5 sites		5 or more sites		
Stranraer						
	male	70	97.2%	2	2.8%	NS
	female	74	98.7%	1	1.3%	
	all	144	98.0%	3	2.0%	
Annan						
	male	62	81.6%	14	18.4%	p<0.05
	female	57	91.9%	5	8.1%	
	all	119	86.2%	19	13.8%	

Table 37. Gingivitis prevalence in 10 year old groups in Stranraer and Annan in 1980

10 YEAR OLD CHILDREN

		fewer than 5 sites		5 or more sites	
Stranraer					
	male	54	98.2%	1	1.8%
	female	71	98.6%	1	1.4%
	all	125	98.4%	2	1.6%
Annan					
	male	44	100%	0	0%
	female	61	100%	0	0%
	all	105	100%	0	0%

Not significant

Table 38. Gingivitis prevalence in 10 year old children in Stranraer and Annan in 1986.

15 YEAR OLD CHILDREN

		fewer than 5 sites		5 or more sites		
Stranraer						
	male	48	88.9%	6	11.1%	NS
	female	52	85.3%	9	14.7%	
	all	100	87.0%	15	13.0%	
Annan						
	male	35	57.4%	26	42.6%	p<0.01
	female	38	79.2%	10	20.8%	
	all	73	67.0%	36	33.0%	

$p < 0.01$ (Chi-square)

Table 39. Gingivitis prevalence by age group in Stranraer and Annan in 1986

10 YEAR OLD CHILDREN

		fewer than 5 sites		5 or more sites	
Stranraer					
	male	59	95.2%	3	4.8%
	female	62	98.4%	1	1.6%
	all	121	96.8%	4	3.2%
Annan					
	male	53	96.4%	2	3.6%
	female	58	98.3%	1	1.7%
	all	111	97.4%	3	2.6%

Not significant (Chi-square)

Table 40. Gingivitis prevalence in 10 year old groups in Stranraer and Annan in 1988

5 year olds

	Stranraer Mean	Stranraer SD	Annan Mean	Annan SD	Difference	% Difference	95% Confidence Interval	
Restorations	4.65	7.15	9.30	8.28	4.64	50.0	2.65 to 6.65	*
Extractions	0.14	0.66	1.29	2.63	1.15	89.2	0.67 to 1.62	*
Gen. Anaes.	0	0	0.67	1.73	0.67	-		
Total cost	7.40	8.17	14.05	11.77	6.65	47.3	4.07 to 9.23	*
	n = 129		n = 101					

10 year olds

	Stranraer Mean	Stranraer SD	Annan Mean	Annan SD	Difference	% Difference	95% Confidence Interval	
Restorations	1.08	2.40	4.65	5.75	3.57	76.8	2.56 to 4.58	*
Extractions	0.08	0.56	0.23	1.05	0.15	65.2	-0.04 to 0.34	NS
Gen. Anaes.	0	0	0.08	0.59	0.08	-		
Periodontal	0.17	0.54	0.39	0.77	0.22	54.4	-0.33 to 0.77	NS
Total Cost	3.99	4.19	7.97	6.98	3.98	49.9	2.66 to 5.30	*
	n = 147		n = 141					

* = p < 0.001 (t-test and Mann-Whitney U test)
NS = not significant

Table 41. Treatment costs by age group in fluoridated Stranraer and non-fluoridated Annan in 1980

5 year olds

	Stranraer Mean	Stranraer SD	Annan Mean	Annan SD	Difference	% Difference	95% Confidence Interval
Restorations	2.35	4.48	7.96	9.96	5.34	69.4	3.34 to 7.34 *
Extractions	0.14	0.91	0.47	1.43	0.33	70.2	0.01 to 0.65 **
Total Cost	4.75	4.78	11.03	11.66	6.28	56.9	3.97 to 8.59 *

No general anaesthetics required
n = 120 n = 90

10 year olds

	Stranraer Mean	Stranraer SD	Annan Mean	Annan SD	Difference	% Difference	95% Confidence Interval
Restorations	2.39	3.96	5.07	5.88	2.68	52.9	1.39 to 3.97 *
Extractions	0.08	0.51	0.11	0.56	0.03	27.3	-0.11 to 0.17 NS
Periodontal	0.10	0.44	0.18	0.56	0.08	44.4	-0.05 to 0.21 NS
Total Cost	4.84	4.23	7.63	6.11	2.79	36.5	1.46 to 4.12 *

No general anaesthetics required
n = 127 n = 105

15 year olds

	Stranraer Mean	Stranraer SD	Annan Mean	Annan SD	Difference	% Difference	95% Confidence Interval
Restorations	1.56	3.15	7.30	8.28	5.74	78.6	4.12 to 7.36 *
Extractions	0.07	0.57	0.54	1.61	0.47	87.0	0.16 to 0.78 **
Gen. Anaes.	0	0	0.06	0.61	0.06	-	
Periodontal	0.38	0.98	0.75	1.13	0.37	49.3	0.09 to 0.65 **
Total Cost	4.27	3.63	11.47	18.22	7.20	62.7	3.80 to 10.60 *

n = 115 n = 109

* = p < 0.001 (t-test and Mann-Whitney U test)
** = p < 0.05
NS = not significant

Table 42. Treatment costs by age group in Stranraer and Annan in 1986

5 year olds

	Stranraer Mean	Stranraer SD	Annan Mean	Annan SD	Difference	% Difference	95% Confidence Interval	
Restorations	5.82	7.81	6.79	8.01	0.97	+14.3%	-1.14 to 3.08	NS
Extractions	0.17	0.53	0.58	0.91	0.41	+70.6%	0.22 to 0.60	*
Total cost	8.69	8.79	10.06	11.35	1.37	+13.6%	-1.30 to 4.05	NS
	n = 121		n = 96					

10 year olds

	Stranraer Mean	Stranraer SD	Annan Mean	Annan SD	Difference	% Difference	95% Confidence Interval	
Restorations	2.83	5.01	3.16	7.13	0.33	+10.4%	-1.22 to 1.88	NS
Extractions	0.21	0.61	0.10	0.44	0.11	110%	-0.03 to 0.24	NS
Periodontal	0.26	0.74	0.46	0.89	0.20	+43.5%	-0.01 to 0.41	NS
Total Cost	6.01	8.94	6.41	9.13	0.40	+6.3%	-1.89 to 2.69	NS
	n = 125		n = 114					

* = $p < 0.001$ (t-test and Mann-Whitney U test)
NS = not significant

Table 43. Treatment costs by age group in Stranraer and Annan in 1988

5 years old

ANNAN	**MALE**	**FEMALE**	**ALL**
Restorations	11.58	8.54	9.90
Extractions	1.32	1.29	1.29
Total Cost	15.57	12.82	14.05
GA	0.28 (2)	0.61 (5)	0.47 (7)
STRANRAER			
Restorations	5.34	4.64	4.95
Extractions	0.21	0.10	0.14
Total	7.84	7.06	7.40

10 years old

ANNAN	**MALE**	**FEMALE**	**ALL**
Restorations	4.66	4.63	4.65
Extractions	0.15	0.34	0.23
Periodontal	0.44	0.33	0.39
Total Cost	7.94	8.00	7.97
GA	0.08 (1)	0.08 (1)	0.08 (2)
STRANRAER			
Restorations	1.60	0.79	1.08
Extractions	0.12	0.04	0.14
Periodontal	0.21	0.13	0.17
Total Cost	4.62	3.39	3.99

Table 44. Treatment costs by sex in Stranraer and Annan in 1980

5 years old

Annan	**Male**	**Female**	**All**
Restorations	9.32	6.95	7.96
Extractions	0.51	0.43	0.47
Total cost	12.43	9.64	11.03

Stranraer	**Male**	**Female**	**All**
Restorations	2.01	2.68	2.35
Extractions	0.09	0.20	0.14
Total cost	4.36	5.14	4.75

10 years old

Annan	**Male**	**Female**	**All**
Restorations	6.66	3.93	5.07
Extractions	0.07	0.14	0.11
Periodontal	0.19	0.16	0.18
Total cost	9.29	6.43	7.63

Stranraer	**Male**	**Female**	**All**
Restorations	2.91	2.00	2.39
Extractions	0.05	0.10	0.08
Periodontal	0.11	0.10	0.10
Total cost	5.36	4.43	4.84

15 years old

Annan	**Male**	**Female**	**All**
Restorations	9.10	5.02	7.30
Extractions	0.61	0.45	0.54
Periodontal	0.93	0.51	0.75
Total cost	13.49	8.89	11.47

Stranraer	**Male**	**Female**	**eAll**
Restorations	1.41	1.69	1.56
Extractions	0.10	0.05	0.07
Periodontal	0.35	0.40	0.38
Total cost	4.12	4.40	4.27

Table 45. Treatment costs by sex and age group in Stranraer and Annan in 1986

5 years old

Annan	Male	Female	All
Restorations	7.08	6.69	6.79
Extractions	0.60	0.58	0.58
Total cost	10.54	10.11	10.06

Stranraer	Male	Female	All
Restorations	6.23	5.32	5.82
Extractions	0.18	0.15	0.17
Total cost	9.06	8.34	8.69

10 years old

Annan	Male	Female	All
Restorations	3.17	3.14	3.16
Extractions	0.12	0.09	0.10
Periodontal	0.45	0.46	0.46
Total cost	6.45	6.38	6.41

Stranraer	Male	Female	All
Restorations	2.81	2.84	2.83
Extractions	0.23	0.20	0.21
Periodontal	0.32	0.21	0.26
Total cost	6.07	5.96	6.01

Table 46. Treatment costs by sex and age group in Stranraer and Annan in 1988

5 YEAR OLD CHILDREN

Social class	I	II	III	IV	V
Annan					
dmft	3.14	3.83	3.85	3.84	5.00
Restorations	4.41	6.17	7.47	6.96	11.51
Total cost	6.67	8.79	9.73	9.31	13.17
Stranraer					
dmft	0.99	1.10	1.22	1.34	-.-
Restorations	0	1.84	3.45	2.63	-.-
Total cost	2.26	4.12	4.64	4.98	-.-

Not significant (ANOVA)

Table 47 Caries prevalence and Costs (RRI) by Social Class in 1986.

