BRIEF COMMUNICATION

An epidemiological comparison of Dean's index and the Developmental Defects of Enamel (DDE) index

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Abstract

Objectives: To compare the Dean's and DDE indices in examining dental fluorosis and diffuse opacities.
Methods: Survey of a random sample of 9-year-old children in Southland, New Zealand. Dental fluorosis was measured using Dean's index. Enamel defects were recorded using the DDE index.
Results: A total of 436 children (74.5 percent) were examined: 24.1 percent had diffuse opacities, and 10.8 percent of children had fluorosis ($P < 0.001$). At tooth level (using the score for the same tooth), the indices were more similar, but 9 percent of the 33 with diffuse opacities showed no visible signs of fluorosis.
Conclusions: We found relatively little concordance between the DDE and Dean's indices in determining person prevalence of defects among children. At the tooth level, concordance between the two was greater, and suggests that little may be lost in fluorosis studies which use the DDE index, particularly as it enables collection of a wider and more comprehensive range of information. Although the use of Dean's index is important for historical comparisons, investigators should appreciate its limitations.

Introduction

Direct comparisons of the findings of population surveys of enamel defects (including fluorosis) have been complicated by the use of different classifications and indices. The latter can be divided into: a) specific fluorosis indices, which identify and categorize only dental fluorosis; and b) descriptive indices, which make no etiological assumption with respect to the defect (1). The Dean (2), Thylstrup and Fejerskov, and TSIF (3) indices are the most commonly used fluorosis indices; they require a diagnosis of fluorosis be made at the clinical examination (3). Of the descriptive indices, the Al-Alousi *et al.* (4) and the Developmental Defects of Enamel (DDE) indices (5) are the most commonly used; both record all defects in enamel, based on the premise that etiology should not be presumed.

The most commonly used fluorosis index is Dean's index (2). However, it has been criticized by various investigators (1,3,6). For example, each individual receives a score corresponding to the clinical appearance of the second most severely affected tooth in the mouth, meaning that it is not able to give sufficient information on the distribution of dental fluorosis within the dentition, and isolated defects are not recorded. The distinctions among some of the other diagnostic categories have been described as unclear, imprecise, or lacking sensitivity (3). Moreover, Dean's scores are ordinal (not continuous), yet using the scale involves averaging those scores, which is inappropriate. Despite these criticisms, Dean's index continues to be widely used, and its continued use is important for historical comparisons. The DDE index allows recording of a broad range of defects, with no ascribing of etiology. Defects are categorized as demarcated opacities, diffuse opacities, or hypoplasia (or combinations thereof). Such a descriptive classification may be more appropriate than a fluorosis–specific index because it enables determination of the overall prevalence

of defects (as it records both non-fluoride and fluoride-induced defects), and it does not require non-fluoride defects to be excluded (which can be a difficult decision) (1). However, it is relatively complex and can be time-consuming to apply, especially when a number of defects are present.

Diffuse opacities of enamel are the feature distinguishing the teeth of children in fluoridated and non-fluoridated areas (7,8). Unfortunately, the characteristics of dental fluorosis are not unique: a large number of possible causes have been proposed (6), and there is also the possibility that some opacities may be idiopathic. This implies that, while fluoride-induced lesions are usually found within the diffuse opacities type, not all diffuse opacities may necessarily be caused by fluoride. No studies have directly compared findings using the DDE index and Dean's index, although direct comparison has been made of the TF index and the DDE index, with good agreement reported (9).

The aim of this study was to compare the Dean's and the DDE indices in examining dental fluorosis and diffuse opacities among 9-year-old New Zealand children.

Methods

Ethical approval was obtained from the Southland Ethics Committee for this cross-sectional study of 9-year-old children. A simple random sample of 600 children was drawn from Year–5 children enrolled with the Southland school dental service, and parents were contacted by mail in September 2002. The sample has been shown to be largely representative of the source population (10). To ascertain each child's residential fluoride exposure, the responding parent was asked to indicate where the child had lived each year from birth to age 9. This enabled allocation of each child to one of three residential fluoride exposure categories: "Continuous" residents had lived in a fluoridated community from birth to the date of the survey; those who had lived all of their lives in non–fluoridated communities were allocated to the "no exposure" category; and all others were categorized as "intermittent."

