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Dental caries and enamel fluorosis among the fluoridated and non-fluoridated populations in the Republic of Ireland in 2002

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Background A national survey of oral health of children and adolescents was carried out in the Republic of Ireland (RoI) in 2001/2002. ***Aims*** To compare the prevalence of caries between child and adolescent residents in fluoridated and non-fluoridated communities in the RoI whilst controlling for disadvantage. To compare caries levels amongst disadvantaged and non-disadvantaged groups with and without water fluoridation. To report the changes in caries levels between the 1960s and 2002 in RoI. To report the changes in dental fluorosis levels between 1984 and 2002. ***Methodology*** Cross sectional oral health survey of a representative, random, stratified sample of 17,851 5-, 8-, 12- and 15-year-old children and adolescents in RoI. WHO examination criteria with the addition of visible, non-cavitated dentine caries were used for recording caries. Fluorosis was measured using Dean's Index. ***Results*** In the RoI the mean dmft/DMFT scores for 5-, 8-, 12-, and 15-year-olds were 1.2, 0.3, 1.1 and 2.3. For those with domestic water fluoridation since birth the scores were 1.0, 0.3, 1.1 and 2.1 respectively. In non-fluoridated areas of RoI the mean dmft/DMFT scores for 5-, 8-, 12-, and 15-year-olds was 1.7, 0.3, 1.3 and 3.2. respectively. For 5-, 12- and 15-year-old age groups dental caries levels were lower amongst children with fluoridated domestic water supplies (all $p<0.0001$). The prevalence of dental fluorosis has increased in RoI since 1984. 23% and 36% of 8- and 15-year olds respectively in fluoridated areas had Dean's Index scores at the questionable or greater level in 2002, compared with 6% and 5% respectively in 1984. ***Conclusions*** Caries levels are lower among children with fluoridated domestic water supplies. Decay levels are much lower in 2002 than they were in 1984 and in the 1960s. The oral health of the less well off is worse than that of the rest of the population. The prevalence of dental fluorosis is higher amongst children and adolescents with fluoridated water supplies. Comparisons with 1984 data show an increase in the prevalence of fluorosis since that time.

Key words: Caries, epidemiology, fluoridation, fluorosis, national survey

Introduction

Since the implementation in 1964 of the Health (Fluoridation of Water Supplies) Act 1960, water supplies in the Republic of Ireland (RoI) have been adjusted to 0.8–1.0 part per million (ppm) fluoride. Currently 71% of the population of the RoI receive fluoridated domestic water supplies. Results of a national survey of children's and adolescents' oral health carried out in 1984 (O'Mullane *et al*., 1986) showed that there had been a major decline in dental caries levels both in fluoridated and non-fluoridated areas since the pre-fluoridation surveys conducted between 1961 and 1965 (Minister for Health, 1961–1965). Regional oral health surveys carried out in the 1990s indicate a continuing decline of dental caries levels amongst 5-, 8-, 12- and 15-year-old children and adolescents in the RoI (Whelton *et al*., 2001).

A critique of many studies of the effectiveness of water fluoridation was their failure to control for confounding factors (McDonagh *et al*., 2000). Socio economic factors are important variables to take into account when comparing caries levels amongst different communities, (Locker, 2000). Since the 'Black Report' on inequalities in health was published in the UK (Townsend and Davidson, 1980), the association between disadvantage and ill health has been widely acknowledged. As with general health, there are many reports of poorer oral health among the less well off. There are conflicting reports on the relative impact of water fluoridation on social inequalities in oral health. It has been reported that water fluoridation reduces the difference in dental caries levels between the social classes (Jones and Worthington, 2000). However a systematic review of water fluoridation (McDonagh *et al*., 2000) reported that the difference in the percentage of children free of caries between the social classes, was no less in the fluoridated than in the non-fluoridated areas, when studies reporting mean numbers of decayed, missing and filled teeth were reviewed. The data from 5-year-old children suggested that water fluoridation was leading to a decrease in dmft across the social classes and reducing the inequalities in caries in primary teeth between the social classes. This trend was not found for permanent teeth amongst older children and adolescents.

