Dental Fluorosis: Epidemiological Aspects

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Contents

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Learning Objectives
- Understand aetiology and clinical appearance of dental fluorosis
- Understand historical trend of dental fluorosis
- Familiarise with main indices of dental fluorosis
- Understand impact of dental fluorosis

7.1 Introduction

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The use of fluorides for oral health has always involved a balance between the protective benefit against dental caries and the risk of developing fluorosis. The association between fluoride and dental health was established as a result of determining the causes of dental fluorosis (enamel mottling). However, it was the benefit of the exposure to fluoride from between 0.7 and 1.2 ppm in public water supplies for the prevention of dental caries that soon became the dominant public health policy. It has been recognised that there is a level of exposure to fluoride that is associated with near-maximal reduction in caries experience with minimal risk of fluorosis (see Fig. 7.1). Establishing that level of exposure has always been a primary goal of population oral health research.

In the population, dental fluorosis serves as the "canary in the coal mine", alerting both members of the public and public health authorities to potential overexposure to sources of fluoride. With the onset of fluoridation and fast expansion of fluoridated toothpaste use in the 1960s and 1970s, the improvement in dental health that followed fluoridation blunted attention or interest in the low prevalence of fluorosis. However, as the prevalence of fluorosis increased during the 1980s, research began to focus on fluorosis again. Hence, it is important to understand epidemiological aspects of dental fluorosis.

7.1.1 Aetiology and Clinical Appearance of Dental Fluorosis

Dental fluorosis is a developmental defect in tooth enamel that is caused by excessive exposure to fluoride during the enamel formation period [1]. Dental fluorosis is the most common adverse effect of fluoride use in prevention of dental caries [2, 3]. Fluoride is considered a necessary factor in the aetiology of fluorosis. However, the presence of fluoride may have an effect only during the tooth development stage. Several authors considered a specific "window" period during enamel development as critical for fluorosis to occur [4, 5]. Other authors suggested that the duration of fluoride exposure during the amelogenesis, rather than specific risk periods, would have more impact on the aetiology of dental fluorosis [6, 7]. However, there was general agreement that exposure during the post-secretory or early maturation period of enamel development may pose a higher risk for fluorosis.

Fluorosed enamel is histologically characterised by hypocalcification and subsurface porosity [8, 9]. Clinically, fluorosis varies from barely visible white striations on the tooth surface to staining and pitting of enamel [1]. In the mild form, the structural arrangement of the crystals in the outer layer of enamel is microscop-

