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Has urbanization become a risk factor for dental caries in Kerala, India: a cross-sectional study of children aged 6 and 12 years

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Objectives. The objectives of this study were to: (i) test the hypothesis that urbanization is a risk factor for dental caries in children aged 6 and 12 years in Kollam, Kerala; and (ii) identify other possible risk factors for dental caries.

Methods. A cross-sectional study design was followed. The subjects were stratified by socio-demographic status into urban middle class, urban poor, and rural poor. Caries experience was measured by visual examination of teeth according to the World Health Organization criteria. Data on potential risk factors were collected using a close-ended, structured, and interviewer-administered questionnaire. Data modelling was conducted using logistic regression analyses.

Results. Eight hundred seventy-six children were examined; 53% of 6-year-olds and 90% of 12-year-olds examined were caries free. The caries experience rates were 1.40 decayed, missing, or filled primary teeth and 0.15 Decayed, Missing, and Filled Teeth (DMFT) for the 6- and 12-year-olds, respectively. Urban children did not have a higher caries experience compared with rural children. The only risk factor associated with a significant difference in DMFT scores was the dental visiting pattern. Children who visited the dentist had a significantly higher mean DMFT score ($P = 0.009$).

Conclusion. There was no evidence that urbanization is a risk factor for dental caries in Kerala. Dental caries experience was low, against any standard, in Kollam. Risk factors for caries were not identified.

Introduction

Dental caries is the most prevalent chronic disease of childhood[1], yet oral health is often neglected within the health care system[2]. Globally, dental caries prevalence is declining in industrialized countries[3], whereas in economically developing countries, urbanization is associated with increased risk of oral health problems[4,5]. Eighty-six per cent of India's population subsist on less than $US2 per day, and 70% reside in rural areas[6]. Recent industrialization in India, with associated urbanization, will soon alter the overall demography[7], and it is expected that diseases seen in developed countries, not only dental caries, will now start to become increasingly prevalent[8].

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The state of Kerala, population of 31.8 million, is located on the south-west coast of India[9]. Kerala is unique among the Indian states in that the social structure is derived from the matriarchal caste system[10]. There has been higher than 95% literacy rates in Kerala for several generations, and its achievements in literacy and health are comparable to developed countries. Whereas in 1991, female life expectancy at birth for all-India was 61.7 years; in Kerala it was 72.8, almost identical to that of 73 years for women in the USA[11]. On the scale of the Human Development Index[12,13], a summary composite index that measures a country's average achievements in three basic aspects of human development: longevity, educational attainment, and adjusted real income, Kerala ranks first in India[14]. In India, documented dental caries experience in the permanent dentition for 12-year-olds in most states is below the Decayed, Missing, and Filled Teeth (DMFT) score of 3[15], the goal set by the World Health Organization (WHO) for countries to achieve by the year 2000[16].

The objectives of this study were to: (i) test the hypothesis that urbanization is a risk factor for dental caries; and (ii) identify other possible risk factors for dental caries among 6- and 12-year-olds in Kollam District, one of 14 administrative districts in Kerala, in order to inform future planning of appropriate dental services.

Materials and methods

Target population

Schoolchildren aged 6 and 12 years from rural, urban middle class, and urban poor socio-demographic groups in the district of Kollam and city of that name, Kerala, were targeted in this study. Because the Indian social hierarchy is clearly defined, both in terms of the environments in which people work and live, children selected from rural schools reflect the socio-demographic sector who subsists on the equivalent of $US2 per day. The urban poor children and the urban middle class children were selected, respectively, from schools in the clearly defined demographic sectors of Kollam. Children attending schools that cater for the highest social class were excluded because they comprise a very small minority of the population and also because migrants from rural areas do not filter into the upper reaches of the social strata.

Sample size and sampling method

The target sample estimate for each age-specific socio-demographic group, based on the assumption of low caries prevalence (at least 20% caries free) was 200, comprising clusters of 25 to 50 children[17]. A one-stage cluster sampling method was used. Urban schools were randomly selected from a sampling frame of potential schools stratified by socio-demographic status. Inclusion of selected schools was dependant upon permission being granted by the school administration. All children aged 6 and 12 years in the selected schools who were present on the day of the survey were invited to participate. School selection continued until the desired sample size was obtained.