Information on disadvantage was collected for each child examined in this study to allow the analysis to control for confounding due to socio-economic differences and to allow further investigation of the impact of water fluoridation on social inequalities in oral health in the RoI.

Another area of interest in this study was dental fluorosis. It is well established that persons residing in

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fluoridated communities have higher levels of questionable and very mild fluorosis. Water fluoridation at a level of 0.8–1.0 parts per million (ppm) fluoride was introduced in the RoI in 1964. Fluoride toothpastes have been marketed in the RoI since the mid 1970s and now hold more than a 95% market share. A national survey conducted in the RoI in 1984 and local studies conducted since then have indicated that there is a slight increase in fluorosis amongst Irish children and adolescence since 1984 (O'Mullane *et al*., 1986; Whelton *et al*., 2001).

The study reported in this paper had four main aims. Firstly, to compare the prevalence of caries among child and adolescent residents in fluoridated and non-fluoridated communities whilst controlling for disadvantage. Secondly, to compare caries levels amongst disadvantaged and non-disadvantaged groups with and without water fluoridation. Thirdly, to monitor the changes in caries levels over time. Finally, to monitor the changes in dental fluorosis between 1984 and 2002 in the RoI.

Methods

The Department of Health and Children and the Health Boards in Ireland funded the study. The aims and protocol were developed in collaboration with a steering group comprised of senior representatives of the public dental service. Ethical approval was obtained prior to the start of the study. The groups chosen were children in Junior Infants, Second Class, Sixth Class and Junior Certificate. Reflecting the approximate ages of children in the classes selected, the groups will be referred to as five, eight, twelve and fifteen year olds. These age groups are comparable with earlier Irish studies and with studies conducted internationally as they include age groups recommended for study by the World Health Organization (WHO) (WHO, 1987).

The survey had a cross sectional design. The total target sample size required was 14,400. The sample size was based on the desire to have 120 children per cell in each of the four age groups in 30 community care areas (120 x 4 age groups x 30 community care areas = 14,400). The cell size of 120 would allow reliable estimates of dmft/DMFT by fluoridation or disadvantage status. The total sample size had a power of 80% to show a difference in DMFT level of at least 0.5 in 5, 12 and 15 year olds and at least 0.2 in 8 year olds between children from fluoridated and non-fluoridated areas in the RoI.

The primary sampling unit was the school. A cluster sampling technique was used with schools as the clustering unit. Children were selected randomly on the basis of age, gender, and geographical location of the school attended and whether they attended a school with fluoridated or non-fluoridated water supply. Parents of the selected children were asked to complete consent forms and at the same time were asked to indicate whether they were in possession of a medical card ('MC yes' or 'MC no'). Medical cards are issued to low-income families on the basis of a means test. Possession of a medical card is used in this study as a surrogate for disadvantage. The consent forms also requested details of the water supply to the child's current and any previous home and their use of fluoride supplements, current or historical. This information was used to determine the child's lifetime exposure to domestic water fluoridation and fluoride supplements.

Thirty-four teams of health board dentists and dental nurses conducted the fieldwork for the survey. The principal trainer (HW) was involved in the training of the examiners in the 1984 National Survey in the Republic of Ireland (O'Mullane *et al*., 1986). Four assistant trainers who were experienced in the survey examination criteria assisted her in the training and calibration of examiners for the current study. The levels of agreement between the examiners and the gold standards in the various indices were calculated and measures of agreement were generated. Additional calibration exercises took place during the training courses between the trainers and the principal examiner to monitor and ensure standardisation among the trainers in the training programme. Kappa statistics were calculated to measure the level of agreement (beyond that expected by chance) between the gold standard examiner and each of the examining dentists for the caries status of each tooth surface and for each subject's Dean's Index score. A small number of examiners were recalled for further calibration on Dean's Index where the Kappa value was below 0.40 (moderate agreement) (Landis and Koch, 1977).

Data were recorded using direct data entry in accordance with data protection legislation.