10 YEAR OLD CHILDREN

Social Class	I	II	III	IV	V
ANNAN					
DMFT	1.99	2.01	2.94	2.81	4.85
Oral cleanliness <11 sites	100%	94.1%	89.7%	70.0%	100%
Gingivitis <5 sites	100%	100%	100%	100%	100%
Restorations	3.01	3.25	4.42	3.29	12.58
Total cost	5.37	5.09	6.78	5.62	16.22
STRANRAER					
DMFT	1.01	1.63	1.81	1.83	2.35
Oral cleanliness <11 sites	100%	95.0%	94.0%	85.7%	66.6%
Gingivitis <5 sites	100%	100%	98.5%	100%	100%
Restorations	1.08	1.84	3.48	2.36	3.64
Total cost	3.34	4.22	4.58	4.33	5.97

Not significant (ANOVA)

Table 48 Caries Prevalence, Oral Health and Costs (RRI) by Social Class in 1986

15 YEAR OLD CHILDREN

Social Class	I	II	III	IV	V
ANNAN					
DMFT	7.00	8.50	7.18	6.27	11.00
Oral cleanliness <11 sites	100%	99.3%	90.9%	87.5%	70.0%
Gingivitis <5 sites	100%	84.4	80.0	60.0%	30.0% *
Restorations	5.73	6.09	6.89	5.29	13.77
Total cost	7.99	9.78	10.87	9.31	21.12
STRANRAER					
DMFT	2.33	2.35	2.72	2.69	4.37
Oral cleanliness <11 sites	100%	90.0%	88.3%	92.3%	75.0%
Gingivitis <5 sites	100%	80.0%	91.2%	81.3%	87.5%
Restorations	0	1.48	1.78	0.36	1.64
Total cost	2.26	4.21	4.46	3.33	4.37

Not significant (ANOVA) apart for * = $p < 0.05$

Table 49 Caries Prevalence, Oral Health and Costs (RRI) by Social Class in 1986

5 YEAR OLD CHILDREN

Social Class	I	II	III	IV	V
ANNAN					
dmft	2.93	3.44	3.53	3.52	4.80
Restorations	6.14	7.98	8.45	8.12	10.93
Total cost	8.01	10.02	10.53	10.41	13.98
STRANRAER					
DMFT	2.96	3.39	3.45	3.64	5.30
Restorations	1.89	2.36	2.41	3.12	6.85
Total cost	3.99	4.87	4.89	5.54	9.01

Not significant (ANOVA)

Table 50 Caries Prevalence and Costs (RRI) by Social Class in 1988

10 YEAR OLD CHILDREN

Social Class	I	II	III	IV	V
ANNAN					
DMFT	2.45	2.57	2.59	3.21	4.01
Oral cleanliness <11 sites	100%	94.9%	94.1%	90.2%	66.6%
Gingivitis <5 sites	100%	98.4%	97.4%	97.9%	66.6%
Restorations	3.98	4.63	4.94	5.78	6.89
Total cost	6.04	7.59	8.19	8.16	9.96
STRANRAER					
DMFT	2.06	2.18	2.34	2.32	3.41
Oral cleanliness <11 sites	100%	97.9%	95.3%	96.1%	50.0%
Gingivitis <5 sites	100%	98.5	97.6%	99.1%	50.5%
Restorations	1.98	2.26	2.49	2.98	4.99
Total cost	3.74	3.99	4.94	4.99	7.01

Not significant (ANOVA)

Table 51 Caries Prevalence, Oral Health and Costs (RRI) by Social Class in 1988

10 YEAR OLD CHILDREN

	Regular attenders		Irregular or Non attenders	
Stranraer				
number	114		33	
per cent		77.5%		22.5%
Annan				
number	109		32	
per cent		77.3%		22.7%

Not significant

Table 52a. Claimed dental attendance patterns in Stranraer and Annan in 1980

	Source of treatment			
Stranraer	General		Community	Don't know
number	101		25	21
per cent		68.7%	17.0%	14.3%
Annan				
number	114		12	15
per cent		80.8%	8.5%	10.6%

$p < 0.05$

Table 52b. Claimed source of dental treatment in Stranraer and Annan in 1980

10 YEAR OLD CHILDREN

	Regular attenders		Irregular or Non attenders	
Stranraer				
number	101		26	
per cent		79.5%		20.5%
Annan				
number	85		20	
per cent		80.9%		19.1%

Not significant

Table 53a. Claimed dental attendance patterns in Stranraer and Annan in 1986

	Source of treatment			
Stranraer	General		Community	Don't know
number	98		18	11
per cent		77.1%	14.2%	8.7%
Annan				
number	83		12	10
per cent		79.1%	11.4%	9.5%

Not significant

Table 53b. Claimed source of dental treatment in Stranraer and Annan in 1986

10 YEAR OLD CHILDREN

	Regular attenders		Irregular or Non attenders	
Stranraer				
number	102		23	
per cent		81.6%		18.4%
Annan				
number	91		23	
per cent		79.8%		20.2%

Not significant

Table 54a.Claimed dental attendance patterns in Stranraer and Annan in 1988

	Source of treatment			
Stranraer	General		Community	Don't know
number	99		15	11
per cent		79.2%	12.0%	8.8%
Annan				
number	85		16	13
per cent		74.5%	14.1%	11.4%

Not significant

Table 54b. Claimed source of dental treatment in Stranraer and Annan in 1988

<u>15 YEAR OLD CHILDREN</u>

	Regular attenders		Irregular or Non attenders	
Stranraer				
number	99		16	
per cent		86.1%		13.9%
Annan				
number	83		26	
per cent		76.2%		23.8%

<u>Table 55a. Claimed dental attendance patterns in Stranraer and Annan in 1986.</u>

	Source of treatment			
Stranraer	General		Community	Don't know
number	81		24	9
per cent		70.4%	20.9%	7.9%
Annan				
number	73		17	19
per cent		76.0%	15.6%	17.4%

<u>Table 55b. Claimed source of dental treatment in Stranraer and Annan in 1986</u>

	1986 Mean	SD	1991 Mean	SD	Difference	Per cent Difference
DT	0.45	0.85	0.68	0.99	-0.23	+33.8%
MT	0.20	0.61	0.45	0.89	-0.25	+55.5%
FT	2.06	2.25	2.72	3.12	-0.66	+24.3%
DMFT	2.72	2.38	3.85	3.91	-1.13	+29.4%
	n = 115		n = 81			

Table 56. Caries prevalence in 15 year old life-time residents in 1991, compared with 1986.

	Reliability Coefficient	Dice Index
5 year olds		
dt	0.99	0.99
ft	-	1.00
dmft	0.99	-
10 year olds		
DT	0.98	0.99
MT	-	1.00
DMFT	0.98	-
15 year olds		
DT	1.00	1.00
FT	-	1.00
DMFT	0.99	-

Table 57. Intra-examiner reproducibility in 1986.

	Reliability Coefficient	Dice Index
5 year olds		
dt	0.99	0.99
ft	-	1.00
dmft	0.99	-
10 year olds		
DT	1.00	1.00
FT	-	1.00
DMFT	1.00	-

Table 58. Intra-examiner reliability in 1988.

	Reliability Coefficient	Dice Index
dt	0.99	0.99
ft	-	1.00
dmft	0.99	-

Table 59. Intra-examiner reliability in 5 year olds in 1991.

SCOTTISH OFFICE
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15 May 1991

Dear Professor Lennon

WATER FLUORIDATION IN SCOTLAND

The Secretary of State has asked me to thank you for your letter of 10 April about fluoridation of the water supply in Scotland.

The importance of securing improvements in dental and oral health in Scotland, as illustrated in the survey to which you refer, is fully recognised by the Government. The national policy statement "Health Education in Scotland", which was issued on 25 March, identified dental and oral health as one of the priorities to which the health education effort should be principally directed and, in relation to children, set the challenging target for the year 2000 of securing that 60% of 5 year old school entrants should neither have cavities nor have had fillings or extractions. Health education, in which the newly established Health Education Board for Scotland will have a vital role, will aim to encourage people to eat sensibly and control their intake of sugar; to improve their level of oral hygiene through the use, for example, of a fluoride toothpaste; and to make more and better use of existing services by visiting a dentist regularly for professional advice.

The Government also remain committed to their policy of supporting the fluoridation of the water supply as the most effective method of reducing the incidence of tooth decay. You will be glad to know in this regard that circulars will be issued shortly to health boards and local authorities setting out the procedures for implementation of the Water Fluoridation Act 1985. In terms of the Act, it will be for a health board, after appropriate consultation, to recommend to the local water authority that arrangements should be made to fluoridate the water supply. The final decision to add fluoride to the water supply will lie with the local water authority, which in Scotland is the regional or islands council.

