Prevalence of dental fluorosis and associated risk factors in Alappuzha district, Kerala

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ABSTRACT

Background. Fluorosis is considered endemic in 15 states of India. Dental fluorosis is the most convenient biomarker of exposure to fluoride. In Kerala, although the condition is reported to be endemic in the districts of Alappuzha and Palakkad, there are no systematic epidemiological studies evaluating dental fluorosis. We studied the prevalence of dental fluorosis among school children in Ambalappuzha taluk, Alappuzha district, Kerala and evaluated the contribution of potential risk factors.

Methods. We conducted a community-based, cross-sectional survey of 1142 school children (630 girls, 512 boys) in the age group of 10–17 years, using a multistage random cluster sampling technique. A pre-tested structured questionnaire was used to assess exposure to various sources of fluoride. A dental specialist examined all the children to determine the presence or absence of dental fluorosis and graded the degree of dental fluorosis using Dean's Index. The water fluoride content in the study area was obtained from the district water authority department. Bivariate associations were examined using the Chi-square and Chi-square trend tests, while multiple logistic regression was used to evaluate the association of select risk factors with the presence or absence of dental fluorosis.

Results. The overall prevalence of dental fluorosis in our study sample was 35.6% and the community fluorosis index was 0.69. The prevalence of dental fluorosis was higher in the urban compared to the rural areas (55.3% v. 16.8%; p < 0.001), and in girls compared to boys (39.2% v. 31.3%; p < 0.01). The prevalence of dental fluorosis was higher among children who consumed pipe water as compared to children who consumed well water (44.8% v. 12.7%; p < 0.001). We noted a step-wise increase in the prevalence of dental fluorosis with a corresponding increase in water fluoride content in different panchayats (p = 0.024). The principal factor associated with the presence of dental fluorosis was a high fluoride content of drinking water (OR 1.85, 95% CI: 1.17–2.92). We did not observe any significant association between dental fluorosis and the intake of brick-tea, consumption of fish or the use of toothpaste.

Conclusion. Dental fluorosis is a public health problem in the Ambalappuzha taluk. Active steps must be taken to partially defluoridate the water before distribution to reduce the morbidity associated with dental fluorosis in this area. Similar surveys are required in other parts of India to identify areas with high water fluoride content and determine the extent and manner in which defluoridation can be carried out.

INTRODUCTION

Fluoride, an element essential for human health, plays a critical role in the calcification of bones and teeth. Fluoride is often called a double-edged sword because deficiency of fluoride intake leads to dental caries while excess consumption leads to dental and skeletal fluorosis. Experience from developed countries suggests that fluoridation of water to prevent caries is always at the expense of a certain degree of dental fluorosis.

The main dietary source of fluoride is drinking water. The optimal carioprotective fluoride content in drinking water is approximately 1 mg/L. Nearly 12 million of the 85 million tons of fluoride deposits on the earth’s crust are found in India. It is not surprising, therefore, that fluorosis is endemic in 15 states of India. The highest rates of endemicity have been reported from Andhra Pradesh, Haryana, Karnataka, Punjab, Rajasthan and Tamil Nadu. Although fluorosis has been reported to be endemic in the districts of Alappuzha and Palakkad in Kerala, there are no well designed epidemiological investigations assessing the magnitude of dental fluorosis and evaluating the risk factors associated with the condition.

Our objectives were to study the prevalence of dental fluorosis among school children in the Ambalappuzha taluk of Alappuzha district of Kerala and to examine the associations of the condition with potential risk factors.

SUBJECTS AND METHODS

Subjects

We performed a cross-sectional survey of school children in the age group of 10–17 years (classes 5 to 10) in the Ambalappuzha taluk of Alappuzha district during the months of January and February 1998. Children in this age group were selected because they represent a population at risk for dental fluorosis; the period
of calcification of teeth from infancy to 6 years of age constitutes
the vulnerable period for the onset of the condition. Ambalappuzha
taluk is located along the coast of Kerala and includes 3 panchayats
(rural area) and the Alappuzha municipal area (urban). We chose
this taluk because of unpublished reports indicating that the area
was endemic for dental fluorosis. The majority of the people in the
study area belong to the low socio-economic class and the principal
adult occupations are fishing, coir manufacture and agriculture.

We used a multistage random cluster sampling technique to
select our study sample. In consultation with the District and
Assistant Education Officers, we compiled a list of schools which
had classes 5 to 10 in the Ambalappuzha taluk area. The total
number of divisions in classes 5 to 10 were serially numbered for
each school and the cumulative total was obtained. Thirty out of
738 divisions were then randomly selected using random number
tables, expecting to get more than 1000 children on the basis of the
average class strength. All the students in each selected division
were included in the study.

