Preventing the preventable – the enigma of dental caries

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Vice-Chancellor, Deans, colleagues and visitors, it is a very great privilege to be invited to present the 50th Founders' and Benefactors' lecture. When I arrived in Newcastle as a lecturer in preventive dentistry in 1972, children aged 5 years living in Northumberland had an average of six bad teeth per child. Now it is much less and it is the purpose of today's lecture to describe the reasons for this success, but also, to indicate that the battle is far from won — the preventable is not yet prevented.

My presentation is in three parts: the changing prevalence of dental caries, the influence of fluoride and the influence of diet.

Dentists are lucky in that teeth survive the longest of any tissue after death. We do not have to rely on contemporary accounts of disease prevalence; we dig up our ancestors. The results of these archaeological surveys reveal that experience of dental caries was low until the nineteenth century, when it rose sharply. Recruitment of soldiers for the Boer war was a defining moment in the recognition of the poor state of health, including teeth, of young men in Britain. 'Poor teeth' was the most important cause of rejection of volunteers for service at that time. This led to the birth of dental epidemiology in this country, and surveys of schoolchildren between 1906 and 1908 revealed that 90% of 12-year-olds had experienced decay, with an average of 4 bad teeth per child. From this parlous state at the beginning of the twentieth century, dental caries experience rose to reach its zenith in the late 1950s and 60s.

In probably the biggest review of records of epidemiological surveys of dental decay undertaken, the Norwegian Reidar Sognnaes documented the effect of the two world wars on caries prevalence and experience, mainly in Europe. Data from 27 studies in 11 countries covering over three quarters of a million children were reviewed. In Britain, caries prevalence in young children fell by 40% during World War 1 and by 30% during World War 2. Since World War 2, dental epidemiology has become more organised. First, the quinquennial surveys of the Health of the School-Child, begun in 1948, included an examination of teeth; second, 1968 saw the beginning of decennial surveys, of adult and child dental health and, third, surveys co-ordinated by the British Association for the Study of Community Dentistry began in 1985 and in which 5- 12- and 14-year-old children are examined every two or four years. The results of these surveys fit together quite well to give a very clear picture of dental caries severity in 5-and 12-year-old children over the past 50 years.

It is worth giving some consideration to the national surveys of children's and adult dental health, partly because they are world-beaters, and also because Newcastle has played a major role in their success. I was an undergraduate at the London Hospital when the seeds of these decennial surveys were being sown: the mastermind was Geoffrey Slack. The seed was the survey of adult dental health in Salisbury and Darlington. He saw the importance of making it a socio-dental study — an aspect which has become such an important hallmark of our national surveys. The results were deeply worrying: half of Darlington's adults were edentulous — had no natural teeth at all — and politically importantly, southern Salisbury was not much better.

Geoffrey Slack then organised the first Adult Dental Health Survey of England and Wales, which took place in 1968. This confirmed the high level of edentulousness: 37% nationally, with nearly every other adult over the age of 16 years in the north of England, with no natural teeth at all. Surveys of adult dental health followed in 1978, 1988 and 1998 and of children's dental health in 1973, 1983 and 1993. After Geoffrey Slack's retirement, Birmingham Dental School organised the next two surveys but since 1983, they have been jointly organised by Newcastle and Birmingham and latterly with Dundee and Cardiff.

I have mentioned that the lack of any natural teeth has been a popular measure of the dental status of adults. From the results of the past surveys, it is possible to predict the virtual eradication of edentulousness in the UK, during the working life of present undergraduates (Table 1).

Table 1. Past and predicted levels of total tooth loss. The per cent of edentulous adults in the United Kingdom

Year	1968	1978	1988	1998	2008	2018	2028	2038
All adults	37	30	21	14	10	7	6	6
75+years	88	79	80	64	48	34	23	19

Source: J E Todd, D Lader. Adult Health 1988. London: HMSO, 1991

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But what of child dental health? A common way to express the amount of dental decay in groups of children, is to count the number of teeth affected by decay, and express this as an average per child. In 1973, the average number of teeth affected per 14-year-old child in England and Wales was 7.4; this fell to 4.7 in 1983 and to 2.0 teeth in the last survey in 1993. An excellent achievement. These are of course permanent teeth; it is also important to examine trends in dental decay of primary teeth of young children. A decline in decay experience occurred for these teeth too, but there has been a levelling off, and in some areas a slight rise over recent years.

