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for Health Services Research

WORKING GROUP ON ACUTE PURCHASING

The Use of Fluoridated School Milk in the Prevention of Dental Caries

October 1998

GUIDANCE NOTE FOR PURCHASERS 98/11

Series Editor: Nick Payne

InterDEC No: 30/1998

Trent Development and Evaluation Committee

The purpose of the Trent Development and Evaluation Committee is to help health authorities and other purchasers within the Trent Region by commenting on expert reports which evaluate changes in health service provision. The Committee is comprised of members appointed on the basis of their individual knowledge and expertise. It is chaired by Professor Sir David Hull.

The Committee recommends, on the basis of evidence provided, priorities for:

- the direct development of innovative services on a pilot basis;
- service developments to be secured by health authorities.

The statement that follows was produced by the Development and Evaluation Committee at its meeting on 12 January 1999 at which this Guidance Note for Purchasers (in a draft form) was considered.

THE USE OF FLUORIDATED SCHOOL MILK IN THE PREVENTION OF DENTAL CARIES

AUTHORS: Calvert N, Thomas N. Trent Institute for Health Services Research, Universities of Leicester, Nottingham and Sheffield 1998. Guidance Note for Purchasers: 98/11

EXPERT ADVISORS TO TRENT DEC: Dr N W Calvert, Research Fellow, Health Economics, ScHARR. Mr N Thomas, Consultant in Dental Public Health, Rotherham, Doncaster and Barnsley Health Authorities.

(The recommendations made by the Committee may not necessarily match the personal opinions expressed by the experts)

DECISION: The Committee strongly supported water fluoridation. It also supported the recommendation that children between four and eight years old should be offered fluoridated school milk in the short term until fluoridated water is made available, and in the long term in areas where fluoridated water is not possible for technical reasons.

October 1998

THE USE OF FLUORIDATED SCHOOL MILK IN THE PREVENTION OF DENTAL CARIES

N W Calvert
N Thomas

Series Editor: Nick Payne

Trent Institute for Health Services Research
Universities of Leicester, Nottingham and Sheffield

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Conflict of Interest None of the authors of this document has any financial interests in the drug or product being evaluated here.

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ABOUT THE TRENT INSTITUTE FOR HEALTH SERVICES RESEARCH

The Trent Institute for Health Services Research is a collaborative venture between the Universities of Leicester, Nottingham and Sheffield with support from NHS Executive Trent.

The Trent Institute:

- undertakes Health Services Research (HSR), adding value to the research through the networks created by the Institute;
- provides advice and support to NHS staff on undertaking HSR;
- provides a consultancy service to NHS bodies on service problems;
- provides training in HSR for career researchers and for health service professionals;
- provides educational support to NHS staff in the application of the results of research;
- disseminates the results of research to influence the provision of health care.

The Directors of the Institute are: Professor R L Akehurst (Sheffield);
Professor C E D Chilvers (Nottingham); and
Professor M Clarke (Leicester).

Professor Clarke currently undertakes the role of Institute Co-ordinator.

A Core Unit, which provides central administrative and co-ordinating services, is located in Regent Court within the University of Sheffield in conjunction with the School of Health and Related Research (ScHARR).

FOREWORD

The Trent Working Group on Acute Purchasing was set up to enable purchasers to share research knowledge about the effectiveness and cost-effectiveness of acute service interventions and determine collectively their purchasing policy. The Group is facilitated by The School of Health and Related Research (ScHARR), part of the Trent Institute for Health Services Research, the ScHARR Support Team being led by Professor Ron Akehurst and Dr Nick Payne, Consultant Senior Lecturer in Public Health Medicine.

The process employed operates as follows. A list of topics for consideration by the Group is recommended by the purchasing authorities in Trent and approved by the Health Authority and Trust Chief Executives (HATCH) and the Trent Development and Evaluation Committee (DEC). A public health consultant from a purchasing authority leads on each topic assisted by a support team from ScHARR, which provides help including literature searching, health economics and modelling. A seminar is led by the public health consultant on the particular intervention where purchasers and provider clinicians consider research evidence and agree provisional recommendations on purchasing policy. The guidance emanating from the seminars is reflected in this series of Guidance Notes which have been reviewed by the Trent DEC, chaired by Professor Sir David Hull.

In order to share this work on reviewing the effectiveness and cost-effectiveness of clinical interventions, The Trent Institute's Working Group on Acute Purchasing has joined a wider collaboration, InterDEC, with units in other regions. These are: The Wessex Institute for Health Research and Development, The Scottish Health Purchasing Information Centre (SHPIC) and The University of Birmingham Department of Public Health and Epidemiology.

Professor R L Akehurst,
Chairman, Trent Working Group on Acute Purchasing.

CONTENTS **Page**

LIST OF TABLES AND FIGURES **Page**

EXECUTIVE SUMMARY

This report explores the use of fluoridated school milk as an intervention to reduce dental caries in young children. Health authorities are charged with examining the milk provision to young children and disease levels in their districts. The paper reviews the evidence of effectiveness, and the situations in the Trent Region where it may be effective as a short and/or long-term measure.

A model of the costs and benefits associated with milk fluoridation is presented, including the potential for NHS cost savings from a reduced need for treatment. A wide range of costs and benefits and, therefore, cost-effectiveness ratios is presented from a societal and an NHS perspective. In respect of costs, the influence of different initial disease levels, and of different forecasts of the DMFT (decayed, missing and filled permanent teeth) benefits after fluoridated milk has ceased to be administered, though not insignificant, are shown to be relatively small.

It is demonstrated that milk fluoridation can be as cost-effective as water fluoridation, although the magnitude of the absolute benefits will not be as great as from fluoridating community water supplies. School milk fluoridation can result in net savings to the NHS under some of the scenarios examined, although savings are not redistributed to health authorities. A central scenario shows a range of costs per decayed missing and filled deciduous teeth (dmft)/DMFT year saved from £0.47 to £26. The range is dependent upon the initial caries level in the community and, significantly, on how much of the non-subsidised cost the health authority is required to take from the Local Authority.

Water is likely to remain the first choice method of fluoridation where it is technically possible, economic, and politically acceptable to fluoridate water supplies. The economic analysis presented in this paper demonstrates that milk provides a relatively cost-effective vehicle for fluoride in the prevention of dental caries. As such, milk fluoridation would appear to have a role in the reduction of dental caries. The role will vary by district. The authors are committed to producing a ready-reckoner spreadsheet to enable health authorities to model cost and benefit implications for their own circumstances.

1. INTRODUCTION

This report examines the feasibility of using fluoridated milk in a community programme to prevent dental caries in young children in the Trent Region. Although not a new idea worldwide, it has only recently been introduced in the UK as a community preventative measure in Merseyside and Cheshire amongst infant and junior school children. Average disease levels in the Trent Region are not as high as in the North-West Region, but individual parts of the Trent Region approach them. The report examines the costs and benefits possible with a programme of fluoridated milk, and the situations and disease levels where such a programme may be of benefit. The Oral Health Strategy for England[1] includes targets for disease reduction in five year old children, and milk fluoridation may be one of the options available to health authorities to achieve progress towards those targets.

1.1 Background and Pathology

Dental caries is the most common disease of late 20th century mankind, affecting virtually everyone at some stage in their lifetime. It is most common in young children, particularly in deciduous teeth, but can recur at the end of life when gingival recession and reduced saliva flow permit root-surface caries. Although deciduous teeth will eventually be lost, their healthy presence is essential for the satisfactory development of the permanent teeth and the jaws.

The cause of dental caries is the dissolving of tooth enamel by acids produced as the result of fermentation of carbohydrates by oral bacteria present in dental plaque. One of the most effective agents in the prevention of dental caries has been the element ‘fluorine’, in the form of its ion, ‘fluoride’.

