

## Review

# A literature review of aesthetic perceptions of dental fluorosis and relationships with psychosocial aspects/oral health-related quality of life

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**Abstract** – Aesthetic perceptions and oral health-related quality of life concerning dental fluorosis have been assessed in several studies during the past two decades. However, no comprehensive review article summarizing the studies investigating this issue has been published. *Objective:* To assess the relationships between perceptions of dental appearance/oral health-related quality of life (OHRQoL) and dental fluorosis. *Methods:* The PubMed database was searched using the Medical Subject Headings (MeSH) for English-language studies from 1985 to March 2009. Thirty-five articles qualified for inclusion and then were classified into three categories based on the type of study approach: (i) respondent review of photographs and assessment concerning satisfaction/acceptance, (ii) respondent assessment of study subject's teeth concerning satisfaction/acceptance, and (iii) respondent assessments of the psychosocial/OHRQoL impact. *Results:* There were varied results from earlier studies focused on satisfaction/acceptance of very mild to mild fluorosis. More recent studies with methodological improvements to assess impact on quality of life clearly showed that mild fluorosis was not a concern. Furthermore, mild fluorosis was sometimes associated with improved OHRQoL. Severe fluorosis was consistently reported to have negative effects on OHRQoL. *Conclusion:* Because dental fluorosis in the United States and other nations without high levels of naturally-occurring fluoride is mild or very mild, with little impact on OHRQoL, dental professionals should emphasize the appropriate use of fluorides for caries prevention and preventing moderate/severe fluorosis.

**Key words:** aesthetic perceptions; dental fluorosis; oral health-related quality of life

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There has been a substantial decline in average caries rates over the past several decades in the United States (1) and many other developed nations (2), along with increased prevalence of fluorosis (1). As a result, there has been increased emphasis on prudent use of fluoride to minimize dental fluorosis

(3). Numerous journal articles have reported on relationships between dental fluorosis prevalence and use of different fluoride sources, including dietary fluoride supplements (4, 5), fluoride dentifrice (6, 7), and fluoridated water (4, 5).

Dental fluorosis is a condition of altered enamel formation caused by excessive intake of fluoride only during tooth formation (8), with a wide range of severity. Mild fluorosis appears as opaque/white parchment enamel, while more severe fluorosis can

<sup>†</sup>It is with regret that we report that Dr. Jane M. Chalmers (1965–2008), friend, colleague and co-author, died in 2008.

be characterized by brown stains or pitting (or mottling) of enamel.

The authors of an early epidemiological study commented that very mild and mild fluorosis are difficult for untrained personnel to detect (9). However, findings from recent studies indicated that very mild and mild fluorosis can be noticeable conditions for some lay persons (10–12).

There can be possible negative effects of fluorosis, such as embarrassment from or being unhappy with appearance and hindering smiling, especially in cases of fluorosis involving staining or pitting characteristic of moderate to severe fluorosis. As a result, there has been an increased number of studies assessing aesthetic perceptions and/or impact of dental fluorosis (10–36).

Individuals often were reported to notice and/or be concerned about the appearance of fluorosis. This has been part of the rationale for reductions in the recommended use of fluoride by/for infants and preschool children when they are at the age of greatest risk for dental fluorosis. For example, in recent years, use of dietary fluoride supplements in the United States is no longer a primary preventive procedure targeted to all children not receiving optimally fluoridated water; fluoride supplements are only recommended for children at elevated risk of caries, without fluoridated water, and with a professional decision based on compliance and expected caries prevention benefit that outweighs fluorosis risk (37). Also, some have recommended fluoride dentifrice not be used until 24 months of age, with health professional advice indicated for use earlier than 24 months (37).

Due to the increased concern about prevention of dental fluorosis, some infants at high risk for caries probably are not receiving necessary caries prevention from fluoride dentifrice. In order to address this, an expert panel convened by the Maternal and Child Health Bureau (MCHB) of the U.S. Health Resources and Services Administration (HRSA) recently made recommendations for expanded use of fluoride dentifrice and varnish with preschool children at high risk of dental caries, including under 24 months of age (38).