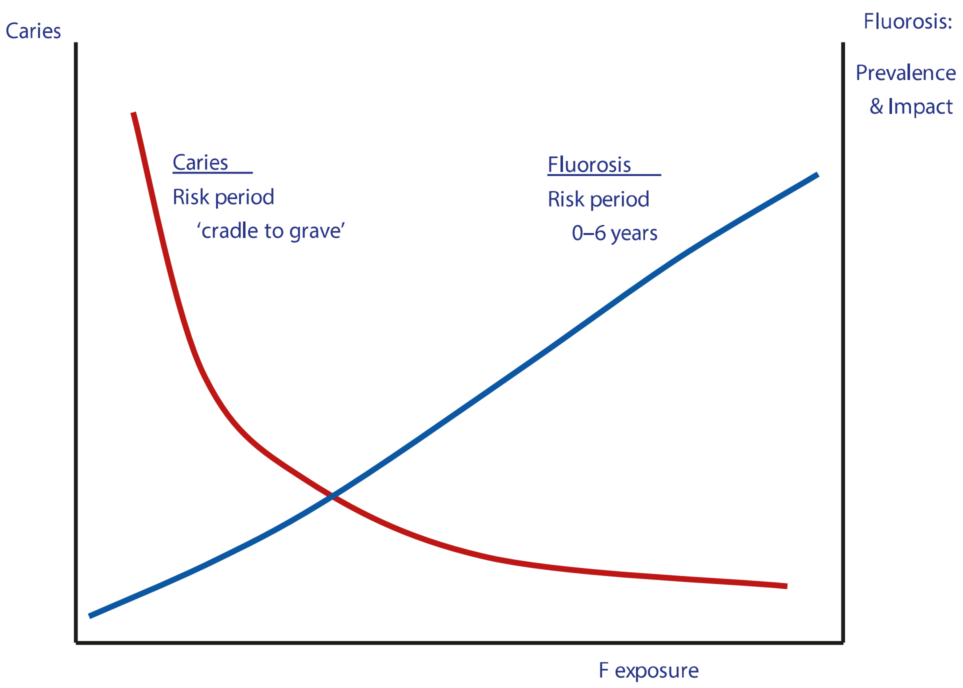

Fig. 7.1 Schematic description of the relationship between fluoride exposure, dental caries and fluorosis

ically normal but is more porous, i.e. the intercrystalline space is larger than normal. The degree and extent of porosity characterise the clinical appearance of fluorotic enamel, and it depends on the concentration of fluoride in the tissue fluids during the tooth development [1].

The mild form of fluorosis appears as white lines along the perikymata, which may merge to form irregular areas. With increasing severity, the affected area is larger and can cover the whole surface of the tooth. Severe fluorosis may be characterised with brownish staining and even minute pitting on the enamel surface. These features are mostly posteruptive changes [1].

Mild fluorotic lesions often affect the whole tooth surface and may be more visible on or near the tip of cusps/incisal edges. The fluorotic lesion is a diffuse discolouration without clear demarcation with normal enamel. Fluorotic teeth erupt with an opaque white colour, or even chalky appearance. Another typical characteristic is that fluorosis always affects homologous pairs of teeth. These characteristics are used to differentiate mild forms of fluorosis from non-fluorotic lesions.

The mechanism underlying the development of enamel fluorosis has not been fully understood. There is general agreement that fluorotic enamel is formed during the period of enamel development. Fluoride is thought to affect the enamel formation process causing enamel porosity [2]. There is a clear linear relationship between fluoride exposure and severity of fluorosis. Despite extensive literature concerning the mechanism which leads to dental fluorosis, there are still unanswered questions. The most accepted concept is that the fluoride ion affects the early maturation phase by causing retention of intact and degraded proteins [4, 10]. Proteins, mainly amelogenins, are not completely removed from the enamel organ. The retention of proteins may explain the incomplete crystal growth that is observed in fluorotic enamel. Enamel developed under that condition may be characterised by greater intercrystalline space and hence is more porous.

7.1.2 Historical Trend of Dental Fluorosis

Dean [11] stated that some 12.2% of children living in areas with the optimal level of fluoride (1 ppm) had mild or very mild fluorosis. This percentage was around 1% in children from areas with negligible levels of fluoride in water. These data were collected when water was the only source of fluoride. They have served as the standard for the balance between the protective effect against caries and the risk of having fluorosis in population water fluoridation.

There have been dramatic changes in the second-half of the last century when fluoride was introduced in other forms. Water ceased to be the only source of fluoride. Studies around the world repeatedly reported a significant increase in the prevalence and severity of fluorosis among children.

A series of studies examining the prevalence of fluorosis reported an increase in the prevalence of fluorosis in both fluoridated and non-fluoridated areas in North America [12–18]. Although these studies employed different scoring methods, it was widely accepted that the prevalence and severity of fluorosis was on a sharp increase from the 1970s. The studies also provided evidence of a greater increase in fluorosis in non-fluoridated areas [16, 19]. The prevalence of fluorosis ranged from 4.4% to 55.0% in non-fluoridated areas and from 11.4% to 80.9% in fluoridated areas, with the majority of changes observed in the milder forms of the conditions [20]. The prevalence of fluorosis reported in European countries had a similar trend [21–24].

Rozier [25] reviewing studies of dental fluorosis in North American children pointed out an increase in the prevalence of fluorosis. The increasing trend was sharper in non-fluoridated areas, whereas the trend was less clear in fluoridated areas. The majority of fluorosis cases were mild, with around 1.3% of the US child population with moderate-to-severe fluorosis. The author suggested that individual behaviours were the main contributing factors to the increase in the prevalence of fluorosis.

