RESEARCH

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IN BRIEF

- Reports 10 year trend findings for non carious tooth conditions in children in the United Kingdom.
- The downward trend of accidental tooth damage continues but the reasons for this are not clear.
- Tooth surface loss continues to be a problem for children in the United Kingdom.
- There is no evidence to suggest that enamel opacities are increasing in children in the United Kingdom.

Non-carious tooth conditions in children in the UK, 2003

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CHILDREN'S SURVEY

1. **The dentinal caries experience of children in the United Kingdom, 2003**
2. **Non-carious tooth conditions in children in the UK, 2003**
3. **Patterns of care and service use amongst children in the UK, 2003**
4. **Oral health habits amongst children in the United Kingdom in 2003**
5. **The reported impact of oral condition on children in the United Kingdom, 2003**
6. **The orthodontic condition of children in the United Kingdom, 2003**

Background The 2003 Children's Dental Health Survey is the fourth of the 10-yearly surveys of children's oral health.
Aim To report the prevalence of three non-carious tooth conditions in children in the UK.
Method A representative sample of children five, eight, 12 and 15 years of age were examined by calibrated examiners in schools across the UK. The dental examination included accidental damage to incisors, tooth surface loss (TSL) and enamel opacities (age 12 only). A postal questionnaire sought parental and child views on marks on teeth which could not be removed by brushing.
Results The proportion of children sustaining accidental damage to permanent incisors decreased to 11% of 12 and 13% of 15-year-olds, but the majority of accidental damage remained untreated. TSL was found on 53% of five-year-olds and on approximately a third of 12 and 15-year-olds. There was a statistically significant change for TSL on permanent teeth at age 15 where 27% upper incisors had TSL palatally in 1993 compared to 33% in 2003. Thirty-four per cent of 12-year-old children had enamel opacities on one or more of their teeth compared with 36% in 1993.
Conclusions Tooth surface loss remains a common finding in children in the UK. A large proportion of accidental damage to teeth remains untreated.

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The National Surveys of Child Dental Health (CDH) provide a 10-yearly summary of the condition of children's teeth in the UK; this is the fourth in the series. The strength of the survey is its cyclical nature that allows not only a cross sectional snapshot of the oral health of the nation's children, but also an indication of the long term trends in oral health. Over the decades the oral health of children in the UK has shown substantial change. As rates of decay have declined, other conditions have become more prominent and important. This paper covers three non-carious clinical conditions that affect the teeth; accidental damage to the teeth, tooth surface loss (tooth wear) and enamel opacities. Although accidental damage has been recorded since the first survey, the latter two have only been recorded since 1993 and indicate some of the changing concerns for children's oral health.

Accidental tooth damage has been recorded in all the CDH Surveys since 1973 and decreasing prevalence has been reported over the last 20 years. It is important to remember that not all damage to teeth following dental trauma can be identified from a clinical examination and that the survey data probably underestimates the prevalence of trauma in the population. For example, teeth with traumatised root or pulpal tissues without coronal fracture or discolouration would not be recorded by the index used in this study.[1] Nevertheless, the survey protocols and criteria have remained unchanged and therefore the measurement of trauma has been consistent over the series of surveys.

The UK CDH Survey 1993[2] was the first to provide prevalence data on non-carious tooth surface loss (tooth wear) in children throughout the UK. In the decade since its publication, increasing evidence on the aetiology of tooth wear has become available. It is known to be multifactoral with erosion, attrition, abrasion and possibly 'abfraction' all playing a part.[3] The term Tooth Surface Loss (TSL) is used in preference to 'erosion' which was used in the 1993 survey as it more accurately reflects the multifactoral aetiology of the condition.

The CDH Survey 1993[2] found 52% of five-year-olds and 27% of 12-year-olds examined to have TSL. Since it was published, concern over levels of TSL in children has remained high. The National Diet and Nutrition Survey of Young People[4] reported tooth wear in children aged four to 18 years and found 58% of four to six year olds and 42% of 11 to 14 year olds to be affected. A study in South East England reported 57% of 14-year-olds to have tooth wear.[5] These surveys suggest that TSL may be increasing but use of different indices and age groups makes direct comparison of different surveys unsafe. The 2003 survey allows the first National comparison of trends in TSL to be reported.