Dental decay is presently very strongly related to social class and the increasing disparity in oral health between the 'haves' and the 'have-nots' in our society is of considerable concern

Improvements in child dental health have now worked through to young adults. I recall as a young lecturer in the early 1970s, being sent down by my Head of Department to the old ABC cinema in the Haymarket to address some 2000 freshers at the university. I and one or two colleagues would ask if any of these freshers were caries-free — that is had no decayed, filled or extracted teeth. We managed to bag about 15 – 20 each year, mainly from overseas, and subsequently investigated why they might have this rare state of being caries-free. If we had done the same last October, we would have run the danger of being swamped by about 700 out of the three and a half thousand freshers. A great success story for the youth of this country.

However, there are some aspects of child dental health which concern me. For example, the 'tail of the distribution': the group of children with the highest experience of dental decay. For example in 1983, 21% of 14-year-olds had eight or more bad permanent teeth. For 5-year-olds, 22% had four or more decayed primary teeth. Epidemiologists will, of course, tell you that someone has to be at the tail of a distribution, but it is worrying that these are the least accessible in our society. Dental decay is presently very strongly related to social class and the increasing disparity in oral health between the 'haves' and the 'have-nots' in our society is of considerable concern.

I said that the occurrence of dental decay in children is presently strongly related to deprivation; this has not always been so. Surveys of schoolchildren around the year 1900 showed dental decay to be more common in children from privileged backgrounds, whilst those carrying out surveys at around 1950 showed mixed results. The conclusion from this twist in disease-social profile would seem to be that 'the affluent get the goodies (or perceived goodies) first'.

In this first part of the lecture, I have shown that the occurrence of dental decay is volatile. Dental decay was rare before the 1850s; it was epidemic during the first two-thirds of the twentieth century, before declining during the last third of that century. It may have declined, but it is far from eliminated. At one and a half billion pounds direct cost a year, dental disease is one of the most expensive disease entities in this country. The job is not yet complete. In the next two parts, I will explain the causes of this cycle of disease.

At the opening ceremony of a large international dental conference, held in the Royal Festival Hall in London in 1980, a minister leant over to the Chief Dental Officer for England and was heard to ask, 'what is this 'tropical' fluoride?' Twenty years on, I believe that ministers, and indeed the general public, are better informed on the dental benefits of fluoride. The success that this element has had in reducing the caries epidemic and improving the lives of millions of people is a

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remarkable story. It is a unique story for, on one hand, dental caries could be seen as a fluoride-deficient disease, much reduced by replicating nature's best. But the preventive value of fluoride goes much further than this, being used therapeutically very effectively, far beyond what occurs in nature. In that, there is no parallel between fluoride and, for example, iron, zinc and iodine.

Although there were a few isolated reports that fluoride might prevent tooth decay before 1900, the twentieth century saw the discovery of its effectiveness in the first half, and implementation of fluoride-based programmes in the second half. The discovery of fluoride's effectiveness is classic epidemiology, and is well illustrated by the relation between the concentration of fluoride in drinking water and the severity of dental caries in adolescents living in 21 cities in America. The same relation emerged from our own studies in north-east England: South Northumberland, Hetton-le-Hole, Sunderland and Newcastle. The obvious inference was made that children living in these cities were deficient in fluoride, and on January, 25, 1945, fluoride was added to the water supply of Grand Rapids city in Michigan State to bring the fluoride concentration in drinking water up to the optimum of 1 mg F/L of water, or 1 ppm. Caries experience in children in Grand Rapids fell as predicted, and water fluoridation became a public health priority for large communities on public water supplies.

Now 62% of the US population drink fluoridated water.

When it was realised that an adequate amount of fluoride in water reduced the occurrence of dental decay, people soon asked if fluoride could benefit teeth in ways other than water. The answer was 'yes'. The 1940s and 1950s saw the publication of the first of very many clinical trials of fluoride solutions, gels and varnishes, fluoride tablets, mouthrinses and toothpastes. Of all these agents, making an effective fluoride toothpaste has been the most difficult, but the most rewarding. Gibbs and Colgate fluoride toothpastes were the first on the UK market but, even in 1970, only 5% of toothpastes contained fluoride. By 1975, 80% of toothpastes contained fluoride, and by the end of the 1970s, the proportion was up to 96%; it has remained close to 100% for the past twenty years.

With their effectiveness clearly established, fluoride tablets, mouthrinses, gels and varnishes became readily available and were seized upon by public health dentists in more developed countries to try to control the ravages of dental caries in community programmes.