The mechanism for the strengthening of tooth enamel against acid solubility appears to be the conversion at the enamel surface of the crystalline hydroxyapatite into the less acid-soluble hydroxyfluorapatite. In addition, fluoride hastens the remineralisation of incipient enamel lesions, and is believed to interfere with glycolysis in which bacteria metabolise sugars to produce acid.

Fluoride is at its most effective when present in the drinking water at a concentration in excess of one part per million (ppm). This ensures that the teeth are constantly exposed to fluoride at an effective concentration. At concentrations in the drinking water greater than one ppm there is an increased risk of dental fluorosis. Hence artificial water fluoridation programmes are designed to deliver this concentration.

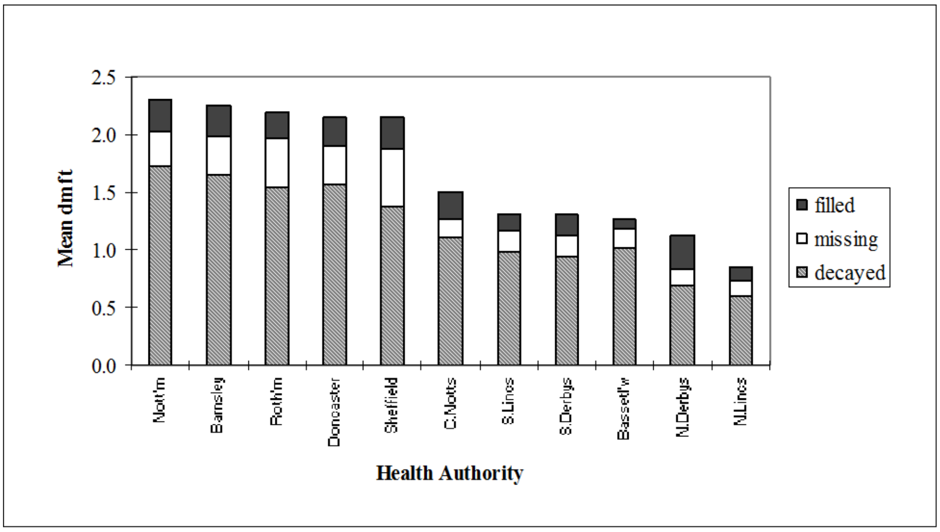
Whilst water fluoridation is the most successful and usually the most cost-effective method of preventing dental caries, for various political and practical reasons only 11% of the population of the UK benefit from it. Milk fluoridation may be a satisfactory alternative to it in areas where water fluoridation is unlikely to be possible, or not yet achievable. An important advantage of fluoridating milk compared with water is that a scheme can be up and running in a period of months rather than years. The time between the decision to fluoridate water to implementation of a scheme is about five years. Also, because of the way the water supply infrastructure transports water around the UK grid, the ability to supply fluoridated water is dependent on gaining the approval of all the relevant bodies within a given supply area.

1.2 Prevalence

Dental caries is a cumulative and progressive disease. Its extent in a given population can be measured simply by reference to the proportion of the population experiencing the disease at that point in time. A better and more widely used indicator of the severity of the disease in a given population is called the decayed, missing, and filled teeth index (dmft in lower case to distinguish deciduous teeth) or the Decayed, Missing and Filled Teeth Index (DMFT in upper case for permanent teeth).[2] These indices measure the average number of decayed missing and filled teeth per person in the population at a given point in time. They also give a measure of historical exposure to the disease via the M and F components. Avoided increases (relative reductions) in the dmft or DMFT indices are used as measures of success in preventing disease.

The wide variation in the point prevalence of dental disease in five year old children in the school year 1993/94 in the Trent Region is demonstrated in the following chart:

Figure 1 **Dental Health of 5 Year Old Children in Trent Region 1993/94**



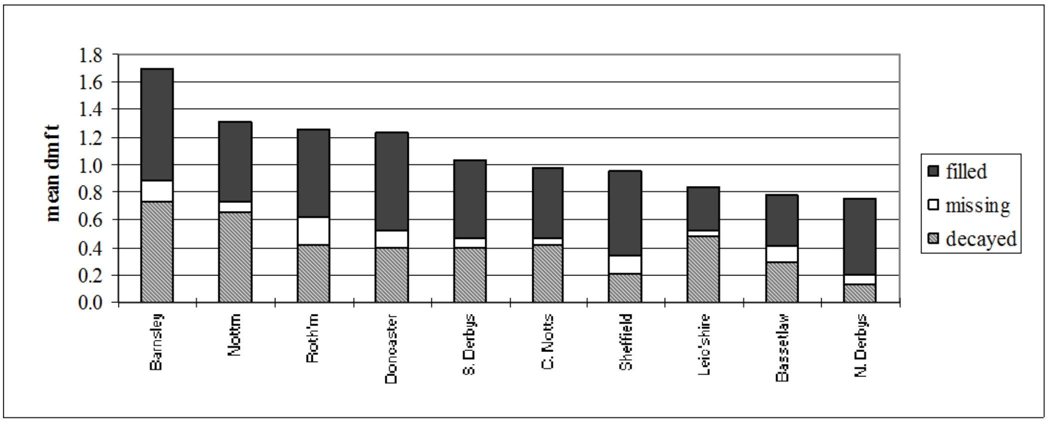
Data not available for Leicestershire

The first main feature of this chart is the size of the inequalities between the South Yorkshire districts and Nottingham, and the remaining districts. This is due to the absence of fluoride at any effective concentration (usually <0.1 ppm) in South Yorkshire and Nottingham. All the other districts in the table have areas of water fluoridation, or natural fluoride, present.

The second main feature is the burden of untreated disease in five year old children compared with the lesser amount of active treatment demonstrated.

Similar results for 12 year old children can be shown, albeit the proportion of untreated to treated disease is considerably lower.

Figure 2 **Dental Health of 12 Year Old Children in Trent Region 1996/97**



Data not available for Lincolnshire

The proportion of the population at five years of age showing evidence of the disease (the cruder measure of prevalence) is similarly variable. Any apparent discrepancies between the above figures (1 and 2) and table 1 can be explained by the fact that dental caries is not uniformly spread throughout the population. There will be pockets of deprived areas where the severity of disease in children is high. This may contribute disproportionately to the dmft index.

Table 1 Percentage of 5 Year Old Children Exhibiting Dental Caries By District In Trent Region in 1995/96

DISTRICT	5 YEAR OLDS WITH DENTAL CARIES EXPERIENCE
Barnsley	47.5
Doncaster	49.9
Lincolnshire	28.5
North Derbyshire	36.1
North Nottinghamshire	44.6
Nottingham	37.8
Rotherham	53.9
Sheffield	46.8
South Humber	41.7
Southern Derbyshire	38.7

Source: Public Health Common Data Set 1997. Dept of Health.

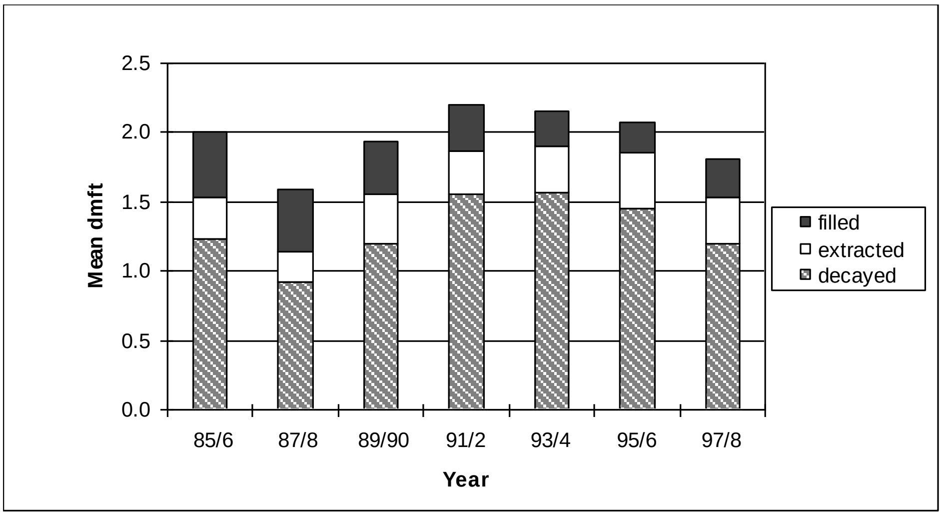
1.3 Outline of Current Service and Scale of Problem in a 'Typical' District - Doncaster.