Recruitment of sample

This survey was conducted in 2007. At schools where permission was granted, a participant information statement written in the local language of Malayalam was provided to the class teachers prior to the day of the survey. The nature of the survey was explained by the teachers to their pupils who relayed this information to their parents. Consent for participation was given by the school principals on behalf of the children and their parents. It was made clear that participation was voluntary. For schools that were under the jurisdiction of the Catholic Diocese of Kollam, written permission to conduct the survey was obtained from the Director of Education of the Diocese. In other non-government schools, written consent was obtained from the school principals.

Clinical examination

A clinical oral examination was carried out to assess dental caries experience. The dental examination was restricted to the primary teeth in 6-year-olds and to the permanent teeth of the children aged 12. Dental caries experience was described using the DMFT index according to diagnostic criteria recommended by the WHO for oral health surveys[17]. Cavities were recorded as greater or less than 4 mm in diameter.

The children were examined under natural day-light and seated beside a window. Diagnosis of dental caries was based on visual confirmation of cavitation alone; the WHO probe was not used to confirm the smallest cavities. Wooden spatulas were used as an aid in retraction of the facial tissues. Data from the clinical examination were entered, by a trained recorder, directly into an electronic database.

Questionnaire survey

The 12-year-olds only were invited to complete a structured questionnaire interview containing seven multiple-choice questions on their oral health-related habits and sugar exposure during the previous 24 h. Only one

nominal answer, coded from 0 to 5, was permitted for each question. The questionnaire was pilot tested among the 12-year-olds in one school before the start of the survey. The method of asking certain questions was modified following the piloting exercise. Each study subject was interviewed separately after their clinical examination by a trained interviewer. The information was recorded on paper during the interview process and after was entered into the electronic database.

Data quality

In order to ensure data quality, all examinations were carried out by one examiner (B.C.). Training and calibration of the examiner were performed during a similar survey of children in Australia, where the examiner (B.C.) and supervisor (R.W.E.) jointly examined subjects and discussed the findings. This process continued until examiner reliability was achieved. The interviewer administering the questionnaire was blind to the oral health status of the children. Duplicate clinical examinations were carried out on 23 randomly selected children from two different schools to determine intra-examiner reliability using the kappa statistic. The kappa value for intra-examiner reliability was 0.97.

Data analysis

The data was analysed using Epi Info, version 3.4.2, and SAS, version 9.1 statistical softwares. Differences between distributions of DMFT as stratified by potential explanatory variables were tested for significance (Kruskal–Wallis). Further analysis of potential predictors of caries experience was conducted using logistic regression analysis.

Ethical clearance

Ethical clearance for this study was obtained from the Human Research Ethics Committee, The University of Sydney.

Results

A total of 876 children were examined, of which 434 and 442 were aged 6 and 12 years, respectively. Boys accounted for 58% of children in the overall sample.

Primary dentition

The caries experience of 6-year-olds is summarized in Table 1. Of these children, 53% were caries free and the overall mean decayed, missing, or filled primary teeth (dmft) score

Table 1. Caries experience statistics for 6-year-olds in Kerala, by gender and socio-demographic status.