In 1990, I tried to estimate the number of people around the world who might be using each of these vehicles for delivering fluoride. To my embarrassment it has, found its way into many publications, including those of the WHO (Table 2). Having had such success I thought I would risk a repeat in 2000. The use of fluoride toothpaste has increased dramatically and salt is now beginning to rival water as a dietary vehicle for fluoride. School fluoridation has virtually faded out and the use of tablets has also declined.

Table 2. Estimate of the number of people throughout the world using various types of fluoride therapy in 1990 and 2000 in millions.

	1990	2000
Water fluoridation (adjusted)	210	300
School fluoridation	0.2	0
Fluoridated salt	4	97
Fluoridated milk	0.1	0.2
Drops/tablets	20	15
Mouthrinses	20	100
Clinical topicals	20	30
Toothpastes	450	1500

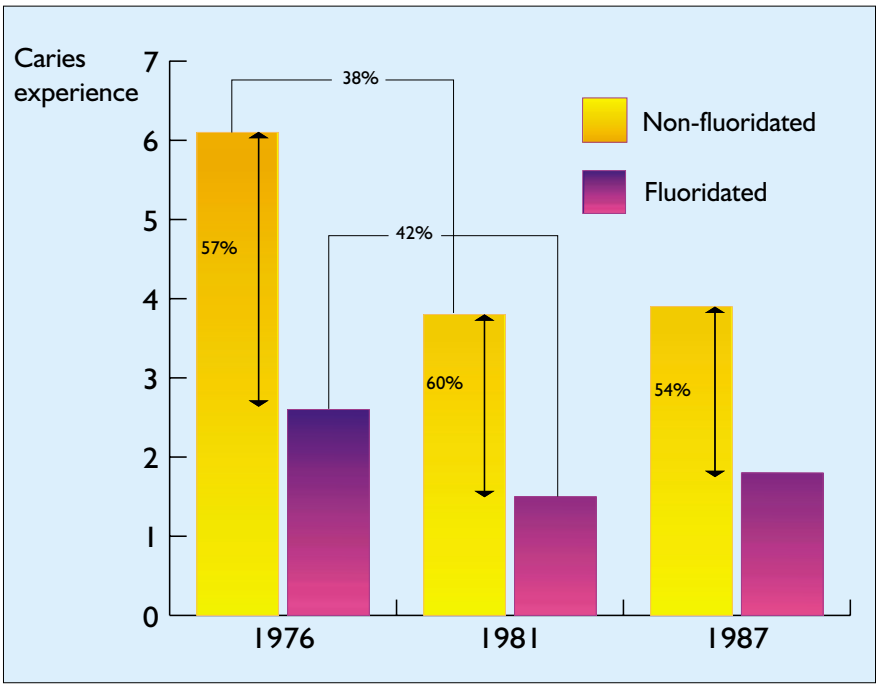
Using a fluoride mouthrinse straight after brushing with fluoride toothpaste led to no additional benefit over that which resulted from brushing alone

In the UK, we have opted for water fluoridation and fluoridated salt is not allowed. Only two major conurbations receive fluoridated water, though: the West Midlands area, which began in 1964; and the Newcastle area, which began 4 years later. The total coverage in the UK is 5.5 million people, or 10% of the population. In fluoride-deficient areas, we recommend fluoride tablets for children at risk of, and from, dental caries. The current sales in the UK are about 6 million tablets per year, but this is equivalent to less than 0.2% of children in fluoride-deficient areas receiving tablets daily: the use of tablets has declined sharply during the last ten years. Sales of fluoride mouthrinses for home use have more than doubled over the past five years and amount to about a quarter of a million litres per year in this country; but this is equivalent to only 70,000 people using fluoride mouthrinses regularly: around 0.2% of the adult population. The amount of toothpaste sold has oscillated from a high point in around 1980, declining towards 1990 and rising slightly in recent years. Currently, sales amount to about three 100 ml tubes per person per year. Thus there is a picture of availability of a wide selection of fluoride agents: all except toothpaste are very underused. Even for toothpaste, there is scope for doubling sales, if all dentate people brushed regularly twice a day. Despite this underuse, they have been phenomenally effective.

With the widespread availability of a number of fluoride agents, the question was asked 'to what extent are the effects additive?' That depends on timing. Teeth benefit most from frequent exposure to fluoride, so that spreading exposure throughout the day is desirable. I illustrate this by recalling that trials show that daily brushing with a fluoride toothpaste or rinsing with a fluoride mouthrinse, each prevent caries by about 30%–40%. However, results of one trial also showed that using a fluoride mouthrinse straight after brushing with fluoride toothpaste led to no additional benefit over that which resulted from brushing alone.