Enamel opacities are changes in colour and density of the tooth surface enamel which appear as patches, mottling and sometimes disturbances of contour on the surfaces of the teeth. Clearly these may adversely affect the appearance of the teeth. Opacities result from alteration in enamel structure during its formation and may be genetic, for example amelogenesis imperfecta, or arise from a variety of insults, for example trauma, infections and nutritional disturbances, including the ingestion of too much fluoride. When the latter occurs 'fluorosis' is the result. Monitoring enamel opacities is an important means of evaluating the scale of any potential negative impact of environmental and dietary fluoride on oral health.

Dental opacities were reported for the first time in the CDH Survey 1993[2] and were measured using the Developmental Defects of Enamel (DDE) Index.[6] In the intervening period concern regarding the risk of fluorosis from excessive intake of fluoride has increased.[7] However, the DDE Index is not specific for fluorosis, indeed it should be noted that it is not possible to determine if fluorosis is present from a clinical examination alone as some hypo-maturation types of amelogensis imperfecta are clinically indistinguishable from fluorosis. An epidemiological survey cannot therefore accurately determine the level of fluorosis in a population. As fluorosis usually has a symmetrical distribution, the inclusion of a measurement of symmetry can allow an estimation of enamel opacities of a type that might be attributable to fluoride to be identified.

Fluorosed enamel has a wide spectrum of presentation from barely detectable white surface striations to brown stained pitted enamel, which easily fractures.[8] While some defects may go completely unnoticed, others may cause aesthetic concern. Hawley *et al.*[9] investigated expressed concern using photographs of teeth with enamel opacities in teenagers in a non-fluoridated community using the Thylstrup and Fejerskov (TF) Index.[10] Subjects were only concerned by a TF score of three or greater.

The aim of this paper is to report on the current status and apparent trends in these three conditions, to report these in the context of measurement difficulties and the implications both for primary care dentists and the provision of health care services as a whole.

SURVEY METHODS AND RESPONSE

In summary, the 2003 survey was based on a representative sample of children aged five, eight, 12 and 15 years attending government maintained and independent schools in the UK. The survey involved 557 primary schools and 132 secondary schools. A total of 12,698 children were sampled from participating schools and asked to take part in a dental examination at school. In total 10,381 children were examined – a response rate of 82%. The children who were examined were seen in their schools by trained and calibrated examiners using standardised indices. As part of the clinical protocol the teeth were examined specifically for evidence of previous trauma, tooth surface loss (TSL) and enamel opacities using standard and widely used criteria. The survey protocol has been reported elsewhere.[11]

The criteria with regard to accidental damage to teeth remained unchanged and permanent incisors of all children were assessed for damage. The other two conditions had minor additions to the survey protocol to reflect current priorities. The term TSL was used in preference to erosion in 2003 and as in 1993 TSL on primary and permanent upper incisors (buccal and palatal) was recorded. In addition TSL on the occlusal surfaces of first permanent molars was recorded in 2003. TSL in enamel is difficult to measure[12] and evaluation of the data collected during the training weeks for this survey showed that, as in the 1993 survey, examiners had relatively low levels of agreement in the case of enamel TSL. This should be taken into account when the results for TSL in enamel only are considered.

As in 1993 enamel opacities were measured using the Developmental Defects of Enamel (DDE) Index;[6] in 2003 the upper first premolars, canines and incisors of 12-year-olds were assessed for enamel opacities and other defects of enamel. In addition, for diffuse opacities only, symmetry of defects was recorded – allowing an estimation of defects that might be attributable to fluorosis. To investigate the severity of symmetrical diffuse enamel defects the present survey used a standardised index photograph from a previous study[9] to determine diffuse opacities with a TF score greater than two.

Questionnaires requesting background data on children's oral hygiene and dental care were sent to the parents of a random subsample of 5,480 examined children. In total, 3,342 questionnaires were returned – a response rate of 61%.

Full details of sampling, response, examination protocols and statistical methods can be found elsewhere.[11] In view of the complexity of the sampling design and resultant weighting procedures, sampling errors were quantified using the statistics programme STATA, and were calculated using a design factor (deft) to take account of the complex sampling and weighting procedures. The statistical significances of differences in means and percentages between sub groups were tested by calculating the confidence interval for the differences observed, based on the standard errors calculated using the design factor. This ensured that sampling error was taken into account in the testing procedure. Where statistically significant differences between groups are reported, the 5% threshold ($p < 0.05$) was used.