Doncaster is a suitable district to choose as an example for the following reasons:

- Differing sources of drinking water, both trunk main and linked bore-hole supply, causing complications for water fluoridation;
- A high average dental caries level in five year old children, which varies considerably through the district;
- The vast majority of the population (99%) drink water with negligible amounts of natural fluoride in it (less than 0.1 ppm).

The changes in dmft for five year old children in Doncaster for the years 1985-1997 are shown below:-

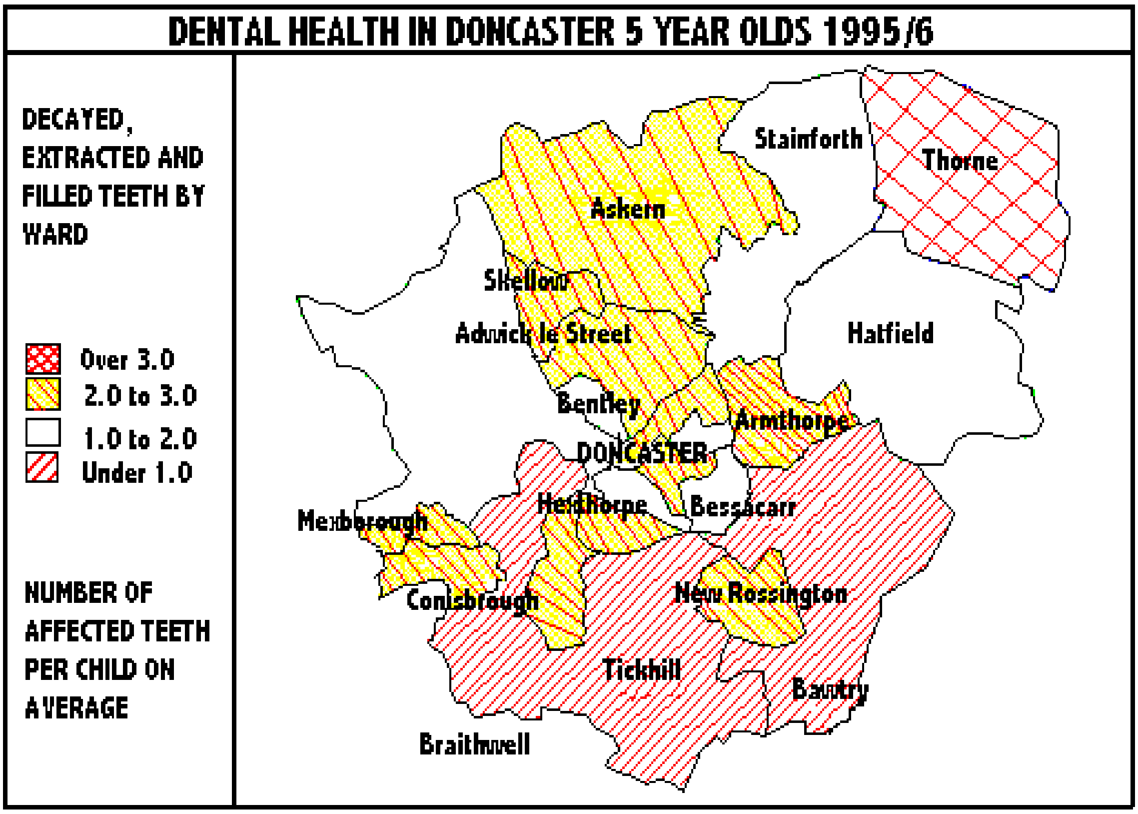
Figure 3 Changes in Dental Health of 5 Year Old Children in Doncaster 1985-1997



It can be seen that there has not been much improvement in 12 years, with the level of active treatment gradually falling, and extractions being favoured over fillings. This may be due to alterations in the payment system to dentists during this period. The average dmft is still persistently near two affected teeth per child (out of 20), and shows no sign of reducing to the Government's target of one by the year 2003.

In addition, the inequality within the Doncaster district is apparent when disease levels are mapped by Local Authority ward.

Map 1 **Dental Health in Doncaster 5 year old Children in Doncaster 1995/96 by Local Authority Ward.**



An additional problem is the water supply to Doncaster. In the event of water fluoridation becoming a practical reality in South Yorkshire, only the western half receives water from the main Yorkshire grid. The eastern half, including the priority area of Thorne (the area with the highest level of dental decay), receives bore-hole water from six linked boreholes. The fluoridation of this small supply scheme would be costly and difficult. At present, however, Yorkshire Water Authority is totally opposed to the health authority's request for fluoridation and will not introduce it unless forced by legislation.

Recent evaluation of oral health promotion outcomes by the Health Education Authority[3] has concluded that the only effective interventions are those which include the provision of fluoride in some form.

2. USE OF FLUORIDATED MILK: SUMMARY OF EVIDENCE OF EFFECTIVENESS

A two-fold approach to the literature search was undertaken. Key-word searches (including both the two words ‘milk’ and ‘fluoridation’) were undertaken in Medline, Embase, Biological Abstracts, HMIC, Science Citation Index and Social Science Citation Index. In addition, known key publications on the subject from the World Health Organisation and the Borrow Dental Milk Foundation (BDMF) were consulted. Fluoridation is reputed to be one of the most researched public health measures of all time.

2.1 Clinical Trials of Effectiveness

(a) Winterthur, Switzerland. Controlled Trial.

Dr E Ziegler, a Swiss paediatrician first proposed milk fluoridation in 1953, and described an initial scheme.[4] This was followed up by a larger scheme involving 1,300 children (749 test, 553 controls), reported by Wirz[5] after six years in 1964 and Ziegler.[6] Caries reduction after six years ranged from 14.8% to 31.5% in deciduous teeth and from 64.2% to 65.2% in permanent teeth. The milk contained one ppm fluoride.

(b) Yokohama, Japan. Controlled Trial.

2-2.5mg sodium fluoride was added to milk or soup served daily with school meals. After four years a 36.3% caries reduction was observed in the permanent teeth of the test group receiving fluoride compared with the control group receiving none. This test group comprised 167 eleven year olds at the start of the trial who consumed the fluoride in milk for 150-180 days per year. This was reported by Imamura (1959).[7]

(c) USA. Controlled Trial.

65 children aged 6-9 years at the start of the trial consumed milk containing 3.5 ppm fluoride daily at school for three years. The overall caries reduction was 35%, but for the youngest children, aged six at the start, there was a 78% difference between test and control groups. This was reported by Rusoff et al (1962).[8]

(d) Scotland. Double-blind Randomly-allocated Controlled Trial.

This was a trial in Glasgow in an area of high dental caries. Four and a half to five and a half year old children received 1.5 mgm fluoride in 200 ml milk, giving a final concentration of seven ppm fluoride. In addition, fluoride monitoring was undertaken by urine sampling and analysis. After five years, this double-blind randomly-allocated clinical study resulted in a 31.2% DMFT reduction in permanent tooth caries in the test group compared with the control group.[9]

(e) Hungary. Longitudinal Controlled Trial.

