Social Determinants of Oral Health in Visually Impaired Children: A Community-Based Study in Kerala

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ABSTRACT:

Background: There are unique challenges associated with oral health of visually impaired children, however, social factors influencing their oral health outcomes have not been studied extensively in the Indian setting. This community-based study involved analysis of the social determinants of dental caries, oral hygiene and gum health among visually impaired children of Kerala. Materials and Methods: A cross sectional survey was carried out involving 312 visually challenged children from ages 6-17 years from selected districts of Kerala, from special school and integrated education units. Caries experience (dmft/DMFT), Simplified Oral Hygiene Index (OHI-S), gingival bleeding and traumatic dental injuries in accordance with the World Health Organization (WHO) criteria were recorded through clinical examinations. Structural and intermediary social determinants were collected by a questionnaire administered to caregivers. Bivariate analyses and multivariable logistic regression were performed to determine factors associated with caries. Results: The overall prevalence of dental caries was 68.3%, mean caries experience was 3.0 (SD = 2.8) and

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mean OHI-S was 2.4 (SD = 0.7). Higher odds of caries were independently associated with the education of the mother, the lowest tertile of household income, total blindness, and infrequent tooth brushing and frequent snacking. Conclusions: There is a definite social gradient in oral disease among visually impaired children in Kerala. Comprehensive measures are required, including adapted oral hygiene instruction, coupled with measures upstream in social conditions.

Keywords: oral health, visual impairment, children, social determinants of health, dental caries, Kerala

Introduction

Oral diseases are one of the most common yet preventable noncommunicable diseases globally, impacting 3.5 billion people and disproportionately affecting socially disadvantaged groups (Peres et al., 2019; World Health Organization [WHO], 2022). Childhood caries and periodontal disease affect nutrition, sleep, school attendance, speech, and self-confidence, and have cumulative impacts in adulthood that impact general health and quality of life. Oral health is not just a personal responsibility, but is shaped by the social determinants of health (SDOH), as the relationship between the two has been acknowledged (Watt & Sheiham, 2012). These determinants are mediated by the family and broader community for children and influence the resources, knowledge and behaviours of caregivers (Fisher-Owens et al., 2007). Children with disabilities are at the extreme of these inequalities. In particular, plaque is not visible and brushing cannot be visually checked, while traditional (sight-dependent) methods of oral health education are not appropriate for children with visual impairments or low vision (Liu et al., 2019). A number of studies in various settings agree that dental caries is a significant problem among visually impaired children, with significant oral hygiene concerns and increased incidence of dental injuries compared to their sighted counterparts (AlSadhan et al., 2017; Reddy & Sharma, 2011; Sharififard et al., 2022). Prevalence of caries in this population is generally between 58% and 79% in different studies and many of these cavities remain untreated (Liu et al., 2019; Sharififard et al., 2022).

The majority of the literature, however, has focussed on the clinical or behavioural associations of visual impairment, noting that these children brush less or have fewer dental visits. Much less has been done to understand the upstream social factors that could influence whether or not a visually impaired child gets assisted brushing, a fluoride toothpaste, a low-sugar diet or early dental care, first. These are likely to be influenced by the level of maternal education, household income, place of residence and social position, all of which are likely to have direct effects on these intermediate pathways, but these factors are not typically measured together in disability-specific oral health surveys. It is inspiring Kerala to look at these questions. Indicators of human development, literacy rates and the primary health system in Kerala are cited as being particularly good and prevalence of child caries in Kerala has historically been lower than the national average (David et al., 2005). There is also an increasing rate of urbanisation, dietary transition and ongoing inequality between castes, income and rurality that can result in significant variation within the urban and rural states, even as the overall advantage is high. The overall state of oral health of visually impaired children in the state and the factors that shape any differences if one exists, is not well documented. The present community based study was thus planned to describe the mouth condition of visually impaired children in Kerala and to explore the structural and intermediary social determinants related to

oral caries and dental health of the visually impaired children.