RESULTS

Accidental damage to teeth

Table 1 shows the proportion of children with accidental damage to their permanent incisors by age and gender. The proportions of children damaging their permanent incisors increased with increasing age from 5% at age eight to 13% by age 15. Within each age group more boys suffered damage than girls. This reflected the pattern seen in previous surveys.

Table 1 Proportion of children with any accidental damage to the incisors by age, sex in the United Kingdom (1983, 1993, 2003)

Age	United Kingdom		
	1983	1993	2003
	Percentage of children		
Boys			
8	12	6	6
12	29	25	14
15	33	21	16
Girls			
8	7	5	4
12	16	9	8
15	19	12	10
All children			
8	10	6	5
12	23	17	11
15	26	17	13

Table 2 Rate of different types of accidental damage by age (United Kingdom, 2003)

Age	8		12		15		8		12		15	
Year	1993	2003	1993	2003	1993	2003	1993	2003	1993	2003	1993	2003
	Rate per 1000 incisors						Rate per 1000 per central incisors					
Discolouration	0.2	0.2	0.8	0.7	2.1	1.5	0.6	0.5	2.0	2.3	6.2	3.6
Fracture (enamel)	5.4	4.1	16.8	10.0	11.6	10.2	12.0	10.7	45.7	27.7	32.4	27.6
Fracture (enamel and dentine)	3.4	2.0	5.9	2.9	5.0	2.6	8.6	6.5	8.7	7.9	14.7	5.9
Fracture (involving pulp)	0.1	*	0.5	0.1	0.3	0.1	0.3	-	0.7	0.2	0.9	0.4
Missing due to trauma	0.1	-	1.1	0.1	0.4	0.2	0.3	-	3.0	0.4	1.8	0.1
Acid etch composite	1.4	1.3	5.3	3.4	7.4	4.1	4.3	4.8	19.3	11.8	24.9	12.8
Permanent replacement	-	0.1	0.5	0.2	2.0	1.3	-	0.4	2.0	0.8	7.1	4.7
Temporary restoration	-	-	-	*	0.4	-	-	-	-	*	1.7	-

Since 1983, the proportion of children with trauma has decreased by at least half in all age groups. In the last decade the decline has been most pronounced among 12-year-old boys, with a reduction in the proportion having accidental damage from 25% in 1993 to 14% in 2003.

The types of accidental damage and the treatment provided are shown in Table 2. When considering types of damage and treatment to teeth in this survey it is important to remember that an individual tooth is counted only once. For example, a tooth that has been lost due to trauma and replaced would only be recorded under the 'permanent replacement category' not as 'missing due to trauma'. Untreated fractures involving enamel only were the most common trauma-related finding for all age groups. The prevalence, for all incisors, rose from 4.1 per thousand incisors at age eight to 10.2 per thousand incisors at age 15.

Upper central incisors are the teeth most likely to sustain damage and the higher rates of accidental damage reflect this. However, it is not surprising to note that the trend for central incisors alone was similar to that for all incisors. The prevalence of enamel fractures in upper incisors was 10.7 per thousand at age eight rising to 27.6 per thousand at age 12, a substantial decrease since 1993 when the prevalence was 45.7 per thousand upper central incisors at age 12. Similarly the proportion of incisors sustaining fractures of enamel and dentine has decreased; for example, 5.9 per thousand central incisors at age 15 in 2003 compared with 14.7 per thousand in 1993. Similar, although smaller, decreases in enamel dentine fractures were seen for the other age groups.

Acid etch retained composite restorations were the most commonly seen treatment with 4.8 per thousand central incisors being restored in this way at age eight rising to 12.8 per thousand at age fifteen. With the exception of eight-year-olds, where slightly more restorations were provided to central incisors, there are fewer restorations per thousand central incisors than in 1993. At age eight years there are more central incisors with dentine enamel fractures (6.5 per thousand) than there are acid etch retained composite restorations (4.8 per thousand). From Figure 1 it can be seen that the majority of fractured incisors remain untreated, although the percentage that are treated rises with age from 18% at age eight to 27% at age 15. At age eight the proportion of treated incisors has risen slightly in 2003; from 13% in 1993 to 18% in 2003. There is no statistically significant change since 1993 among 12 and 15-year-olds.