Australia has seen a sharp increase in the prevalence of dental fluorosis in the 1980s–1990s [26, 27]. This trend was attributed to discretionary fluoride sources such as fluoride in infant formula powder, fluoride supplements and fluoride toothpaste [28–30]. Reduction in such fluoride sources has led to reduction in the prevalence and severity of dental fluorosis [31, 32]. The recent large population-based National Child Oral Health Study (NCOHS 2012–2014) reported that fluorosis in Australia children was predominantly very mild to mild (▣ Table 7.1). The prevalence of moderate-to-severe fluorosis (TF score of 4 or higher) was 0.1% in both fluoridated and non-fluoridated areas. It is important to note that around 80% of the Australian children lived in fluoridated areas, and low concentration fluoridated toothpaste was used by the majority of the children. Such finding indicates significant role of fluoridated toothpaste in development of dental fluorosis, similar to findings reported by other studies [33, 34]. Some other small studies in a number of European countries reported varying prevalence of dental fluorosis using the TF Index. The prevalence of fluorosis at the TF score of 3+ was mostly low in both fluoridated and non-fluoridated areas. Studies in the USA using the Dean Index also reported low prevalence of moderate-to-severe fluorosis. The New Zealand National Oral Health Survey also reported low prevalence of moderate-to-severe fluorosis in both fluoridated and non-fluoridated areas.

Table 7.1 Prevalence and severity of dental fluorosis measured by the TF or the Dean Index in different regions

Study/year	Location (sample size)	Fluoridation status	Fluorosis severity, % (95% CI)[a]		
Data using the TF Index			*TF 1*	*TF 2*	*TF 3+*
Do and Spencer 2012–2014	Australia (10,369)	F	14.4 (12.9–15.8)	5.1 (4.4–5.8)	1.1 (0.9–1.4)
Do and Spencer 2012–2014	Australia (5228)	NF	5.6 (4.7–6.5)	2.2 (1.7–2.7)	0.4 (0.2–0.5)
Pretty et al. [24] 2015	Manchester, UK (466)	NF	33	3	2
Pretty et al. [24] 2015	Liverpool, UK (473)	NF	30	3	2
Pretty et al. [24] 2015	Newcastle, UK (510)	F	42	11	9
Pretty et al. [24] 2015	Birmingham, UK (450)	F	39	11	2.8
Cochran et al. [47] 2002	Cork, Ireland (325)	F	59	26	4
Cochran et al. [47] 2002	Knowsley, UK (314)	NF	54	11	1
Cochran et al. [47] 2002	Oulu, Finland (315)	NF	61	21	0
Cochran et al. [47] 2002	Athens, Greece (283)	NF	48	5	0
Cochran et al. [47] 2002	Reykjavik, Iceland (296)	NF	51	16	1
Cochran et al. [47] 2002	Haarlem, Netherland (303)	NF	54	22	4
Cochran et al. [47] 2002	Almada/Setubal, Portugal, (210)	NF	43	7	1
Data using the Dean Index			*Very mild*	*Mild*	*Moderate/severe*
Beltran et al. [35] 1986–1987	US NIDR (NA)	Varied	17.2 (12.1–22.2)	4.1 (2.9–5.7)	1.3 (0.6–1.5)
Beltran et al. [35] 1999–1904	US NHANES (NA)	Varied	28.5 (25.8–32.3)	8.6 (7.0–10.3)	3.6 (2.5–4.5)
NZ MoH 2009	NZ (NA)	F	10.2 (5.5–16.9)	3.0 (0.8–7.6)	1.7 (0.3–5.5)
NZ MoH 2009	NZ (NA)	NF	10.3 (5.7–16.8)	7.8 (4.3–12.7)	2.3 (0.5–6.8)

[a]95% confident intervals of estimates. Not available in all studies

In general, the prevalence of dental fluorosis was on a sharp increase in the last three decades of the twentieth century. The increase was suggested to be a result of an introduction of numerous forms of fluoride available for children's use. The trend has reversed in countries and population where discretionary fluoride sources have been limited or eliminated.