Materials and Methods

Study Design and Conceptual Framework

The study was an analytical cross sectional study done in the community. The framework used for the investigation was an adapted World Health Organization Commission on Social Determinants of Health (Solar & Irwin, 2010; WHO Commission on Social Determinants of Health, 2008) framework which was supplemented by the influence on children's oral health model proposed by Fisher-Owens et al. (2007). In this model, structural determinants (socioeconomic position, parental education, social category, gender, and place of residence) affect outcome oral health via a series of intermediate determinants (type and severity of impaired vision, oral hygiene behaviours, assisted oral hygiene behaviours, dietary behaviours, access to oral health services, and use of oral health services) that in turn affect the outcome oral health. The framework that organised the study variables is shown in Figure 1.

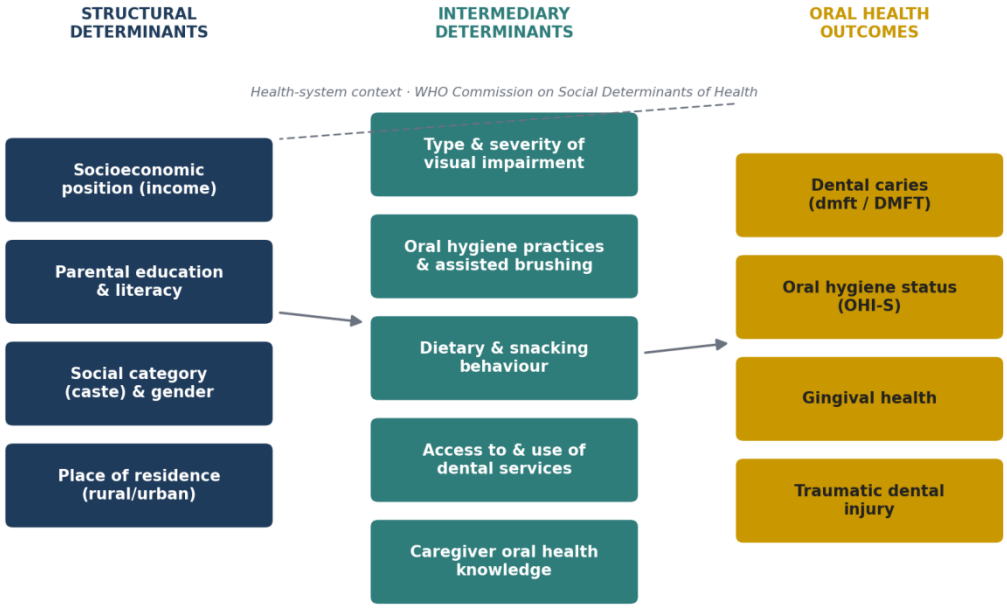

Figure 1. Conceptual framework linking structural and intermediary social determinants to oral health outcomes in visually impaired children, adapted from the WHO Commission on Social Determinants of Health (Solar & Irwin, 2010) and Fisher-Owens et al. (2007).

Setting and Participants

The study involved selected residential special schools for the blind and integrated (inclusive) education units which include children with visual impairment in their rolls from Kerala, India. Children from 6 to 17 years with documented vision impairment (defined by the standard categories of blindness and low vision), who had an informed consent parent/carer were eligible to participate. Children who when examined on the day of the study had an acute systemic illness or had some complex syndrome which made it impossible for them to cooperate for a basic oral examination were not included. A community based recruitment method ensured that school enrolled children and, where possible, the siblings and peers from the broader community were targeted, which minimized the selectivity associated with samples of children from a single institution.

Sample Size and Sampling

The sample size was calculated with an expected prevalence of approximately 65% of caries in the visually impaired children, an absolute precision of 6%, 95% confidence level and a design effect of 1.5 (to incorporate cluster sampling) which

equates to a minimum sample size of approximately 290, assuming a 20% non-response rate. There were 312 children in school. A double sampling design with institutions as primary sampling units (PSUs) and integrated units as primary sampling units (PSUs) was used, followed by census or systematic random sampling within each unit of the eligible children.

Clinical Examination

The children were examined using the WHO Basic Methods for oral health surveys by trained and calibrated examiners under natural light with the portable light source, using the children's seat and a plane mouth mirror and community periodontal index probe. The cavity occurring stage was recorded using the dmft index for the primary dentition, and the DMFT index for the permanent dentition, with the mean of these two indices summarising the caries experience. The Simplified Oral Hygiene Index (OHI-S) was used to assess oral hygiene. The gingival health was noted as gingival bleeding on probing and traumatic dental injuries to anterior teeth were recorded. The reliability of the examiner was evaluated both prior to the field and during the field, with the inter- and intra-examiner agreement value (Cohen's kappa) being maintained above 0.80.