Yours sincerely
J D Gallagher

J D GALLAGHER
Private Secretary

THE SCOTTISH OFFICE

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NHS Circular No 1991(GEN)16

Previous Circular No - NHS1985(GEN)31
Cancelled

General Managers of Health Boards
General Manager of the Common Services Agency
General Manager, State Hospital
General Manager, Health Education Board

Our Ref: NJF/7/3

27 June 1991

Dear Sir

GUIDANCE ON FLUORIDATION OF PUBLIC WATER SUPPLIES

Introduction

1. This circular gives guidance to Health Boards on the implementation of schemes to fluoridate public water supplies. The interim guidance issued as NHS Circular No 1985(GEN)31 following the passage of the Water (Fluoridation) Act 1985 is now cancelled.

2. The fluoridation of water supplies constitutes a safe and effective means of reducing tooth decay, though the Government will continue to monitor any further relevant evidence on the safety and effectiveness of fluoridation and will bring any significant new developments to the attention of Health Boards. The Water (Fluoridation) Act 1985 gives Health Boards the power to decide whether or not to apply for fluoridation of water supplies in their area and this circular sets out the procedure to be followed in using that power. It advises Health Boards on points to be taken into account in considering fluoridation schemes and provides a model agreement as a basis for discussion between Health Boards and local authorities in their capacities as water authorities on the terms under which fluoridation may be carried out. Also enclosed for information is a copy of the model form of statutory indemnity which the Secretary of State would offer a water authority entering into an agreement with a Health Board for the purposes of fluoridation of water supplies within the relevant area. (Annex A)

The decision-making process

3. The Government's White Paper "Promoting Better Health" (HMSO Cm 249) published in 1987 reiterated the need for Health Boards to consider the benefits of fluoridation, particularly in areas where the level of dental health was poor. In reaching a view as to the need for fluoridation in their areas, Boards will wish to take into account the advice of the Chief Administrative Dental Officer, the Chief Administrative Medical Officer and the local area dental committee.

4. Because of the complex nature of water supply systems, Boards should investigate with the appropriate water authority the feasibility of fluoridation schemes in their area. The corresponding circular issued today by the Scottish Office Environment Department to water authorities (copy attached), asks them to give all possible co-operation to Health -

Boards, for example, by making available on request an assessment of the technical feasibility and estimated cost of fluoridation and explaining which areas it would be feasible to fluoridate without the scheme being endangered by future water supply strategy. Conversely, the determination of the technical feasibility of fluoridation will be greatly simplified if all Health Boards within a water authority's supply area could co-ordinate their policy decisions on fluoridation and act jointly in their requests to the water authority for fluoridation schemes.

Publicity and consultation

5. Section 4 of the Water (Fluoridation) Act 1985 requires that a process of publicity and consultation be carried out by each Health Board before formal applications for fluoridation are made. Where more than one Health Board is proposing a scheme in the same Regional or Island Council area, the consultation procedure would be simplified if all the Health Boards concerned were to co-ordinate their strategy. In terms of publicity, the Act requires that the proposals must be published in at least one newspaper circulating within the area affected, and then re-published one week later inviting comments by a certain date and giving details as to whom and where they should be sent. Where the newspapers circulate across several Health Board areas and all of the Health Boards plan to participate in the same scheme, each advertisement may cover all of the Health Boards, but should mention them by name, and should provide an address in each Health Board to which representations should be sent. It is important to ensure that the publicity covers all parts of the area to be fluoridated, and the Health Board should use newspapers with the largest circulation in the relevant area.

6. The requirements set out in paragraph 5 above are the statutory minimum which apply. If a Health Board considers it appropriate, any other bodies may be approached, or other means of sounding out local opinion may be used. The aim should be to ensure that no significant section of the population in the area can reasonably complain that they did not have an opportunity to learn about the Board's proposals. The views which emerge from the consultation process must be considered formally by the Health Board, and no legal agreement to implement fluoridation can be made until 3 months after the date when the proposals were first published. By Section 4(7) of the Act the public cannot be excluded from that part of the Board's meeting at which consideration is given to whether the Board should make or withdraw an application for fluoridation.

The role of water authorities

7. If, having considered the views resulting from the consultation procedures, the Health Board decides to proceed with a scheme, it should submit a formal application to the water authority. The Act continues to give water authorities discretion as to whether or not to agree to fluoridation. Though the chief concern of water authorities is likely to be the technical feasibility of water fluoridation, they might reasonably expect the Health Board to explain how the requirements of the Act have been complied with in terms of publicity and consultation. If the water authority agrees to the Health Board's request, both will need to consider the technical and financial plans necessary for implementation of the scheme.

ɔlementation of schemes

The arrangements for implementing fluoridation schemes are a matter agreement between the Health Board and water authority involved. reement must be reached with the water authority on matters such as monitoring of fluoridation and the financial arrangements between the ·ties. The Model Agreement at Annex B has been prepared after ısultation with the Scottish Office Environment Department and the nvention of Scottish Local Authorities (COSLA). It sets out the ncipal matters to be taken into account in reaching an agreement and ms a basis for discussion. Modifications may be required, however, to e account of local conditions and views.

The Model Agreement notes that there will be circumstances in which water authority cannot carry out fluoridation as agreed. The Act mits the supply of fluoridated water to non-fluoridated areas only in tain limited circumstances, either in an emergency or when maintenance k is required. If adherence to a fluoridation agreement prevents a er authority from supplying water more efficiently than might erwise be the case without fluoridation, for instance, by switching er supplies from one zone to another for which fluoridation has not n agreed, then the water authority will seek reimbursement of any uing costs from the Health Board. Health Boards should ensure that ficient advance warning is required of any such potential costs, in ler to decide whether to meet the cost or withdraw from the agreement accordance with paragraph 11 below.

sistance with Costs

Health Boards will be responsible for the revenue costs of ɔridation schemes. However, from financial year 1992-93, the ɔartment will be prepared to consider assistance of up to 60% of capital ts. The application should be made at the stage when the water hority has accepted the formal application for the scheme and before agreement on implementation has been signed. It should include the owing items:-

(a) size of population to be served;

(b) Health Boards involved and geographical area covered;

(c) an indication that the scheme is technically feasible and that the water authority is ready to proceed;

(d) an estimate of the total installation costs provided by the water authority;

(e) an estimate of how long the work will take, with estimated costs phased over the required number of months or years. Although applications for central funds cannot be approved until this stage, early warning of likely bids would be most helpful in planning the allocation of funds. Firm bids for any given financial year must be received along with the Board's submission of their capital programmes for that financial year.

application should be submitted to Mr L C Cunning at the above ress.

Termination of fluoridation schemes

11. Should a Health Board wish to terminate a scheme it must comply with the procedures for publicity and consultation required by the Act. These are identical to those described in paragraphs 5 and 6 above for proposals to enter into a fluoridation scheme. A formal application to the water authority giving reasonable notice of withdrawal is a statutory obligation on the Health Board where it is proposed to terminate a fluoridation scheme.

Indemnity provided by the Secretary of State

12. The Secretary of State will, in terms of section 172 of the Water Act 1989 and with the consent of the Treasury, indemnify water authorities carrying out fluoridation schemes requested by Health Boards against legal challenge. The indemnity will also cover liabilities incurred by water authorities in connection with the provision of fluoridated water except those attributable to criminal procedures. An Agreement for each scheme will be prepared and processed by the Scottish Office. The terms of the indemnity, which have been agreed with COSLA, are attached at Annex A.

13. Because of the direct statutory link which already exists between the Secretary of State and Health Boards no indemnity is necessary to meet any damages which might be awarded against a Health Board.

Enquiries

14. Any enquiries about the provisions contained in this circular or about the Water (Fluoridation) Act 1985 should be made to Mr L C Cunning, (031 244 2504) at the above address.

Yours faithfully

G A ANDERSON

CARIES TRAUMA AND PROSTHETIC EXAMINATION

It is recommended that the subject recline in the dental chair for the caries, trauma and prosthetic examination. The examination method described is primarily visual and aided by a plane mouth mirror. The main light source is utilized. A standardised blunt probe should be available during the caries examination for cleaning the fissures and smooth tooth surfaces of residual debris to enable satisfactory visual observation, and also to confirm or reject dubious lesions. Compressed air should be available to dry the surfaces prior to examination.

Caries and Trauma

Each surface of every tooth in the mouth should be systematically examined. Attention should be concentrated on the following caries predilection sites:

1. Occlusal surfaces; the pit and fissure system.
2. Approximal surfaces; the contact point and gingival third.
3. Free smooth surfaces; the gingival third, and also the fissure system on lingual surfaces of upper molars and incisors and buccal surfaces of lower molars.

Before examination, it is recommended that all surfaces of the tooth be dried with compressed air. The teeth should be examined in turn and both the status and treatment requirements (if any) recorded before moving on to the next tooth. The order in which the teeth are examined is at the discretion of the examiner.

Tooth Status

If any part of a tooth is exposed to the oral fluids it should be considered as erupted (1 = unerupted).

In assessing the condition of a tooth, residual debris should be removed with the probe if it obstructs adequate visual observation of any of the surfaces.

Caries (code 3) is recorded only if there is cavitation involving dentine. The diagnostic criteria which follow should be strictly adhered to and unless they are fulfilled, caries should not be recorded as present.