7.1.3 Risk Factors for Dental Fluorosis

There is well-established agreement that dental fluorosis can occur only during the enamel development period. Therefore, any source of systemic fluoride available during the amelogenesis phase may pose a level of risk for the condition. Up to now, fluoride from water and beverages, fluoride supplements, dietary fluoride, fluoride toothpaste and the number of topical fluoride applications are known sources of fluoride that can be available systemically during the enamel formation period [3, 33, 36]. The evidence of these sources as risk for fluorosis will be considered below.

7.1.3.1 Fluoridated Water

Fluoridated water had been the first controlled source of fluoride in the fight against dental caries. While the caries-protective effect of water fluoridation has been well documented [37–40], fluoride from water has also been a known risk for fluorosis.

When Dean conducted his path-finding studies, there was a difference found in the prevalence of dental fluorosis between areas with varying levels of fluoride. Residence in an area where fluoride in the water supply was around 1 ppm carried significantly higher risk for fluorosis compared to residence in an area with a negligible level of fluoride in water. The prevalence of mild to very mild fluorosis was about 18-fold higher in the former area compared to the latter. However, risk of having fluorosis in an optimally fluoridated area is now only twice as high compared to a non-fluoridated area. This phenomenon can be explained by the universal availability of fluoride from numerous sources such as fluoride supplements, fluoride toothpaste and dental products. Also, the so-called "diffusion" effect can occur, in that residents in a non-fluoridated area can be exposed to fluoride in foods and beverages that are produced in a fluoridated area and transported for consumption into that non-fluoridated area.

A number of published studies investigated water fluoridation as a risk factor for fluorosis [14, 18, 29, 41–44]. Griffin and co-workers [45] investigated the risk of having aesthetically objectionable fluorosis that could be attributable to water fluoridation using the Dean Index and the anterior index (a modification of the Dean Index applied for use on anterior teeth only). Using the anterior index, fluoridation was a risk factor for very mild (attributable risk = 15%) and mild fluorosis (attributable risk = 3%). The risk of fluorosis (very mild or greater) attributable to fluoridation using the Dean Index was 24%. The authors concluded that approximately 2% of US schoolchildren might experience a perceived aesthetic problem related to dental fluorosis which could be attributed to water fluoridation. Do and Spencer, evaluating risk and benefit trade-off of exposure to water fluoridation among Australian children, estimated some 55% of cases of fluorosis with a TF score of 2 (very mild) or higher were attributed to early life exposure to fluoridated water [42]. The prevalence of more severe fluorosis (TF score of three or higher) was very low in that population.

7.1.3.2 Fluoride Toothpaste

One of the most popular sources of fluoride is fluoride toothpaste. Introduced in the 1970s, fluoride toothpastes consist of more than 90% of the toothpaste market in western countries [46]. Available in different forms and concentrations, fluoride toothpaste significantly contributes to the prevention of dental caries [47]. However, its use can be a risk factor for fluorosis as well [34]. Children can ingest an amount of fluoride from toothpaste that may well exceed the optimal daily intake [48, 49].

Recent studies reported a link between toothpaste and the prevalence and severity of fluorosis [30, 50]. Some studies found that early use of toothpaste was a risk factor for fluorosis [51, 52]. Another study reported higher frequency of brushing with toothpaste as a risk indicator for fluorosis [53].

Studies that calculated adjusted attributable risk also found factors linked to toothpaste use as risk factors for fluorosis. A study among Western Australian children living in a fluoridated area reported that 47% of fluorosis cases were attributed to swallowing toothpaste in infancy [27]. Another study [53] reported that 72% of fluorosis cases could be explained by commencement of tooth brushing in the first 2 years of life. Using more than a pea-sized amount of toothpaste more than once per day in a fluoridated population attributed to 46% of fluorosis cases, whereas brushing more than once per day in the first 2 years of life by children in non-fluoridated areas explained a third of fluorosis cases [30]. Do and Spencer estimated that using standard 1000-ppm toothpaste in early age and eating toothpaste attributed to over 60% of cases with fluorosis (TF score of 2 or higher) in Australian child population [42].

There are recommendations to reduce fluoride intake from fluoridated toothpaste by using a lower concentration of fluoride toothpaste and implementing stricter guidelines for its use [46]. Low concentration fluoride toothpaste is available for use in a number of countries including European nations and Australia. Its use was reportedly linked with a lower prevalence of fluorosis among children [31, 32].