Quality of life aspects of general and oral health have also recently received more attention, and several specific tools for assessment of Oral Health-Related Quality of Life (OHRQoL) have been developed (39, 40). Also, there now is greater appreciation of the importance of assessing the impact of fluorosis beyond just awareness/concern, acceptability and/or satisfaction regarding this

condition. This is important because those studied previously who reported that they were aware, concerned, or dissatisfied with dental fluorosis might not have been having any problem with or impact on everyday life from it. Thus, several more recent studies have assessed the effect of dental fluorosis on OHRQoL/psycho-social aspects of children.

When developing fluoride recommendations for preschoolers, it is essential to balance caries prevention and increased fluorosis risk, together with consideration of the true impact of dental fluorosis on children and parents. No comprehensive review article has summarized the studies on the impact of fluorosis. The purpose of this paper is to review the published literature assessing relationships between perceptions of dental appearance/oral health-related quality of life and dental fluorosis.

## Methods

This is not a definitive, systematic review, but a general literature review with some systematic review components. The review focused on all available published, human, English-language studies from 1985 to March 2009. The PubMed database was searched using the Medical Subject Headings (MeSH). *Dental Fluorosis* and each of the following keywords, *Perception* or *Dental Esthetics* or *Attitude* or *Judgment* or *Quality of Life*, were used in the search strategies. Using the MeSH search ensured the covering different keywords used in the articles. For example, *Dental Fluorosis* includes the following keywords: (i) *Fluoroses, Dental*, (ii) *Dental Fluoroses*, (iii) *Dental Fluorosis*, (iv) *Mottled Enamel*, (v) *Enamel, Mottled*, (vi) *Enamels, Mottled*, and (vii) *Mottled Enamels*.

There were 136 published articles identified for abstract screening (if any of did not have an abstract, the full article was used for screening). Eighty-three articles were excluded because they either focused on treatment options for dental fluorosis or were not original studies (review/case report/letter/news/editorial). Eleven studies were excluded because they reported only on prevalence/risk of fluorosis. Six studies were excluded because they either only reported dental health and oral health practices of dental students (41), reported knowledge of dentists about fluorosis (42), had only minimal information presented about parents' aesthetic perceptions of fluorosis over time (43) or used the same data as in

previously published articles (44–46). Griffin et al. (44) used data from five previously published studies to estimate perceived aesthetic problems attributable to very mild and mild fluorosis. Lawson et al. (45) re-analysed previously published data on a subset of individuals using multivariable analyses which controlled for Dental Aesthetic Index (DAI) score. However, the previous article (36) had more appropriate categorization for the present review and larger sample size. Locker (46) re-analysed previously published data to assess the validity of single-item parental ratings of child oral health. Another study was excluded because it assessed the association between aesthetic concern and water fluoride levels (47).

The remaining 35 articles then were classified into three categories based on the main type of study approach: (i) respondent review of photographs and assessment concerning satisfaction, acceptance, etc., (ii) respondent assessment of study subject's teeth concerning satisfaction, acceptance, etc., and (iii) respondent assessments of the psychosocial/OHRQoL impact. The third category took priority over the first two, so studies were placed into category 3 (and not in 1 or 2) if they had psychosocial/quality of life components. The results and discussion of the review are presented separately based on these three categories. For the two studies (18, 24) in which respondents reviewed both photographs and assessed subjects' teeth (but without psychosocial aspects/OHRQoL), the two different parts of the study findings are presented separately in each of the photographic and subject categories.

For each of these three categories, key information is presented in Tables 1–3, including the authors/locations, subjects and key findings, but only for those with designated analytical comparisons. We provide more detailed article information in tables in the Appendices, with categories of (i) author(s) and location(s), (ii) subjects, (iii) perception/impact of dental appearance assessment and fluorosis reference condition(s)/assessment, (iv) data collection validity and reliability, (v) analytical method and (vi) findings, both descriptive and analytical. The Appendices also include the four photographic and six subject-assessment studies excluded from Tables 1–3.

## Results

There were 13 studies in which respondents reviewed photographs, 16 of respondent assessment

of study subjects' teeth and eight of respondent assessment concerning the psychosocial/OHRQoL impact.