**Questionnaire**

The data were collected and recorded, based on a structured close-
ended pre-tested questionnaire to obtain information on the socio-
economic status, occupation and level of education of the parents,
the source of drinking water, amount of water consumed, brick-
tea consumption, sea-fish intake and use of fluoride-containing
toothpaste by the students. These factors have been identified as
potential risk factors for dental fluorosis in previous studies.3-4
The printed questionnaires were supplied to the students 1-2 days
prior to the dental examination, with clear instructions to submit
the completed form on the day of examination.

**Oral examination**

The oral examination of each student was carried out by a dental
specialist in the common hall of the school or in the concerned
classroom with the subject seated in an ordinary chair in bright
daylight. The dental specialist used a sterile mirror and a dental
probe for oral examination. The presence and severity of dental
fluorosis was recorded, along with any other dental conditions
observed. Dean’s index was used to determine the grade of dental
fluorosis, thus:

Normal: No white discoloration of the teeth

Grade I (Questionable): Occasional white flecking over the tooth
surfaces mainly on the incisor tips and cusp tips

Grade II (Mild): White opaque areas involving less than 25% of
the tooth surface

Grade III (Moderate): White opaque areas involving more than
25% and less than 50% of the tooth surface

Grade IV (Severe): White opaque areas involving more than 50% of
the tooth surface.

**Water fluoride content**

The fluoride content of water sources was obtained from the water
authority department of Alappuzha. This department conducts
routine water analysis by taking water samples from different
places in the municipal and panchayat areas.

**Statistical analysis**

Assuming an alpha error of 5% and an estimated prevalence rate
of 40% with an acceptable error in the estimate of ±3%, the
required sample size was calculated as 1024. Accounting for a
10% non-response rate, we estimated a sample size of 1127 for the
present study.

The prevalence of dental fluorosis was estimated by taking all
cases of dental fluorosis as the numerator and the total child
population evaluated in the age group of 10-17 years as the
denominator. A Community Fluorosis Index was computed by
summarizing the scores of individual grades (as described by Dean)
and dividing the sum by the total sample size. A community
fluorosis index of greater than 0.4 has been used to identify areas
where fluorosis is a public health problem.5 The association of
dental fluorosis with select individual risk factors was studied
using Chi-square and Chi-square trend tests. Besides examining
bivariate associations, we performed multivariable logistic re-
gression (with step-wise forward selection) to evaluate the inde-
pendent association of select risk factors with prevalence of dental
fluorosis. The dependent event was dichotomous (presence or
absence of dental fluorosis). The predictor variables were age
(continuous variable), sex (boy=1; girl=2), water fluoride content
(<1 ppm=1; >1 ppm=2), quantity of water consumed daily (2-3
glasses=1; 4-6 glasses=2; 7 or more glasses=3), consumption of
brick-tea (yes=1; no=2), consumption of sea fish (yes=1; no=2) and
use of fluoride-containing toothpaste (yes=1; no=2). A p
value of <0.01 was used for entry of the variables in the multivari-
able models. Odds ratios (and their 95% CI) for the association of
the predictor variables with the dependent variable were com-
puted. All analyses were performed with SPSS PC+ version 5.0.
A p value of <0.05 was taken to indicate statistical significance.

**Intra-observer variability**

A sub-sample of students was re-evaluated for the presence or
absence of dental fluorosis by the dental specialist on a second
occasion, approximately one month after the initial examination.
The specialist was blinded to the results of the initial examination.
The agreement between the two sets of readings obtained on two
different occasions was used as a measure of intra-observer
variability.

**RESULTS**

**Study sample characteristics**

Our study sample comprised 1142 students (630 girls and 512
boys) in the age group of 10-17 years. The mean age of the
population was 13.5 years. Nearly half the study sample lived in
rural areas. Pipe water was the major source of drinking water in the
taluk. Most of the children consumed fish in their diet and
four-fifths of them drank brick-tea. Nearly three-quarters used
toothpaste for cleaning their teeth (Table I).

**Prevalence of dental fluorosis and associated risk factors**

The overall prevalence of dental fluorosis in school children in

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (years)</td>
<td>13.45</td>
</tr>
<tr>
<td>Female (%)</td>
<td>55.2</td>
</tr>
<tr>
<td>Urban residence (%)</td>
<td>49.0</td>
</tr>
<tr>
<td>Pipe water for drinking (%)</td>
<td>72.5</td>
</tr>
<tr>
<td>Well water for drinking (%)</td>
<td>20.6</td>
</tr>
<tr>
<td>Brick-tea intake (%)</td>
<td>79.5</td>
</tr>
<tr>
<td>Sea fish intake (%)</td>
<td>96.1</td>
</tr>
<tr>
<td>Dry-fish consumption (%)</td>
<td>79.4</td>
</tr>
<tr>
<td>Toothpaste used for dental cleansing (%)</td>
<td>73.0</td>
</tr>
</tbody>
</table>
our study sample was 35.6%. The calculated community fluorosis index was 0.69, suggesting that fluorosis is a major public health problem in the study area.

