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Original Research Article

A Cross-Sectional Study Examining the Association between Dental Caries and Oral Health Literacy among Adolescents in Tamil Nadu, India

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Abstract: In India, prevalence and severity of dental caries is increasing due to an increase in the adoption of the 'westernized diet'. There is little recognition for oral health education in the Indian school curriculum compared with general health education. The study's aim was to measure the association between dental caries and the level of oral health literacy among an adolescent population residing in Tamil Nadu, a southern state of India. The study aim was addressed by a quantitative cross-sectional study measuring the association between oral health literacy and the prevalence and severity of dental caries in 974 adolescent school students (12-15 year-olds) living in either rural and urban areas of Tamil Nadu, India. The severity of dental caries and prevalence of dental caries were associated with oral health literacy scores and results were statistically significant. Multiple linear regression analyses indicated that factors such as gender, community and oral health literacy were significant predictors of dental caries. Scheduled Caste and Tribe populations living in rural areas and females attending public schools in either urban or rural areas were identified as the most vulnerable populations to be affected by high rates of dental caries. Development of oral health policies which are targeted efficiently to these adolescent populations are recommended for the Tamil Nadu region..
Keywords: Dental Caries, Health Promotion, Oral health literacy, Health Education, Epidemiology, Oral health promotion, Adolescent's oral healthth, dental caries

INTRODUCTION

The Australian Bureau of Statistics (2006) noted that "Health literacy is the knowledge and skills needed to understand and use information relating to health issues such as drugs and alcohol, disease prevention and treatment, safety and accident prevention, first aid, emergencies, and staying healthy"[1]. International literature also reports a strong correlation exists between health literacy and health outcomes in the communities [2-4], and this extends to oral health where various published studies stress the importance of oral health literacy in oral health outcomes[5, 6]. To this end, improved oral health literacy is fundamentally an outcome of good oral health promotion [7]. With urbanization, education and industrialization, the literacy rate is increasing considerably in Indian subcontinents [8]. Given that the link between general literacy and oral health literacy has been demonstrated in the literature [9], the oral health promotion approach coupled with improvement in oral health literacy is likely to lead to further oral health gains in developing countries like India.

Oral health literacy is essential to achieve improved oral health status of individuals and communities [7]. The current research was conducted to understand the association between oral health literacy among adolescents and its association with their oral health status. Increasing evidence demonstrates a link between oral health and general health necessitates the need for achieving excellent oral health literacy in children. The concept of improving oral health literacy to improve oral health status is not currently included in the health promotion strategies of the Indian Government [10] despite their efforts to improve oral health services [11].

There is few oral health literacy instruments in literature developed to use in the adult and English speaking population. The literature search did not identify any oral health literacy instrument for an adolescent population, especially which suits a non-English speaking population. Only one published Japanese study has measured oral health literacy in adolescents in the international literature [12]. Participants were asked to draw their own front teeth

and gingiva using a mirror and drawings before and after oral health education and these were marked by three dentists. The study was carefully designed to eliminate bias, but the dentists who marked the drawings were not blinded to the study's aims and they knew which picture was drawn before and after the oral health education. Knowing which pictures were drawn after the oral health education could have affected the score given to each picture. In our view, the disadvantages of using the visual oral health literacy include the differences in artistic merit of each participant; and their abilities and interest in drawing. Hence, in the current study, we used a short oral health literacy instrument which measured the basic oral health knowledge, oral health attitudes, oral health behaviours, comprehensive skills and self-managing ability was used. More details about items in the questionnaire and psychometric results are presented by Veerasamy [12].

METHODS

The current oral health literacy study was conducted in Tamil Nadu, the southernmost state in India. Adolescents aged 12-15 years were recruited from two districts within Tamil Nadu. The rural population was recruited from the Thanjavur district, one of the least urbanized districts in the State and the urban population from the Chennai district, a fully urbanized metropolitan city. In both districts, private and public schools were selected randomly and participants were recruited with informed consent provided by both parents and adolescents. More detailed description for the selection procedure was given in our previous publication [13]. The inclusion criteria for the study were 12-15 year olds attending one of the selected schools in Tamil Nadu and having a full set of permanent teeth. Data from participants with mixed dentition were removed from the study after oral examination. Ethical approvals for the study were obtained from the Human Ethics Committee, University of Canterbury, Christchurch, New Zealand and the Institutional Ethics Committee Board, Sree Balaji Dental University, Tamil Nadu.