Caries was recorded at the dentinal level of involvement using WHO (WHO, 1987) criteria. Cavitation was recorded when the presence of a cavity could be confirmed with a CPITN probe with a 0.5mm ball tip. The criteria were expanded to include coding for caries that was visibly into dentine but had not cavitated. The coding system allowed for analysis of the data for caries at the dentinal level of involvement with or without cavitation. At cavitation level (dmft/DMFT) the results could be compared with earlier national surveys. Analysis of the caries data including the visual component (vdmft/VDMFT) was also possible. Non-cavitated dentine caries, where the caries is visible as a shadow under the enamel, was previously ignored in many systems for recording caries and as a result, not recorded in the dmft/DMFT index. It was recorded separately as treatment need when using WHO criteria. If a child or adolescent with visual caries had a course of dental treatment, the visual caries would have been filled thus increasing the 'F' component of the DMFT. This filling would then have been counted in the dmft/DMFT index. As caries levels have declined and access to treatment has increased the impact of the exclusion of visible but not cavitated dentine caries is likely to be expressed as an apparently higher dmft/DMFT in areas with good services and a lower dmft/DMFT score in areas with less access to services. Therefore, inclusion of the non-cavitated visual component of caries is important when considering social inequalities in oral health. This approach also allows comparison of the Irish data with UK surveys using the British Association for the Study of Community Dentistry criteria, which include caries at the visual level (Pitts *et al*., 1997).

The teeth were not dried for the dental examination, the mouth was illuminated using a portable dental light source and no radiographs were taken.

In this study, fluorosis was recorded using Dean's

Table 1. Distribution of children examined in the Republic of Ireland according to gender, their level of disadvantage as classified by their parents' ownership of a Medical Card (MC, MC = less well off, RoI) within age group and fluoridation status.

		Age group				
	Gender	*5*	*8*	*12*	*15*	*Total*
	Female	3236	1875	1992	1755	8858
	Male	3425	1894	1894	1780	8993
	Total	6661	3769	3886	3535	17851
Fl Status	Disadvantage status	n	n	n	n	n
Non FL	No MC	1770	654	576	456	3456
	MC	380	154	170	175	882
	Total*	2160	814	747	632	4353
Full FL	No MC	2661	1654	1618	1493	7426
	MC	945	541	470	561	2517
	Total*	3616	2208	2090	2062	9976
Total	No MC	5053	2858	2975	2554	13440
	MC	1550	874	896	959	4279
	Total**	6661	3769	3886	3535	17851
	Mean age years	5.3	8.4	12.4	15.2	

* Includes children for whom MC details were missing
** Includes all children examined who did not fit "Full Fl" and "Non Fl" fluoridation categories.

Index (Dean, 1934) in natural light. This index classifies fluorosis by six grades, Normal (no fluorosis), Questionable, Very Mild, Mild, Moderate and Severe. The permanent teeth of eight, twelve and fifteen year old children were examined for signs of fluorosis.

The fieldwork was conducted between October 2001 and June 2002. The overall response rates were 68% (68%, 68%, 68% and 66% in the 5-, 8-, 12- and 15-year-old age groups, respectively).

Statistical analysis

The data were exported from the direct entry software as an ASCII type II file and imported to the SAS statistical package for analysis. Health board and national results have been weighted according to the relative population sizes of the community care areas, which make up the health board regions. The impact of fluoridation and disadvantage on caries levels were investigated using Generalised Linear Models for a negative binomial distribution and a logarithmic link function. The factors included were fluoridation status of the home water supply since birth ('Full fl' and 'Non fl') and disadvantage (ownership of a medical card by the parents or child in ROI: 'MC yes', 'MC no'. The interaction between these two factors was also included. This method allowed the measurement of the difference in caries levels according to fluoridation status whilst controlling for disadvantage and similarly the measurement of differences in caries levels according to disadvantage whilst controlling for fluoridation status. The inclusion of the interaction term determines whether any difference between groups according to, for example, fluoridation status, is the same for both disadvantaged and non-disadvantaged groups and vice versa. Caries levels were compared between 1984 and 2002 using two-sample t-tests. Levels of dental fluorosis were compared between 'Full fl' and 'Non fl' groups using Fishers exact tests. All tests were two sided with a 5% level of significance.