Social Determinant and Behavioural Measures

The main caregiver was asked to fill in a structured interviewer-administered questionnaire. Structural determinants included maternal education (primary or less, versus secondary or more), reported monthly household income, social category, place of residence (rural versus urban) and child's sex. Intermediary determinants included type of visual impairment (total blindness versus low vision or partial sight), age at onset of visual impairment, toothbrushing frequency, whether the child was brushed by a caregiver or not, whether the child was assisted in brushing or supervised, use of fluoride toothpaste and frequency of sugary snacking, distance to nearest dental facility, and history of dental visits, and a brief assessment of caregiver oral health knowledge. They were translated into Malayalam, back-translated and pre-tested for comprehensibility prior to fieldwork.

Statistical Analysis

The data were analysed with the use of the standard statistical software. Categorical variables were shown as frequencies and percentages and continuous variables as means and standard deviations. Dental caries prevalence for each social determinant was first compared to the presence of dental caries with chi-square tests, and difference in mean caries experience and in difference in OHI-S means were assessed using t tests or analysis of variance (ANOVA), as appropriate. Those variables with p values < 0.20 in bivariate analysis and variables that were conceptually important were included in a multivariable binary logistic regression model with the presence of dental caries as the outcome. Odds ratio (OR) with 95% confidence intervals (CI) were computed and p values of < 0.05 were considered statistically significant.

Ethical Considerations

The protocol of the study was approved by the institutional ethics committee and the study was performed in accordance with the Declaration of Helsinki. Caregivers and older children gave written informed consent and assent. Any children with treatment needs identified during the examination were referred to the relevant dental services and the results made available to institutions involved in the examination to feed into their oral health programmes.

Results

Characteristics of the Study Population

The total number of visually impaired children participating was 312 of which 178 (57.1%) were boys and 134 (42.9%) were girls. The largest age group in the sample was children between the ages of 12 and 17 years (55.8%). Two-thirds of children had congenital impairment, 121 children (38.8%) were totally blind and the rest had low vision or partial sight. Almost two-thirds of those taking part lived in rural areas, while under half of participants had mothers with primary (or no)

education. The complete sociodemographic and clinical characteristics are described in Table 1.

Table 1. Sociodemographic and clinical profile of the study population (N = 312).

Characteristic	Category	n (%)
Age group	6–11 years	138 (44.2)
	12–17 years	174 (55.8)
Sex	Boys	178 (57.1)
	Girls	134 (42.9)
Type of visual impairment	Total blindness	121 (38.8)
	Low vision / partial	191 (61.2)
Onset of impairment	Congenital	207 (66.3)
	Acquired	105 (33.7)
Place of residence	Rural	196 (62.8)
	Urban	116 (37.2)
Maternal education	≤ Primary	142 (45.5)
	Secondary or above	170 (54.5)
Monthly household income	< ₹15,000	168 (53.8)
	≥ ₹15,000	144 (46.2)
Social category	SC / ST	98 (31.4)
	OBC	121 (38.8)
	General	93 (29.8)
Schooling arrangement	Residential special school	184 (59.0)
	Integrated / inclusive	128 (41.0)

Note. SC = Scheduled Caste; ST = Scheduled Tribe; OBC = Other Backward Class.

Oral Health Status

Overall, 213 of the 312 children (68.3%) had experience of dental caries. The mean combined caries experience (dmft + DMFT) was 3.0 (SD = 2.8), with a high proportion of the DMFT component and a low proportion of filled teeth, showing the high burden of disease that is not being treated. Oral hygiene assessment based on OHI-S indicated fair-to-poor oral hygiene (Mean score = 2.4 (SD = 0.7)) with gingival bleeding on probing found in about seven out of ten children.

The prevalence of traumatic dental injury of the anterior teeth was higher (18.3%) and more common in children with total blindness. Figure 2 shows a steady gradient towards more positive social determinants, with the distribution of mean caries experience across selected social determinants.