Luckily, fluoridated water provides a 'drip feed' of fluoride which, even at 1 ppm, provides a substantial intra-oral or topical effect on teeth present in the mouth. Very fortunately, the benefits of fluoride in water and fluoride in toothpaste are additive, as is apparent from our studies of 5-year-old children in fluoridated Newcastle and fluoride-low Northumberland (Figure 1). Surveys were undertaken in 1976, 1981 and 1987. The number of decayed teeth per child in fluoridated Newcastle was half the number in non-fluoridated Northumberland, and this was seen consistently in all three surveys. However, the number of decayed teeth fell in both areas between 1976 and 1981, in line with the results of other surveys in the UK and abroad, and coinciding with the introduction of fluoride toothpastes as described earlier. The 5-year-old children in 1976 would have had their teeth brushed mostly with fluoride-free toothpaste, while the 5-year-olds in 1981, would have used fluoride-containing toothpastes almost entirely. What a difference between six bad teeth in the absence of fluoride in water and toothpaste, and 1.5 bad teeth in the

Figure 1. Caries experience (mean dmft) of 5-year-old children in fluoridated Newcastle and non-fluoridated Northumberland in 1976, 1981 and 1987



Source: Rugg-Gunn A. J, et al. *Br Dent J* 1998; **165**: 359-364.

presence of fluoride in water and toothpaste. Water fluoridation and fluoride in toothpaste are not alternatives, as has been proposed occasionally, but are both key elements in public health strategy.

But are there any hazards in the proliferating use of fluoride: can you have too much of a good thing? The answer is 'yes'. Excessive ingestion of fluoride while teeth are forming results in unsightly teeth, with severity related to the amount of fluoride ingested.

There have been suggestions that the prevalence of enamel opacities has increased slightly in the USA and in the UK, but the present level is considered to be below the level of aesthetic concern. A recent study in Newcastle showed that opacities likely to be on the threshold of aesthetic concern occurred in 3% of Newcastle children and 1% of Northumberland children. This study also showed, for the first time, that occurrence of opacities was lower in children who had used a low-fluoride paste.

It is important to realise that fluoride is only one of the many causes of dental opacities, as illustrated here, where the cause was a hereditary disorder, amelogenesis imperfecta. Nevertheless, the difference of two children per hundred, between fluoridated Newcastle and fluoride-deficient Northumberland, is likely to be due to water fluoridation, and it is the task of those in public health to balance this risk against the savings in caries-free teeth. It is generally accepted that the balance is very much in favour of fluoridation, especially as the impact of dental caries is much greater than dental opacities.

Water fluoridation has another tremendous advantage — it is a most equitable public health measure — it reaches the whole population, regardless of location or social position. Five-year-olds from worse off families (social classes IV and V) have twice as many bad teeth as children from social classes I and II families, those better off. This occurs in both fluoridated and non-fluoridated areas (Figure 2). Fluoridation is effective in all social groups — in percentage terms about 50%. But in the number of teeth saved per child, the social class IV and V children benefit most. This is very valuable as they are the least accessible for preventive and reparative care.

One of our tasks is to think globally. Each country has to decide for itself an optimum fluoride policy, based on more information than just climatic temperature, and this caution is now included in WHO documentation. It is becoming increasingly apparent that extrapolation of public health policies, particularly details of policies, from one country to another, is hazardous. Local conditions are very important, and I will return to the issue of inter-country comparisons, later.

Virtually everyone in the UK is on mains water, yet only 10% of the population receives optimally fluoridated water. Fluoridation is uneconomic for small water supply systems, or where caries severity is low. It is reasonable to expect, though, that 30% – 40% of the UK population should be receiving optimally fluoridated water. The reason for the inaction is political. The present Government said that they wished to tackle 'inequalities in health' — no simpler way than getting fluoridation moving. Lest we get complacent about the need for water fluoridation in Newcastle, we should remind ourselves that when the town of Wick in Scotland ceased fluoridation, caries experience in children rose by 50%.