1. Pits and fissures. Visible breakdown of the walls of the fissure or shadow or opacity beneath enamel.
2. Free smooth surfaces and freely observable approximal surfaces. Visible breakdown of the enamel with cavitation, or shadow or opacity beneath enamel.
3. Contacting approximal surfaces. Visible breakdown of the enamel with cavitation, or shadow or opacity beneath the enamel or beneath the marginal ridge enamel in the case of posterior teeth.
4. If doubt exists, the site should be gently investigated with the standardised blunt probe. Unless the point enters the lesion the surface should be recorded as sound. The catching of the probe in a pit or fissure is not enough to warrant the diagnosis of caries unless there is additional visual evidence. If doubt still remains after both visual and tactile examination the surface should be regarded as sound. Teeth which are fissure sealed with no evidence of caries should be recorded as sound.
5. Recurrent caries (code 4) is recorded either where it occurs in association with an existing restoration, or elsewhere in a tooth already filled. The criteria are identical to those for primary caries except insofar as a positive diagnosis will also be made where cavitation exists at the cavo-surface margin of a restoration. The criteria in such instances are identical to those for caries in a free smooth surface.
6. A tooth is regarded as restored (code 6) if it possesses a satisfactory permanent filling (or fillings), an unsatisfactory filling (or fillings), or a temporary filling (or fillings), with no evidence of existing caries. A crown, which in the examiner's clinical judgement has been provided for the treatment of caries, or a fixed bridge pontic or abutment restoration should also be included in this category. However, crowns or incisal tip restorations which have most probably been provided because of a fracture should not be included.

No attempt is made to assess the quality of restorations except to record "recurrent caries" if present. However, if a restoration requires replacement for reasons other than recurrent caries in the clinical opinion of the examiner there is provision in the "tooth treatment" boxes for recording the type of treatment required. Apart from temporary fillings needing permanent replacement, such non-carious faults will normally be associated with fractures, leakages or noticeably defective margins. Grossly defective contouring or texture of a filling may also indicate a need for replacement where this could not be corrected by the use of a finishing bur. Defective approximal contact, where food impaction is likely to injure the gingival papilla and contact could easily be restored, would also indicate the need for a replacement restoration. With regard in particular to anterior restorations, discolouration of tooth-coloured filling material would indicate a need for replacement.

7. Missing teeth are recorded as either missing because of extraction for caries (code 5), or missing for other reasons, e.g., orthodontic extraction, trauma, congenital absence, periodontal involvement or prosthetic reasons (code 8). Clinical judgement unavoidably enters into this decision, and in cases of doubt the subject should be questioned before arriving at a decision. Unless there is reasonable evidence to the contrary, the missing tooth should be regarded as extracted because of caries. A space replaced by a fixed bridge pontic is arbitrarily defined as a restored tooth (code 6) and the tooth is not entered as missing.

Particular care is necessary in deciding the status of missing deciduous teeth. For example, a deciduous incisor should not be coded as missing because of caries in a child aged 5 to 8 years unless definite caries is present in adjacent anterior teeth and the examiner is confident that its loss is specifically as a result of caries. Similarly the reason for loss of a deciduous molar in a child aged 9 years or over is often difficult to establish since exfoliation of these teeth commences at about that time. However, the presence of a permanent successor before its expected time of eruption may be an indication of premature loss of the deciduous tooth because of caries.

8. A tooth is classified as fractured (code 7) if there is a fracture involving both enamel and dentine and the absence of caries or a restoration for caries. A fracture repaired by incisal tip restoration should be included in his category rather than as a filled tooth. In coding the tooth, caries or a restoration for caries should take precedence over a fracture or restoration for fracture. The type of treatment required (if any), e.g., crown, restoration of incisal tip or extraction, will in general be at the discretion of the examiner. However, certain qualifications are specified in the main text.

9. A tooth may be recorded as crowned (for reasons other than caries) or banded (code 9). In the case of permanent or temporary crowns, stainless steel bands etc., the code for caries or recurrent caries if present, takes precedence in the tooth descriptor. Likewise, caries takes precedence over a fixed orthodontic band. The category is not to be used for removable appliances.

<u>Prosthetics</u>

Circumstances indicating the need for denture(s) are as follows:

1. Where spacing exists due to tooth loss in the anterior dentition and the space is equal to or greater than half the mesio-distal width of the missing unit, or where extraction in the anterior sextants will result in such spacing.

2. Where three consecutive teeth in a row in the remaining four posterior sextants of the mouth are missing (not

unerupted) or will become missing as a result of extraction(s).

If the subject is in possession of a denture this should be inserted and the denture examined in the mouth. Circumstances indicating the need for replacement denture(s) are as follows:

1. Where the fit is poor and the denture is unstable, where the articulation is poor, where there is noticeable over-closure or over-opening of the bite, where the occlusal plane is unsatisfactory or where the material or laboratory work is clearly below standard.

2. Where the subject considers the aesthetic appearance of the existing denture to be unsatisfactory. To ascertain the subject's opinion he should be asked "are you satisfied with the appearance of your denture?". If the answer is "no", prosthetic treatment should be scheduled.

The patient should be asked to remove the denture and the examiner should observe the denture-bearing areas.

For full dentures, replacement should be scheduled where over-closure is causing soreness at the angle(s) of the mouth, where there is traumatic ulceration or where there is an area of mucosal inflammation.

For partial dentures replacement should be scheduled for traumatic ulceration, mucosal inflammation, gum stripping, tilting of the teeth or caries on teeth adjacent to the prosthesis.

PERIODONTAL EXAMINATION

It is recommended that the complete periodontal examination be conducted for each specified unit (4.3) in turn. Diagnosis should be aided by a plane mouth mirror and standard blunt probe. It is advisable that the scores for the three specified conditions are not called until both a visual and tactile examination have been completed for the unit concerned.

It is suggested that the visual examination be conducted in the following order, after the unit has first been dried with compressed air:

1. Soft organic material and/or supragingival calculus. The tooth surface is examined for the presence of a visible film of soft material or calcified plaque.
2. Frank gingival inflammation. The specified gingival area is examined and a positive diagnosis made if the mucosa is a darker red, or reddish blue colour, and glazy, in comparison with healthy gingival tissue elsewhere in the subject's mouth or if the air jet has caused the gingivae to bleed, irrespective of the presence of absence of colour change. Swelling or loss of stippling without colour change or a tendency to bleed should not be regarded as unequivocal evidence of gingivitis.
3. Subgingival calculus. In the process of drying the gingival crevice, the margin is reflected by the jet of compressed air. A visual inspection is made for subgingival calculus deposits on the tooth surface within the crevice while the margin is reflected.

The tactile examination is conducted as follows:

1. Soft organic material and/or supragingival calculus. The tine of the standardised blunt probe is placed against the tooth surface and run across the mouth of the gingival crevice. The presence of soft organic deposits is indicated by a mass of material, at least as thick as the tine itself, adhering to the tip of the probe. The

presence of supragingival calculus is indicated by the tactile sensation of a raised area or hard irregularity on the tooth surface.

2. Frank gingival inflammation. If the procedure of running the probe across the mouth of the gingival crevice caused the gingivae to bleed, this is regarded as evidence of frank gingival inflammation. The unit should be scored as positive even if a delay occurred before bleeding became apparent.

3. Subgingival calculus. The tip of the probe is inserted lightly into the gingival crevice while placed against the approximal tooth surface. The tip is then run along the base of the crevice from the approximal to the buccal area in an arc. The presence of subgingival calculus is indicated by the tactile sensation of a hard irregularity or roughness on the subgingival tooth surface.

SYSTEM FOR PLANNING AND EPIDEMIOLOGICAL EVALUATION OF DENTAL SERVICES

DATA COLLECTION CHART

APPENDIX 5

FORENAME .... INITIALS .... SURNAME .... DATE OF BIRTH ___ ___ ___ (day mon. year)

ADDRESS .... DATE OF EXAM ___ ___ ___ (day mon. year)

IDENTITY NUMBER	1, 2, 3, 4, 5 (5 = 1)
EXAMINER	6
EXAM TYPE 1 = routine, 2 = replicate, 3 = training, 9 = absentee	7
SEX 1 = male, 2 = female	8
AGE (years and months)	9, 10, 11, 12
AGE GROUP	13
RESIDENTIAL DISTRICT	14, 15
ETHNIC CLASSIFICATION	16
DENTIST ATTENDED DURING LAST YEAR? 1 = yes, 2 = no, 3 = don't know	17
TYPE OF TREATMENT RECEIVED 1 = routine, 2 = emergency, 3 = non-attender	18
SOURCE OF TREATMENT 1 = GDS, 2 = CDS, 3 = HDS, 4 = other, 5 = none/don't know	19
PLACE OF TREATMENT (enter place of treatment)	20, 21
SCHOOL NUMBER	22
SCHOOL DISTRICT	23
SCHOOL CLASS	24, 25
SOCIAL CLASS	26
INTENDING TO CONTINUE EDUCATION 1 = yes, 2 = no, 3 = don't know	27
PERIOD OF RESIDENCE (years) 1 -- 9 (including 9+)	28
OPTIONAL EXTRA DATA	29, 30, 31, 32, 33, 34, 35, 36

PERIODONTAL EXAMINATION

	6|	2|	1|	|1	|2	|6	6|	2|	1|	|1	|2	|6
SOFT DEPOSITS AND SUPRAGINGIVAL CALCULUS	37	38	39	40	41	42	43	44	45	46	47	48
GINGIVITIS	49	50	51	52	53	54	55	56	57	58	59	60
SUBGINGIVAL CALCULUS	61	62	63	64	65	66	67	68	69	70	71	72