The dental teams examined 17,851 children and adolescents (Table 1). The North Eastern Health Board requested a population survey of all 5-year-old children in that area; hence the number of 5-year-olds was larger than that for the other age groups. An even gender balance was achieved in the sample.

The numbers and mean ages of children examined are shown according to medical card ownership and fluoridation status in Table 1.

Although the sample was selected on the basis of school water fluoridation status, the results are presented according to each child's domestic water fluoridation status.

The degrees of exposure of subjects to fluoridated water supplies at home and at school, to fluoride tablets and to fluoride mouth rinsing varied a great deal. In this paper the results for the following three groupings are presented. The total sample included children and adolescents with any exposure to water fluoridation, i.e. continuously since birth or sporadically during their lifetime, those with no exposure to domestic water fluoridation or supplements and those who were exposed to supplemental fluoride, e.g. mouthrinses.

- Full Fl
  The subjects' home water supply had been fluoridated continuously since birth; they may also have had exposure to school fluoridation, fluoride tablets or fluoride mouthrinses.
- Non Fl
  The subjects' home water supply had never been fluoridated, their present school water supply is not fluoridated and they never had fluoride tablets or mouthrinses.

The number of children and adolescents in these groups are shown in Table 1.

The age groups examined were 5-, 8-, 12- and 15-year-olds. The mean age on the day of examination of the children examined in these age groups were 5.3, 8.4, 12.4,

15.2 respectively. The mean ages of children in the different strata (fluoridation status and disadvantage) were comparable.

Results

Caries levels according to age group, fluoridation status and disadvantage

Mean dmft/DMFT scores and standard deviations are presented by fluoridation status and disadvantage within age group. The differences in the distribution of the scores among these groups were investigated using Generalised Linear Modelling to control for confounding due to fluoridation and disadvantage. Results are presented separately for caries at cavitation level (Table 2) and caries at the visual plus cavitation level (Table 3).

Cavitated caries

The overall mean cavitated dmft score for 5-year-olds was 1.2, the mean DMFT scores for 8-, 12- and 15-year-olds were 0.3, 1.1 and 2.3 respectively (Table 2). These mean scores are based on caries levels found among all children in the sample.

The level of cavitated dental caries (mean DMFT) in 2002 among 5-, 8-, 12- and 15-year-old children and adolescents according to fluoridation status is shown in Table 2. Five-year-old children with full water fluoridation had on average 1.0 decayed, missing or filled primary or milk teeth (mean dmft). For 8-, 12- and 15- year olds with full domestic water fluoridation, the corresponding figures for permanent teeth (mean DMFT) were 0.3, 1.1 and 2.1 respectively. In non-fluoridated areas the pattern is similar, but with higher levels of caries at all ages. On average, 5-year-olds in non-fluoridated areas had 1.7 decayed, missing or filled primary teeth, while 8-, 12- and 15- year olds had on average 0.3, 1.3 and 3.2 permanent teeth respectively affected by caries. The mean cavitated caries experience according to disadvantage status within fluoridation status is also shown in Table 2. The mean dmft/DMFT score for medical card holders (MC, disadvantaged group) tended to be higher for both fluoridated and non-fluoridated children and adolescents except for non-fluoridated 15-year-olds. In fluoridated areas 5-year-old medical card holders had a mean dmft of 1.5, those without a medical card had a mean dmft score of 0.9. In non-fluoridated areas the scores were 2.1 and 1.6 respectively. The differences were smaller for permanent teeth of older children.

Table 2. Mean number (and standard deviation) of decayed, missing and filled teeth (dmft 5-year-olds, DMFT 8-, 12-, 15-year-olds) at cavitation level for total sample and among children and adolescents with fluoridated and non-fluoridated domestic water supplies according to disadvantage (MC/No MC) in 2002 (MC = disadvantaged/ No MC = not disadvantaged).