	N	%	%cf§	$d_{1\ mm}$†	$d_{4\ mm}$‡	*d*	*m*	*f*	dmft	SD	*P* value*
Boys											
Urban middle class	167	62	55	0.35	0.63	1.04	0.07	0.15	1.27	1.99	
Urban poor	53	20	49	0.71	0.77	1.49	0.05	0.00	1.55	1.91	
Rural	50	19	54	0.42	1.06	1.48	0.04	0.00	1.52	2.53	0.600
Total	270	62	54	0.44	0.81	1.21	0.06	0.10	1.37	2.09	
Girls											
Urban middle class	71	43	54	0.36	0.97	1.42	0.04	0.16	1.63	2.34	
Urban poor	41	25	46	0.65	0.85	1.51	0.07	0.00	1.58	1.73	
Rural	52	32	54	0.30	0.55	0.86	0.13	0.05	1.06	1.44	0.439
Total	164	38	52	0.42	0.74	1.27	0.08	0.09	1.44	1.95	
Total											
Urban middle class	238	55	55	0.36	0.73	1.15	0.06	0.16	1.37	2.10	
Urban poor	94	22	48	0.69	0.80	1.50	0.06	0.00	1.56	1.82	
Rural	102	24	54	0.36	0.80	1.16	0.08	0.02	1.28	2.05	0.307
Total	434		53	0.43	0.77	1.23	0.07	0.09	1.40	2.04	

*Kruskal–Wallis H.
†Cavity at least 1 mm in size.
‡Cavity of 4 mm or more.
§Percentage caries free (dmft = 0).

Table 2. Caries experience statistics for 12-year-olds in Kerala, by gender and socio-demographic status.

	N	%	%cf§	$D_{1\ mm}$†	$D_{4\ mm}$‡	*D*	*M*	*F*	DMFT	SD	*P* value*
Boys											
Urban middle class	90	38	92	0.00	0.04	0.04	0.01	0.03	0.09	0.32	
Urban poor	93	39	89	0.08	0.10	0.17	0.00	0.00	0.17	0.58	
Rural	55	23	89	0.18	0.11	0.13	0.00	0.02	0.18	0.58	0.707
Total	238		90	0.03	0.08	0.11	0.00	0.02	0.14	0.50	
Girls											
Urban middle class	45	22	93	0.09	0.02	0.07	0.00	0.00	0.11	0.44	
Urban poor	67	33	89	0.00	0.10	0.10	0.03	0.00	0.13	0.42	
Rural	92	45	87	0.05	0.09	0.14	0.00	0.04	0.18	0.53	0.548
Total	204		90	0.04	0.08	0.11	0.01	0.02	0.15	0.48	
Total											
Urban middle class	135	31	93	0.03	0.04	0.05	0.01	0.02	0.10	0.36	
Urban poor	160	36	89	0.04	0.10	0.14	0.01	0.00	0.16	0.52	
Rural	147	33	88	0.04	0.10	0.14	0.00	0.03	0.18	0.55	0.381
Total	442		90	0.04	0.08	0.11	0.01	0.02	0.15	0.49	

*Kruskal–Wallis H.
†Cavity at least 1 mm in size.
‡Cavity of 4 mm or more.
§Percentage caries free (DMFT = 0).

was 1.40. Most caries experience occurred in the primary molars, and only 8% of children had experienced caries in their anterior teeth. The gender-specific scores were similar. There were few missing and filled teeth and, therefore, the overall dmft scores represent the decayed component mainly. The ratio of large (≥ 0.4 mm) to smaller cavities was around 2 : 1. The distribution of caries experience by socio-demographic status demonstrated that the rural children tended to have a lower caries experience, but this result was not significant.

Permanent dentition

Ninety per cent of 12-year-olds were caries free, and the mean DMFT score was 0.15, there being no gender difference (Table 2). In the permanent dentition, the caries experience was confined almost exclusively to the occlusal surfaces of the first molars. There was a non-significant trend showing that the urban middle class children had the lowest DMFT score (0.10) and rural children had the highest (0.18).

Analysis of caries risk

DMFT distributions for 12-year-olds, stratified by a set of potential caries risk factors, are shown in Table 3. As already noted, DMFT differences across the socio-demographic groups were not significant. A slight but non-significant trend of increasing caries experience is associated with increasing frequency of exposure to sugar containing items (daily totals). Significant differences between the distributions were observed only in relation to the variable of dental visits and use of fluoridated toothpaste. Children who had visited a dentist had a higher caries experience than the non-visitors; however, because the need to visit a dentist is a consequence of caries experience, dental visiting behaviour itself is not a caries risk factor. Children using locally branded fluoridated toothpaste had, in one case a negligible caries experience, whereas in the other case, users had the highest caries experience; however, the number of children using the locally branded toothpaste was few. The toothpaste effect was explored further in a logistic regression analysis. Compared with a standard international brand of toothpaste, users of one local brand of toothpaste were five times more likely to experience dental caries (OR = 5.31, 95% CI of 1.78, 15.79, $P = 0.003$). Other such comparisons of caries experience, among children using other brands of toothpaste, did not yield significant differences. A series of multiple logistic regression models were explored in which each of the individual caries risk factors