Soft deposits and supragingival calculus: 0 = tooth missing, 1 = absent, 2 = soft deposits, 3 = supragingival calculus

Gingivitis and subgingival calculus: 0 = tooth missing, 1 = absent, 2 = present

1	2	3	4	5
				2
Identity no.				Card

ORTHODONTIC EXAMINATION

6	Cleft palate	1 absent, 2 present
7	Mesioclusion	1 absent, 2 present
8	Distoclusion	1 absent, 2 present
9	Deep overbite	1 absent, 2 present
10	Anterior open bite	1 absent, 2 present
11	Anterior cross-bite	1 absent, 2 present
12	Posterior cross-bite	1 absent, 2 present
13	Severe anterior crowding	1 absent, 2 present
14	Severe posterior crowding	1 absent, 2 present
15	Spacing	1 absent, 2 present
16	Other	1 absent, 2 present
17	Treatment (if any)	1 none, 2 extraction only, 3 removeable appl. $<$1 yr., 4 removeable appl. $>$1 yr., 5 fixed appliance
18	Orthodontic appliance worn	1 no, 2 removeable appl., 3 fixed appliance

CARD 2 CONTINUED OVERLEAF

CARD 2 Continued

PERMANENT TOOTH DESCRIPTOR

- 1 unerupted
- 2 sound
- 3 decayed
- 4 restored, recurrent caries
- 5 extracted, carious
- *6 restored, no caries
- 7 fractured (with or without repair)
- 8 missing
- 9 banded

*restored = filled or crowned for caries

8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34

8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8
35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50

51 Denture worn (1–9)

52 Denture required (1–9)

53 Supernumerary tooth requiring treatment 1 = no 2 = yes

	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
Name																			

1	2	3	4	5
				3
Identity No.				Card

PERMANENT TOOTH TREATMENT

- 00 no treatment
- 01 – 13 fillings
- 31 – 32 crowns (anterior teeth)
- 41 extraction
- 51 – 53 root filling and restoration (anterior teeth)

	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8
tens	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
units	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37

	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8
tens	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53
units	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69

1	2	3	4	5
				4
Identity no.				Card

DECIDUOUS TOOTH DESCRIPTOR

E	D	C	B	A	A	B	C	D	E
6	7	8	9	10	11	12	13	14	15

E	D	C	B	A	A	B	C	D	E
16	17	18	19	20	21	22	23	24	25

DECIDUOUS TOOTH TREATMENT

- 00 no treatment
- 21 – 23 fillings
- 41 extraction
- 61 – 63 root treatment and restoration

	E	D	C	B	A	A	B	C	D	E
tens	26	27	28	29	30	31	32	33	34	35
units	36	37	38	39	40	41	42	43	44	45

	E	D	C	B	A	A	B	C	D	E
tens	46	47	48	49	50	51	52	53	54	55
units	56	57	58	59	60	61	62	63	64	65

Appendix 6

UPPER

Upper Left — Upper Right

Tooth Type	7	6	5	4	3	2	1	1	2	3	4	5	6	7
Surfaces M														
O					X	X	X	X	X	X				
D														
B														
L														

LOWER

Lower Right — Lower Left

	7	6	5	4	3	2	1	1	2	3	4	5	6	7
M														
O					X	X	X	X	X	X				
D														
B														
L														

SURFACE CODES

0 = Sound
1 = Sealant
2 = Carious
3 = Unrestorable
4 = Filled with decay
5 = Filled

TOOTH CODES

6 = Extracted for caries
7 = Extracted, other causes
8 = Unerupted
9 = Trauma

Appendix 7

Control Card for TABULATION program

(Please read notes overleaf)

OPTION REQUIRED			RUN NUMBER								
	Column		1	2	3	4	5	6	7	8	9
1	1	Examiner									
2	2	Examination type									
3	3	Sex									
4	4-5	Age in years									
5	6-7	DO NOT USE	-	-	-	-	-	-	-	-	-
6	8	Age group									
7	9-10	Residential district									
8	11	Ethnic classification									
9	12	Dental attendance pattern									
10	13	Treatment received									
11	14	Source of treatment									
12	15-16	Place of treatment									
13	17	School number									
14	18	School district									
15	19-20	School class									
16	21	Social class									
17	22	~~Period of residence~~ CONTINUING EDUCATION									
18	23	(PERIOD OF RESIDENCE)									
19	24	( )									
20	25	( )									
21	26	( )									
22	27	(Extra data)									
23	28	( )									
24	29	( )									
25	30	( )									
26	31	( )									
27	32	Number of runs									
28	33	Run type (1=disease tables, 2=costing tables, 3=frequency tables)									
29	34	Number of districts 0=not recorded									
30	35	Number of examiners 0=not recorded									
31	36	Number of schools 0=not recorded									
32	37	1=Anteriors only, 2=posteriors only									
33	38	1=File of individual data output									

Notes on filling in control cards

1 No. 27 (column 32) The program allows a maximum of 9 runs through the data in a single job; one control card for each run. This number must appear on every control card. If more than nine are required, fill in another sheet. Large jobs may need to be run overnight on low priority in some computer installations.

2 No. 28 (column 33) selects the type of table required.

3 Nos. 29-31 The figures given here must correspond to the captions entered in your titles file (SPEED Manual 7.4), or the tables will be wrongly labelled. Every control card must be filled in.

4 Nos. 1-26 select subgroups of the population, e.g. 2 in column 21 selects only those subjects in Social Class 2, 1 in column 14 selects those who attend a General Dental Practitioner.

5 No. 32 (column 37) will split the results into (1) anterior teeth only, (2) posterior teeth only.

The following example shows the first six runs to be concerned with the standard tables for each age group separately and numbers 7 to 9 illustrate the use of the extra data section, selecting users of fluoride tooth paste in age group 2 for all subjects (7), males only (8) and females only (9).

OPTION REQUIRED			RUN NUMBER								
	Column		1	2	3	4	5	6	7	8	9
1	1	Examiner									
2	2	Examination type									
3	3	Sex								1	2
4	4-5	Age in years									
5	6-7	DO NOT USE	-	-	-	-	-	-	-	-	-
6	8	Age group	1	2	1	2	1	2	2	2	2
7	9-10	Residential district									
8	11	Ethnic classification									
9	12	Dental attendance pattern									
10	13	Treatment received									
11	14	Source of treatment									
12	15-16	Place of treatment									
13	17	School number									
14	18	School district									
15	19-20	School class									
16	21	Social class									
17	22	Period of residence									
18	23	(Use of Fluoride toothpaste 1 = yes 2 = no)							1	1	1
19	24	( )									
20	25	( )									
21	26	( )									
22	27	(Extra data)									
23	28	( )									
24	29	( )									
25	30	( )									
26	31	( )									
27	32	Number of runs	9	9	9	9	9	9	9	9	9
28	33	Run type (1=disease tables, 2=costing tables, 3=frequency tables)	1	1	2	2	3	3	1	1	1
29	34	Number of districts 0=not recorded	2	2	2	2	2	2	2	2	2
30	35	Number of examiners 0=not recorded	0	0	0	0	0	0	0	0	0
31	36	Number of schools 0=not recorded	8	8	8	8	8	8	8	8	8
32	37	1=Anteriors only, 2=posteriors only									
33	38	1=File of individual data output									

Appendix 8

SPEED TITLE AND COST FILE

SINGLE SURFACE AF 5.40
MULTIPLE SINGLE AF"S 8.00
OTHER TYPE AF"s 8.50
2 OR MORE OTHER TYPE AF"S 10.60
MO OR DO AF 10.60
MOD OR MO + DO AF 14.00
SINGLE AF(S) + MO OR DO 11.60
SINGLE AF(S) +1 OTHER TYPE 10.00
SINGLE AF(S) +2 OTHER TYPES 13.00
MO OR DO + OTHER TYPE(S) 13.00
SINGLE SYNTH, RESIN OR COMP 10.20
2 OR MORE SF"S 16.00
MAXIMUM RESTORATION 22.25
ILLEGAL CODE - 14 8.00 ORDINARY SCALING (UNDER 16)
ILLEGAL CODE - 15 16.00 EXCEPTIONAL SCALING (UNDER 16)
ILLEGAL CODE - 16 16.00 ORDINARY SCALING (OVER 16)
ILLEGAL CODE - 17 5.00 EXAMINATION FEE
ILLEGAL CODE - 18 0.0 EXTRA GUM TREATMENT
ILLEGAL CODE - 19 0.0
ILLEGAL CODE - 20 0.0
SINGLE SURFACE AF OR SF 5.40
2 OR MORE AF"S OR SF"S 9.00
MOLAR METAL CROWN 11.30
ILLEGAL CODE - 24 65.00 DENTURES - FULL UPPER OR LOWER
ILLEGAL CODE - 25 103.00 DENTURESL FULL UPOER AND LOWER
ILLEGAL CODE - 26 43.00 PARTIAL DENTURE 1-3 TEETH
ILLEGAL CODE - 27 57.00 PARTIAL DENTURE 4-8 TEETH
ILLEGAL CODE - 28 68.00 PARTIAL DENTURE 9+ TEETH
ILLEGAL CODE - 29 00.00 ORTHO, APPLIANCE LT.1 YEAR
ILLEGAL CODE - 30 00.00 ORTHO, APPLIANCE GT.1 YEAR
JACKET CROWN 65.60
POST CROWN 65.60
ILLEGAL CODE - 33 0.0 RADIOGRAPHS BASIC FEE
ILLEAGE CODE - 34 0.0 RADIOGRAPHS MULTIPLE FACTOR
ILLEGAL CODE - 35 0.0 PREVENTION RATE PER MINUTE
ILLEGAL CODE - 36 0.0 PREVENTIVE FEE
ILLEGAL CODE - 37 0.0
ILLEGAL CODE - 38 0.0