### *Photographic studies*

These 13 studies are mainly from North America and Europe (Appendix S1). Agreement with the reference statements, or acceptability or satisfaction with the photographs was assessed. Most studies compared the perceptions of dental appearance of different fluorosis severity with perceptions of normal enamel. However, three other studies (18–20) did not have normal enamel photograph(s) as a comparison group. These studies reported decreasing satisfaction/attractiveness/acceptability with increasing fluorosis severity. Ten studies included normal enamel in their presentation of conditions. However, one study had only descriptive results (24). Among the nine (see Table 1), four studies (14, 16, 17, 21) used photographs with a range from normal to mild or moderate fluorosis, but not severe fluorosis. For comparing different fluorosis severities with normal enamel among lay persons, mild fluorosis was rated less satisfactory in three studies (13, 15, 16), not significantly different in two studies (23, 25) and more satisfactory in one study (14). Two studies (21, 22) examined the effects of the size of the image viewed, reporting that photos that showed the whole face/extra-oral view generally had similar acceptability for normal enamel, mild and moderate fluorosis, while mild fluorosis had lower acceptability for the closer-up photos.

All five studies (13, 15, 22, 23, 25) that compared normal enamel and severe fluorosis reported significantly less satisfaction/acceptance with severe fluorosis compared with normal enamel. Two of these studies (22, 25) also examined the role on aesthetic perceptions responses of cueing the subjects to concentrate on the teeth. They found that not cueing significantly increased the likelihood of 'yes' response to positive words for severe fluorosis.

Concerning rater types, one study (17) reported more favourable aesthetic perceptions of mild fluorosis of 4th year dental students compared with the results when they were 1st year students. Additionally, one study (18) reported that mothers were more critical than children were.

Among studies in which respondents reviewed photographs, three studies compared fluorosis cases with other conditions. Mild fluorosis was rated less satisfactory than rotated teeth in one study (16) and was rated more favourably than diastema in another study (17). One study reported

**Table 1.** Descriptions and findings from studies in which respondents viewed photographs

<b>Authors and Location</b>	<b>Subjects</b>	<b>Findings</b>
Clark (1995) (13) Canada	48 children, 49 parents and 139 dental professionals	Mean scores of all rater groups were significantly different for TSIF 0 versus 1, 0 versus 2 or 3, 0 versus 4, 0 versus 5 or 6 and 0 versus 8 ( $P < 0.0001$ )
Hawley et al. (1996) (14) UK	534 14-year-old students	The trends for children's unacceptable appearance and their desire for treatment increased with increasing TF scores ( $P < 0.001$ )
McKnight et al. (1998) (15) USA	179 adults (18-44 years old)	Fluorosed teeth were generally scored less favorably than nonfluorotic teeth ( $P < 0.05$ )
McKnight et al. (1999) (16) USA	61 entering dental students	Mild fluorosis was less favorable than normal and isolated opacity ( $P < 0.05$ )
Levy et al. (2002) (17) USA	45 fourth-year dental students	Diastema was less favorable than fluorosis ( $P < 0.05$ )
Edwards et al. (2005) (21) UK	239 14- to 15-year-old students	Fourth-year students generally had more favorable aesthetic perceptions of mild fluorosis than they had 3 ½ years earlier
		Greater distance of viewing generally improved acceptability of the appearance
		No significant differences in acceptability scores across TF 0 - TF 4 for "full-face photos"
Williams et al. (2006) (A) (22) UK	90 18- to 66-year-old volunteers	Extra-oral images without cueing were least likely to have different responses of attribution of characteristics with varied fluorosis levels (Dean's index)
Williams et al. (2006) (B) (23) UK	40 18- to 34-year-old volunteers	Mild fluorosis (Dean's index) did not have markedly different judgments from normal enamel
		Severe fluorosis and untreated caries were judged less favorably than no and mild fluorosis ( $P < 0.001$ )
Bennett et al. (2008) (25) UK	80 undergraduate volunteers	Response direction of severe fluorosis (Dean's index) indicated less likely to respond 'yes' to positive words than for lesser severity fluorosis ( $P < 0.001$ ), after adjusting for other variables
		For severe fluorosis, not cueing increased chance of 'yes' response to positive words ( $P < 0.01$ )

TF index = Thylstrup & Fejerskov index, TSIF = Tooth Surface Index of Fluorosis.

Note: Only studies with relevant results to address an association between aesthetic perceptions and fluorosis conditions were included here (Appendix 1 includes 4 studies excluded here).