Table 3. Decayed, Missing, and Filled Teeth (DMFT) of 12-year-old Keralites stratified by potential explanatory variables.

	N	%	% CF†	DMFT	SD	*P* value*
Socio-demographic factors						
Gender						
Male	238	54	90	0.14	0.50	
Female	204	46	89	0.15	0.48	0.699
Location						
Urban middle class	135	31	93	0.10	0.36	
Urban poor	160	36	89	0.16	0.52	
Rural poor	147	33	88	0.18	0.55	0.381
Frequency of daily exposure to cariogenic risk factors						
All sugar-containing items						
<3	172	39	91	0.13	0.47	
4–5	137	31	91	0.15	0.54	
6+	133	30	88	0.16	0.46	0.720
Dental services						
Visit to dentist						
Never	227	51	93	0.08	0.32	
Yes	215	49	86	0.22	0.61	0.009
Oral hygiene practice						
Teeth cleaning aid						
Toothbrush	388	88	90	0.14	0.47	
Finger	53	12	91	0.17	0.64	0.863
Dentifrice type						
Fluoridated toothpastes	381	86	90	0.15	0.50	
Other‡	61	14	90	0.13	0.43	0.914
Fluoridated dentifrice only						
Colgate	256	68	90	0.15	0.49	
Anchor F§	26	7	96	0.04	0.20	
Cibaca§	16	4	63	0.44	0.63	
Close up	52	14	96	0.06	0.31	
Pepsodent	25	7	92	0.12	0.44	0.003
Tooth cleaning frequency						
Less than daily	12	3	92	0.08	0.29	
Once daily	317	72	91	0.16	0.51	
More than once daily	113	26	89	0.12	0.45	0.818

*Kruskal–Wallis H.
†Percentage caries freedom.
‡Includes non-fluoridated dentifrice types and tooth powders.
§Local dentifrice brands.

was investigated both, together and separately, with both socioeconomic status and gender. No variable was identified as a significant predictor of caries.

Discussion

This study highlights the fact that caries experience in Kollam District is low compared with elsewhere in Kerala. Primary dentition dmft scores of children in: (i) an urban region of Malappuram District (included in the state-wide survey referred to below); (ii) the semi-urban area of Varkala, nearby to Kollam in an adjacent district; and (iii) the peri-urban area surrounding the state capital, Trivandrum, were 3.50, 2.43, and 2.58, respectively[18–20]. These values were about double the Kollam District value of 1.40 observed in this study.

The overall DMFT score of 0.15 for 12-year-olds in Kollam District is lower than a recently reported score of around 0.5 for Trivandrum 12-year-olds[21], and both are lower than the scores of 2.07 and 1.70, respectively, for children of this age in Varkala (Trivandrum District), and those included in the state-wide survey of 2003[18,19].