7.1.3.3 Fluoride Supplements

Fluoride supplements have been used to prevent dental caries in children for more than half a century. They are available in the form of tablets, drops or lozenges. These supplements are recommended for children living in fluoride-deficient places. Dosage schemes are available to guide their use based on the age of the child and on the fluoride level of drinking water [54–56]. However, evidence is available that fluoride supplements are prescribed to children without taking into account the level of fluoride in drinking water [30]. Supplement use has been linked with low compliance with recommended dosage schedules [57].

Numerous studies identified fluoride supplement use as a risk factor for fluorosis both in fluoridated and fluoride-deficient areas [3, 33, 58]. Therefore, the risk of fluoride supplement use for having fluorosis is well confirmed. Recommendations were made to reduce the available dosage schedule [59] as well as eliminate fluoride supplement use in children [60]. These recommendations were incorporated into national guidelines for fluoride use [61, 62].

7.1.3.4 Fluoride from Foods

Children can be exposed to differing levels of fluoride available from their diet during the tooth formation period. Various foods have been found to contain varying amounts of fluoride [63–66]. Several infant foods were also found to have high levels of fluoride, such as mechanically processed chicken or food sources in a number of African populations [67, 68]. However, those sources of fluoride are not available to the general population in western countries.

In the last decade, infant formula was often found to have high levels of fluoride and could potentially be responsible for a certain proportion of fluorosis in children [30, 69]. In Australia before the 1990s, the fluoride content of milk-based formula ranged from 0.23 to 3.71 and for soy-based formula from 1.08 to 2.86 micrograms of fluoride in a gram of powder [70]. Infant formula was earlier considered a risk factor for fluorosis in but that has changed after manufacturers' reduction of fluoride level in formula powder [33, 71] [31, 41, 72].

7.1.4 The Measurement of Dental Fluorosis

7.1.4.1 Approaches in the Measurement of Fluorosis

Enamel fluorosis is a developmental defect of the tooth appearance. It is one of numerous discolourations observed on the tooth's enamel surface. Instruments available to record such developmental changes of enamel can be divided into descriptive and fluorosis-specific indices. The descriptive indices do not specifically diagnose fluorosis but rather describe the appearance of discolouration on the tooth surface. They include the Developmental Defects of Enamel (DDE) Index [73], Murray-Shaw Index [74] and Al-Alousi Index [75]. Among these indices, the DDE Index is the most commonly used. These indices, however, do not allow for estimation of the prevalence of dental fluorosis. Therefore, they are not relevant instruments for this study, which investigated fluoride-related development changes.

The fluorosis-specific indices initially diagnose dental fluorosis and then record it according to a range of severity levels. These indices are the Dean Index [11, 76], the Thylstrup and Fejerskov (TF) Index [77], the Tooth Surface Index of Fluorosis (TSIF) [78] and the Fluorosis Risk Index (FRI) [79]. These indices are more relevant to the epidemiological evaluation of dental fluorosis and will be discussed in more details.

7.1.4.2 Differential Diagnosis of Fluorosis

Clinical diagnosis of mild form of enamel fluorosis is often problematic owing to similarities in its appearance with other non-fluorotic enamel conditions [80]. In order to document the presence/absence of fluorosis in a person and/or an individual tooth, a differential diagnosis of the condition is required. The differential diagnosis is based on specific characteristics of fluorotic lesions such as bilateral symmetry, colour or shape of lesion. The criteria developed by Russell [80] and presented in ◘ Table 7.2 are the most widely accepted.