Table 2 Key findings from studies in which respondents assessed subjects' teeth

Authors and Location(s)	Subjects	Findings
Clark (1993) (10) Canada	1,131 pairs of children and parents	Aesthetic ratings among TSIF score groups were different for both children ( $P < 0.0001$ ) and parents ( $P < 0.00001$ ) For both children and parents, the percentages with no problem were similar for TSIF 0 versus 1, and for TSIF 2-3 versus 4+
Riordan (1993) (26) Australia	110 observers (university students, parents, public servants, or dentists)	With increased TF score, decreased agreement that the teeth appeared pleasing ( $P < 0.0001$ ) Observers felt that the appearance would increasingly embarrass the child as the TF increased ( $P < 0.0001$ )
Ellwood and O'Mullane (1995) (27) UK, Iceland and Wales	918 12- to 14-year-old children	TF 0 and 1 had similar responses. Children with TF 2+ had greater concerns with appearance than those with TF 0 or 1 ( $P = 0.04$ )
	Sub-study five dentists and 12 lay examiners	Difference in scores between dentists and lay examiners was not significant ( $P = 0.09$ ) Mild fluorosis (TF index) and small demarcated opacity did not significantly affect the aesthetic scores for dentists or lay examiners ( $P > 0.10$ ), but medium and large demarcated opacities and moderate/severe fluorosis affected aesthetic scores ( $P < 0.001$ )
Woodward et al. (1996) (28) Canada	424 8- to 9-year-old children and their parents	Parents of a child with TSIF 2+ were half as likely to be satisfied with the appearance as parents of a child with TSIF 0 or 1 ( $P = 0.016$ )
Lalumandier and Rozier (1998) (30) USA	705 child-parent pairs	More parents of children with TSIF 1 were dissatisfied with their children's tooth colour than parents of those with no fluorosis ( $P < 0.05$ ) Parents' levels of satisfaction with the colour decreased as fluorosis severity increased ( $P < 0.0001$ )
Astrom and Mashoto (2002) (33) Tanzania	478 students, mean age 16 years	More females than males reported that they were dissatisfied with their dental appearance ( $P < 0.05$ ) Appearance of teeth significantly worse for TF 1-4 (OR = 2.8, 95% CI = 1.4, 5.8) and TF 7-9 versus 0 (OR = 3.1, 95% CI = 1.4, 6.8), after adjustment for other factors
Martinez-Mier et al. (2004) (34) USA and Mexico	166 children and 93 parents	TSIF score was not significantly associated with child's or parent's reported concern about colour ( $P > 0.16$ ) and reported pleasant colour of child's teeth ( $P > 0.054$ ) in both cities
Sigurjons et al. (2004) (12) UK and Iceland	215 parents	The proportion of parents unhappy with the appearance of their children's teeth for TF 0-1 was not significantly different than for TF 2-3 ( $P = 0.20$ ) TF 3+ was associated with greater percentage of parents not happy with child's tooth colour than those with lower TF scores ( $P = 0.005$ )

Table 2 Continued

Authors and Location(s)	Subjects	Findings
Shulman et al. (2004) (35) Canada	2495 children with parents and dentists	Children and parents of children with TF 1 or 2 were not significantly more critical than those with TF 0 ( $P > 0.18$ ), while those with a TF 3+ were ( $P < 0.001$ ) Dentists were significantly more critical for children with TF 2 and 3 than children with TF 0 ( $P < 0.02$ ) Parent's overall satisfaction ( $P < 0.001$ ) and satisfaction with colour ( $P = 0.03$ ) decreased with higher fluorosis (FRI) scores
Levy et al. (2005) (36) USA	577 parents of 9-year-old children	

TF index = Thylstrup & Fejerskov index, TSIF = Tooth Surface Index of Fluorosis, FRI = Fluorosis Risk Index.

Note: Only studies with relevant results to address an association between aesthetic perceptions and fluorosis conditions were included here (Appendix 2 includes six studies excluded here)

that untreated caries was judged less favourably than normal enamel and mild fluorosis (23).

*Self- and subject-assessment studies*

These 16 studies are also mainly from North America and Europe, and most conducted fluorosis examinations on children's teeth and assessed the aesthetic perceptions of the children and/or their parents (Appendix S2). Four (26, 27, 29, 35) also assessed aesthetic perceptions of persons who were not related to the children (lay persons, dentists and jurors). Two studies (12, 36) assessed only parents' aesthetic perceptions of their children's teeth.