After the single examiner (TDM) was calibrated by two experienced dental epidemiologists, standardized clinical examinations took place in schools during October–November 2002. The teeth were examined visually utilizing portable lighting, dental mirror and with a blunt probe (to detect surface changes in the enamel). The teeth were not dried or cleaned. The Dean's and DDE indices recorded dental fluorosis and enamel defects, respectively. The second most severely affected tooth was recorded for the former, and the labial surfaces of ten 10 index teeth (all teeth from the upper right first premolar to the upper left first premolar, and the two first mandibular molars) for the latter. Digital images of the children's anterior teeth were taken to allow later confirmation of the diagnoses of dental fluorosis and enamel defects with an experienced epidemiologist (WMT). Bivariate associations were tested for statistical significance using the chi-square test, and the kappa statistic was used to examine concordance.

Results

At least one tooth with an enamel defect was found in 51.6 percent of the 436 children examined, and there were no sex differences (Table 1). Demarcated opacities were the most common type, with hypoplastic lesions the least common. With Dean's index, 89.2 percent of children had no fluorosis; 6.7 percent were categorized as very mild or mild, and the remainder (4.1 percent) had moderate fluorosis. There were

Table 1 Prevalence of enamel defects using the DDE index, by sex and residential water fluoride exposure (percentages in brackets)

	Sex of child		Residential water fluoride exposure			
	Male	Female	None	Intermittent	Continuous	Entire sample
Entire sample	224 (51.4)	212 (48.6)	183 (42.0)	116 (26.6)	137 (31.4)	436 (100.0)
DDE index defect category						
Demarcated opacity	90 (40.2)	79 (37.3)	70 (38.3)	47 (40.5)	52 (38.0)	169 (38.8)
Diffuse opacity	47 (21.0)	58 (27.4)	30 (16.4)	33 (28.4)	42 (30.7)*	105 (24.1)
Hypoplastic defect	14 (6.3)	10 (4.7)	7 (3.8)	9 (7.8)	8 (5.8)	24 (5.5)
Any defect†	115 (51.3)	110 (51.9)	83 (45.4)	63 (54.3)	79 (57.7)	225 (51.6)†
Dean's index category						
No fluorosis	197 (87.9)	192 (90.6)	181 (98.9)	100 (86.2)	108 (78.8)*	389 (89.2)
Very mild	4 (1.8)	8 (3.8)	0 (0.0)	4 (3.4)	8 (5.8)	12 (2.8)
Mild	12 (5.4)	2 (2.4)	1 (0.5)	6 (5.2)	10 (7.3)	17 (3.9)
Moderate	11 (4.9)	7 (3.3)	1 (0.5)	6 (5.2)	11 (8.0)	18 (4.1)
Any fluorosis	27 (12.1)	17 (9.4)	2 (1.1)	16 (13.8)	29 (21.2)	47 (10.8)

* $P < 0.05$; cross-tabulations done separately for each DDE index category, but together for the Dean's Index categories.

† Numbers do not correspond exactly because some children had teeth with more than one defect: 14 children had at least one tooth with diffuse opacities and a demarcated opacity, and 2 children had at least one tooth with diffuse opacities and a hypoplastic defect.

Table 2 Dean's index category by DDE index category for the same tooth used by both indices*

	Dean's index category				
	No fluorosis	Very mild	Mild	Moderate	All combined
DDE index category					
No defect	374 (99.5)	0 (0.0)	1 (0.3)	1 (0.3)	375
Demarcated opacity	4 (21.2)	5 (26.3)	5 (26.3)	5 (26.3)	19
Diffuse opacity	3 (9.1)	7 (21.2)	11 (33.3)	12 (36.4)	33
Hypoplastic defect	8 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	8
All combined	399	12	17	18	

* Total number exceeds 436 because of defect combinations recorded: 14 children had at least one tooth with diffuse opacities and a demarcated opacity, and 2 children had at least one tooth with diffuse opacities and a hypoplastic defect.

gradients apparent by residential water fluoride exposure for diffuse opacities and for fluorosis.