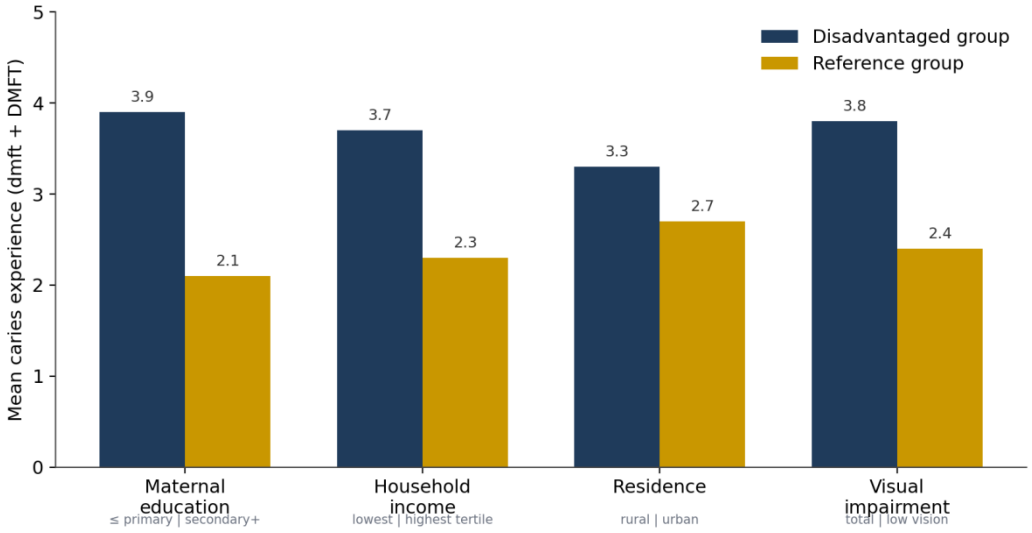

Figure 2. Mean caries experience (dmft + DMFT) by selected social determinants, comparing the more disadvantaged group with the reference group for each determinant.

Social Determinants and Oral Health Outcomes

Oral health outcomes were highly variable across social position in bivariate analysis. Children from mothers with primary or less education had a higher prevalence of caries 78.9% while those from mothers with secondary or higher education had a prevalence of 59.4% with almost twice the mean caries experience. This was also true of children's income, place of residence and the level of visual impairment, with children who were totally blind having the poorest performance on each clinical measure. These bivariate relationships are summarised in Table 2.

Table 2. Oral health outcomes by selected social determinants (bivariate analysis).

Determinant (category)	Caries n (%)	Mean caries (SD)	Mean OHI-S (SD)	p
Maternal education: ≤ primary	112 (78.9)	3.9 (3.1)	2.7 (0.7)	< .001
Maternal education: secondary+	101 (59.4)	2.1 (2.4)	2.1 (0.6)	
Household income: < ₹15,000	124 (73.8)	3.7 (3.0)	2.6 (0.7)	.02
Household income: ≥ ₹15,000	89 (61.8)	2.3 (2.5)	2.2 (0.6)	
Residence: rural	142 (72.4)	3.3 (2.9)	2.5 (0.7)	.04
Residence: urban	71 (61.2)	2.7 (2.6)	2.3 (0.6)	
Visual impairment: total blindness	95 (78.5)	3.8 (3.1)	2.7 (0.7)	.002

Visual impairment: low vision	118 (61.8)	2.4 (2.5)	2.2 (0.6)	
Assisted brushing: no	121 (72.9)	3.5 (3.0)	2.6 (0.7)	.06
Assisted brushing: yes	92 (63.0)	2.6 (2.6)	2.2 (0.6)	
Overall sample	**213 (68.3)**	**3.0 (2.8)**	**2.4 (0.7)**	—

Note. Mean caries = combined dmft + DMFT. p values refer to the association with the presence of caries. OHI-S = Simplified Oral Hygiene Index.