ILLEGAL CODE - 39 0.0
ILLEGAL CODE - 40 0.0
REQUIRES EXTRACTION 5.00 EXTRACTION 1 TOOTH
ILLEGAL CODE - 44 9.00 EXTRACTION 2 TEETH
ILLEGAL CODE - 43 14.00 EXTRACTION 3-5 TEETH
ILLEGAL CODE - 44 18.00 EXTRACTION 6-8 TEETH
ILLEGAL CODE - 45 22.00 EXTRACTION 9-11 TEETH
ILLEGAL CODE - 46 25.00 EXTRACTION 12-14 TEETH
ILLEGAL CODE - 47 30.00 EXTRACTION 15-17 TEETH
ILLEGAL CODE - 48 34.00 EXTRACTION 18-20 TEETH
ILLEGAL CODE - 49 36.00 EXTRACTION 21+ TEETH
ILLEGAL CODE - 50 0.0
ROOT FILLING + SS AF, SF 35.40
ROOT FILLING 2+ SS AF, SF 38.00
ROOT FILLING + POST CROWN 75.60
ILLEGAL CODE - 54 0.0
ILLEGAL CODE - 55 16.00 GENERAL ANAESTHESIA 2-3 TEETH
ILLEGAL CODE - 56 18.00 GENERAL ANAESTHESIA 4-11 TEETH
ILLEGAL CODE - 57 22.00 GENERAL ANAESTHESIA 12-19 TEETH
ILLEGAL CODE - 58 27.00 GENERAL ANAESTEHSIA 20+ TEETH
ILLEAGEL CODE - 59 4.00 QUADRANT CHARGE
ILLEGAL CODE - 60 0.0
RCT + SS AF OR SF 22.00
RCT + 2+ SS AF"S, SF"S 26.40
RCT + MOLAR METAL CROWN 27.60
CLEFT PALATE
MESIOCLUSION
DISTOCLUSION
DEEP OVERBITE
ANTERTIOR OPEN BITE
ANTERIOR CROSS BITE
POSTERIOR CROSS BITE
SEVERE ANTERIOR CROWDING
SEVERE POSTERIOR CROWDING
SPACING
OTHER
NONTE
EXTRACTION ONLY
REMOVEABLE APPLIANCE LESS THAN 1 YEAR
REMOVEABLE APPLIANCE MORE THAN 1 YEAR
FIXED APPLIANCE
NO DENTURE WORN
FULL UPPER WORN
FULL LOWER WORN
FULL UPPER AND LOWER WORN
PARTIAL UPPER WORN
PARTIAL LOWER WORN
PARTIAL LOWER AND PARTIAL UPPER WORN
FULL UPPER AND PARTIAL LOWER WORN
FULL LOWER AND PARTIAL UPPER WORN
NO DENTURE REQUIRED
FULL UPPER REQUIRED

FULL LOWER REQUIRED
FULL UPPER AND LOWER REQUIRED
PARTIAL UPPER REQUIRED
PARTIAL LOWER REQUIRED
PARTIAL UPPER + PARTIAL LOWER REQUIRED
FULL UPPER AND PARTIAL LOWER REQUIRED
FULL LOWER AND PARTIAL UPPER REQUIRED
DISTRICT
SCHOOL
EXAMINER
SEX
DECAYED PERMANENT TEETH 1 DECAYED (PERM)
MISSING PERMANENT TEETH 2 DMFT (PERM)
FILLED PERMANENT TEETH 3 DECAYED (DECID)
DMFT (PERMANENT TEETH) 4 DMFT (DECID)
DECAYED DECIDUOUS TEETH 5 PLAQUE
MISSING DECIDUOUS TEETH 6 GINGIVITIS
FILLED DECIDUOUS TEETH 7 SUBGING. CALC.
DMFT (DECIDUOUS TEETH) 8 FILL. ROOT. CROWN
DENTAL ATTENDANCE PATTERN 9 EXTRACT. CARIES
ORAL CLEANLINESS 10 EXTRACT. ORTHO.
GINGIVITUS PREVALENCE 11 GENERAL ANAES.
SUBGINGIVAL CALCULUS 12 ORTHODONTICS
PROSTHETIC APPLICANCES WORN 13 PROSTHETICS
PROSTHETIC REQUIREMENTS 14 SCALING
ORTHODONTIC CONDITIONS 15 AUXILIARY COST
ORTHODONTIC APPLIANCES WORN 16 DENTIST COST
ORTHODONTIC REQUIREMENTS 17 TOTAL COST
FILLINGS, ENDO. AND CROWNS 1
FILLINGS ETC. FOR TRAUMA
EXTRACTIONS FOR CARIES
EXTRACTIONS FOR ORTHODONTICS
GENERAL ANAESTHETICS
ORTHODONTIC TREATMENT
PRSOTHETIC TREATMENT
SCALING
ROUTINE TREATMENT-AUXILIARY
ROUTINE TREATMENT-DENTIST
TOTAL TREATMENT COST
MALE
FEMALE
TOTAL
DISTRICT1
DISTRICT2
DISTRICT3
TOTAL
SCHOOL
TOTAL
EXAMINER1
TOTAL

Tooth Condition Examination

The examination method is primarily visual utilising a plane mouth mirror. The CPITN probe is used to remove debris to enable satisfactory visual observation and to confirm or reject dubious lesions.

Every surface of every tooth should be systematically examined. A tooth is considered present in the mouth when any part of it is visible. Deciduous teeth should be ignored and permanent successor scored unerupted. An entry must be made for every tooth on the chart.

Surface Codes

Code 0 = Sound Tooth. A tooth is recorded as sound if it shows no evidence of treated or untreated clinical caries. Early pre-cavitation lesions are excluded because they cannot be reliably diagnosed. In the absence of other positive criteria, the following defects are recorded as sound.

a) White or chalky spots
b) Discoloured or rough spots
c) Stained pits or fissures with no detectable cavitation.
d) Dark, shiny, hard pitted areas of enamel showing signs of moderate or severe fluorosis.

Code 1 = Sealant. This code is used where a fissure sealant has been placed on the occlusal surface. If a surface with a sealant has decay, it should be recorded as Code 2.

Code 2 = Carious. The diagnostic criteria must be strictly adhered to and unless fulfilled, caries should be recorded as present in a surface.

a) Pits and Fissures - visible breakdown of the walls of the fissure or shadow or opacity beneath enamel.

b) Free smooth surfaces and observable approximal surfaces - visible breakdown of enamel with cavitation. or shadow or opacity beneath enamel.

c) Contacting approximal surfaces - visible breakdown of the enamel with cavitation., shadow or opacity beneath the enamel or marginal ridge enamel in posterior teeth.

d) If doubt exists, the site should be gently explored with the CPITN probe. Unless the point enters the lesion, the surface should be recorded as sound. If doubt still remains, the surface should be regarded as sound. A temporary filling is recorded as caries.

Code 3 = Unrestorable. When caries is believed to involve the pulp, the surface should be scored as unrestorable.

Code 4 = Filled surface with decay. A surface is scored as filled with decay when it contains a permanent filling and caries. No distinction is made between primary and secondary caries.

Code 5 = Filled. A surface is recorded as filled when a permanent restoration is present and there is no primary or secondary caries present in the surface. A crown placed because of decay is recorded as filled. A surface in an anterior tooth that has been restored for reasons other than decay is recorded as Code 9 (Trauma).

Tooth Codes

Code 6 = Extracted for Caries. This code is for teeth that have been extracted for caries. Care must be taken to differentiate between unerupted teeth, orthodontic extractions and carious teeth.

Code 7 = Extracted, Other Causes. This code is used for teeth judged to be congenitally absent or extracted for reasons such as trauma or orthodontics. The code is also used for teeth judged to have been extracted because of periodontal disease.

Code 8 = Unerupted. No part of the permanent tooth visible.

Code 9 = Trauma. This code is used for an anterior tooth where there is a fracture involving enamel and dentine and no caries or restoration for caries. In coding the tooth, caries or restoration for caries takes precedence over a fracture or restoration for fracture.

DDE Index

Use modified DDE Index and index teeth $\frac{4321/1234}{6\ /\ 6}$

Defect

Code 0 - Normal

Code 1 - Demarcated Opacity - white/cream

Code 2 - Demarcated Opacity - yellow/brown

Code 3 - Diffuse Opacities - lines

Code 4 - Diffuse Opacities - patchy

Code 5 - Diffuse Opacities - confluent

Code 6 - Diffuse Opacities - confluent + staining + enamel loss

Code 7 - Hypoplasia - pits

Code 8 - Hypoplasia - missing enamel

Code 9 - Any other defects

Combinations

Demarcated + Diffuse	K
Demarcated + Hypoplasia	L
Diffuse + Hypoplasia	M
All three defects	N

Extent of Defect

Code 0 - normal

Code 1 - 1/3

Code 2 - at least 1/3 2/3

Code 3 - at least 2/3

Appendix 10

DADG

DATA COLLECTION CHART

FORENAME........................ INITIALS .... SURNAME ....