In this group of studies, six (11, 18, 24, 29, 31, 32) did not have relevant results to address whether there is an association between aesthetic perceptions and fluorosis conditions. Of the other 10, five (12, 26, 27, 29, 33, 35) used the Thylstrup & Fejerskov (TF) index (48), four (10, 28, 30, 34) used the Tooth Surface Index of Fluorosis (TSIF) (49) and one (36) used the Fluorosis Risk Index (FRI) (50) (see Table 2). Among five studies using the TF index, they used different cutoffs in their analysis, which makes direct comparison very difficult. Very mild fluorosis (TF score 1) in one study (27) and very mild and mild fluorosis (TF scores 1 or 2) in one study (35) were rated by children and parents similar to normal enamel. Two studies (12, 27) reported that children's and parents' aesthetic perceptions of normal or very mild fluorosis (TF scores 0 or 1) were not significantly different from mild fluorosis (TF scores 2 or 3). These findings generally indicate that aesthetic perceptions concerning children with very mild and/or mild fluorosis were not significantly different from responses concerning those with no fluorosis. One study by Riordan (26) reported a trend of decreased satisfaction with increased TF score. One study (33) was conducted in a population with more than 40% of children classified as severe fluorosis. This study compared aesthetic perceptions of mild or moderate fluorosis with those of normal enamel and found that mild or moderate fluorosis was more likely to be associated with dissatisfaction than was normal enamel.

For studies using the TSIF, three studies (10, 28, 34) reported that children's and/or parents' aesthetic perceptions of mild fluorosis (TSIF score 1) and normal enamel were not significantly different, but one study (30) reported that they were significantly different. Additionally, Woodward et al. (28) reported that parents of children with TSIF

Table 3 Key findings from studies in which respondents assessed psychosocial aspects/OHRQoL

Authors and Location	Subjects	Findings
van Palenstein Helderman and Mkasabuni (1993) (51) Ethiopia	50 pairs of 13- to 15-year-old children and their adult relatives	Children with greater number of teeth with severe fluorosis (TF index) worried more ( $P < 0.05$ ) and had more hindered smiling ( $P < 0.01$ ) Adults less frequently expressed feelings of distress and hindered smiling than children ( $P < 0.01$ )
Mwaniki et al. (1994) (52) Kenya	113 mothers of children age 3-6 years old	More lower income mothers expressed unwillingness to smile if their teeth were affected by severe fluorosis (TF index) ( $P < 0.05$ )
Sujak et al. (2004) (53) Malaysia	1,024 16-year-old children	23% of children with enamel defects (modified DDE index) and 16% without enamel defects dissatisfied with their tooth colour ( $P < 0.02$ ) No different consequences relating to the colour of the front teeth between children with defects and without defects ( $P > 0.47$ ) Females had more dissatisfaction with their tooth colour than males ( $P = 0.007$ )
Michel-Crosato et al. (2005) (55) Brazil	513 6- to 15-year-old children	There was no association between dental fluorosis (Dean's index) and any of the eight activities investigated ( $P > 0.13$ )
Robinson et al. (2005) (56) Uganda	174 12-year-old-children	More children with TF > 2 had impacts on their OHRQoL (80% versus 66%), but difference not statistically significant The total impact burden from dental fluorosis was much lower than for dental caries
Do and Spencer (2007) (57) Australia	8- to 14-year-old children ( $n = 638$ ) and parents ( $n = 654$ )	Having a TF 2 was associated with better OHRQoL than TF 0 (for parents and 11- to 14-year-old children only) ( $P < 0.05$ ) Children with TF 1 or 2 were more likely to perceive their oral health as excellent/very good than with TF 0 ( $P < 0.05$ )
Locker (2007) (58) Canada	152 11- to 12-year-old and 218 13- to 14-year-old children	There was no association between fluorosis (none, very mild or mild fluorosis) (TSIF) and mean OHRQoL scores
Biazevic et al. (2008) (59) Brazil	247 15- to 17-year-old children	Dental fluorosis (very mild, mild and few moderate) (Dean's index) did not interfere with daily activities more compared to no fluorosis ( $P = 0.18$ ) Greater untreated decay was correlated with more frequent interference with daily activities

TF index = Thystrup & Fejerskov index, TSIF = Tooth Surface Index of Fluorosis, DDE index = Developmental Defects of Enamel index.

score 2 or more were significantly less likely to be satisfied with the appearance of their children's teeth than parents of children with TSIF scores 0 or 1.