In total, 974 participants completed a self-administered oral health literacy questionnaire of 33 items including sociodemographic variables. The sample size was determined by a power calculation. The conventional level of confidence (Z= 1.96) was chosen to present the result at the 95% confidence interval (CI) with an assumed prevalence rate of 50% (P=0.05) to identify a conservative sample size. The confidence interval (d) was chosen as 0.05 to obtain a narrow interval level. The estimated sample size was 392 which was rounded up to 400. It was therefore anticipated to recruit 800 participants in total from the rural and urban study areas but the final total sample size increased as every student in the selected classes were recruited to participate in the survey for ethical reasons; that is, it was considered unethical not to select some children from the study classes as this would deny them the opportunity to undergo a clinical oral health survey which was linked to selection to complete the oral health literacy questionnaire.

Participants who completed the oral health literacy questionnaire were also examined to calculate the Decayed Missing Filled Teeth (DMFT) score, a commonly used oral health metric. Later, the DMFT scores and calculated oral health literacy scores were compared and analysed using the software package, the Statistical Package for Social Studies, (SPSS version 22). Bivariate analyses were conducted using the Chi-square test and Pearson correlational test. The effect of oral health literacy on DMFT by controlling for different socio-demographic variables was identified using a multivariable linear regression analysis. The socio-demographic variables in the current study were gender, age, caste, type of school, location of school and mother's and father's education.

RESULTS

The descriptive analyses of DMFT and oral health literacy scores are presented in the Table 1.

The Levene's test for equality of variance (Table 2) indicated the F value is not significant (F= .105; P> 0.05) which suggests that variances are not significantly different. Hence, the appropriate t-test to interpret data was one which assumed equal variance. The results indicate that the mean difference between adolescents' oral health literacy scores who were affected by dental caries (M=31.28; SD= 5.6) is significantly lower than the scores for those who did not have dental caries (M=33.41; SD=5), ($t=5.690$; $p<0.05$).

Similarly, DMFT scores significantly decreased with an increase in overall oral health literacy scores (Table 3) in Pearson correlation test; that is, adolescents with the highest oral health literacy scores also had the lowest DMFT scores ($\rho= -.207$; $p< 0.001$).

A multivariable regression analysis was performed with all the sociodemographic variables and oral health literacy scores as predictor variables and DMFT scores as the dependent variable. Two models were developed and all independent variables were entered into the model in one step using a forced entry approach. In the first model, oral health literacy and all sociodemographic variables were entered. In the final reduced model, only the significant predictors identified in the first model were entered. The predictors used in the second model were caste, gender, and oral health literacy scores. The second model was used to derive the regression equation.

The R-square value for the resultant model (table 4) was 0.08, hence only 8% of the variance in the DMFT scores was explained by the combination of sociodemographic variables entered into the model. The

range of DMFT scores recorded in the current study was between 0-9 with a median of one. The mean DMFT score was 2.03 with a standard deviation of 2.03. These results show that the DMFT scores varied little between the participants. Hence, the regression model with little variability resulted in a model with a low R-square value. Field and Miles (2010) pointed out that in a regression model with little variability and low R-square value the result is still important, as determined by using the F statistic which reaches statistical significance. In the current study, this was indeed the case, ($F= 16.856$; $p<0.001$).

Table 1: Distribution of total DMFT and Oral Health literacy by Demographic variables

Category	Frequency	DMFT			Oral health Literacy Total Score		
	N (%)	Mean	Standard deviation	Median	Mean	Standard deviation	Median
All	974 (100)	2.03	2.30	1	32.10	5.77	32.25
Gender							
Male	542 (55.6)	1.76	2.12	1	31.89	5.463	31.87
Female	432 (44.4)	2.39	2.50	2	32.36	6.13	32.62
Age							
12 years	23 (2.4)	1.57	1.93	1	31.17	4.749	31.50
13 years	224 (23.0)	1.75	2.08	1	31.96	5.92	32.25
14 years	529 (54.3)	2.12	2.31	1	32.37	5.82	32.50
15 years	198 (20.3)	2.22	2.61	1	31.65	5.54	31.50
Father's/Male Guardian's highest level of education							
8^{th} standard	258 (26.5)	2.31	2.35	2	30.45	5.19	30.50
10^{th} standard	228 (23.4)	2.14	2.28	1.5	31.81	5.25	31.87
12th standard	108 (11.1)	2.13	2.43	1	32.02	5.44	32.00
University	274 (28.1)	1.50	2.01	1	34.55	5.79	34.75
No Father/guardian	32 (3.3)	3.16	3.15	2	30.29	6.22	31.50
Don't Know	74 (7.6)	2.18	2.47	1	30.57	6.47	31.12
Mother's/Female Guardian's highest level of education							
8^{th} standard	336 (34.5)	2.40	2.43	2	30.90	5.37	31.00
10^{th} standard	181 (18.6)	2.03	2.33	1	31.89	5.24	31.50
12^{th} standard	129 (13.2)	1.74	2.07	1	32.46	5.75	32.50
University	210 (21.6)	1.39	1.95	0	34.76	5.83	34.87
No Mother/Guardian	15 (1.5)	3.13	2.61	4	30.85	5.70	32.75
Don't Know	103 (10.6)	2.44	2.56	2	30.67	6.06	31.25
Community							
Forward Caste	60 (6.2)	1.70	2.21	1	34.85	6.22	34.75
Backward Caste	443 (45.5)	1.65	2.06	1	33.03	5.40	33.00
Most Backward	198 (20.3)	2.19	2.52	1	32.17	5.68	32.75
Scheduled Caste/Tribes	273 (28.0)	2.64	2.46	2	29.93	5.65	30.00
Geography and Type of school							
Rural School	516 (53.0)	1.70	2.39	2	31.50	5.57	32.00
Urban School	458 (47.0)	1.65	2.24	1	32.70	5.934	32.75
Private School	509(52.3)	2.19	2.13	1	32.96	6.039	33.25
Public School	465 (47.7)	2.64	2.47	2	31.15	5.31	31.50