Compared to rural areas, the prevalence of dental fluorosis was higher in the urban areas (Table II). The severity of dental fluorosis was also greater in children in the urban area. It is also evident from Table II that dental fluorosis was more prevalent among girls than boys. This observation was not related to the amount of water consumed because boys in the study sample drank more water than girls (p<0.001). Interestingly, we also noted an inverse association between age and the prevalence of dental fluorosis; a higher prevalence was noted in the younger children compared to the older ones. The source of drinking water in our study sample was pipe water 70%, well water 19%, tubewell water 9% and pipe water combined with well water 2%. Table III shows the prevalence of dental fluorosis according to the sources of water consumed by the subjects. The prevalence of dental fluorosis was lowest among children who consumed well water alone, whereas the children who drank mainly pipe water had the highest prevalence. An intermediate prevalence rate was observed among children who drank water from both sources.

We also examined the patterns of water distribution in the urban and rural parts of the study area. A larger proportion of the urban area used pipe water compared to the rural area (93.9% vs. 62.5%, respectively; p<0.001). This suggests that the urban–rural differences in the prevalence of dental fluorosis noted above may in part be related to the increased use of pipe water in the urban areas.

Table IV relates the prevalence of dental fluorosis to the water fluoride content in different panchayats in our study sample (similar information on the municipal wards is not presented because data on water fluoride content were not available). A step-wise increase in the prevalence of dental fluorosis was noted with a corresponding increase in the water fluoride content in different panchayats. We did not observe any association between the prevalence of
dental fluorosis and brick-tea drinking, sea-fish consumption, use of fluoride-containing toothpaste or parental education or socio-economic status (data not presented).

**Multivariable analyses**

Five hundred and eighty-two children had complete information on the fluoride content of water consumed and other predictor variables. These children were eligible for study in the multivariable logistic regression models. The results of multivariable analysis are presented in Table V. The fluoride content of drinking water was the principal determinant of dental fluorosis. A water fluoride content >1 ppm was associated with 1.85-fold elevated risk of prevalence of dental fluorosis, compared to the reference group with a water fluoride content of <1 ppm. Once water fluoride content entered the multivariable model, none of the remaining predictor variables were significantly associated with dental fluorosis.

**Intra-observer variability**

One of the classes was randomly selected for a second evaluation of the students by the dental specialist. For the presence or absence of dental fluorosis, the agreement between observations on the two occasions was 95.7%. However, agreement regarding the degree of fluorosis was modest (63%).

**DISCUSSION**

India lies within a geographical fluoride belt which extends from Turkey up to China. Leaching of fluoride from geological formations accounts for most of the fluoride in drinking water. Large areas of India are therefore at risk of fluoride toxicity. Clinical dental fluorosis has been described as the most convenient biomarker of fluoride exposure. It has therefore been advocated that periodic surveys be conducted to monitor the rates of dental fluorosis in communities at risk for the condition. The present study was conducted with such a purpose.

**Prevalence of dental fluorosis**

The high prevalence of dental fluorosis and the high community fluorosis index suggest that fluorosis is a major public health problem in the study area.

We found important gender-, age-, and residence-related differences in the prevalence of dental fluorosis. The prevalence of dental fluorosis and its severity was higher in the urban area compared to that in the rural area, in girls compared to boys and in younger children compared to older ones. Prior studies have not noted any urban–rural differences in the prevalence of dental fluorosis. We believe that the urban–rural differences in our study area may be related in part to the increased use of pipe water for drinking purposes in the urban areas; we have presented data to substantiate that the intake of pipe water was associated with a higher prevalence of fluorosis compared to consumption of well water. The higher prevalence of dental fluorosis among girls is also contrary to earlier reports. This increased prevalence of dental fluorosis among girls in our study is particularly intriguing because girls consumed less water than boys in our study sample. We believe that further research is required to confirm and investigate these gender-related differences.