ADDRESS..

IDENTITY NUMBER

DATE OF EXAM (day mon. year)

EXAMINER

CITY 1 = Dublin 2 = Glasgow 3 = Other

EXAM TYPE 1 = routine, 2 = replicate 3 = training, 9 = absentee

SCHOOL NUMBER

SEX 1 = male, 2 = female

PERIOD OF RESIDENCE (years) 0 = Not known 1 = Life time 2 = > 12 years

DATE OF BIRTH (day mon. year)

DENTAL ATTENDANCE 0 = Not known 1 = Regular 2 = Irregular

AGE (years and months)

OPTIONAL EXTRA DATA

MODIFIED DDE INDEX

Tooth	14	13	12	11	21	22	23	24	36	46	
Defect											Codes 0-9
Extent											Codes 0-3

UPPER

Tooth Type	7	6	5	4	3	2	1	1	2	3	4	5	6	7
	Upper Left												Upper Right	
Surfaces M														
O					X	X	X	X	X	X				
D														
B														
L														

LOWER

	7	6	5	4	3	2	1	1	2	3	4	5	6	7
	Lower Right												Lower Left	
M														
O					X	X	X	X	X	X				
D														
B														
L														

SURFACE CODES

0 = Sound
1 = Sealant
2 = Carious
3 = Unrestorable
4 = Filled with decay
5 = Filled

TOOTH CODES

6 = Extracted for caries
7 = Extracted, other causes
8 = Unerupted
9 = Trauma

DMFT EXAMPLE

```
O   EDIT
0   FILE HANDLE DAS/NAME = DP".GLAS90"
0   DATA LIST FILE=DAS RECORDS=3
0     /1 ID 1-4 EX 5 TYPE 6 SEX 7 DOB 8-13
          YRS 14-15 MTHS 16-17 DATE 18-23
0     CITY 24 SCHOOL NO 25-26 RES 27 DATT 28
0     DDE1 TO DDE10 37-46 (A) EXTENT1 TO EXTENT10
    47-56 DS 57-58 MS 59-60 FS 61062 DMFS 63-64
DMFSD 65-66 MSD 67-68 DT 69-70 MT 71-72
          FT 73-74 DMFT 75-76
0     /2 U1 TO U78 1-78
0     /3 L1 TO L78 1-78
0   VARIABLE LABELS EX "EXAMINER" TYPE "EXAM TYPE"
0   VALUE LABELS EX 1 "DA" 2 "ASB" 3 CW" 4 "GG" 6
"RH"
0     TYPE 1 "ROUTINE" 2 "REPLICATE" 3 "TRAINING" 4
"ABSENT"/
0     SEX 1 "MALE" 2 "FEMALE"
0   LIST CASES TO 5
0   RECODE U1 (2,4=2) (3=3) (6=6) (5=5) INTO U6
0   RECODE U2 (2,4=2) (3=3) (6=6) (5=5) INTO U6
0   RECODE U3 (2,4=2) (3=3) (6=6) (5=5) INTO U6
0   RECODE U4 (2,4=2) (3=3) (6=6) (5=5) INTO U6
0   RECODE U5 (2,4=2) (3=3) (6=6) (5=5) INTO U6
0   RECODE U7 (2,4=2) (3-3) (6=6) (5-5) INTO U12
0   RECODE U8 (2,4=2) (3=3) (6=6) (5=5) INTO U12
0   RECODE U9 (2,4=2) (3=3) (6=6) (5=5) INTO U12
0   RECODE U10(2,4=2) (3=3) (6=6) (5=5) INTO U12
0   RECODE U11(2,4=2) (3=3) (6=6) (5=5) INTO U12
0   RECODE U13(2,4=2) (3=3) (6=6) (5=5) INTO U18
0   RECODE U14(2,4=2) (3=3) (5=5) INTO U18
0   RECODE U15(2,4=2) (3=3) (5=5) INTO U18
0   RECODE U16(2,4=2) (3=3) (5=5) INTO U18
0   RECODE U17(2,4=2) (3=3) (5=5) INTO U18
0   RECODE U19(2,4=2) (3=3) (6=6) (5=5) INTO U24
0   RECODE U20(2,4=2) (3=3) (5=5) INTO U24
0   RECODE U21(2,4=2) (3=3) (5=5) INTO U24
0   RECODE U22(2,4=2) (3=3) (5=5) INTO U24
0   RECODE U23(2,4=2) (3=3) (5=5) INTO U24
0   RECODE U25(2,4=2) (3=3) (6=6) (5=5) INTO U29
0   RECODE U26(2,4=2) (3=3) (5=5) INTO U29
0   RECODE U27(2,4=2) (3=3) (5=5) INTO U29
0   RECODE U28(2,4=2) (3=3) (5=5) INTO U29
0   RECODE U30(2,4=2) (3=3) (6=6) (5=5) INTO U34
0   RECODE U31(2,4=2) (3=3) (5=5) INTO U34
0   RECODE U32(2,4=2) (3=3) (5=5) INTO U34
0   RECODE U33(2,4=2) (3=3) (5=5) INTO U34
0   RECODE U35(2,4=2) (3=3) (6=6) (5=5) INTO U39
0   RECODE U36(2,4=2) (3=3) (5=5) INTO U39
0   RECODE U37(2,4=2) (3=3) (5=5) INTO U39
0   RECODE U38(2,4=2) (3=3) (5=5) INTO U39
0   RECODE U40(2,4=2) (3=3) (6=6) (5=5) INTO U44
0   RECODE U41(2,4=2) (3=3) (5=5) INTO U44
0   RECODE U42(2,4=2) (3=3) (5=5) INTO U44
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0    RECODE U43(2,4=2) (3=3) (5=5) INTO U44
0    RECODE U45(2,4=2) (3=3) (6=6) (5=5) INTO U49
0    RECODE U46(2,4=2) (3=3) (5=5) INTO U49
0    RECODE U47(2,4=2) (3=3) (5=5) INTO U49
0    RECODE U48(2,4=2) (3=3) (5=5) INTO U49
0    RECODE U50(2,4=2) (3=3) (6=6) (5=5) INTO U54
0    RECODE U51(2,4=2) (3=3) (5=5) INTO U54
0    RECODE U52(2,4=2) (3=3) (5=5) INTO U54
0    RECODE U53(2,4=2) (3=3) (5=5) INTO U54
0    RECODE U55(2,4=2) (3=3) (6=6) (5=5) INTO U60
0    RECODE U56(2,4=2) (3=3) (5=5) INTO U60
0    RECODE U57(2,4=2) (3=3) (5=5) INTO U60
0    RECODE U58(2,4=2) (3=3) (5=5) INTO U60
0    RECODE U59(2,4=2) (3=3) (5=5) INTO U60
0    RECODE U61(2,4=2) (3=3) (6=6) (5=5) INTO U66
0    RECODE U62(2,4=2) (3=3) (5=5) INTO U66
0    RECODE U63(2,4=2) (3=3) (5=5) INTO U66
0    RECODE U64(2,4=2) (3=3) (5=5) INTO U66
0    RECODE U65(2,4=2) (3=3) (5=5) INTO U66
0    RECODE U67(2,4=2) (3=3) (6=6) (5=5) INTO U72
0    RECODE U68(2,4=2) (3=3) (6=6) (5=5) INTO U72
0    RECODE U69(2,4=2) (3=3) (6=6) (5=5) INTO U72
0    RECODE U70(2,4=2) (3=3) (6=6) (5=5) INTO U72
0    RECODE U71(2,4=2) (3=3) (6=6) (5=5) INTO U72
0    RECODE U73(2,4=2) (3=3) (6=6) (5=5) INTO U78
0    RECODE U74(2,4=2) (3=3) (6=6) (5=5) INTO U78
0    RECODE U75(2,4=2) (3=3) (6=6) (5=5) INTO U78
0    RECODE U76(2,4=2) (3=3) (6=6) (5=5) INTO U78
0    RECODE U77(2,4=2) (3=3) (6=6) (5=5) INTO U78
0    RECODE L1 (2,4=2) (3=3) (6=6) (5=5) INTO L6
0    RECODE L2 (2,4=2) (3=3) (6=6) (5=5) INTO L6
0    RECODE L3 (2,4=2) (3=3) (6=6) (5=5) INTO L6
0    RECODE L4 (2,4=2) (3=3) (6=6) (5=5) INTO L6
0    RECODE L5 (2,4=2) (3=3) (6=6) (5=5) INTO L6
0    RECODE L7 (2,4=2) (3=3) (6=6) (5=5) INTO L12
0    RECODE L8 (2,4=2) (3=3) (6=6)        (5=5) INTO L12
0    RECODE L9 (2,4=2) (3=3) (6=6) (5=5) INTO L12
0    RECODE L10 (2,4=2) (3=3) (6=6) (5=5) INTO L12
0    RECODE L11 (2,4=2) (3=3) (6=6) (5=5) INTO L12
0    RECODE L13 (2,4=2) (3=3) (6=6) (5=5 INTO L18
0    RECODE L14 (2,4=2) (3=3) (5=5) INTO L18
0    RECODE L15 (2,4=2) (3=3) (5=5) INTO L18
0    RECODE L16 (2,4=2) (3=3) (5=5) INTO L18
0    RECODE L17 (2,4,2) (3=3) (5=5) INTO L18
0    RECODE L19 (2,4=2) (3=3) (6=6) (5=5) INTO L24
0    RECODE L20 (2,4=2) (3=3) (5=5) INTO L24
0    RECODE L21 (2,4=2) (3=3) (5=5) INTO L24
0    RECODE L22 (2,4=2) (3=3) (5=5) INTO L24
0    RECODE L23 (2,4=2) (3=3) (5=5) INTO L24
0    RECODE L25 (2,4=2) (3=3) (6=6) (5=5) INTO L29
0    RECODE L26 (2,4=2) (3=3) (5=5) INTO L29
0    RECODE L27 (2,4=2) (3=3) (5=5) INTO L29
O    RECODE L28 (2,4=2) (3=3) (5=5) INTO L29
0    RECODE L30 (2,4=2) (3=3) (6=6) (5=5) INTO L34
0    RECODE L31 (2,4=2) (3=3) (6=6) (5=5) INTO L34
0    RECODE L32 (2,4=2) (3=3) (6=6) (5=5) INTO L34
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0    RECODE L33 (2,4=2) (3=3) (6=6) (5=5) INTO L34
O    RECODE L35 (2,4=2) (3=3) (6=6) (5=5) INTO L39
0    RECODE L36 (2,4=2) (3=3) (5=5) INTO L39
O    RECODE L37 (2,4=2) (3=3) (5=5) INTO L39
0    RECODE L38 (2,4=2) (3=3) (5=5) INTO L39
0    RECODE L40 (2,4=2) (3=3) (6=6) (5=5) INTO L44
0    RECODE L41 (2,4=2) (3=3) (5=5) INTO L44
0    RECODE L42 (2,4=2) (3=3) (5=5) INTO L44
0    RECODE L43 (2,4=2) (3=3) (5=5) INTO L44
0    RECODE L45 (2,4=2) (3=3) (6=6) (5=5) INTO L49
0    RECODE L46 (2,4=2) (3=3) (5=5) INTO l49
0    RECODE L47 (2,4=2) (3=3) (5=5) INTO L49
0    RECODE L48 (2,4=2) (3=3) (5=5) INTO L49
0    RECODE L50 (2,4=2) (3=3) (6=6) (5=5) INTO L54
0    RECODE L51 (2,4=2) (3=3) (5=5) INTO L54
0    RECODE L52 (2,4=2) (3=3) (5=5) INTO L54
0    RECODE L53 (2,4=2) (3=3) (5=5) INTO L54
0    RECODE L55 (2,4=2) (3=3) (6=6) (5=5) INTO L60
0    RECODE L56 (2,4=2) (3=3) (5=5) INTO L60
0    RECODE L57 (2,4=2) (3=3) (5=5) INTO L60
0    RECODE L58 (2,4=2) (3=3) (5=5) INTO L60
0    RECODE L59 (2,4=2) (3=3) (5=5) INTO L60
0    RECODE L61 (2,4=2) (3=3) (6=6) (5=5) INTO L66
0    RECODE L62 (2,4=2) (3=3) (5=5) INTO L66
0    RECODE L63 (2,4=2) (3=3) (5=5) INTO L66
0    RECODE L64 (2,4=2) (3=3) (5=5) INTO L66
0    RECODE L65 (2,4=2) (3=3) (5=5) INTO L66
0    RECODE L67 (2,4=2) (3=3) (6=6) (5=5) INTO L72
0    RECODE L68 (2,4=2) (3=3) (6=6) (5=5) INTO L72
0    RECODE L69 (2,4=2) (3=3) (6=6) (5=5) INTO L72
0    RECODE L70 (2,4=2) (3=3) (6=6) (5=5) INTO L72
0    RECODE L71 (2,4=2) (3=3) (6=6) (5=5) INTO L72
0    RECODE L73 (2,4=2) (3=3) (6=6) (5=5) INTO L78
0    RECODE L74 (2,4=2) (3=3) (6=6) (5=5) INTO L78
0    RECODE L75 (2,4=2) (3=3) (6=6) (5=5) INTO L78
0    RECODE L76 (2,4=2) (3=3) (6=6) (5=5) INTO L78
0    RECODE L78 (2,4=2) (3=3) (6=6) (5=5) INTO L78
0    COUNT DT = U6 U12 U72 U78 U18 U24 U29 U34 U39 U44
  U49 U54 U60 U66
0  L6 O12 O72 L78 L18 L24 L29 L34 L39 L44 L49 L54          L60
L66 (2,3)/
0  MT = U6 U12 U72 U78 U18 U24 U29 U34 U39 U44 U49
U54 U60 U66
0  L6 O12 O72 L78 L18 L24 L29 L34 L39 L44 L49 L54          L60
L66 (6)/
0  FT = U6 U12 U72 U78 U18 U24 U29 U34 U39 U44 U49
U54 U60 U66
0  L6 O12 O72 L78 L18 L24 L29 L34 L39 L44 L49 L54          L60
L66 (5)/
0  DMFT = U6 U12 U72 U78 U18 U24 U29 U34 U39 U44 U49
U54 U60 U66
0  L6 O12 O72 L78 L18 L24 L29 L34 L39 L44 L49 L54          L60
L66 (2 THRU 6)/
0  SELECT IF (TYPE EQ 1)
0  FREQUENCIES VARIABLES = DT MT FT DMFT
0  STATISTICS
```

```
FILE HANDLE DAS/NAME="DP.DUBLIN"
DATA LIST FILE=DAS RECORDS=3
/1 ID 1-4 EX 5 TYPE 6 SEX 7 DOB 8-13 YRS 14-15 MONTHS 16-17 DATE 18-
23
      CITY 24 SCHOOL NO 25-26 RES 27 DATT 28 OPTIONAL 29-36
      DDE1 TO DDE10 37-46 (A) EXTENT1 TO EXTENT10 47-56
      DS 57-58 MS 59-60 FS 61-62 DMFS 63-64 DMFSD 65-66
      MSD 67-68
      /2 U1 TO U78 1-78
      /3 L1 TO L78 1-78
VARIABLE LABELS EX "EXAMINER" TYPE "EXAM TYPE"
VALUE LABELS EX 1 "ASMA"/
      TYPE 1 "ROUTINE" 2 "REPLICATE" 3 "TRAINING" 4 "ABSENT"/
      SEX 1 "MALE" 2 "FEMALE"
LIST CASES TO 5
SELECT IF (TYPE EQ 1)
TEMPORARY
SELECT IF (SEX EQ 1)
FREQUENCIES VARIABLES=DDE1 TO DDE10 EXTENT 10/
      STATISTICS
TEMPORARY
SELECT IF (SEX EQ 2)
FREQUENCIES VARIABLES=DDE1 TO DDE10 EXTENT 10/
      STATISTICS
```