Table 2: Independent t-test for prevalence of dental caries and oral health literacy scores

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	.105	.746	5.690	972	.000	2.13	.37	1.39	2.86
Equal variances not assumed			5.691	797.4	.000	2.13	.37	1.39	2.86

Table 3: Pearson Correlation for Oral health literacy and DMFT scores

		DMFT	Oral Health Literacy- Total Score
DMFT score	Pearson Correlation	1	-.207
	Sig.		.000*
	N	974	974
OHL-Total Score	Pearson Correlation	-.207	1
	Sig.	.000*	
	N	974	974

Key: *= p<0.001

Table 4: Regression Analysis of DMFT with Sociodemographic variables and Oral Health Literacy

	Unstandardized Coefficients		t	Sig.
	B	Std. Error		
(Constant)	4.454	.451	9.878	**.000***
Gender (Male-1; Female 0)	-.622	.145	-4.292	**.000***
Oral Health Literacy- Total Score	-.074	.013	-5.728	**.000***
Caste FC	.123	.308	.399	.690
BC	Reference Category			
MBC	.450	.191	2.354	**.019***
SC/ST	.704	.177	3.975	**.000***
R Square: .080				
ANOVA test: F= 16.856; p<0.001				
Note: Controls for first model: Gender; Age; Father's and Mother's education; Location of school Controls for final model: Gender; Oral health literacy and caste (Age, Father and Mother's education; locations of school; type of school were omitted due to non-significant beta values in the first model) For caste variable, Backward caste is the reference category. The gender was coded 1 for male and 0 for female.				
Regression Equation: DMFT= 4.454 - .622 Gender - .074 Oral health literacy score + .450 MBC caste + .704 SC/ST				

Key: *= p<0.001

The regression result presented in Table 4 indicates a negative beta coefficient (β= -.074; p<0.005) for oral health literacy which suggests that DMFT increases with a decrease in the oral health literacy score, as noted above. The community's sociodemographic variable, Scheduled Caste/Tribes (β=.704; p<0.005) and Most Backward Caste (β=.450; p<0.05) were both positively related to DMFT scores which suggests that being in this community increases the chance of getting dental caries even when controlling for oral health literacy skills. The significant beta coefficient for gender indicates that DMFT scores are predicted by gender (β=-.622; p<0.005) in the Tamil Nadu adolescent population, with females having higher DMFT scores compared to males.

Further analysis was conducted to understand the effect of location and type of school on gender and caste categories to identify the most vulnerable groups. The descriptive analyses (Table 5) divided the data into rural and urban (location); and private and public schools (type). The mean differences in DMFT and oral health literacy scores were identified. The descriptive results also suggest that females in rural schools had more decay when compared to urban school females and all male participants. Another important finding was girls in urban schools scored considerably higher scores in oral health literacy skills but they had severe dental caries compared to boys attending both urban and rural schools. Hence, for females, oral health literacy alone was not sufficient to prevent dental caries. When the mean difference between DMFT and

oral health literacy scores were compared between private and public schools, the girls attending private schools had better tooth hygiene when compared to females attending public schools. The private school females had more decay than boys attending private and public school irrespective of scoring considerably higher scores in oral health literacy skills. Hence, the socio-cultural environment in which females live in both urban and rural areas of Tamil Nadu has an important influence on overall oral health status.