◘ **Table 7.2** Differential diagnostic criteria *for dental fluorosis* [80]

Characteristics	Dental fluorosis	Enamel opacities
Area affected	The entire tooth surfaces (all surfaces) often enhanced on or near tips of cusp/incisal edge	Usually centred in smooth surface of limited extent
Lesion shape	Resemble line shading in pencil sketch, which follow incremental lines in enamel (perikymata). Lines merging and cloudy appearance. At cusp/incisal edges formation of irregular white caps ("snow cap")	Round or oval
Demarcation	Diffuse distribution over the surface of varying intensity	Clearly differentiated from adjacent normal enamel
Colour	Opaque white lines or clouds; even chalky appearance. "Snow cap" at cusp/incisal edge. Some lesions may become brownish discoloured at mesio-incisal part of central upper incisors after eruption	White opaque or creamy-yellow to dark reddish-orange at time of eruption
Teeth affected	Always on homologous teeth. Early erupting teeth (incisors/first molars) least affected. Premolars and second molars (and third molars) most severely affected	Most common on labial surfaces of single or occasionally homologous teeth. Any teeth may be affected but mostly incisors

7.1.4.3 Fluorosis Indices Available

The Dean Index [76]

Dean had made a fundamental contribution to the assessment of dental fluorosis. While conducting his investigation of dental mottling, Dean recognised the value of a classification system for the clinical manifestation of the condition in answering several research questions. The questions to be addressed by Dean's efforts were aetiology and pathogenesis of dental fluorosis and its pattern in a population. Therefore, Dean developed a six-category index with the aim of describing the clinical manifestation of fluorosis and reflecting as closely as possible the biological effects of fluoride on tooth enamel. The description of the categories is shown in the ◘ Table 7.3.

This index has been a historically remarkable instrument in measuring fluorosis. It has been the most widely used index of fluorosis, especially in population descriptive studies. However, there are several limitations of the index that may affect its validity in relating fluorosis to sources of fluoride exposure and in risk assessment studies in light of the current knowledge of fluoride action. The index does not clearly identify histological characteristics of fluorotic enamel. It may incorrectly accept extrinsic discolouration as an indication of the severity of fluorosis. Also, the category "Questionable" is vaguely characterised. Therefore, diagnosis of fluorosis by the index may vary depending on the case definition chosen by investigators. On the other hand, as more severe fluorotic enamel is not classified in detail, its use may be limited where populations have more severe conditions.

The Thylstrup and Fejerskov (TF) Index [77]

The Thylstrup and Fejerskov (TF) Index assesses buccal surfaces of teeth using a 10-point scale (◘ Table 7.4). This index was designed in the late 1970s with the aim of

◘ **Table 7.3** The Dean Index

Category	Description
Normal	The enamel surface is smooth, glossy and usually a pale creamy-white colour
Questionable	The enamel shows slight aberrations from the translucency of normal enamel, which may range from a few white flecks to occasional spots. This classification is used where the classification "normal" is not justified
Very mild	Small opaque paper-white areas scattered irregularly over the tooth but involving less than 25% of the labial tooth surface
Mild	The white opacity of the enamel of the teeth is more extensive than in category 2, but covers less than 50% of the tooth surface
Moderate	The enamel surface of the teeth shows marked wear, and brown stain is frequently a disfiguring feature
Severe	The enamel surface is badly affected, and hypoplasia is so marked that the general form of the tooth may be affected. There are pitted or worn areas, and brown stains are widespread; the teeth often have corroded appearance

◘ **Table 7.4** Criteria for the Thylstrup and Fejerskov (TF) Index

Category	Description
TF score 0	The normal translucency of the glossy creamy-white enamel remains after wiping and drying of the surface
TF score 1	Thin white opaque lines are seen running across the tooth surface. Such lines are found on all part of the surface. The lines correspond to the position of the perikymata. In some cases, a slight "snow-capping" of cusps/incisal edge may also be seen
TF score 2	The opaque white lines are more pronounced and frequently merge to form small cloudy areas scattered over the whole surface. "Snow-capping" of the incisal edges and cusp tip is common
TF score 3	Merging of the white lines occurs, and cloudy areas of opacity occur over many parts of the surface. In between the cloudy areas white lines can also be seen
TF score 4	The entire surface exhibits a marked opacity, or appears chalky white. Parts of the surface exposed to attrition or wear may appear to be less affected
TF score 5	The entire surface is opaque, and there are round pits (focal loss of the outermost enamel) that are less than 2 mm in diameter
TF score 6	The small pits may frequently be seen merging in the opaque enamel to form bands that are less than 2 mm in vertical height. In this class are included also surfaces where the cuspal rim of facial enamel has been chipped off, and the vertical dimension of the resulting damage is less than 2 mm
TF score 7	There is a loss of the outermost enamel in irregular areas, and less than half of the surface is so involved. The remaining intact enamel is opaque
TF score 8	The loss of the outermost enamel involves more than half of the enamel. The remaining intact enamel is opaque.
TF score 9	The loss of major part of the outer enamel results in a change of the anatomical shape of the surface/tooth. A cervical rim of opaque enamel is often noted.