	Total		*Full Fl*		*Non Fl*		*Full Fl vs Non Fl*	*MC vs no MC*	*Interaction*
	mean	*Sd*	*mean*	*Sd*	*mean*	*Sd*	*p-value*	*p-value*	*p-value*
5 MC			1.5	2.6	2.1	3.0			
5 no MC			0.9	1.9	1.6	2.1			
5 all	1.2	2.2	1.0	2.1	1.7	2.1	<0.0001	<0.0001	0.0652
8 MC			0.4	0.9	0.5	1.0			
8 no MC			0.3	0.7	0.3	0.8			
8 all	0.3	0.8	0.3	0.8	0.3	0.8	0.0748	0.0033	0.8832
12 MC			1.2	1.6	1.5	2.0			
12 no MC			1.0	1.4	1.2	1.6			
12 all	1.1	1.5	1.1	1.4	1.3	1.7	<0.0001	0.0003	0.5519
15 MC			2.3	2.6	3.2	3.3			
15 no MC			2.1	2.3	3.3	3.2			
15 all	2.3	2.6	2.1	2.3	3.2	3.1	<0.0001	0.0569	0.4719

Table 3. Mean number (and standard deviation) of decayed, missing and filled teeth (vdmft 5-year-olds, VDMFT 8-, 12-, 15-year-olds) at the dentinal level of involvement (visual plus cavitation level) among children and adolescents, for whole sample and for those with fluoridated and non-fluoridated domestic water supplies according to disadvantage (MC/No MC) in 2002.

	Total		*Full Fl*		*Non Fl*		*Full Fl vs Non Fl*	*MC vs no MC*	*Interaction*
	mean	*Sd*	*mean*	*Sd*	*mean*	*Sd*	*p-value*	*p-value*	*p-value*
5 MC			1.9	2.9	2.6	3.3			
5 no MC			1.1	2.1	2.1	2.4			
5 all	1.6	2.5	1.3	2.3	2.2	2.3	<0.0001	<0.0001	0.0547
8 MC			0.6	1.1	0.7	1.1			
8 no MC			0.3	0.8	0.4	0.9			
8 all	0.4	0.9	0.4	0.9	0.5	0.9	0.0274	<0.0001	0.9066
12 MC			1.5	1.8	1.8	2.2			
12 no MC			1.2	1.6	1.6	1.8			
12 all	1.4	1.7	1.3	1.6	1.6	1.8	<0.0001	<0.0001	0.4677
15 MC			3.0	3.0	3.9	3.9			
15 no MC			2.5	2.5	3.8	3.3			
15 all	2.8	2.9	2.6	2.6	3.8	3.4	<0.0001	0.0010	0.4139

Analysis of the data using a Generalised Linear Model to compare the distribution of caries scores amongst the different fluoridation and deprivation groups showed that:

- Caries levels were lower among five-year-old children with full water fluoridation ($p<0.0001$). Though caries levels were also lower for non-medical card holders ($p<0.0001$), the effect of fluoride was independent of medical card status ($p=0.0652$).
- Caries levels tended to be lower among eight-year-old children with full water fluoridation (DMFT in Full Fl and Non Fl groups 0.29 and 0.32 respectively, both rounded to 0.3 in Table 2), though the difference did not reach statistical significance ($p=0.0748$). Caries levels were lower for non-medical card holders ($p=0.0033$). This effect is independent of fluoridation status ($p=0.8832$)
- Caries levels were lower for non-medical card holders ($p=0.0033$). This effect was independent of fluoridation status ($p=0.8832$).
- Caries levels were lower among twelve-year-old children with full water fluoridation ($p<0.0001$). Though caries levels were also lower for non-medical card holders ($p=0.0003$), the effect of fluoride was independent of medical card status ($p=0.5519$).
- Caries levels were lower among fifteen-year-old adolescents with full water fluoridation ($p<0.0001$). Caries levels also tended to be lower for non-medical card holders, though the difference did not reach statistical significance ($p=0.0569$). The effect of fluoride is independent of medical card status ($p=0.4719$).

Thus, in RoI cavitated caries levels were lower amongst 5-, 12- and 15-year-olds with domestic water fluoridation since birth. Social inequalities in oral health were found for 5-, 8- and 12-year old medical card holders but not for 15-year-olds. The data generally support the published literature, which asserts that the oral health of the less well off is worse than that of the rest of the population. Water fluoridation does not reduce social inequalities in cavitated dental caries levels for medical card holders in the RoI.