Only one study (36) in this group used the FRI, which only categorized children into normal, questionable (FRI score 1) or definitive fluorosis (FRI score 2 or 3). This study reported that parents' satisfaction with normal enamel and questionable fluorosis were similar. However, they found a significant trend of decreasing satisfaction with increasing FRI score.

Clark and Berkowitz (29) found that dentists were more accepting of dental fluorosis than were children and parents, but Ellwood and O'Mullane (27) reported that dentists responded more strongly to enamel hypo-mineralization than did lay persons. Two studies (10, 18) reported that parents were more critical of dental fluorosis than children were.

Martinez-Mier et al. (34) conducted a parallel study in two cities, Indianapolis and Mexico City. Children in Indianapolis were more concerned about dental fluorosis than children in Mexico City were.

### *Psychosocial and quality of life studies*

Table 3 presents brief summary descriptions and key results of the eight studies in which respondents assessed psychosocial aspects/oral health-related quality of life. In the 1990s, the first two studies were conducted in Africa. The majority of later studies were from Africa and South America. They are discussed below in slightly more detail than the first two categories of studies (see also Appendix S3).

The study by van Palenstein Helderma and Mkasabuni (51) published in 1993 was the first one that assessed the effects of fluorosis on psychosocial aspects/quality of life. This study assessed the effects of fluorosis on physical, mental and social well-being in Ethiopian children. About 96% of these children had a maximum TF score >4. The children were divided into four groups (<4 teeth, 4-5 teeth and >5 affected teeth) based on the number of maxillary incisors, canines and first premolars with a TF score >4 (maximum 8 teeth). The children and their adult relatives who had at least five out of the eight teeth with a TF score >4 were interviewed. They were asked whether they had distress, were worried, and/or were hindered in smiling freely because of the way their teeth looked. The authors found that feelings of distress

and worry and hindered smiling were expressed by some children, more so among those in the group with more teeth involved with fluorosis (TF > 4). The adults less frequently expressed feelings of distress and hindered smiling than the children did.

Mwaniki et al. (52) conducted a study in Kenya to compare the perceptions of fluorosis of mothers of 3- to 6-year-olds from three communities representing low, middle and higher incomes. A colour photograph of permanent incisors with TF scores of 7-9 (severe fluorosis) was used as a reference during discussions pertaining to oral health. More than 77% of respondents viewed severe fluorosis as an embarrassing condition. Between 65% and 84% of respondents had observed affected people covering their mouths with their hands when laughing. There were 52-78% of the respondents reportedly unwilling to consciously smile if their teeth were affected. The mothers with lower income were more likely to express unwillingness to smile if affected.

Sujak et al. (53) investigated the psychosocial impact of enamel defects of 16-year-old Malaysian children. The Modified Developmental Defects of Enamel Index (54) was used. General appearance of the teeth, appearance of the anterior teeth and whether these factors affected children's social activities and psychological well-being were assessed using self-administered questionnaires. They found that about two-thirds were affected by enamel defects. More than 80% of the children were satisfied with the condition and colour of their front teeth. There were significantly more children with enamel defects who reported dissatisfaction with colour than those without enamel defects. However, there were similar responses concerning impact among those with and without enamel defects, such as covering the mouth when smiling, avoiding going out with friends, consulting a dentist, worrying about the condition and lack of confidence when socializing. Moreover, having enamel defects became a nonsignificant factor in the adjusted statistical analysis. More than 95% of those dissatisfied with tooth colour reported that the whiteness of the teeth was a reason.

Michel-Crosato et al. (55) examined the impacts of fluorosis on children's daily activities (food intake, speech, oral hygiene, sleep, smiling, emotional stability, studying, and entertainment). About 18% of these Brazilian children had fluorosis, with about 4% in the mild, moderate or severe

fluorosis categories (modified Dean's Index) and about 14% very mild. A modified Oral Impacts on Daily Performance (OIDP) questionnaire was used to examine the impacts of fluorosis in the different areas listed above. However, no significant association was found between dental fluorosis and any of the 8 activities.