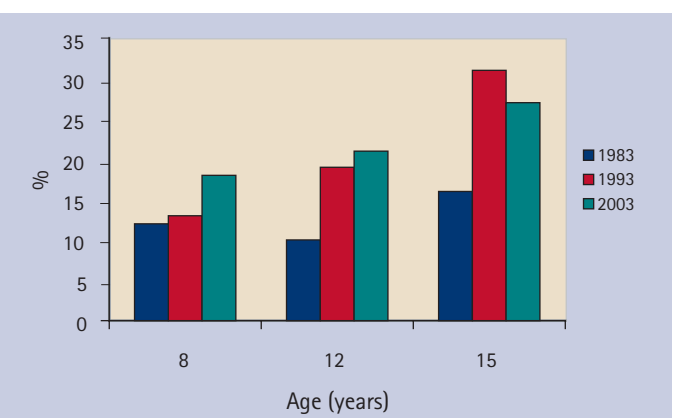

Fig. 1 The proportion of accidental damage to the incisors which had been treated (1983, 1993, 2003)

Table 3 Proportion of five year old children with tooth surface loss (TSL) on the surfaces of the primary incisors (United Kingdom, 1993, 2003)

	Any TSL	Into dentine or pulp
	Percentage of children with TSL on:	
Incisors		
Buccal surfaces		
1993	18	1
2003	20	3
Palatal surfaces		
1993	52	24
2003	53	22

Table 4 Proportion of children aged eight, 12 and 15 with tooth surface loss on the surfaces of the permanent incisors and first permanent molars by depth of tooth surface loss (United Kingdom, 1993, 2003)

	Age					
	8		12		15	
	1993	2003	1993	2003	1993	2003
	Percentage of children:					
Incisors						
Buccal surfaces						
Any TSL	4	4	9	12	12	14
Into dentine or pulp	*	*	*	*	*	*
Palatal surfaces						
Any TSL	11	14	27	30	27	33
Into dentine or pulp	*	1	1	3	2	5
Molars						
Any TSL	n/a	10	n/a	19	n/a	22
Into dentine or pulp	n/a	*	n/a	2	n/a	4
Weighted base	1694	2599	1502	2689	1129	2556

Table 5 Proportion of 12-year-olds with enamel opacities and other defects of the tooth enamel (United Kingdom, 1993, 2003, upper incisors and premolars)

	Country							
	England		Wales		Northern Ireland		United Kingdom	
	1993	2003	1993	2003	1993	2003	1993	2003
	Percentage of children:							
Demarcated opacity	19	18	15	20	20	24	20	17
Diffuse opacity	20	18	15	9	7	11	19	16
Demarcated and diffuse opacity	3	3	2	2	4	2	3	3
Hypoplasia	1	2	1	1	1	2	1	2
Demarcated opacity and hypoplasia	1	*	1	*	-	1	1	*
Diffuse opacity and hypoplasia	1	1	-	*	-	1	1	1
All three defects	-	*	-	*	-	-	-	*
Other defects	-	-	-	-	-	-	-	-
Any of the above defects	36	35	27	29	27	33	36	34

Tooth surface loss

Table 3 shows that there has been little change in the proportion of five-year-olds with TSL, either buccally or palatally since the last survey. As in 1993 palatal TSL was more common with over half (53%) of five-year-olds affected while 22% of children had TSL in dentine or pulp on palatal incisal surfaces.

Table 4 shows that TSL of permanent incisors was both less common and less severe than that of primary incisors. As in primary teeth, a higher proportion of children have TSL on the palatal surfaces than the buccal surfaces. TSL increased with increasing age from 4% on the buccal surfaces at age eight to 14% at age 15. A similar trend emerges for palatal surfaces with 14% and 33% of children with TSL at ages eight and 15 respectively. As this is an irreversible condition the trend with increasing age is not surprising.