classifying the clinical features of fluorosis reflecting the histological changes in enamel in association with differing degrees of fluorosis severity. The index was based on histological and electron microscopic characteristics of fluorotic enamel. Several clinical manifestations such as discolouration and surface pitting were considered as posteruptive and were subsequently taken into account in the design of the index.

One of the advantages of this index is that it distinctively identifies fluorosis, especially milder forms of fluorosis, from other non-fluorotic discolourations. The requirement for drying teeth before examination increases the capability of the index to identify teeth with fluorosis. The assessment can be made for any present teeth, which may facilitate the description of the intra-oral distribution of fluorosis. Comparability of data collected from different studies with a different number of examined teeth is also feasible provided the same tooth (or group of teeth) is to be compared. These features have made the TF Index one of the methods of choice in studying the prevalence and severity of dental fluorosis.

The Fluorosis Risk Index (FRI) [79]

The FRI features a scoring system of different zones of a tooth surface. It divides tooth surfaces into four surface zones: occlusal/incisal edge; incisal one-third; middle one-third; and cervical one-third [79]. The index then divides the surface zones into two distinctive classifications based on their time of mineralisation: classification I zones are 10 surface zones that are mineralised in the first year of life; classification II zones are 48 zones that are mineralised during the third year through to the sixth year of life. Surface zones that are mostly mineralised during the second year after birth are not included in the classification system for the index. This makes the two classifications more distinctive from each other. The rationale for this classification was that different fluoride exposures may have different effects on fluorosis experience on surface zones that are mineralised at different times during an individual's life. The surface zones of the two classifications are presented in ◘ Table 7.5.The diagnostic criteria for fluorosis used in this index are shown in ◘ Table 7.6.

The Tooth Surface Index of Fluorosis (TSIF) [78]

The Tooth Surface Index of Fluorosis (TSIF) was designed to record fluoride-related conditions on different tooth surfaces (◘ Table 7.7). It consists of a 7-point scale based on the area affected and the presence of discolouration and pitting. The biological effect of fluoride on tooth enamel, however, is less emphasised in this index. It may, therefore, be less sensitive to changes in fluorosis severity because of different levels of fluoride exposure.

◘ **Table 7.5** Surface zone classifications by the FRI

Tooth number	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Upper teeth							
Occlusal/incisal edge	C2	C1	C2	C2			C1
Incisal 1/3	C2		C2	C2			
Middle 1/3	C2		C2	C2	C2		
Cervical 1/3						C2	C2
Lower teeth							
Occlusal /incisal edge	C2	C1	C2	C2		C1	C1
Incisal 1/3	C2		C2	C2			
Middle 1/3	C2		C2	C2	C2		
Cervical 1/3						C2	C2

C1: classification I surface zone
C2: classification II surface zone
Blank: not classified surface zones

◘ **Table 7.6** Criteria for the Fluorosis Risk Index (FRI)

Category	**Description**
Negative finding	
Score 0	A surface zone will receive a score of 0 when there is absolutely no indication of fluorosis being present. There must be a complete absence of any white spots or striations, and tooth surface colouration must appear normal
Questionable finding	
Score 1	Any surface zone that is questionable as to whether there is fluorosis present (i.e. white spots, striations or fluorotic defects cover 50% or less of the surface zone) should be score as 1
Score 7	Any surface zone that has an opacity that appears to be a non-fluoride opacity should be score as 7
Positive finding	
Score 2	A smooth surface zone will be diagnosed as being positive for enamel fluorosis if greater than 50% of the zone displays parchment-white striations typical of enamel fluorosis. Incisal edges and occlusal tables will be scored as positive for enamel fluorosis if greater than 50% of that surface is marked by the snow-capping typical of enamel fluorosis
Score 3	A surface zone will be diagnosed as positive for severe fluorosis if greater than 50% of the zone displays pitting, staining and deformity, indicative of severe fluorosis.