Caries at the visual and cavitated level

In Table 3 the mean cavitated caries scores with the addition of the visual component (vdmft/VDMFT) are presented. The measurement of the impact of disadvantage on dental caries levels is more meaningful with the inclusion of visual caries as described in the methods section.

The inclusion of the visual component increased the mean caries scores. For the entire sample the mean vdmft score for 5-year-olds and VDMFT for 8-, 12- and 15-year-olds was 1.6, 0.4, 1.4 and 2.8 respectively. The mean vdmft for 5-year-old children with full water fluoridation was 1.3. For 8-, 12- and 15- year olds with full domestic water fluoridation, the mean VDMFT scores were 0.4, 1.3 and 2.6 respectively. In non-fluoridated areas the vdmft/VDMFT scores were higher at all ages than in the fluoridated groups. The mean visual plus cavitated caries experience according to disadvantage status within fluoridation status is also shown in Table 3. The mean vdmft/VDMFT scores for the disadvantaged groups (medical card holders) were higher than those for the rest of the population for both fluoridated and non-fluoridated children and adolescents. In fluoridated areas 5-year-old disadvantaged children had a mean vdmft of 1.9, the non-disadvantaged group had a mean vdmft score of 1.1. In non-fluoridated areas the scores were 2.6 and 2.1 respectively. The mean scores for older children are also shown in Table 3.

The statistical significance of the difference in the distribution of vdmft/VDMFT scores within the two fluoridation and two disadvantage groups is shown in Table 3. The data were analysed using the GLM to control for confounding due to disadvantage or due to fluoridation. Caries levels were lower among all four age groups with full water fluoridation ($p<0.0001$ for 5-, 12- and 15-year-olds, $p=0.0274$ for 8-year-olds). Though caries levels were also lower for non-medical card holders ($p<0.0001$ for 5, 8- and 12-year-olds, $p=0.0010$ for 15-year-olds), the effect of fluoride was independent of medical card status ($p=0.0574$, 0.9066, 0.4677 and 0.4139, respectively).

Changes in caries levels over time

Caries levels in RoI have changed dramatically between the early 1960s and 1984 and also between 1984 and 2002 in both fluoridated and non-fluoridated areas. The changes are shown in Table 4. Data are shown for 1961–1965 (Minister for Health, 1961–1965) and 1984 (O'Mullane *et al*., 1986). The 1961–1965 data are from the statutory pre-fluoridation surveys, which were carried out in all areas of the country during that time. These data are therefore not presented by fluoridation status. The 1984 data are from the National Survey of Children's Dental Health (O'Mullane *et al*., 1986), and are presented for non-fluoridated and fully fluoridated groups, which are comparable with the similar groupings in the present survey. In the 1984 and 1961/'63 surveys, a sharp probe was used to confirm a diagnosis of cavitation. The use of sharp probes was abandoned in the later studies and replaced with a probe with a 0.5 mm ball tip, which was used to confirm cavitation. This change is likely to have a small impact on caries levels as slightly less caries

Table 4. Mean dmft 5-year-olds, DMFT 8-, 12- and 15-year-olds for children and adolescents among fluoridated communities in 1984 and 2002 and non-fluoridated communities in the 1960s, 1984, and 2002

	5-year-olds		*8-year-olds*		*12 year-olds*		*15 year-olds*	
	Full Fl	*Non Fl*	*Full Fl*	*Non Fl*	*Full Fl*	*Non Fl*	*Full Fl*	*Non Fl*
1960s*	–	5.6	–	1.7	–	4.7	–	8.2
1984	1.8	3.0	0.6	1.0	2.6	3.3	4.1	5.4
2002	1.0	1.7	0.3	0.3	1.1	1.3	2.1	3.2
1984s *vs* 2002 *p*-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

*Standard deviations for the 1960s were not available – t-tests could not be applied.