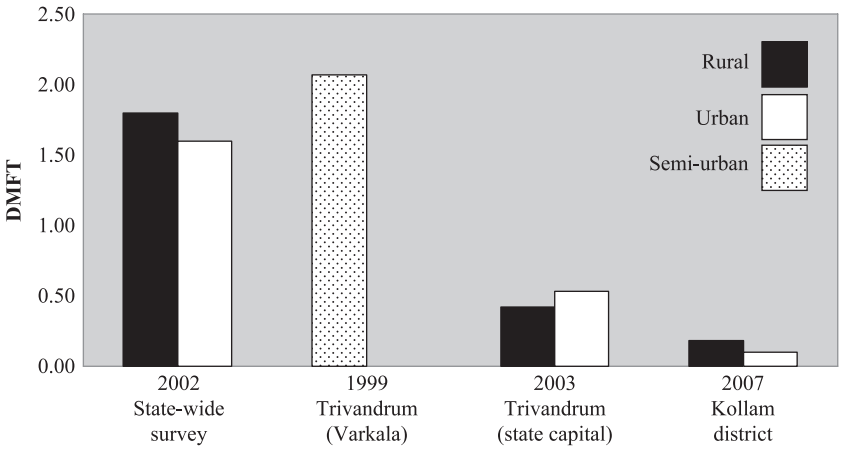

Fig. 1. Comparison of Decayed, Missing, and Filled Teeth scores for urban and rural 12-year-olds across Kerala.

In addition, this study indicates that in Kollam District, an urbanization-related caries experience increase was not evident among 12-year-olds. Although there are children in Kollam that may properly be regarded as urban poor, there are no urban slums in this city. In Trivandrum District, a small but significant difference between the DMFT scores (0.53 vs. 0.42) of urban (state capital) 12-year-olds and their counterparts in the surrounding rural area was reported by David *et al.*[21]. On the other hand, there is a state-wide urban–rural difference (significance not reported) of 0.2 in favour of urban children[18]. Of more interest, however, is the disparity (as summarized in Fig. 1) between the higher caries experience state-wide and in Varkala (prevalences of 67%), on the one hand, and that in Trivandrum and Kollam, on the other (respective prevalences of 27% and 10%). Because the authors of these four studies reported that they had used WHO diagnostic criteria, it is likely that the disparity among the results is caused by variation by the respective authors in their application of WHO criteria. The low dmft/DMFT scores reported in this study may represent a slight underestimation of the caries experience because caries diagnosis was determined by visual means alone, that is, without confirmation by probing. However, because caries experience for the 12-year-olds was extremely low, a DMFT score of only 0.15, it is unlikely that the use of a probe would have uncovered many more cavities because vulnerable pit and fissure surfaces usually present with cavities soon after tooth eruption rather than 6 years later.

It is likely to be the case that the Trivandrum and Kollam results reflect the Kerala situation overall. This satisfactory oral health outcome ranks alongside Organisation for Economic Co-operation and Development countries[22]. Although Kerala's gross domestic product was reported as one of India's lowest[23], Kerala ranks first in terms of the Human Development Index[14], already noted, demonstrating that factors other than wealth contribute to health status.

In this rural area of India, caries risk was low and risk factors were not evident. By contrast, it has been reported that caries risk in remote Mexican villages is extremely high where the risk factor identified, soda consumption (presumably sweetened) between meals, is usually associated with the problem of urbanization[24].

The unusual results regarding the use of locally branded fluoridated toothpastes should be investigated further to determine whether the observed differences in caries experience of children using the different brands of fluoridated toothpaste were real or whether they were caused by sampling issues (type 2 error).

The low filled component of the DMFT index, as observed in this study, was also reported by David *et al.* in his study on 12-year-olds in Trivandrum[21]. These authors suggested a possible reason for the high percentage of unrestored teeth as being caused by 'a low perception of the need for treatment and the low priority placed on oral healthcare compared with other needs'[21]. It is

likely that this explanation would also apply in Kollam.

Conclusion and recommendation

Risk of dental caries was low, against any standard, in Kollam, Kerala. Evidence of deterioration in oral health caused by urbanization in Kerala is weak, and risk factors for caries were not identified.

The disparity among recent dmft/DMFT scores for children of the same age in Kerala should be investigated further.

What this paper adds

- An urbanization-associated risk of caries in Kerala has not yet occurred.
- There is a disparity among recently reported dmft/DMFT scores for children of the same age across Kerala.

Why this paper is important to paediatric dentists

- In Kerala, where caries prevalence is currently low, it should be possible to establish a dental service for children that has a focus on primary prevention and therefore be in a position to meet any future challenge arising from a likely rise in urbanization.

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