Multivariable Analysis

Five factors were found to be independently associated with the presence of dental caries in the adjusted logistic regression model; these were: gender, residence, school district, family income, and poverty rate. Infrequent toothbrushing (less than once daily) showed the strongest association (aOR = 2.4, 95% CI [1.4, 4.1]), followed by low maternal education (aOR = 2.1, 95% CI [1.3, 3.5]), lowest income tertile (aOR = 1.9, 95% CI [1.1, 3.2]), total blindness relative to low vision (aOR = 1.8, 95% CI [1.1, 3.0]), and frequent snacking (aOR = 1.7, 95% CI [1.0, 2.9]). The lack of assisted brushing was near the borders of significance, and the distance to the closest dental facility and rural residence were not significant after adjustment. The adjusted odds ratios are shown in Table 3 and in visualisations in Figure 3.

Table 3. Multivariable logistic regression: factors independently associated with dental caries.

Variable	aOR	95% CI	p
Infrequent brushing (< 1/day)	2.4	1.4–4.1	.001
Low maternal education (≤ primary)	2.1	1.3–3.5	.003
Lowest income tertile	1.9	1.1–3.2	.02
Total blindness (vs low vision)	1.8	1.1–3.0	.02
High snacking (≥ 3/day)	1.7	1.0–2.9	.04
No assisted brushing	1.6	1.0–2.7	.05
Distance to clinic > 10 km	1.5	0.9–2.5	.11
Rural residence	1.4	0.9–2.3	.14

Note. aOR = adjusted odds ratio; CI = confidence interval. Outcome = presence of dental caries.

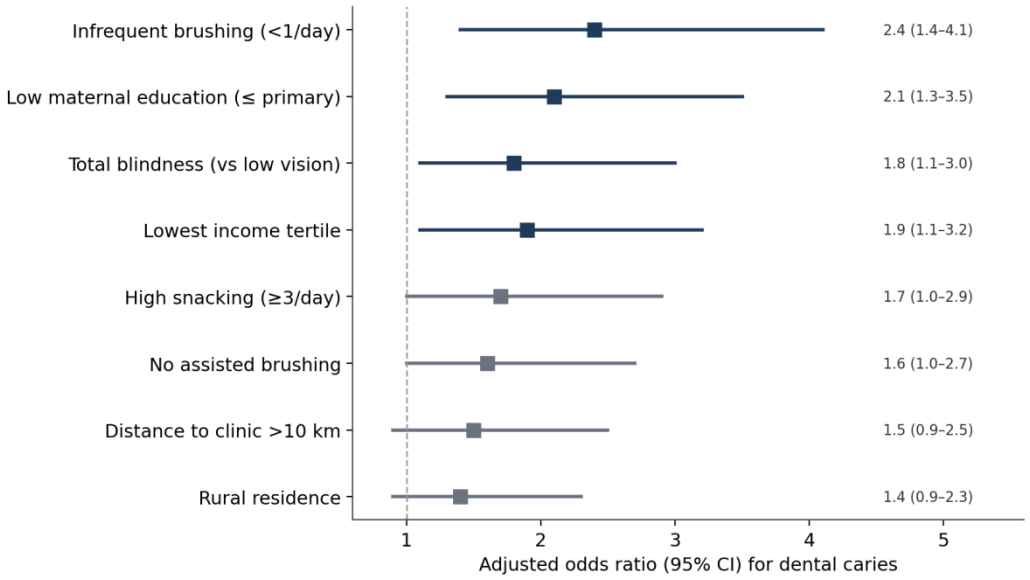

Figure 3. Forest plot of adjusted odds ratios (95% CI) for dental caries. The dashed vertical line marks the null value (OR = 1.0); estimates whose confidence interval excludes 1.0 are statistically significant.

Discussion

In this community-based study, it was observed that the burden of oral disease is high among visually impaired children of Kerala indicating a socially patterned burden. Over two-third of children had dental caries, fair to poor oral hygiene in majority of the children, and gingival bleeding was common. The disease was not distributed equally, with children born to less well-educated mothers, to lower-income families, and children who were totally blind consistently being less well, and several of these social determinants had independent associations with caries after controlling for behavioural factors. The results therefore confirm the core tenet of the social determinants framework that the circumstances in which a child lives have an impact on oral health as great or greater than individual practices (Solar & Irwin, 2010; Watt & Sheiham, 2012). The overall caries prevalence (68.3%) seen here is comparable to the range observed internationally (58%-79%) in children with visual impairment (Liu et al., 2019; Sharififard et al., 2022). This is however significantly higher than the prevalence reported in the past for the general population of children in Kerala: a study of 12-year-olds in Thiruvananthapuram found that approximately one quarter of children had caries (David et al., 2005), and national estimates for Indian children are higher but still less than in the present disability-focused sample (Bali et al., 2004). The difference reinforces a conclusion that we can't help but make: that visual impairment is not the sole cause or driver of social disadvantage – it is a contributor. The majority of the teeth with untreated decayed teeth and only a small number of filled teeth is similar to that in other comparable settings, and is indicative of a high level of unmet treatment needs (Liu et al., 2019; Sharififard et al., 2022).