Fluoride has been very effective at preventing dental caries, but it does not remove the cause of the disease. To paraphrase Denis Birkett, 'If water is making a mess on the floor, it is better to turn off the tap than mop the floor'. Sugar is the cause of dental caries. Caries prevalence was low before the

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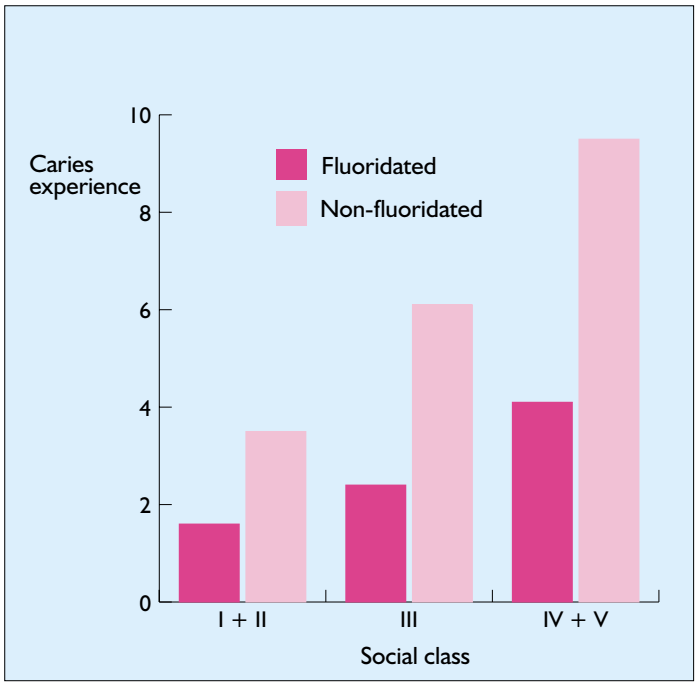

Figure 2. Caries experience (mean dmft) of 5-year-old children in fluoridated Newcastle and non-fluoridated Northumberland in three social class groupings (Registrar General's classification) 1987

Source: Carmichael, C. L. *et al Br Dent J* 1989; **167**: 57-61

rise in availability and consumption of sugar, despite much plaque on teeth and before the discovery and use of fluoride.

Historically, our early understanding of the relationship between diet and dental decay paralleled our understanding of fluoride and dental decay. The 1920s and 30s were the era for discovering vitamins, and dental caries was thought to be a deficiency disease. Lady May Mellanby (whose husband discovered vitamin D in 1919) led the way in this area of research — she believed that vitamin D deficiency was a major cause of dental caries — not a surprising view, since vitamin D is intimately involved with calcification. Her work was drowned under the deluge of research in the 1940s and 50s, indicting sugar in the mouth as the cause of dental decay. However, the issue of vitamin D is not completely dead, as in our Northumberland diet and caries study, we found an inverse relation between dietary vitamin D and caries development — but only in boys. This was statistically highly significant (less than 1 in 1000 probability that this relationship occurred by chance alone) but only in boys and not in girls — what a conundrum. I have no explanation for this quirk and pass it on unresolved.

In 1946, a clinical trial began in Sweden, which changed the perception of diet and caries. This was a study of dietary supplementation, conducted in a mental hospital in Vipeholm, Sweden. By modern standards, it would be considered unethical, for inmates were fed high sugar diets and the subsequent development of caries recorded. It is often forgotten that the study included a vitamin and mineral supplementation phase. The results though, showed the paramount importance of sugar and over the next 30 years, every kind of study confirmed this view. Dietary sugar is broken down by bacteria in the plaque layer on our teeth to form acids, and these acids dissolve the mineral in our teeth. When enough mineral has been dissolved away, a hole develops. The basis of dental caries is thus very simple.

It is not surprising therefore, that advice followed to cut down on eating sugars. Answers to questions, such as, 'are all types of sugary foods equally harmful?', or 'is the frequency of eating sugars more important than the amount?', were being given too. Such clarifications of the message were useful but, from the public health perspective, targets for consumption had to be set and these would, in turn, determine policy. The crucial report for setting targets for sugar consumption, was the Report on Dietary Reference Values for the UK, published by the Department of Health in 1991. This set out recommendations for 40 nutrients, including sugar. Absolutely crucially, it divided carbohydrates into the desirable and undesirable. It lumped sugars found in milk, fruits and vegetables along with starch in the desirable component, leaving the remaining sugars, the 'added' sugars as the undesirable component. These added sugars, added by the manufacturer, cook or consumer, are better called non-milk extrinsic sugars — nicely shortened to NME or 'enemy', which is what they are! The World Health Organisation (WHO) calls these sugars 'free' sugars and both the Department of Health in London and the WHO recommend that, first, there is no nutritional need for these NME or free sugars and, second, that consumption should be less than 10% of total food energy intake.