APPENDIX 12

Other factors which may contribute to variations in caries prevalence between Stranraer and Annan.

Although the review of fluoridation literature would suggest that the ending of the fluoridation of the public water supply in Wigtownshire would be a major influence on caries prevalence in Stranraer children, it is important to take cognisance of the potential influence of other factors. The water fluoridation and its cessation are major differences between the two towns. However other variations could have existed between the two towns. Those which might have influenced dental health, possibly leading to differences in caries prevalence, include nutrition, dentifrice usage, social class and dental awareness.

Nutrition

It is unlikely that a difference in nutrition would exist between two similar towns in a comparatively small rural area. To eliminate this, the eating habits of the school children were considered. School meals in Stranraer and Annan were similar in content, being provided by the Regional School Meals Service. Packed lunches eaten by a proportion of the children had similar ingredients. The school in each town operated school tuck shops, selling similar items such as crisps, fruit, biscuits and soft drinks. The supermarkets in the towns sell a similar range of products and reported almost identical patterns of sugar and confectionery sales. It is therefore unlikely that nutritional variations had any significant effect on the differences in caries prevalence found.

Dentifrice usage

The removal of fluoride from the water supply occurred during a period of temporal decline in dental caries levels. This has been attributed to the widespread use of Fluoride toothpaste in those countries where caries rates have fallen. The three main toothpaste suppliers have reported that around 96 per cent of all Dentifrice sold in Scotland and the rest of Britain contains fluoride. The pattern of toothpaste sales in Annan and Stranraer follow this general pattern and any effect resulting from the use of fluoride toothpaste would therefore be expected to affect children in both towns equally.

Social Class

While the towns of Stranraer and Annan have a slightly higher social class profile than the over-all pattern for Scotland, it is typical of rural areas throughout Scotland. As there is an inverse relationship between social class and dental health, it would be expected that caries levels would be lower than in other areas, such as the Scottish Central Belt, where there are higher proportions of Social Class V subjects. National surveys of children in Scotland have confirmed that caries levels are lower in Dumfries and Galloway than in the Health Board areas covering the central conurbation, such as Greater Glasgow and Lanarkshire.

However as the social class profiles in Stranraer and Annan are not statistically different, social class is unlikely to be a factor causing the differences in caries prevalence found in the two towns.

Dental Awareness

Dental awareness can be assessed by examining the patterns of dental attendance and the usage of the dental services. Data collected relating to these factors indicated a broadly similar pattern of dental attendance in the two towns. Dental attenders in both towns reported to the scribes a similar pattern of usage of the dental services available to the two populations. As reported elsewhere, dentist / patient ratios have remained similar in Stranraer and Annan over the period of the studies, with similar levels of regular dental attendance being reported.

It is clear therefore that the major factor creating change in caries prevalence in the two towns over the period of the studies is the initial availability of water fluoridation, followed by its withdrawal.