0.4 mg fluoride for kindergarten children and 0.75 mg for primary school children were added daily to 200 ml milk or milk-cocoa for children in a Children's Community in Hungary. The children were examined after three, five and 10 years of fluoridated milk consumption. The greatest difference between test and control children occurred in both seven and 14 year olds. Those fluoridated longest benefited most. The overall mean caries difference was calculated between test and control groups, giving a 36.8% DMFT reduction favouring subjects in the fluoridated milk groups.[10,11]

The results of these trials are summarised in the following tables.

Table 2 Clinical and Community Experiences with Fluoridated Milk; Permanent Dentition Comparisons

Country	**Duration (years)**	**Changes in DMFT**		**% Caries Reduction (DMFT)**	**Age at Start of Trial**	**Reference**
		Fl	Non-Fl			
Japan	5	-	-	36.3	11 yrs	Imamura (1959)[7]
USA	3.5	0-0.34	0-1.70	78†	6-9 yrs	Rusoff (1962)[8]
Switzer-land	6	-	-	65.2	9-44 months	Ziegler et al. (1964)[6]
Scotland	5	0-2.14	0-3.11	31.2	4.5-5.5 yrs	Stephen et al. (1984)[9]
Hungary	10	0.63 - 3.61	1.16 - 9.11	36.8	2-5 yrs	Gyurkovics (1992)[11]

† First and second bicuspids and second permanent molars.

Table 3 Clinical and Community Experiences with Fluoridated Milk; Deciduous Dentition Comparisons

Country	Duration (years)	Changes in DMFT		% Caries Reduction (dmft)	Age at Start of Trial	Reference
		Fl	Non-Fl			
Switzer-land	6	-	-	14.8-31.5	9-44 months	Ziegler (1964)[6]
Scotland	5	4.3-6.3	4.5-6.0	Not significant	4.5-5.5 years	Stephen et al. (1984)[9]
Hungary	5	1.42-2.40	1.69-4.01	40.1	2-5 years	Banoczy et al. (1985)[10]

2.2 Current UK Trials with Fluoridated Milk

The first UK milk fluoridation scheme commenced in St. Helens, Merseyside in June 1993, following a successful feasibility study completed in 1991.[12] The study conducted by a team from the University of Liverpool, headed by Professor M A Lennon, looked at the organisational, epidemiological and legal aspects of using milk as a vehicle for fluoride. The study showed that 23% of four year old children in St Helens had high caries experience (dmft>4). There are currently over 3,000 children between the ages of three and seven in St. Helens drinking 189ml school milk to which 0.5 mg of fluoride has been added. This concentration is 2.65 ppm, which is the current recommended level.[13] The scheme has provided valuable experience in technical and organisational aspects of milk fluoridation and generated interest in other districts investigating the possibility of introducing milk fluoridation. In 1996, Wirral Health Authority introduced milk fluoridation and there are now over 6,000 children in this scheme. More recently, in 1997, St. Helens & Knowsley Health Authority extended the existing scheme in St. Helens to neighbouring Knowsley and a scheme was implemented in Winsford, South Cheshire. There are currently over 15,000 children participating in the UK programme. The University of Liverpool is evaluating the dental health gain and is also monitoring urinary fluoride excretion, to ensure that fluoride intake from all sources by the children involved is at the appropriate level. In addition, it monitors the microbiological quality of school milk (fluoridated and non-fluoridated), and the levels of fluoride in the fluoridated milk. Storage temperatures are also recorded at distribution depots and schools. Initial results were reported by Lennon et al. in 1995.[14] The pre-trial decay levels of five year olds in the Wirral in 1993 were 2.23 dmft per child. This is comparable with the disease levels in South Yorkshire and Nottingham districts at that period.

2.3 Comparisons with Water Fluoridation

Worldwide studies in excess of 100 since 1945 have shown a reliable reduction of 40-49% in dmft levels of in deciduous teeth for lifetime consumption of water fluoridated at one ppm.[15] The comparable benefit for permanent teeth has been in the region of 50-59%, where caries levels were high.

Water fluoridation is usually effective for 365 days of the year; however, because of the problems of supplying individual children on non-school days, milk fluoridation is undertaken at school only. Thus, the effect of the fluoride is reduced as the average school attendance is approximately 200 days per year. The benefits of fluoride in school water have been demonstrated in the USA.[16] Horowitz reports that the caries reduction is approximately 30% in permanent teeth, which is perhaps predictable from the proportion of 200:365 days exposure to school water. Jaso-Margarit et al.[17] have shown that the bio-availability of fluoride incorporated into either milk or water is similar.

2.4 Conclusion on Direction of Evidence and its Quality

The randomised controlled trials using double-blind allocation and examination provide the highest level of evidence of effectiveness. The comparatively small scale of the early trials may be seen as a disadvantage, but the consistency of the results in five different countries weighs against this. The close agreement with the results for water fluoridation (one of the most studied public health measures ever), and comparison with the laboratory-derived theoretical data, provide evidence of the effectiveness of milk fluoridation in the reduction of the level of dental decay in children. Because fluoride in milk would be administered after the age of risk from dental fluorosis, the latter is not an issue of concern.

There are, however, certain points which would benefit from further study. These relate to the benefit obtained at various levels of dental decay from fluoridated milk, and its role in areas where water fluoridation may be a possibility. The evidence shows clearly that its effectiveness is not as great as that of water fluoridation, and it should not be promoted as a preferred alternative to it.

3. COST AND BENEFIT IMPLICATIONS OF ADOPTING INTERVENTION

3.1 Introduction

There are no known papers published in English formally reporting the cost-effectiveness, nor indeed the costs, of milk-fluoridation schemes. Few publications make even a passing reference to costs[18,19,20,21] and in papers written in Spanish, Villa[22,23] argues that milk fluoridation can be thousands of times more cost-effective than water fluoridation under certain circumstances. Stamm, on the other hand, concluded that using milk as a fluoride vehicle could be costly, although the relevance of this analysis to today is limited in that this was based on 1955 data for New York City.[24] The WHO, (which has classified milk as a highly cost-efficient vehicle for fluoridation[19]) is co-ordinating a number of clinical trials of milk fluoridation throughout Europe and Africa. One of these is the trial in the Wirral already referred to in chapter 2. No economic analysis is expected from this trial before the year 2000.

In view of the lack of published research evidence on the cost-effectiveness of milk fluoridation, this paper attempts to estimate the costs and benefits of milk fluoridation using a spreadsheet modelling approach. The modelling assumptions are made using evidence of benefits from the literature, and local knowledge for consent and costing information, where necessary.

3.2 Economic Analysis: Estimation of Health Benefits

The benefits of fluoridation are usually expressed in terms of reduced dmft/DMFT. The model uses results presented by Birch[25] which estimate the dmft/DMFT benefits of water fluoridation with necessary adjustments for fluoridation using milk. This study is used in preference to milk fluoride research evidence because of the more detailed age-specific evidence about dmft and DMFT benefits. Birch reports the health benefits from the age of 4 to 14, ignoring any benefits of water fluoridation before the age of four years for children who have been exposed to fluoridated water from birth. There are no health benefits from milk fluoridation before administration of the product at the age of four years. Consequently, the results reported by Birch need to be adjusted.

Key Model Assumptions:-

- The model assumes that a high caries area is one where the dmft is 3.3 for five year olds, and a low caries area is one where the dmft is 1.0 for the same age group.

- Fluoridated school milk is administered for four years from the age of four to eight.

- Milk fluoridation produces the same benefit effect as water but with a pro-rata adjustment for the number of days exposure.[16,17] It is assumed that school milk is administered 200 days of the year so that the benefits of milk fluoridation are assumed to be those of water multiplied by 0.55, (200/365).

All the above are central scenario assumptions and can be tested using sensitivity analysis.