About 2.2 million tons of sugar are sold in the UK each year. Twenty five percent of this sugar goes to the confectionery industry and their sales were just under £1 billion in 1999. Another 25% of sugar goes to the soft drinks industry, where sales totalled £7.4 billion in the same year. There is considerable industrial

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muscle here and, not surprisingly, they have not taken kindly to the suggestion that we should cut down on eating sugar. Their first priority is to make money for their shareholders and to maximise profit for their corporations. The methods of the sugar industry to preserve their sales parallel those of the tobacco industry *vis à vis* smoking, very closely. First, they dispute the evidence. They are sure to find some academic to support their view, thereby suggesting that the profession is divided. They shift the blame by saying that all carbohydrates cause dental caries, starches as well as sugars — which is totally misleading. We should encourage consumption of staple starchy foods, and these are not a threat to dental health.

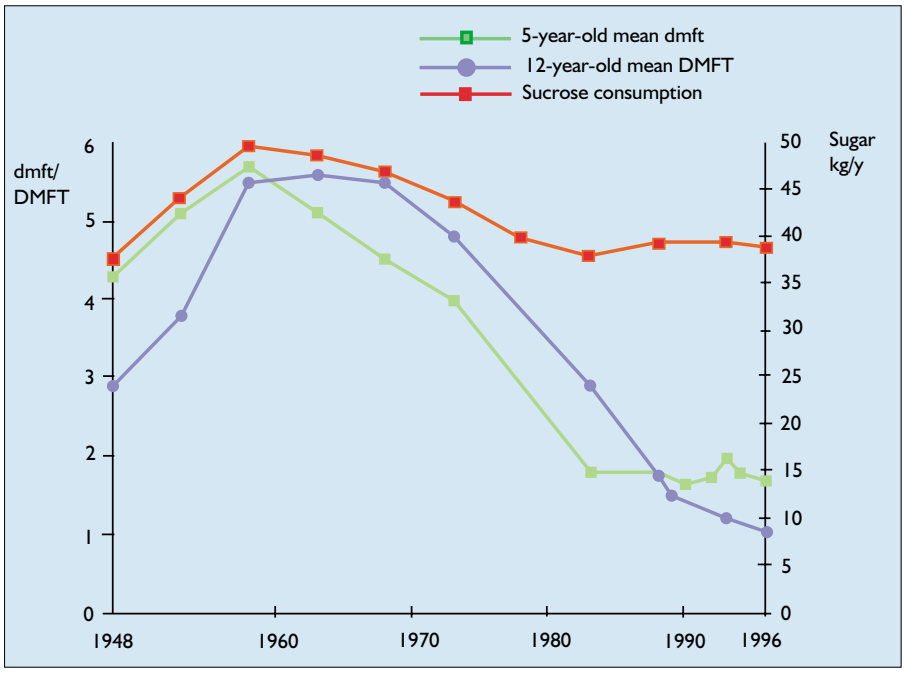
Sponsorship offers are seductive — for hard-pressed societies and even departments — but they always come at a price. Likewise, freebies look attractive — it is what they do not say that is important. They will not tell you that it is UK policy to reduce sugar intake. The sugar industry is quite prepared to spend £2 million in a year on advertising the benefits of sugar; the budget for the confectionery and the soft drinks industries is £100 million a year each. One might conclude that faced with such financial power, one might as well give up, roll-over, forget it. That is not an option for the health profession.

Although it has been Department of Health policy for over 30 years for consumption of sugar in the UK to be reduced, pressure from the sugar industry was one reason why an expert panel was created by the Committee on Medical Aspects of Food Policy (COMA), to examine the relation between dietary sugars and human disease. I was pleased to be a member of that panel, and the report, published in 1989, stated quite clearly that 'non-milk extrinsic sugars should be reduced and replaced by staple starchy foods, fresh fruit and vegetables'. This would benefit general and dental health. It was left to the 1991 report, which I have mentioned already, to set the ceiling of 10% of food energy coming from NME sugars. A multitude of Department of Health reports since then have all confirmed that policy. Importantly, the 'Health of the Nation' and 'Our Healthier Nation', endorsed the COMA recommendations. They are also endorsed by the British Dental Association, British Medical Association and the British Dietetic Association. Thus, the broad guidelines of nutritional policy have been clear and consistent for many years.