Table 5. Dean's Index of Fluorosis, % of 8-, 12- and 15-year-old children and adolescents with a score of 'normal', 'questionable', 'very mild', 'mild', 'moderate' or 'severe' on their permanent dentition according to fluoridation status in 2002 and 1984. Statistical significance of difference in distribution of Dean's Index scores between Full Fl 2002 and Non Fl 2002, between Full Fl 2002 and Full Fl 1984 and between Non Fl 2002 and Non Fl 1984

8-year-olds	*Full Fl 2002*	*Non Fl 2002*	*Full Fl 1984*	*Non Fl 1984*	*p-values*		
Normal	76	90	94	98	Full Fl	Full Fl	Non Fl
Questionable	11	7	5	2	2002	2002	2002
Very Mild	8	2	1	0	v's	v's	v's
Mild	4	0	0	0	Non Fl	Full Fl	Non Fl
Moderate	0	0	0	0	2002	1984	1984
Severe	0	0	0	0	< 0.0001	< 0.0001	< 0.0001
12-year-olds	*Full Fl 2002*	*Non Fl 2002*			*p-value*		
Normal	72	82			Full Fl		
Questionable	14	10			2002		
Very Mild	9	4			v's		
Mild	5	2			Non Fl		
Moderate	1	0			2002		
Severe	1	0			< 0.0001	–	–
15-year-olds	*Full Fl 2002*	*Non Fl 2002*	*Full Fl 1984*	*Non Fl 1984*	*p-values*		
Normal	61	81	95	99	Full Fl	Full Fl	Non Fl
Questionable	19	10	4	1	2002	2002	2002
Very Mild	10	4	1	0	v's	v's	v's
Mild	5	3	0	0	Non Fl	Full Fl	Non Fl
Moderate	1	0	0	0	2002	1984	1984
Severe	1	0	0	0	< 0.0001	< 0.0001	< 0.0001

would be confirmed with a 0.5 mm probe than with a sharp probe. Within the different studies identical standardised criteria were used for measurement of all conditions across fluoridated and non-fluoridated groups.

The data show that for both children and adolescents with (Full) and without (Non) water fluoridation, decay levels were much lower in 2002 than they were in 1961/'63 in all age groups. The changes in mean cavitated caries scores since 1984 are statistically significant ($p<0.0001$ all groups).

Dental fluorosis

Measurement of enamel fluorosis is a recognised method of monitoring intake of fluoride from different sources. In all three age groups, 80% or over of children had a Dean's Index score of 'normal' or 'questionable' (Table 5). In fully fluoridated areas a score of 'normal' was given to 76% of eight year olds, 71% of twelve year olds and 61% of fifteen year olds. In non-fluoridated areas these percentages were 90%, 82% and 81% respectively. In all age groups the percentage of children with scores at the higher end (mild and moderate) was low. There was a statistically significant difference in the distribution of Dean's Index scores between fluoridated and non-fluoridated groups for the three age groups (all $p<0.0001$), with the prevalence of fluorosis being higher among the fluoridated groups.

In the National Survey of Children's Oral Health in 1984, fluorosis was measured in four of the eight health board regions for 8- and 15-year-olds (Table 5). At that time, among 8-year-olds in fluoridated regions 94% had normal enamel, 5% had questionable fluorosis and 1% had fluorosis at the Dean's 'mild' level. The figures for 15-year-olds were 95% 'Normal', 4% 'Questionable' and 1% 'Very Mild' fluorosis. The prevalence of fluorosis among 8-year-olds and 15-year-olds in RoI has increased since 1984 ($p<0.0001$ for both groups).

Discussion

The results show that the oral health of children and adolescents with domestic water fluoridation is better than those who reside in non-fluoridated areas in the Republic of Ireland. In the case of 8-year-olds the difference did not reach statistical significance for cavitated caries ($p=0.0748$). Caries levels in the permanent dentition in both fluoridated and non-fluoridated groups are relatively low at age 8. As children enter their teens, there is a greater increase in caries levels among residents of non-fluoridated communities and the difference between fluoridated and non-fluoridated groups becomes more pronounced (as seen in the 12- and 15- year-old groups). Where caries at the visual and cavitated level were compared the difference for fluoridation was significant for all age groups. Confounding due to disadvantage was controlled in this comparison of fluoridated and non-fluoridated groups. Although caries levels are higher amongst the less well off, disadvantage does not account for the difference seen between fluoridated and non-fluoridated groups.