3.2.1 Modelled Benefits to an Individual

The model reports the estimated reductions in dmft and DMFT, saved dmft and DMFT years. It does this for an individual four year old and for the population of children aged 4 to 14 in a health district of 500,000 total population.

Birch reports the following reductions in dmft/DMFT for water fluoridation for children living in high and low caries prevalence areas.[25] These figures imply a caries reduction of 60% in dmft at eight years of age and 54% reduction in DMFT at 14 for a high caries area. The equivalent figures for a low caries area are 40% and 34% respectively.

Table 4 Water Fluoridation Reduction in dmft/DMFT by Age and Caries Level [25]

Caries	**Age**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
HIGH	**dmft**	1.0	2.0	2.0	3.0	3.0	1.5					
	DMFT					0.5	0.8	1.2	1.5	2.1	2.4	2.7
	Total	***1.0***	***2.0***	***2.0***	***3.0***	***3.5***	***2.3***	***1.2***	***1.5***	***2.1***	***2.4***	***2.7***
LOW	**dmft**	0.2	0.4	0.6	0.8	0.8	0.4					
	DMFT					0.1	0.2	0.2	0.3	0.5	0.7	0.9
	Total	***0.2***	***0.4***	***0.6***	***0.8***	***0.9***	***0.6***	***0.2***	***0.3***	***0.5***	***0.7***	***0.9***

The effects of removing the benefits of fluoride before four years of age are presented in table 5.

Table 5 Assumed Water Fluoridation Benefits from Fluoride Introduced at Age 4

Caries	age	4	5	6	7	8	9	10	11	12	13	14
HIGH	dmft	0.0	1.0	1.0	2.0	2.0	1.0					
	DMFT					0.5	0.8	1.2	1.5	2.1	2.4	2.7
	Total	***0.0***	***1.0***	***1.0***	***2.0***	***2.5***	***1.8***	***1.2***	***1.5***	***2.1***	***2.4***	***2.7***
LOW	dmft	0.0	0.2	0.4	0.6	0.6	0.3					
	DMFT					0.1	0.2	0.2	0.3	0.5	0.7	0.9
	Total	***0.0***	***0.2***	***0.4***	***0.6***	***0.7***	***0.5***	***0.2***	***0.3***	***0.5***	***0.7***	***0.9***

The reduced days of exposure to fluoride via school milk mean that the central case assumes that the reduced dmft/DMFT benefits of milk fluoridation are only 55% of those from water fluoridation. Because fluoridated milk is only administered for four years, assumptions have to be made about the DMFT benefits of milk fluoridation, once fluoridated milk has ceased at the age of eight. The literature provided no evidence about what happens to caries prevalence in a given cohort of patients on cessation of fluoridation. The papers which did look at cessation of fluoridation examined the effects on different cohorts of patients with a given age.[26,27,28] For example, Attwood[28] reported a 50% difference in caries prevalence present in 10 year olds living in a fluoridated and a non-fluoridated community. Three years after cessation of fluoridated water, the difference in caries prevalence between 10 year olds in the two communities had fallen to 39%.

For modelling purposes, a pessimistic scenario assumes that the benefits of milk fluoridation last only for the four years that the school milk is administered, so that the DMFT reverts to that of the non-fluoridated group from nine years of age. An optimistic scenario assumes that children aged 8 to 14 gain the 55% of the benefits achieved by that age group in the Birch water fluoridation work as given in table 5. A more central assumption is that the DMFT benefits reduce linearly from 55% at 8 years of age to 0% at 15. Table 6 shows the assumed percentage reductions in DMFT as determined by these three benefit scenarios.

Table 6 Assumed DMFT Reductions under Three Different Benefit Scenarios

	DMFT Reduction at Age 11		DMFT Reduction at Age 14	
Scenario	**Low Caries**	**High Caries**	**Low Caries**	**High Caries**
Pessimistic	0%	0%	0%	0%
Central	6%	16%	3%	4%
Optimistic	11%	27%	21%	30%

The table shows the relatively modest benefit assumptions of the central scenario, particularly for the 14 year old age group. Teeth are at their greatest risk from caries immediately after eruption.[29] As such, it could be argued that even the above central scenario assumptions err on the side of pessimism.

The central scenario assumptions imply that a four year old from a high caries area receiving fluoridated school milk for four years would benefit by 6.5 dmft/DMFT free years for the 10 years between the ages of 4 and 14. In a low caries area, the benefit would be lower at 1.77 years. Using a discount rate of 6%, the discounted benefits are 5.29 and 1.45 dmft/DMFT free years respectively. These results, together with the optimistic and pessimistic scenario results are presented in table 7.

Table 7 dmft/DMFT Years Saved per Child Treated (in 10 Years following Start of Treatment at Age 4)

	Undiscounted		Discounted (6%)	
Scenario	**Low Caries**	**High Caries**	**Low Caries**	**High Caries**
Pessimistic	1.21	4.11	1.06	3.62
Central	1.77	6.50	1.45	5.29
Optimistic	2.74	9.97	2.06	7.51

The table shows a range of dmft/DMFT years saved per child treated. Depending on the use of a discounting rate, the model indicates a range from 3.62 to 9.97 dmft/DMFT years saved in a high caries area, to 1.06 to 2.74 dmft/DMFT years saved in a low caries area.

3.2.2 Modelled Benefits to the Community

In order to model the benefits to the community, further assumptions need to be made. These include:-

- The central scenario assumes that 70% of parents give their consent for fluoridated milk to be administered to their child.
- To model the population benefits, the model assumes that the percentage of four year olds in a 'typical' district is the same as the proportion of four year olds in England and Wales. The latter has been estimated using the proportion of 1-4 year olds in England and Wales (5.17%)[30] and dividing by four (1.29%). This figure is re-multiplied by four to estimate the number of 4-8 year olds receiving fluoridated milk.[a]
- All the benefit scenarios count only the benefits in the 10 year period following the start of consumption of fluoridated milk. The number of four year olds in the population has

[a] Because we are referring to school years, children's ages will range from four to eight even though we only consider four school years.

been multiplied by 10 to derive an estimate of the number of children in the 4-14 year age band.

- The model is a steady state model in that it assumes a scheme has been up and running for at least 10 years. The population benefits will be lower at the start of a scheme for the first cohorts of five, six and seven year olds, who would only receive three, two and one year of treatment respectively.

The 70% consent figure is based on an overall consent figure of 72% of children in the Wirral scheme who receive school milk and have taken up the fluoridated milk option. There is considerable variation around this mean figure. For example, the uptake figures using negative and positive consent forms are 84% and 61% respectively. Using these central scenario assumptions, it is assumed that there are 6,430 four year olds in a health district of 500,000 total population. Table 8 presents the estimated annual benefits in terms of dmft/DMFT years saved to the children aged 4 to 14 from such a health district under steady state assumptions.

Table 8 Steady State Modelled dmft/DMFT Years Saved per annum for a Health District of 500,000 population

DMFT Scenario	Low Caries	High Caries
Pessimistic	5,426	18,496
Central	7,962	29,277
Optimistic	12,331	44,884

The model indicates a range from 18,496 to 44,884 dmft/DMFT years saved per annum in a high caries area, to 5,426 to 12,331 dmft/DMFT years saved per annum in a low caries area. It will take 10 years of a milk fluoridation scheme to reach these levels of benefit.

3.3 Economic Analysis: Estimation of Net Costs

3.3.1 Introduction

The cost of a school milk fluoridation scheme raises some interesting issues in the context of this Guidance Note series. Health economists normally like to include all the societal costs of health care interventions when undertaking economic analyses. That is, all the direct and indirect opportunity costs irrespective of who pays, whether it be Government, tax payers, the NHS, Trusts, health authorities, GPs, patients or their families, friends, carers or employers. In this series of Guidance Notes, it is the usual practice to measure only the direct costs of interventions to the NHS. The costs to others are usually treated as negative benefits.