The participants belonging to the Scheduled Caste scored lower in oral health literacy skills and had higher DMFT scores both in urban and rural schools. The scheduled caste participants scored almost the same DMFT and oral health literacy scores in both private and public schools. By contrast, the oral health literacy skills for the Scheduled Caste and Tribes are lower when compared to other caste categories studying in the private schools. This result indicates that Scheduled Caste and Tribes tend to have more dental caries irrespective of their economic status. The Most Backward community in rural and public schools had severe dental caries and poor oral health literacy scores when compared to those in urban and private schools.

Table 5: DMFT and OHL Scores in Urban and Rural Schools for Gender and Caste Variables

Effect of location of school									
	Urban			Rural			Total sample		
	n	Mean	SD	n	Mean	SD	n	Mean	SD
DMFT									
Male	271	1.68	2.12	271	1.85	2.13	542	1.76	2.12
Female	187	2.09	2.30	245	2.63	2.56	432	2.39	2.50
Forward	45	1.44	1.93	15	2.47	2.82	60	1.70	2.21
Backward	199	1.60	2.08	244	1.69	2.04	443	1.65	2.06
Most backward	106	2.23	2.60	92	2.14	2.43	198	2.19	2.52
Scheduled Caste	108	2.07	2.22	165	3.02	2.54	273	2.64	2.46
Oral Health Literacy Score									
Male	271	31.22	5.92	187	31.90	5.69	542	31.89	5.93
Female	271	33.87	6.09	245	31.87	5.23	432	32.36	5.57
Forward	45	36.04	5.78	15	31.30	6.34	60	34.85	6.22
Backward	199	33.50	5.45	244	32.64	5.34	443	33.03	5.40
Most backward	106	31.69	6.57	92	32.72	4.4	198	32.17	5.68
Scheduled Caste	108	30.84	5.36	165	29.33	5.77	273	29.93	5.65
Effect of Type of School with Respect to Gender and Caste									
	Private			Public			Total sample		
	n	Mean	SD	n	Mean	SD	n	mean	SD
DMFT									
Male	297	1.58	1.99	245	1.98	2.27	542	1.76	2.12
Female	212	1.85	2.29	220	2.91	2.58	432	2.39	2.50
Forward	52	1.46	2.05	8	3.25	2.71	60	1.70	2.21
Backward	276	1.55	2.02	167	1.82	2.11	443	1.65	2.06
Most backward	68	1.29	1.86	130	2.65	2.69	198	2.19	2.52
Scheduled caste	113	2.41	2.40	160	2.81	2.50	273	2.64	2.46
Oral Health Literacy									
Male	297	32.52	5.71	245	31.12	6.42	509	31.89	6.03
Female	212	33.58	5.04	220	31.19	5.60	465	32.36	5.31
Forward	52	35.62	6.11	8	29.90	4.74	60	34.85	6.22
Backward	276	33.56	5.61	167	32.15	4.93	443	33.03	5.40
Most backward	68	33.45	6.36	130	31.50	5.20	198	32.17	5.68
Scheduled caste	113	29.99	5.79	160	29.89	5.57	273	29.93	5.65

These results were further confirmed in multivariable linear regression analysis (Table 6) with a reported a significant interaction effect. The multivariable linear regression analysis with gender and caste categories split into rural, urban, public and private schools indicated that the categories, Most Backward community from public schools(β=.91; $p<0.005$) ; gender in public schools (β=.64; $p<0.005$); and Scheduled Caste and Scheduled Tribes in rural schools are predictors of DMFT (β=.704; $p<0.005$).The oral health literacy skill was identified as the predictor of DMFT (β=.-.06; $p<0.005$) when controlled for gender and caste with respect to location and type of school.

Table 6: Regression Analysis with Interaction for Caste and Gender within Type and Location of School

	Unstandardized Coefficients		t	Sig.
	B	Std. Error		
(Constant)	3.53	.430	8.19	**.000***
Oral Health Literacy- Total Score	-.06	.013	-4.80	**.000***
Rural FC	.50	.592	.84	.402
Rural MBC	-.44	.308	-1.44	.151
Rural SC/ST	.83	.237	3.50	**.000***
Public School MBC	.91	.270	3.37	**.001***
Public: caste FC	1.03	.802	1.28	.200
Public school SC/ST	.17	.244	.68	.498
Rural school- Gender	.20	.204	.97	.330
Public School-Gender	.68	.217	3.14	**.002***
R Square= .107				
F=12.774; p< 0.001				
Dependent Variable: SMEAN(DMFT)				
Predictors: (Constant), Public school: Gender, Public school: Caste, Oral Health Literacy- Total Score, Rural School: Gender, Rural School: Caste For caste variable, Backward caste is the reference category. The gender was coded 1 for female and 0 for male.				
Regression Equation: DMFT = 0.430 - 0.06 Oral health Literacy Score + 0.83 Rural school SC/ST+ 0.91 Public school MBC+ 0.68 Public school Females				

Key * = p<0.005

DISCUSSION

The current study is the first to report the association between adolescent's oral health status and their oral health literacy and highlights the negative relationship between DMFT scores and oral health literacy scores. The statistically significant association between dental caries severity/prevalence and oral health literacy is identified in the current study. The current study results are consistent with studies conducted among adult populations to understand the association between oral health literacy and oral health status.