With the exception of buccal TSL in eight-year-olds, there has been an increase in the proportion of children with TSL in all age groups on both surfaces since 1993. The most obvious is among 15-year-olds where there has been a statistically significant six percentage point increase in the prevalence of TSL palatally. However, most of the TSL was fairly mild; in 2003 and in 1993 very little was seen in dentine or pulp. The proportion of children with TSL on the occlusal surface of the first permanent molars increased in each age cohort with 10%, 19% and 22% affected at age eight, 12 and 15 years respectively. However, few children had TSL into dentine or pulp, reflecting the trend seen in the incisor teeth.

Enamel opacities

Table 5 shows that overall, just over one third (34%) of the children who were examined had one or more enamel opacity compared with 36% in 1993. As in 1993, the most prevalent defects were demarcated and diffuse opacities: 17% and 16% of 12-year-olds respectively had these on one or more teeth. In 3% of 12-year-olds, one or more tooth exhibited both demarcated and diffuse opacities. Hypoplasia affected few 12-year-olds with 2% having hypoplasia alone and 1% hypoplasia in combination with diffuse opacities. Compared with the 1993 survey the proportion of 12-year-olds in the United Kingdom presenting with enamel defects has decreased slightly.

More 12-year-olds in England (35%) had enamel opacities than in either Wales (29%) or Northern Ireland (33%) but the differences were not significant. Children in Northern Ireland and Wales were most likely to exhibit demarcated opacities (24% and 20%) while among English children both demarcated opacities and diffuse opacities were common (18%).

Table 6 details the symmetry of diffuse defects. Among the 20% of 12-year-olds who presented with diffuse enamel defects (alone and in combination) almost two thirds (65%) were symmetrical. The proportion of children with symmetrical defects was highest in England, at 66%, with Wales and Northern Ireland having lower levels of 48% and 46% respectively. Only 1% of 12-year-olds were found to have symmetrical diffuse defects at a level considered to cause aesthetic concern by reference to a standardised photograph (10% of those with diffuse symmetrical defects).

While the children were not asked about their opacities at the time of the examination, questionnaire data were available for a

Table 6 Diffuse enamel defects (United Kingdom, 2003, 12-year-olds).

	England	Wales	Northern Ireland	United Kingdom
	%	%	%	%
Symmetry				
Not symmetrical	34	52	53	35
Symmetrical	66	48	46	65
Base (100% of children with defect)	272	54	60	409
Severity				
Similar or less severe than photo	89	[98]	[93]	90
More severe than photo	11	[2]	[6]	10
Base (100% of children with defect)	179	28	26	248

[ ] Caution low base number of respondents - results are indicative only

Table 7 Different types of enamel opacities by parental report of marks on teeth that won't brush off (United Kingdom, 2003, 12-year-olds)

	Parental report of marks on teeth that don't rub off		Parental report of whether the marks bother their child		
	Yes	No	Yes	No	Don't know
	Percentage of children:				
Demarcated opacity	26	15	28	27	11
Diffuse opacity	33	13	44	29	18
Demarcated and diffuse opacity	9	2	4	9	18
Any enamel opacity	61	28	72	59	42
Base	113	685	38	63	10

total of 798 12-year-olds whose parents answered the question 'Does your child have any marks on his or her teeth which won't brush off?' The results are presented in Table 7. A total of 113 parents reported that their children had marks that could not be removed; of these 61% of the children had opacities of some type on one or more of their teeth at examination. However, there were also 685 parents who reported that their children did not have marks on their teeth but in 28% of cases the children were found to have one or more opacity at examination.

Parents who responded positively to the first question were also asked if the marks bothered them or their child. Of those parents reporting that the marks were of concern to their child, 72% of their children did have one or more opacity; for those reporting that the marks were of no concern to their child, 59% had an opacity.

DISCUSSION

Accidental damage to teeth

While it is pleasing to note the continuing downward trend in accidental damage to incisors at all ages, the reasons for this are not entirely clear. A reduction in sporting injuries may reflect better protection but it may also reflect lower levels of involvement in contact or other activities (such as cycling and outdoor play). One could be seen as a health success, the other a health concern. Sporting injuries are the easiest to prevent with the provision of mouthguards for contact sports[13,14] and while data on their use in the UK are not available, their use in schools is now widely encouraged. Dental practitioners have an important role in this regard and should continue to recommend them proactively to patients participating in contact sports.