The elements which make up the vast majority of the costs of a fluoridated milk scheme include the following:

- The production costs including the cost of fluoride, packaging, and distribution;
- Distribution to and within the school;
- General scheme administration costs (e.g. obtaining parental consent).

The production costs for fluoridated school milk are effectively the same as those of non-fluoridated milk. The costs of adding the fluoride to the milk, packaging, and labeling it are so minimal that these marginal costs have been absorbed by the dairies involved in the North-West schemes. For example, a dairy not already producing fluoridated milk may decide to purchase a tank devoted to the production of fluoridated milk. Such stainless steel tanks cost around £5,500 and have a long working life. Assuming a capital life of 30 years, and a discount rate of 6%, the annualised cost of such an investment is estimated at £400 per annum, or £1.09 per day. The tank cost per carton of milk is negligible, therefore.

The purchase price of fluoridated milk is about 11p per 189ml ($^{1}/_{3}$ of a pint) carton. Local Authorities are responsible for contracting for the milk with the local dairy. Since the 1986 Social Security Act, Local Authorities are prevented from providing free school milk to primary as well as secondary school children. Local Authorities are responsible for levying a parental contribution for the provision of school milk. The amount to be levied can vary by Local Authority.

There are two subsidies available for school milk. Both are available for children up to five years of age. The European Community (EC) School Milk Subsidy Scheme is provided through the Government Intervention Board[31] and is available to children, whatever their age, as long as they are in full time primary education. At September 1998, the subsidy levied is 12.42 pence per pint of whole milk (approximately 40% of the cost of the milk product). It has to be claimed by the Local Authority on behalf of schools.

The Welfare Food Scheme is operated by the Welfare Food Reimbursement Unit (WFRU)[31] and provides free school milk (one third of a pint) up to the fifth birthday for children in full time education. It can be claimed by schools on an individual basis, and funds the full cost of the milk product minus any EC subsidy claimed by the Local Authority. Under the strictest definitions, the addition of fluoride to milk turns milk from being a natural food into a processed food and, as such, it may not be eligible for subsidy. However, in practice to date, the subsidy has been paid.

Unless health authorities decide to contribute to the cost of the product itself, the greatest cost to the NHS is the time of staff spent on setting up and monitoring a scheme, for example, the printing, distribution, and collation of parental consent forms. This will normally be co-ordinated by the Consultant in Dental Public Health, or one of his/her staff. Many of the operational costs of a school milk service can fall upon the Community Dental Service (CDS), including the promotion of the scheme amongst the schools, dealing with consent issues, and gathering uptake data for the health authority. The local Community Trust involved in the Wirral Scheme has estimated the staff time commitment at 0.5 of a whole time equivalent for a dental worker, implying a cost of about £10,000 per annum. The health authority staff resource is considerably less than the Community Trust figure for the Wirral scheme. This analysis does not include an estimate of Local Authority staff time.

The health authority may choose to co-ordinate the whole scheme, but the BDMF can have a significant role to play. It can provide technical support to the dairies, and can help to plan a scheme. It is willing to consider providing assistance in the form of an operational consultant for the implementation of a scheme.

Given the distribution of the cost burden of a fluoridated milk scheme, this Guidance Note presents costings taken from a societal, an NHS, and a health authority perspective.

3.3.2 Gross Costs

A costing analysis should always attempt to measure marginal opportunity costs. In this context it is difficult to identify the margin as it will depend, amongst other things, on the current provision of school milk in a 'typical' district. The margin, as far as the health service is concerned, will also depend upon the level of subsidies available and on how much of the cost burden the health authority and the Local Authority are willing to take on between them.

The following analysis presents cost estimates with and without subsidies included, and will include the full cost of fluoridated milk. In effect, the analysis is assuming that the NHS is taking on the full marginal costs of a fluoridated milk scheme and is, thus, a pessimistic view as far as the NHS is concerned.

The current price of a one third pint carton of fluoridated milk is about 11 pence. Assuming 200 school days per annum, the annual cost is estimated at £22 per child. This cost will be subsidised to the full amount for children under the age of five years, and by 12.42 pence per pint for children aged five or over (September 1998 subsidy figure).

Assuming, rather pessimistically, that the costs of the health authority staff are half of those of the community trust, the annual NHS staff costs are estimated at £15,000. Assuming 70% consent, a 'typical' district could expect 18,003 children aged 4-8 to be on the scheme at any one time. Consequently, the staff cost per child per year is about 83 pence only.

Table 9 Four Year Societal Costs of Fluoridated Milk: Cost per Treated Child

Cost Item	Year 1 £	Year 2 £	Year 3 £	Year 4 £	Total £	Average p.a. £
Fluoridated Milk Price	22.00	22.00	22.00	22.00	**88.00**	**22.00**
NHS Staff Time	0.83	0.83	0.83	0.83	**3.33**	**0.83**
Total	22.83	22.83	22.83	22.83	**91.33**	**22.83**
Discounted Total	22.83	21.54	20.32	19.17	**83.87**	**20.97**

For a 'typical' population of 500,000 people with 18,000 children on the scheme at any one time, the societal cost is estimated as £377,000 per annum. Table 10 takes a health authority costing perspective and assumes that the EC and Government subsidies are available.

Table 10 Four Year Discounted NHS Costs of Fluoridated Milk: Cost per Treated Child

Cost Item	Year 1 £	Year 2 £	Year 3 £	Year 4 £	Total £	Average £ p.a.
Fluoridated Milk Price	22.00	22.00	22.00	22.00	**88.00**	**22.00**
EC Subsidy	8.28	8.28	8.28	8.28	**33.12**	**8.28**
UK Subsidy	6.86	-	-	-	**6.86**	**1.72**
EX. Subsidised Cost	6.86	13.72	13.72	13.72	**48.02**	**12.01**
NHS Staff Time	0.83	0.83	0.83	0.83	**3.33**	**0.83**
Subsidised Total	7.69	14.55	14.55	14.55	**51.35**	**12.84**
Discounted Total	7.69	£13.73	12.95	12.22	**46.59**	**11.65**

The estimated gross subsidised cost to a health authority is £210,000 per annum. These are reasonably high cost assumptions in that they assume that the health authorities pick up the full marginal cost minus the subsidies. An optimistic health authority costing scenario assumes that the cost to the health authority is simply the cost of staff time. That is, £15,000 per annum, or £0.83 per treated child per annum.

3.3.3 Modelled Treatment Cost Savings

In addition to the health benefits of milk fluoridation, there will be some savings to the NHS resulting from avoided treatment costs. The following analysis uses the dmft/DMFT saving figures which were used to model benefits in the previous sub-section of this paper. It is the incidence and not the prevalence of caries which is the relevant concept to measure in this context. It is assumed that each incidence of caries is only treated once in the 10 year period when a child is aged 4 to 14. Whilst this assumption is reasonable to make in the context of extractions, it is a conservative assumption for restorations. Analysis of Trent data indicates that only about 25% of caries is treated (by fillings and extraction), the remaining 75% is untreated tooth decay. It is assumed, therefore, that only 25% of saved dmft/DMFT avoids treatment costs in the following analysis.

The cost savings of avoided treatment are then estimated using an assumed cost of £20 per treatment[32] and a financial discount rate of 6%. The actual cost of treatment is clearly dependent upon the casemix under consideration in terms of fillings, extractions and the type of tooth affected by caries. The £20 estimate includes an estimate of costs to patients and their families. This rather high cost assumption counterbalances to some extent the conservative once in the ten year treatment assumption used. The estimated net present values (NPVs) of the cost savings of avoided treatment for an individual four year old as estimated to age 14 are given in table 11.