Twenty four per cent of the total sample examined in RoI had medical cards. This figure is likely to be similar to the proportion of children in the entire population who are dependants of medical card holders as the General

Medical Service (GMS) payments board estimated that in 2001 31% of the entire population of RoI was eligible for medical card benefits (General Medical Services Payments Board, 2002). The survey found that, in general, the oral health of the less well off is worse than that of the rest of the population. Decay levels among dependants of medical card holders were higher than in the rest of the population. Innovative approaches to further reduce decay levels and address inequalities in oral health are required.

It is interesting to note that these data do not support the suggestion that fluoridation reduces social inequalities in oral health for medical card holders. Those in the disadvantaged group with water fluoridation have lower caries levels than those without water fluoridation. Similarly, non-disadvantaged children and adolescents in the fluoridated group have lower caries levels than those in non-fluoridated areas; however, the difference in the distribution of caries scores between the disadvantaged and non-disadvantaged groups is not impacted by fluoridation.

Caries levels have declined dramatically since 1961/'63 and have declined further since 1984 in both fluoridated and non-fluoridated areas. Fluoride has contributed to improvements in oral health in non-fluoridated as well as in fully fluoridated areas. The use of fluoridated toothpaste is almost universal in 2002; over 95% of toothpaste sold in RoI contains fluoride (Forum on Fluoridation, 2002). These toothpastes were introduced to the market in the early 1970s. Another factor is the consumption in non-fluoridated areas of foods and drinks, which contain fluoride incorporated into the food during processing with fluoridated water in urban areas (the "halo effect"). Research is currently underway to develop methods of measurement of dietary fluoride intake levels amongst Irish children in both fluoridated and non-fluoridated areas.

Despite the overall decline in decay levels over the last three decades, there is little cause for complacency since tooth decay continues to be a very common childhood disease.

The prevalence of dental fluorosis is higher amongst children and adolescents with fluoridated water supplies. Comparisons with 1984 data show an increase in the prevalence of fluorosis since that time. Studies on the level at which the public perceive fluorosis to be a problem are currently being designed. The relative contribution of fluoride toothpastes and water fluoridation to enamel fluorosis in Ireland should be studied further. Recent research suggests a significant relationship between patterns of toothpaste usage in infancy and prevalence of fluorosis at age eight years amongst children in counties Sligo and Leitrim (Ormsby, 1999; Crowley *et al*., 2001). These findings support those of international research (Osuji *et al*., 1988; Milsom and Mitropoulos, 1990) which indicate that early use of fluoride toothpaste in infants leads to excessive ingestion and absorption of fluoride at a time when the enamel of the permanent teeth is forming, leading to fluorosis of the permanent incisor teeth. A recent review of water fluoridation in Ireland 'The Forum on Water Fluoridation 2002', (www.fluoridationforum.ie) was commissioned by the Minister for Health. The report of the review group made recommendations regarding the rational use of fluoride toothpaste and the reduction of the level of fluoride in the water supplies. It is anticipated that adoption of the recommendations will minimise the occurrence of dental fluorosis and at the same time maintain the important caries preventive benefits experienced to date. There is a need for regular monitoring of dental fluorosis in the Republic of Ireland.

Conclusions

Caries levels in RoI are lower amongst children who reside in communities served with fluoridated water supplies than they are amongst children resident in non-fluoridated communities.

Decay levels are much lower in 2002 than they were in 1984 in both fluoridated and non-fluoridated areas. There has also been a dramatic decline in dental caries levels since the 1960s.

The survey found that in general the oral health of the less well off is worse than that of the rest of the population.

The prevalence of dental fluorosis is higher amongst children and adolescents with fluoridated water supplies. Comparisons with 1984 data show an increase in the prevalence of fluorosis since that time, in both fluoridated and non-fluoridated communities.

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