There are some issues regarding sugar and dental caries, which are worth examining. The first is 'fluoride is reducing the occurrence of caries perfectly well, and there is no need to tinker with sugar consumption'. It is pointed out that while caries experience has been declining in developed countries, there has been little change in sugar consumption. Broad generalities hide differences within and between countries. Within the UK, some changes in sugar consumption have occurred. Figure 3 is taken from a recent article in the British Dental Journal, by Martin Downer. In green, is caries experience of 5-year-old children between 1948 and 1996. Caries experience for 12 year-olds is shown in blue, and total sugar consumption for all ages is given in red. The great decline in caries from 1975 onwards, can be seen clearly, but Martin Downer put the positive correlation between sugar and caries for 5-year-olds at 0.6 and for 12-year-olds at 0.8 — both high correlations.

An example of the positive interaction between fluoride availability and sugar restriction was recorded locally in North and South Shields during the war years (Table 3). Caries experience was lowest in South Shields, with its optimally

Figure 3. Caries experience and sugar consumption between 1948 and 1996



Source: Downer, M. C. *Br Dent J* 1998; **185**: 36-41.

	Caries experience (mean DMFT) in 12 year olds	
	Pre-war	Sugar retriction
North Shields (0.1 ppmF)	4.3	2.4
South Shields (1.0 ppmF)	2.4	1.3

Source: Weaver R. Br Dent J 1950; 88: 231-239.

Table 3. Combined effect of war-time sugar restriction and optimum water fluoride level

	%
Confectionery	33
Soft drinks	27
Table sugar	12
Biscuits and cakes	11
Sweet puddings	6
Breakfast cereals	5
Sugars and preserves	2
Other	4

Source: Rugg-Gunn A. J. et al. *J Hum Nutr Diet* 1993; 6 419-431.

Table 4. Sources of non-milk extrinsic sugars in the diets of young adolescent children in Northumberland

fluoridated water and after war-time sugar restrictions. The effects were additive.

I have mentioned before that extrapolating results and policies between countries is often hazardous. This is so for information on sugar consumption. From our own studies of young adolescent Northumbrians, 76% of total sugars were NME sugars. These 90 g of NME sugars provided 17% of energy — much higher than the 10% recommended ceiling. The sources of these sugars are given in Table 4 — 72% come from just three sources: confectionery, soft drinks, and table sugar. Confectionery is also the second most important source of dietary fat in these children, more important than chips or spreading fats, such as butter and margarine. It was possible to compare our results for sugar consumption with those for American children. Milk and fruit were much more important sources of dietary sugars in the American children, while the reverse was true for confectionery and table sugar. American children got their sugar from desirable sources, but not so for British children — total sugar consumption figures can be misleading. Fluoride has been wonderfully successful, but since sugar is the cause of dental caries and sugar restriction decreases caries development, control of dietary sugars seems a sensible option.

With the decline in caries prevalence and experience has come a shift in the distribution of disease. In 15-year-olds, 65% of the disease occurs in 40% of children. Is it not sensible, therefore, to target those with the disease and forget about population strategy? A seductive argument with which I would agree, if we were able to predict those at risk of developing caries accurately. The predictive validity of the many tests which have been proposed, remains low; they also rely on attendance for any such screening. In Finland, with low caries prevalence and very well-funded public health services for children, they do target their preventive care, but reports suggest that the effectiveness of this targeting is not high. As Geoffrey Rose pointed out in his classic thesis, small gains for the whole population are very often likely to be more efficient than larger reductions in disease in high risk people.

To be efficient, oral health promotion has to be part of wider health promotion involving multi-disciplinary working

There is another reason for favouring a population approach. Too often we have focused on single diseases and devised preventive strategies for those diseases alone. Many major chronic diseases have common risk factors, often based in lifestyles. To be efficient, oral health promotion has to be part of wider health promotion involving multi-disciplinary working. This is particularly important for oral health if one looks at current strategy as revealed in 'Saving Lives'. In wider health promotion, you cannot avoid a population approach.

But if NME sugar consumption is to be reduced, what should replace it? With the prevalence of obesity doubling over ten years you could argue that not all of the energy needs to be replaced. From cross-sectional studies, where the population is looked at just once, it has been observed that people who eat low sugar diets, eat more fat and vice versa. This is the so-called fat/sugar seesaw and has now been confirmed in many studies. It is obviously undesirable to eat more fat in an effort to cut down sugars. Some of the explanation is simple mathematics related to the cross-sectional nature of the data. If one major source of energy goes down, other major sources are likely to go up. Such 'once-only' studies have severe limitations and what is needed are interventional trials — trials where diets of people change because of health promotion intervention. Also, for too long, dietary advice has been negative — don't eat this or that — and it is only fairly recently that the shift to positive messages has been evaluated. A group of adults in London who were given a positive mes-

sage to increase their fibre intake achieved this by increasing their fruit, vegetables and starch and in the process lowered both fat and NME sugar. A major intervention study is two-thirds complete within the Human Nutrition Research Centre, testing strategies to increase consumption of starch in families. This three-group study involves 709 people in 206 families in the east and north of Newcastle. The interventions, to increase starch intake, are of different complexity and cost. The results should be known in about a year's time. The robustness of the sugar/fat seesaw needs to be tested in intervention studies such as this, not inferred from single study, cross-sectional data.