Table 11 Estimated NPV of Cost Savings per Treated Child

Scenario	Low Caries (£)	High Caries (£)
Pessimistic	1.78	6.33
Central	2.07	7.16
Optimistic	3.23	10.47

The table shows the estimated cost savings from avoided treatment for an individual to be small, especially in an area of low caries prevalence. The annual cost savings from a district population perspective and under steady state assumptions are given in Table 12.

Table 12 Annual Cost Savings to NHS for a Health District of 500,000 Population

Scenario	Low Caries (£)	High Caries (£)
Pessimistic	8,023	28,482
Central	9,320	32,227
Optimistic	14,514	47,137

Both of the above tables indicate that the central scenario cost savings are skewed towards the results of the pessimistic scenario. This phenomenon is a result of the fact that the Birch results for water fluoridation show the DMFT index gap widening as time increases. Consequently, there is assumed to be new incidence of caries avoided year on year in the optimistic scenario. This is not true for the pessimistic scenario, nor for the central scenario which, because of the way it is constructed, assumes very little new incidence of avoided caries for children aged nine or over. It is important to note that, under present arrangements, these savings will be made by the NHS centrally and will not be redistributed to purchasing authorities.

3.3.4 Modelled Net Costs

In modelling net cost estimates, three perspectives are presented. The societal perspective, the NHS perspective, and the health authority perspective. In the former, the full costs of a milk fluoridation scheme (without subsidies) are included along with all estimates of treatment savings. Two NHS perspectives are presented. The low cost scenario assumes that only NHS staff costs are included in the analysis, together with estimated treatment savings. In the high cost scenario, the NHS is assumed to absorb all of the non-subsidised costs of a scheme together with the estimated treatment savings. The two health authority costing scenarios are the same as the NHS scenarios except that the gross costs are not offset by any treatment cost savings, as currently these are kept centrally and are not re-distributed to the health authorities.

To derive net costs, the NPV of the discounted cost savings (estimated over 10 years) is subtracted, when appropriate, from the NPV of the costs incurred over the four years of treatment. Table 13 shows the estimated NPVs of the net costs per child treated under the three DMFT benefit scenarios. A 6% discounting assumption is used.

Table 13 Estimated NPV of Net Costs Per Treated Child

	Pessimistic DMFT Scenario		Central DMFT Scenario		Optimistic DMFT Scenario	
Costing Perspective	**Low Caries £**	**High Caries £**	**Low Caries £**	**High Caries £**	**Low Caries £**	**High Caries £**
Societal	82.08	77.54	81.80	76.71	80.64	73.39
HA High Cost	46.59	46.59	46.59	46.59	46.59	46.59
HA Low Cost	3.06	3.06	3.06	3.06	3.06	3.06
NHS High Cost	44.81	40.27	44.52	39.43	43.37	36.12
NHS Low Cost	1.28	-3.27	0.99	-4.10	-0.16	-7.41

There is no difference between gross and net costs, if adopting a health authority perspective, because they realise no treatment cost savings. Consequently, the health authority cost figures are also independent of any DMFT benefit scenario assumptions. Table 14 presents the net cost figures based on a ‘typical’ health authority population of 500,000 total residents.

Table 14 Population-Based NPV Net Costs per Annum

	Pessimistic DMFT Scenario		Central DMFT Scenario		Optimistic DMFT Scenario	
Costing Perspective	**Low Caries £**	**High Caries £**	**Low Caries £**	**High Caries £**	**Low Caries £**	**High Caries £**
Societal	369,440	348,981	368,143	345,236	362,947	330,327
HA High Cost	209,709	209,709	209,709	209,709	209,709	209,709
HA Low Cost	13,774	13,774	13,774	13,774	13,774	13,774
NHS High Cost	201,686	181,227	200,388	177,482	195,192	162,572
NHS Low Cost	5,751	-14,708	4,453	-18,453	-742	-33,363

Tables 13 and 14 illustrate the relatively small impact of the different caries levels and benefit assumption compared with the impact of the costing perspective adopted. The difference between the high and low cost health authority scenarios is dependent on how much of the cost of the milk product the health authorities are willing to bear, or are made to bear by Local Authorities.

3.4 Economic Analysis: Estimation of Cost-effectiveness

Possible measures of cost-effectiveness in the current context are the cost per DMFT/dmft avoided and the cost per DMFT/dmft free years. The previous two sections have illustrated a wide range of estimates of benefits and costs for a milk fluoridation scheme. The range of benefits available will depend, amongst other things, on the current prevalence of caries in the community and the assumptions made about the effectiveness of milk fluoridation during and beyond the administration of the school milk years. The range of cost estimates is largely dependent on how the margin is defined and from whose perspective the costing is undertaken; Society: the NHS as a whole, or a health authority. This range of cost and benefit estimates will combine to give a wide range of estimates of cost-effectiveness.

Table 15 presents the cost per dmft/DMFT year saved where avoided caries years saved are undiscounted, but where costs are net costs and are discounted using a 6% discounting factor. The ratios are presented using optimistic, central, and pessimistic predictions of DMFT benefits for high and low caries areas. The costing scenarios again represent societal, NHS, and health authority perspectives. Table 15 demonstrates a wide range of cost-effectiveness results.

Table 15 Cost Per dmft/DMFT Year Saved

	Pessimistic DMFT Scenario		Central DMFT Scenario		Optimistic DMFT Scenario	
Costing Perspective	**Low Caries £**	**High Caries £**	**Low Caries £**	**High Caries £**	**Low Caries £**	**High Caries £**
Societal	68.09	18.87	46.24	11.79	29.43	7.36
HA High Cost	38.31	11.24	26.10	7.10	16.85	4.63
HA Low Cost	2.54	0.74	1.73	0.47	1.12	0.31
NHS High Cost	36.83	9.70	24.93	6.00	15.68	3.58
NHS Low Cost	1.06	net saving	0.56	net saving	net saving	net saving

From a societal perspective, the estimates vary from £7 to £68 per caries year saved. It could be argued that all these societal cost-effectiveness ratios overestimate the true cost - effectiveness ratios in that the marginal cost is the whole cost of the fluoridated milk, whereas the benefits only measure the caries benefits of fluoridated milk. It could be argued that, because the economic analysis only measures the caries benefits of fluoridated milk, the relevant marginal cost is the cost of the fluoride and the administration costs of a fluoridated milk scheme. This would be the case, for example, where a school milk scheme was already in place and we were interested in measuring the marginal costs and benefits of adding fluoride to the milk. The cost-effectiveness ratios given for the NHS low cost scenario in table 15 are more representative of this viewpoint. Four of these six ratios indicate a net saving, and the worst case scenario is £1.06 per dmft/DMFT year saved.

The 12 ratios giving the NHS and HA perspectives are similar and only differ because the former allows for net cost savings from a reduced need for dental treatment. From a health authority perspective, the figures range from 31 pence to £38 per dmft/DMFT year saved depending on costing perspective, high versus low caries prevalence, and DMFT forecasted benefit scenario. Again, the HA and NHS high cost perspectives are relatively pessimistic in that they assume the NHS picks up the full non-subsidised cost of a milk fluoridation scheme. The experience in the North-West has been that the NHS has paid only for the NHS staff resource in the scheme, so that the HA low cost row of table 15 is the most relevant set of cost-effectiveness ratios for the North-West scheme.