Given the decrease in the proportion of children sustaining dental trauma it is disappointing to find that between 82% and 73% of traumatised incisors remain untreated. Although there were fewer dentine and enamel fractures in 2003, with the exception of central incisors in eight-year-olds, there were also fewer acid etch restorations placed. The low treatment figures for incisors with accidental damage in part reflect the fact that most injuries are minor enamel fractures, which do not always require treatment. However, some of the untreated teeth have enamel and dentine fractures. This is important as there is evidence that failure to protect exposed dentine in traumatised incisors is one factor that can predispose to pulp death.[1,15] It is not clear whether dentists choose not to treat some fractured incisors or whether parents fail to seek treatment for their children; appropriate education for both groups is required.

Tooth surface loss

Despite the difficulty in calibrating examiners and the relatively low levels of agreement between examiners in the identification of enamel TSL, a cautious evaluation of trends since 1993 is not unreasonable, as criteria have remained the same, apart from the inclusion of first permanent molar teeth. TSL into dentine and dental pulp are much easier to identify and it is possible to obtain good agreement between examiners for this level of tooth involvement. More severe TSL may require treatment and therefore has clinical implications.

There was a statistically significant increase in TSL on the palatal surface of incisors at age 15 and overall these results suggest an increasing trend in UK children, particularly in permanent teeth, which supports other reports.[4,5] While the upward trend is less marked for primary teeth, data from the National Diet and Nutrition Survey of children aged 1½ to 4½[16] show that the effects are evident early in life, with 9% of children aged 1½ already showing palatal TSL on central incisors. To date, most surveys of TSL have been cross-sectional, and it is not clear if children who have TSL in their primary dentition are more likely to present with marked TSL in the permanent dentition, but it would seem reasonable to assume that this may be the case until there is evidence to the contrary.

TSL has a multifactoral aetiology, but erosion is the major contributor in children.[17-19] The effects of gastric acid cannot be discounted[20,21] but there is evidence to suggest that the consumption of fruit drinks, squashes and carbonated beverages play a major role.[19,22] Not all children with TSL have a high consumption of acidic beverages[19] so the prevention of this problem needs to be broader based than diet advice alone. The importance of tooth wear to the child population is not the costly interventions that are often associated with tooth wear in adults – as we have seen, few children get to the stage of extensive dentine exposure and operative intervention in childhood is rare. The importance is that the condition is irreversible and unless the causes are addressed it may continue unchecked into adulthood. However, the progression of tooth wear throughout life has not been documented. Effective detection, prevention and early intervention are important if an adult lifetime of complex restorative treatment is to be avoided[23] and these are the cornerstones of the management of TSL in children. Enamel is designed to last a lifetime, so if much of it has disappeared on exposed tooth surfaces by adolescence, the long term implications could be serious. The data presented here show that this is not a rare phenomenon, and it is the general dental practitioner who has the pivotal role in the detection and prevention of tooth wear.

Enamel opacities

Overall there has been no change in the proportion of children presenting with enamel opacities. Dental appearance is one factor contributing to self-perceived body image.[24] One study in a non-fluoridated community reported that teenagers expressed aesthetic concerns with TF scores greater than 3.[9] A TF score of 3 was also the point at which some of 3,000 observers in Australia, began to find teeth unattractive.[25] This is the threshold used in the current survey, where 20% of 12-year-olds were judged to have diffuse opacities alone or in combination with other defects. Of those, 65% were symmetrical and 10% were judged to be above the threshold level. Overall, severe defects of a type possibly attributable to fluorosis were not seen commonly in this survey (1% of examined 12-year-olds). There is no evidence to suggest that such defects are increasing, infact there has been a slight, although not significant, decrease in the proportion of children presenting with diffuse defects in the past 10 years (1993: 23%, 2003: 20%). Unfortunately the sample structure does not allow the impact of living in a fluoridated area to be established.

This paper has identified the prevalence of three non-carious tooth conditions and shown that while the prevalence of traumatic injuries has declined, the proportion of children with enamel opacities has remained constant since 1993 and there is a suggestion that the prevalence of TSL may have increased slightly. The dental profession has a role to play in the monitoring and treatment of these conditions.

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