The prevalence of dental fluorosis was also greater in the younger age groups. One possible explanation for this intriguing observation is that younger children drink more pipe water compared to older children. While 75.6% of children aged 10–11 years drank pipe water, the corresponding figures for pipe water consumption for the age groups 12–13 years and 14–15 years were 73.6% and 65.9%, respectively. Another possibility is that the increase in intake of dietary fluoride may be a recent phenomenon (within about the last 10 years) in Ambalappuzha taluk. This hypothesis can be verified by observing the water fluoride content in the study area for the last 20 years. Unfortunately, the results of water analysis for fluoride content are not available with the authorities prior to 1994 to substantiate or refute this hypothesis. This trend of a higher prevalence of fluorosis in younger age groups can be further examined by studying the prevalence of dental fluorosis in younger children in the study area. A study of the prevalence of skeletal fluorosis and non-skeletal manifestations in the area (with the cooperation of orthopaedic experts and gastroenterologists) may also shed light on this observation.

**Risk factors for dental fluorosis**

We noted a significant positive association between water fluoride content and prevalence of dental fluorosis in our study sample. This was noted in both bivariate associations presented and in the multivariable analyses. A step-wise increase in prevalence of dental fluorosis was noted with a corresponding increase in water fluoride content in different *panchayats*.

The prevalence of dental fluorosis is high among children who used pipe water for drinking purposes. The reason for this may be that the fluoride content of pipe water is higher compared to that of other water sources. In Alappuzha, ground water pumped from deep wells is the source of water supply through pipes in both urban and rural areas. It is likely that domestic wells and those bored by the water authority vary both in their location and depth, and consequently in the fluoride content of their water. It has been previously demonstrated that even within a small community, different wells have widely varying water fluoride content. This is related in part to divergent hydro-geological conditions; the proportion of rocks with readily leachable fluoride can vary substantially within a given geographical belt.

The socio-economic status of the parents had no influence on the prevalence of dental fluorosis in our study area. This is contrary to a prior report that described a higher prevalence of fluorosis in children belonging to a high socio-economic status. Furthermore, brick-tea drinking, sea- or dry-fish consumption, and the use of toothpaste were not associated with the prevalence of dental fluorosis.

Our multivariable logistic regression analysis demonstrated that water fluoride content was the principal determinant of dental fluorosis in the sub-sample eligible for such analysis. The inverse relation with age seen in the bivariate analysis was not observed in the multivariable models.

**Implications of the present study**

As high fluoride content in drinking water is the main reason for dental fluorosis in Ambalappuzha taluk, measures have to be
taken to distribute the water after partial defluoridation. This requires the synergistic action of health planners, health administrators, engineers and the water supply authorities. Research on the development of affordable technology for the partial defluoridation of household water is also critical. In this context, it is worth mentioning the successful use of granulated bone charcoal household defluoridators in Kenya and Thailand. Our study also underscores the need for conducting detailed fluoride mapping and geochemical surveys of existing water sources in Alappuzha. Clear guidelines to limit the exploitation of ground water should be formulated, so that sinking bore wells in high fluoride zones is either not attempted or is accompanied by necessary steps for defluoridation of water.

Limitations of this study
This is a cross-sectional study. The major risk factor in the development of dental fluorosis is drinking water. Fluorosis develops in an individual during the time of calcification of teeth, which takes place from early infancy. The fluoride content of the water which was consumed during that period is of critical importance, but cannot be measured now. It is presumed in this study that the fluoride content of water in each area has not changed over the last 15 years.

School children were selected for the present study because most of them could be available for investigation during working hours. It is likely that school drop-outs in the study area are excluded from our sample. This is not a major limitation because it is estimated that school drop-outs are very few in Kerala.

Conclusion
Our study suggests that dental fluorosis is a major public health problem among school children in Ambalappuzha taluk and is related to the high fluoride content of drinking water. There is an urgent need to institute partial defluoridation of drinking water in the area to lower the burden of dental fluorosis in this community.

ACKNOWLEDGEMENTS
We are indebted to officials of the Kerala Water Authority, Alappuzha for providing information regarding water fluoride content in various panchayats and municipalities and to the District and Assistant Education Officers, heads of schools, teachers and students for their assistance and cooperation in carrying out this study.

REFERENCES

Initial experience with day case laparoscopic cholecystectomy at a tertiary care hospital in India


ABSTRACT

Background. Cholecystectomy is one of the commonest general surgical operations. Laparoscopic cholecystectomy is currently the most favoured approach. As it is associated with less postoperative pain and ileus, it allows early discharge of patients from the hospital. Studies from the West have reported that ‘day case laparoscopic cholecystectomy’ is feasible and safe. In India, the current practice is to admit patients for laparoscopic cholecystectomy 24-48 hours prior to surgery and to discharge most patients within one to two days of surgery. There is no report from any Indian centre describing ‘day case laparoscopic cholecystectomy’. We conducted a prospective study to assess the feasibility, safety and patients’ acceptance of ‘day case laparoscopic cholecystectomy’ in a tertiary care hospital.

Methods. Eighty-four patients with symptomatic cholelithi-