3.5 Economic Analysis: Discussion

It is widely perceived that the most cost-effective method of community fluoridation is via the water supply.[33,34,35] Having made various assumptions about discounting rates and the size of the population to be served, Birch[25] has produced estimated costs per dmft/DMFT year saved ranging from £1.60 to £27.02. To make a fair comparison with our analysis, the Birch figures need to be inflated by 10 years. The Retail Prices Index (RPI) indicates an inflation rate of 40% for the period 1988 to 1998.[36] Inflating the Birch figures to 1998 prices using the RPI implies a range of water fluoridation cost-effectiveness figures from £2.24 to £37.83. Even allowing for inflation, there are differences in discounting rate and population size assumptions and the Birch analysis ignores any potential savings from avoided treatment costs. Bearing these differences in mind, the cost-effectiveness ratios resulting from the two sets of analyses are broadly comparable and of similar magnitude. Dixon and Shackley[37] point out that because published papers on the economics of water fluoridation (including Birch) have not taken into account the economic welfare losses (e.g. utility losses and/or the costs of having to purchase fluoride filters) for those members of society opposed to water fluoridation, the health and economic benefits of such water fluoridation schemes have been over-estimated. Also, any non-caries health benefits of fluoridated milk have been explicitly excluded from the analysis presented in these guidelines, so that the overall benefits of milk fluoridation have been under-estimated. Allowing for all these factors, it seems reasonable to argue that milk fluoridation can be as cost-effective as water fluoridation under certain circumstances. This comparison is a relative one and it is important to point out that both the costs and the benefits to the community in absolute terms will be higher for water fluoridation schemes.

The modelling presented in this paper has required a number of simplifying assumptions about key variables, including the number of years that children receive fluoridated milk, the number of days per year that the milk is administered, and the proportion of parents giving consent. Whilst affecting the absolute levels of costs and benefits, changes to the values in the above variables will have very little impact on the cost-effectiveness results presented because of the proportional effects on both the numerator and the denominator.

An issue from the health authority's point of view is to consider how much of the cost of a fluoridated milk scheme it is willing, or will have, to bear relative to the Local Authority and/or parents. In the schemes in the North-West of England, the only costs born by the NHS are the staff costs for the health authority and the community dental service. Thus, the most relevant cost and cost-effectiveness scenarios presented in this Guidance Note would be the health authority low cost scenarios. However, the high cost scenarios may be more relevant for health authorities in areas where Local Authorities and or parents are unable or unwilling to meet the costs of schemes.

In order to help health authorities estimate their own cost and benefit scenarios a ready-reckoner spreadsheet will be developed to supplement this Guidance Note. This will be made available on the Working Group on Acute Purchasing (WGAP) web-site: (http://www.shef.ac.uk/uni/academic/R-Z/tiwgap/).

The relative cost-effectiveness of a fluoridation scheme for a whole health district will depend on the differing proportions of the population at the various levels of risk of caries. Clearly, the most cost-effective strategy for a health authority to adopt would be to target the high caries areas initially, moving to lower caries areas at a later stage. However, because of equity considerations, such a policy may not be acceptable.

The relative cost-effectiveness of methods of fluoridation is dependent upon disease levels and upon political, administrative, and technical influences. Water is likely to remain the first choice method of fluoridation where it is technically possible, economic, and politically acceptable to fluoridate water supplies. We have demonstrated that milk fluoridation is as cost-effective, if not more cost-effective than water fluoridation under many of the circumstances modelled, though the total benefits will clearly not be as great as from a water scheme.

4. OPTIONS FOR PURCHASERS AND PROVIDERS

The following options are not necessarily mutually exclusive.

Option 1: *Do nothing*. The evidence from Doncaster and most other districts in Trent indicates that without any fluoride-based intervention[3] it is extremely unlikely that the Government's target of a dmft of one for five year old children by the year 2003 will be achieved. This is, therefore, not a reasonable option.

Option 2: In districts where universal water fluoridation may prove to be impractical for technical, political or other reasons, *consider milk fluoridation as a long-term strategy to reduce dental caries in the infant and junior school children in those areas which may never benefit from water fluoridation.* Factors, such as, a central milk supply, Local Authority support and a sufficiently high disease level for there to be a demonstrable benefit must be taken into account. Value for money for purchasers must be a strong feature of a milk fluoridation scheme. However, as shown above, the benefits may be acquired relatively cheaply.

Option 3 *In districts with a low level of dental caries, but with pockets of high disease, milk fluoridation may be considered* as a cost-effective solution for those small areas. For example, Boston has a mean dental caries level in five year old children which is more than twice that of the surrounding rural area in South Lincolnshire.[38] Fluoridated milk in targeted areas could be a cost-effective alternative to the fluoridation of the water supply to the whole of a sparsely-populated rural area, and its use could be considered as a long-term strategy.

Option 4 *Pursue water fluoridation in each district in the Trent Region.* This option is the one most likely to enable all districts to achieve the Government's target, but not by 2003. However, despite the passing of the Water Fluoridation Act in 1985, there have been no new water fluoridation schemes since then. A flaw in the current legislation gives a veto on all water fluoridation schemes to the water authorities who exercise this veto. Yorkshire Water Authority in particular is implacably opposed to the introduction of it in their water supply until the Government makes it mandatory. The Government's policy on this is not yet formulated despite recommendations from the Acheson Report.[39] Even if the Act is amended in 1999, it may still take an average of five years before any new schemes are operating. The benefit would certainly not then be demonstrated by 2003. Thus, this remains the long-term strategy of choice.

Option 5 *In districts where universal water fluoridation may be possible, consider fluoridated milk as a short-term strategy until water fluoridation is achieved.* The benefits of fluoride would be provided directly to the most vulnerable age groups, but there is still no real possibility of the Government's target for five year olds being achieved by 2003. The scheme would then subsequently be made redundant if water fluoridation was introduced for the benefit of the whole population.

5. DISCUSSION AND CONCLUSIONS

Dental caries is a universal disease of the industrial age. Whilst it is not usually fatal (except for the persistent number of deaths each year of young children under general anaesthesia for extractions), it is a disease causing pain, infection, misery and possible disfigurement for any member of society, but particularly children. It is almost entirely preventable by dietary control of non-milk extrinsic sugars[40], and the introduction into the water supply of fluoride at one ppm.[41] However, epidemiological studies of a rigorous nature in the Trent Region show that the level of dental caries remains at an unacceptable level in most districts in the region. Indeed, the variation in disease experience within each district may be greater than the whole range of averages between districts, as shown for Doncaster as an example. The Government's target of an average dmft of one for five year old children may not be achieved by 2003 without community programmes delivering fluoride at an efficacious level in most districts. This report has examined one of those community programmes for possible use in the Trent Region. The conclusions drawn from the study are as follows:-

a) Fluoride as part of a community programme is the only reliable method available to health authorities to achieve the Government's target for the reduction of dental caries in five year olds by the year 2003.

b) Fluoridated water at one ppm remains the most effective way of reducing dental caries in the whole population. However, little progress has been made in the UK as a whole, and the Trent Region in particular, in extending this since 1985.

c) Fluoridated milk can be a relatively cost-effective and practical way to prevent dental decay in the populations which consume it. Whilst it does not provide lifetime cover as water fluoridation does, nor the overall level of caries reduction, it does reduce decay in a crucial period of development of the mouth, at an age when operative dental care is not easy to provide or be tolerated. If started at age four, it may enable some districts in the Trent Region to achieve the Government's target for caries reduction in five year olds by 2003.

d) Fluoridating milk has the advantage that it does not require widespread consultation with the public, as consent is required only from the parents of the children who receive it. This is a factor in why fluoridated milk schemes can be introduced relatively quickly compared with water schemes. Consequently, milk fluoridation may be considered as a forerunner to fluoridation of water during the years taken to set up a water scheme.

e) Fluoridated milk may be a cost-effective way of preventing dental caries in younger children on a permanent basis where water fluoridation remains impractical or impossible. Whilst it may never achieve the caries-reduction of water fluoridation, nevertheless it remains a proven preventative measure for those who consume it.

f) Districts in the Trent Region should examine their individual circumstances, using the previously-described methodology, to assess the benefits of milk fluoridation for target groups of their population, and consider introducing it as soon as possible.

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