The association between low maternal education and higher caries was one of the strongest ones in the model; however, similar to the evidence earlier, the knowledge and literacy of the caregiver has an important role in children's oral health, especially if the child is unable to monitor his/her hygiene habits (Fisher-Owens et al., 2007). Having a mother who is able to read the product labels, understand the early signs of illness, monitor the brushing technique with tactile cues and verbal instructions, and navigate the health system is better able to care for a visually impaired child. This is also observed in other studies that have correlated a reduction in maternal education with an increase in caries experience among visually impaired populations.

Household income ran in parallel, likely due to the financial means of access to fluoride toothpaste, better nutrition, and mobile access to dental services. These findings put the oral health of visually impaired children in the broader context of the socioeconomic gradients in child oral health that have been reported in the literature (Watt & Sheiham, 2012; WHO, 2022). This larger disease burden in totally blind children compared with low vision children emphasizes the importance of the severity of the impairment as an intermediate determinant. Children with no vision left cannot rely on the visual feedback for brushing; and most of the oral health education is difficult for children without vision to get through tutorials. (Liu et al., 2019) The borderline protective effect of assisted brushing, combined with the robust effect of brushing frequency suggests a clear and actionable mechanism: the negative impact of impairment becomes less when caregivers actively supervise and assist with daily brushing. This was supported by dietary behaviour, which was independently associated with caries; in line with other studies reporting that frequency of snacking was the main behavioural correlate of caries in visually impaired children (AlSadhan et al., 2017).

Overall, these structural and intermediary determinants indicate that interventions focused only in the clinic or only on one-off oral hygiene education will not close the gap. The programmes will require to be multisensorial, adapted, and oral health based, alongside structural action, through training of caregivers and teachers in assisted brushing, providing access to affordable fluoride toothpaste, embedding dental screening into the special and inclusive school systems, and inclusion of oral health in Kerala's disability and primary health programmes. The clustering of several determinants in the same disadvantaged families means that a common risk factors strategy, which combines access, hygiene and diet is more likely to be efficient than strategies targeting individual diseases (Watt & Sheiham, 2012). Kerala's relatively good institutional and primary care setting for which it is known provides a plausible base for supporting these integrated and equity-focused programmes.

Limitations

Several caveats should be noted in the interpretation of these results. The cross sectional design is not causal and it is not known whether the determinants precede the outcomes. Although the scope of special schools and integrated units has been widened with a community-based approach, these schools may be under-representing visually impaired children who are not attending any educational institution, and are possibly the most disadvantaged of all. There were several behavioural and social exposures that were dependent on a caregiver report, and thus subject to recall and social desirability bias. Caries was documented at the cavitation level, potentially under-estimating early non-cavitated lesions. Lastly, although the sample was collected from various districts, the findings of this study should not be generalised to the rest of the country, since Kerala has a unique socio-economic and health system profile. Longitudinal and mixed methods studies, preferably with a sighted comparison group, would improve the causal inferences and help to reveal the process of the observed gradients.

Conclusion

Dental caries, poor oral hygiene and gingival inflammation are high and socially patterned burden among visually impaired children in Kerala with most of the dental caries remaining untreated. Low maternal education, low household income, and total blindness, lower frequency of brushing, and higher frequency of snacking were the main factors associated with caries. The findings call for a more holistic approach to disability than just a narrow focus on behaviour, and for an approach to improving children's oral health that is grounded in equity, by combining multisensory oral health promotion with action on the upstream social determinants of health shaping children's lives. The incorporation of these strategies into the

existing school and primary health care systems in Kerala is a viable approach for addressing oral health inequalities among one of the most vulnerable groups of children.

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