Wehmeyer *et al.*'s study reported a negative correlation between periodontal index and oral health literacy in an adult population [14]. Parker and Jamieson identified the association between poor oral health literacy scores with poor self-reported oral health domains such as perceived gum disease, perceived need for filling and extraction, and poor oral health related quality of life in a study among an Australian indigenous adult population [15]. An association between poor oral health literacy and failed attendance at a dental appointment in a university based general dental clinic was identified in an American study [16]. Lee *et al.* identified a correlation between oral health literacy and self-reported oral health status and dental neglect [17].

Most studies described above correlated oral health literacy with self-reported oral health status and dental neglect. Clinical oral health examinations were not performed except for the study conducted by Wehmeyer *et al.* in which the periodontal index was compared with oral health literacy among periodontal patients [14].

The current study results also suggest adolescentfemales had better oral health literacy when compared to males which is consistent with results reported for adults. Eventhough females scored better than males in oral helth literacy skills, the severity of dental caries was higher in females. This result was unexpected and further research is recommended to identify the reasons for this result. This indicates that the level of oral health literacy skills expected to achieve good oral health in females might need to be even higher when compared to males. But it also could suggest that a complex mix of factors interact with each other in determining the oral status of females living in Tamil Nadu, of which, oral health literacy by itself is not sufficient to ensure good oral health status. Earlier studies with adults reported that oral health literacy in females of all ages is higher than males, but possibly there is a need for females to have even higher oral health literacy skills than their male counterparts to counteract other influences on oral health status, unique to females, so that they can better manage their oral health. This has not been discussed in the international or Indian academic literature but investigation is warranted to determine the factors that are likely to be multi-factorial, interactional and interdependent that underpin the reported relationships in this study. The association between adolescent females having poor teeth and yet good oral health literacy skills (compared to adolescent males) is first reported in this study. A female's oral health could be compromised because of the nature of tooth anatomy and various hormonal issues [18]. A unique contributing issue for females in

India is a cultural one: sons/males are considered to be more important, with the consequence that female children, even from birth, donot receive as much nutritious food [19]. This increases the burden on female oral health. These factors together might demand a higher level of oral health literacy skills in females so that they can attain a similar oral health status to that reported for male peers. This result needs further investigation to understand whether a gender consideration is needed in future development of an oral health literacy instrument, and in designing oral health literacy interventions.

The caste of adolescents was identified as a significant predictor in the current study when controlling for other independent variables including oral health literacy scores. The lower caste categories, such as the Scheduled caste, Scheduled tribes and Most Backward were identified as the most vulnerable populations. The Most Backward Caste participants in rural schools have the most severe dental caries when compared to Most Backward Caste in urban schools. Oral health literacy skills were reported as lower among the Scheduled Caste and Tribes populations. Irrespective of where they live, or which school they attend, the Scheduled Caste and Tribes had poorest oral health literacy and oral health status. Further research is needed to identify why the adolescents who belong to the Scheduled Caste and Tribes had the poorest oral health literacy and higher dental caries reported in the present study, even when they attended private schools in the urban areas of Tamil Nadu. For example, future research could include genetic, nutritional, environmental and cultural factors which are likely to be interdependent in their effect and impact on oral health status.

CONCLUSION

In conclusion, strong associations were identified between lower oral health literacy skills and higher prevalence and severity of dental caries. This pattern implies that oral health policies should focus more on oral health literacy interventions to improve oral health status of the adolescent population in Tamil Nadu. The oral health policies could be concentrated more on highly affected adolescent groups such as females studying in the public schools, Scheduled Caste/ Tribes in the rural schools and Most Backward communities in the public schools to improve overall oral health outcomes in Tamil Nadu. Future research utilising both quantitative and qualitative designs could be implemented to understand how culture, traditions and gender disparities impact on oral health. Moreover, knowledge about the current status of oral health education in Tamil Nadu schools and the challenges to implementation of oral health education are recommended for future oral health promotion education and planning in Tamil Nadu.

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