Crosstabulation of the presence (at the child level) of any fluorosis (10.8 percent) with any DDE defect (51.6 percent) revealed a significant association ($\chi^2 = 169.3$; d.f. = 1; $P < 0.001$) and gave a kappa value of 0.20. Repeating this for the diffuse opacities only (10.8 and 24.1 percent, respectively) also revealed a significant association ($\chi^2 = 26.8$; d.f. = 1; $P < 0.001$) and gave a kappa value of 0.38. For the latter, the sensitivity was 20.9 percent, while the specificity was 100.0 percent. The predictive value positive was 100.0 percent, and the predictive value negative was 54.2 percent, indicating that all of those identified as fluorosis cases had diffuse opacities, but just over half of those with diffuse opacities were identified as fluorosis cases.

The scores for Dean's and DDE indices were crosstabulated using the score for the same tooth (that is, the DDE score for the same tooth which was scored for the Dean's index). Of the 376 children with no enamel defect, nearly all had no fluorosis (Table 2). The percentage with one or more demarcated opacities was similar across the three categories of Dean's index. None of the children with hypoplastic enamel defects had fluorosis. About 9 percent of the 33 children with diffuse opacities showed no visible signs of fluorosis, and the remainder had very mild or moderate fluorosis. Of the 47 children identified by Dean's index as having fluorosis, 30 (63.8 percent) had diffuse opacities.

Discussion

This study compared the DDE and Dean's indices in a survey of enamel defects among 9-year-old New Zealand children. It found that the two indices differ markedly in their overall prevalence estimates, with just over half of the examined children determined by using the DDE to have one or more enamel defects, but about 1 in 10 determined using Dean's index to have fluorosis. At the level of the second-most affected tooth – that which is scored for Dean's index – the prevalence of diffuse opacities corresponded quite closely to the prevalence of dental fluorosis.

The "yields" from the two indices clearly differed: at child level, the fluorosis prevalence estimates determined with Dean's index were markedly lower than those for either any defect or diffuse opacities determined using the DDE index. The relatively low concordance was reflected in the kappa values and the low sensitivity. At the individual tooth level, the difference was less marked, with diffuse opacities showing a consistent and biologically plausible gradient across the Dean's index categories (Table 2). That was to be expected, as diffuse opacities correspond closely to the milder fluoride-associated defects (2,3), and each type showed the expected prevalence gradient across the water fluoridation exposure categories. The magnitude of the difference in prevalence estimates is of concern, however, and reflects the philosophical difference underlying the etiological and descriptive indices (1). Diffuse opacities are the point of difference between fluoridated and non-fluoridated areas where fluoride levels are optimal (7,8). In the present study, however, the prevalence of diffuse opacities was more than double that of "Deans–determined" dental fluorosis. Part of this difference may be explained by the fact that, when recording Dean's index, a score for fluorosis was recorded only if the typical bilateral distribution pattern (11) was noted. As pointed out by Cutress and Suckling (11), the differential diagnosis of fluorosis calls for "discrimination between symmetrical and asymmetrical patterns of opacities." This is based upon the important facts of (1) synchronicity of development of homologous teeth and (2) the critical plasma concentration during enamel development being the same for each pair of teeth: for a given opacity to be considered to be fluorosis, it must be able to be observed on homologous teeth; otherwise, it is not fluorosis and must either be idiopathic or have a local cause. By contrast, each individual diffuse opacity was scored for the DDE index, even if only one tooth was affected. Cutress *et al.* (7) stated that the diagnosis of defects for individual participants is extremely difficult, especially in low-

fluoride areas, and that any classification, whether it is to measure fluoride or non-fluoride defects, should be based solely on descriptive criteria without any etiological assumptions. Our data tend to support this assertion.

In conclusion, this study has found little concordance between the DDE and Dean's indices in determining person-level defect prevalence in a group of New Zealand 9-year-old children. At the tooth level, the high proportion of teeth with diffuse opacities which had dental fluorosis was greater. This suggests that little may be lost in fluorosis studies which use the DDE index, particularly as it enables collection of a wider and more comprehensive range of information than Dean's index does. Although the use of Dean's index is important for historical comparisons, investigators should appreciate its limitations.

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