Robinson et al. (56) used the Child Perceptions Questionnaire (CPQ) to assess the impacts (oral symptom, functional limitation, emotional well-being and social well-being) of fluorosis on OHRQoL in Ugandan 12-years-olds. About 24% of the children had fluorosis, with about 6% having a maximum TF score >3. More children with marked fluorosis (TF score >2) had impacts on their OHRQoL than those with mild or no fluorosis; however, the difference was not statistically significant. The number of impacts experienced 'often' or 'everyday' by each child for those with marked fluorosis were statistically significantly higher than for those with mild or no fluorosis.

Do and Spencer (57) evaluated the OHRQoL of 8- to 13-year-old Australian children by fluorosis status. A total of 304 8- to 10- and 334 11- to 14-year-old children completed the CPQ and 654 parents completed the Parent Perception Questionnaire (PPQ). Fluorosis was assessed using the TF, with scores ranging from 0 to 3 (72% with TF 0). Children with a TF score of 1 were less likely to perceive their tooth colour as stained compared with children with no fluorosis and children with higher scores. Children with a TF score of 1 were more likely to perceive their tooth colour as attractive compared with children with TF scores of 0, while there was similarity among children with TF scores of 0, 2 and 3. The proportion of children/parents rating a global rating of oral health as 'Excellent/very good' increased when fluorosis severity increased from a TF score of 0-2, but decreased with a TF of 3. Having a TF score of 2 was associated with better OHRQoL compared with those with normal enamel.

Locker (58) identified factors affecting OHRQoL in a group of 370 Canadian children aged 11-12 and 13-14. Clinical data, including caries experience, treatment needs, dental trauma, fluorosis and malocclusion, were collected during a school-based dental screening program. Children's OHRQoL was assessed using a short form of the CPQ. Parents completed a questionnaire concerning their children's personal and family characteristics and rating their children's dental health on a scale

ranging from excellent to poor. In bivariate and multivariable regression analyses, there were no statistically significant differences in CPQ scores between parents of children with none, very mild and mild fluorosis. The author concluded that oral disorders generally had little impact on the OHRQoL of higher income children, but a marked impact on lower income children.

The most recent study by Biazevic and colleagues (59) assessed relationships between oral status and OHRQoL in 247 children 15-17 years of age. Children were examined using the DMFT, CPI (Community Periodontal Index) and Dean's fluorosis index. The Oral Health Impact Profile (OHIP) was used to assess children's OHRQoL, including domains of functional limitation, physical pain/disability, psychological discomfort/disability, social disability and handicap. Untreated decay was significantly correlated with more frequent interference with daily activities. However, children with dental fluorosis (including children with very mild, mild and a few with moderate fluorosis) and children with no fluorosis did not have significantly different OHIP scores, indicating similar frequency of interference with daily activities between children with and without dental fluorosis.

## Discussion

The fact that the studies concerning the effects of dental fluorosis on aesthetic perceptions/OHRQoL had substantial heterogeneity of design, methods, indexes, outcomes, and analyses precluded us from conducting a true 'systematic review'. However, we adopted several approaches used in systematic reviews to decrease potential bias on our part and provide additional methodological detail. We identified all published relevant studies, assessed their quality and summarized the evidence. However, it is important to acknowledge that this review is not a true systematic review.

Publication bias usually plays an important role in a systematic review of any topic involving intervention studies, including clinical trials or other experimental studies. Failure to include unpublished studies, which probably more often had negative or inconclusive results, might indicate a possible bias of the review. In this review, since the studies included in the review were observational studies, publication bias probably does not play as important a role. However, readers should

keep in mind that this review did not include unpublished studies.

Dental fluorosis is not a condition that causes pain or has clinical symptoms. The effects of mild fluorosis are subjective; thus, reports of dental fluorosis prevalence and severity alone do not give enough information to understand the effects at the public health level. To examine the effects of dental fluorosis, the early studies assessed acceptability and/or aesthetic perceptions concerning photographs of cases and/or subjects' teeth with and without dental fluorosis in interested populations.

Some of the studies in which the respondents evaluated photographs used real clinical photographs. However, because differences in other oral conditions (e.g., tooth contours, spacing, gingival characteristics, etc.) would affect the perception of fluorosis condition, some studies used computer-manipulated photographs to eliminate those differences.