There is a further reason for encouraging intervention studies, and this is because one hears too often 'you can't change diet'. Britain is fortunate that snap-shots of our diet have been taken annually for 60 years. Considerable changes have taken place, not all for the better, and show quite clearly that diets do change. We need to ensure that changes are in the right direction.

Interest in food and healthy eating has increased much over the past 20 years — the media, the food industry and the Health Education Authority have all been active. The activities of the food industry, of course, have been a mixed blessing, but the media, on the whole, have been helpful, supporting the principal messages that too much fat, sugar and alcohol are bad, and fruit, vegetables and milk are desirable foods.

There are some excellent signs that diets of children are at last moving in the right direction. About 400 young adolescent children in south Northumberland have kindly recorded their diets in 1980, 1990 and in 2000: they have attended the same seven Middle Schools in each of the three surveys. While there was very little change in the percentage of food energy coming from fat (about 40%) between 1980 and 1990, fat intake has fallen very sharply between 1990 and 2000; very close to the target of 35% of food energy. A drop of five percentage points is a lot. It is also very encouraging to see a compensatory increase in starch consumption — wholly in line with recommendations. The fall in fat consumption was not accompanied by a rise in sugar consumption.

Criticism of the sugar and sugar-related industries is fully justified but, where possible, it is much more productive to work with industry than against it

Much effort has been put into nutritional education aimed at children, in the belief that habits gained then are formed for life. There is far too little information on the important hypothesis — does diet track from adolescence to adulthood? — and we have seized on the opportunity to follow-up Ashington children surveyed in 1980: they were then 11 – 12 years old and are now 31–32 years old. This cohort study is just ending and will provide unique information on this issue in this country. We are also examining perceptions of change, and reasons for change, and whether their children are being fed the same way as they were 20 years ago.

Recent research has indicated a 70% reduction in caries in five year-old children whose mothers chewed xylitol gum

Industry is a major determinant of what foods we eat — a reasonable opinion — although they would deflect such implied criticism by saying they only respond to consumer demand. Criticism of the sugar and sugar-related industries is fully justified but, where possible, it is much more productive to work with industry than against it.

Some sections of the food industry have been helpful at trying to improve dental health — I will single out two. First, manufacturers of chewing gum. Over the past twenty years, it has become quite clear that chewing sugarless gum actively benefits dental health, compared with not chewing gum; and xylitol gum appears to be more effective than sorbitol-sweetened gum. Chewing xylitol gum has become a major component of oral health preventive programmes in schools in Finland. The recent development and successful testing of chewable xylitol sweets provides a welcome alternative to gum, for those worried about their floors and other surfaces to which gum can be stuck. Very recent research has also indicated a 70% reduction in caries in 5-year-old children, whose mothers chewed xylitol gum during the so-called 'window of infectivity', 3 – 24 months after delivery; xylitol suppresses the more cariogenic oral bacteria.

The second example is the drinks industry. We were pleased to see the introduction of sugar-free drinks some 20 years ago, but there remains the problem of erosion to teeth from these acid drinks. Ribena has always had a disastrous reputation with dentists and, helped considerably by the media, sufficient pressure was put on SmithKline Beecham, for them to decide to develop a dentally safe version of Ribena some eight years ago. After about five years' development and testing, Ribena Toothkind was launched in April 1998. There was sufficient evidence that it constituted a minimal risk to teeth — caries and erosion — for it to be accredited by the British Dental Association. Since its launch, Ribena Toothkind has substituted the original Ribena and this must be good for dental health. Other manufacturers follow their lead and I hope that in 5 –

10 years time, the majority of soft drinks will be safe for teeth.

And so we come to the end of this review of the enigma of dental caries. The past 25 years have seen enormous improvements in oral health. I have been privileged to have worked through this period. However, the battle is not yet won. Over the whole population, the level of disease is still too high and sections of our population suffer greatly. This is frustrating, as the disease processes are very well understood. The preventable is not yet prevented. However, disease levels are seldom static and I am confident that my successors will ensure the continued decline of this unnecessary disease.