Table 7.6 (continued)

Category	Description
Surface zone excluded	
Score 9	A surface zone is categorised as excluded (i.e. not adequately visible for a diagnosis to be made) when any of the following conditions exist: Incomplete eruption Rule 1: If a tooth is in proximal contact but the occlusal surface is not parallel with existing occlusion, the occlusal two-thirds of the tooth are scored, but the cervical one-third is recorded as excluded Rule 2: If a tooth is erupted, but not yet in contact, the incisal/occlusal edge is scored, but all other surfaces are recorded as excluded Orthodontic appliances and bands Rule 1: If there is an orthodontic band present on a tooth, only the occlusal table or incisal edge should be scored Rule 2: If greater than 50% of the surface zones are banded, the surface should be recorded as excluded Surface crowned or restored Rule: Surface zones that are replaced by either a crown or restoration covering greater than 50% of the surface zone should be recorded as excluded Gross plaque and debris Rule: Any subject with gross deposits of plaque or debris on greater than 50% of the surface zones should be excluded from examination

Table 7.7 The Tooth Surface Index of Fluorosis (TSIF)

Numerical score	Descriptive criteria
0	Enamel shows no evidence of fluorosis
1	Enamel shows definite evidence of fluorosis, namely, areas with parchment-white colour that total less than one-third of the visible enamel surface. This category includes fluorosis confined only to incisal edges of anterior teeth and cusp tips of posterior teeth ("snow-capping")
2	Parchment-white fluorosis totals at least one-third of the visible surface but less than two-thirds
3	Parchment-white fluorosis totals at least two-third of the visible surface
4	Enamel shows staining in conjunction with any of the preceding levels of fluorosis. Staining is defined as an area of definite discolouration that may range from light to very dark brown

Table 7.7 (continued)

Numerical score	Descriptive criteria
5	Discrete pitting of the enamel exists, unaccompanied by evidence of staining of intact enamel. A pit is defined as a definite physical defect in the enamel surface with a rough floor that is surrounded by a wall of intact enamel. The pitted area is usually stained or differs in colour from the surrounding enamel
6	Both discrete pitting and staining of the intact enamel exist
7	Confluent pitting of the enamel surface exists. Large areas of enamel may be missing, and the anatomy of the tooth may be altered. Dark-brown stain is usually present

7.1.5 Public Opinion on Fluorosis

Public opinion is an important feedback mechanism for policies on fluoride use. When dental caries was endemic in western countries in the middle of the last century [81], the public opinion focused on finding effective prevention. However, when population oral health improved, attention turned to fluorosis [82]. Early research on public opinion about fluorosis often focused on perception of appearance [83]. Research considered effect of fluorosis on perception of oral health-related quality of life [84, 85] that made it easier to define health effect of fluorosis.

Mild fluorosis was found to be discernible by children and their parents. The impact of mild fluorosis on the perception of dental appearance, however, was less pronounced in this child population. Some fluorosis was tantamount to lower caries experience – the other side of the balance of risk and benefit of fluoride use. Caries experience seemed to have a more pronounced impact by causing more oral symptoms and functional limitations. Children and their parents who had mild fluorosis were even better off in terms of emotional well-being and social well-being when other factors were controlled for in multivariate models. This rather unexpected finding might be explained by the fact that better oral health was often perceived as being without caries. The psychological impact of fluorosis on the perception of dental appearance, if any, was outweighed by a feeling of being free from the impact of caries.

A longitudinal study of dental fluorotic lesions reported that mild fluorosis diminished with time [86]. This finding is highly important in epidemiological evaluation of dental fluorosis and its impact on oral health of the populations of interest.

Final Considerations

This chapter summarises the epidemiological aspects of dental fluorosis. Aetiology, histological features of fluorotic lesions and indices of measurement have been presented and discussed. Information on risk factors and time trend inform appropriate measures to be considered. Dental fluorosis is an important oral epidemiological condition. Understanding epidemiological aspects of this condition and its impact on population oral health informs relevant policies and practices in using fluoride for preventing dental caries.

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