Most studies in which the respondents evaluated photographs of only normal enamel and mild fluorosis found that mild fluorosis was evaluated as less acceptable. However, the studies that included photographs of severe fluorosis found that mild fluorosis was acceptable or had similar responses to normal enamel. Two studies (21, 22) indicated that the size (area involved) of the photographs that were used in the study substantially affected the results of the study, suggesting that the studies using large intra-oral views of fluorosis might get responses that exaggerated the effects of dental fluorosis.

Two studies (22, 25) assessed the effect of cueing on the responses of the subjects. They found that cueing, by asking the respondents to pay attention to the teeth, appeared to increase participants' attribution to dental fluorosis compared with when they were not cued.

Another method that assessed acceptability/aesthetic perceptions of dental fluorosis involved respondents evaluating subjects' teeth. This method was used more frequently than the others. Self-perceptions of subjects is the outcome that may be most important, because it can reflect the impact of the condition on the individual; however, in school-age children, parents' perceptions might also be important, affecting the treatment decisions for the children. The studies in which respondents viewed subjects' teeth evaluated perceptions of subjects' teeth with different conditions. Some studies also provided reference statements related to subjects' tooth conditions.

This group of studies found that the responses of children and/or parents to mild or very mild dental fluorosis were generally similar to the responses of those with normal enamel. One study (11) found that older children (15 years old) were more concerned about the colour of the teeth than younger children (12 years old). One study (10) found that many fewer children had concerns about mild fluorosis than the number of children with mild fluorosis. Thus, this indicates that mild fluorosis is not much of a problem. One study in this group (34) presented differences in the aesthetic concerns of children in difference cities (Indianapolis and Mexico City), suggesting that cultural and/or SES differences might affect the aesthetic perceptions of children.

A number of more recent studies assessed the effect of fluorosis on OHRQoL/psycho-social aspects of the condition in children with dental fluorosis. Some studies asked respondents to assess OHRQoL related to their own teeth, but some studies asked the respondents to assess OHRQoL using case photos as a reference condition.

The results from the studies in this group generally indicate that very mild and mild fluorosis had little if any effect on OHRQoL. One study (57) presented evidence that children with mild fluorosis reported better OHRQoL than those with normal enamel. None of these studies reported negative effects of mild dental fluorosis. In contrast, the several studies involving severe fluorosis consistently reported that it had a negative effect on oral health-related quality of life.

In comparing results across the study types, it is evident that mild dental fluorosis was able to be detected and was sometimes viewed less favourably than nonfluorosis cases. However, this happened in the studies with relatively artificial study conditions (i.e., with specific cueing to the fluorosis, magnified images, etc.). In the more recent studies with methodological improvements to assess impact on quality of life, mild dental fluorosis clearly was not a concern. In fact, sometimes it was associated with improved oral health-related quality of life, probably due to the public's greater emphasis on white teeth.

## Conclusions

1. In the earlier studies not focused on OHRQoL, there were varied results from respondents concerning perceptions of very mild to mild

fluorosis. Respondents often could distinguish mild fluorosis from nonfluorosis cases, when cued to look at them this way. Some reported these low levels of fluorosis were more acceptable/favourable, some equally acceptable/favourable and others less acceptable/favourable compared with cases with no fluorosis.

2. There were no negative effects on respondents' OHRQoL from very mild to mild fluorosis, with some evidence suggesting enhanced OHRQoL with mild fluorosis.
3. Severe fluorosis was consistently reported to be evaluated less favourably and to have negative effects on the respondents' OHRQoL.
4. The vast majority of dental fluorosis in the United States and other nations without high levels of naturally-occurring fluoride is mild or very mild fluorosis, which does not adversely impact OHRQoL. Therefore, Dental Public Health and Paediatric Dentistry leaders should focus efforts primarily on the appropriate use of fluorides for caries prevention and preventing moderate/severe fluorosis.

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## Supporting Information

Additional Supporting Information may be found in the online version of this article:

**Appendix S1.** Descriptions and findings from studies in which respondents viewed photographs.

**Appendix S2.** Descriptions and findings from studies in which respondents assessed subjects' teeth.

**Appendix S3.** Descriptions and findings from studies in which respondents assessed psychosocial aspects/OHRQoL.

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