Review Article

Prevalence and Risk Factors for ECC Among Preschool Children from India along with the Need of its Own CRA Tool- A Systematic Review

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Received : 24-02-22
Revised : 08-04-22
Accepted : 19-04-22
Published : 17-06-22

ABSTRACT

Introduction: Caries in the deciduous dentition of children under six years of age is termed as early childhood caries (ECC).ECC is prevalent among Indian children and identifying modifiable risk factors is important for prevention. This systematic review was undertaken to describe the burden of ECC in India, its prevalence, associated risk factors along with its repercussions on childhood health. **Materials and Methods:** A search was conducted for published Indian studies on ECC through electronic databases and complemented with hand search. The protocol for the present systematic review was registered at PROSPERO (Ref No.CRD42022306234)Care was taken to include studies which could represent all parts of India- Central, North, South, East and West. Included papers were reviewed for prevalence of ECC and reported risk factors. **Results:** Overall 37 studies on ECC in India were identified relating to prevalence, 11 reported risk factors and two reported on the association between severe ECC and nutritional health and well-being. The prevalence of ECC in India in these studies varied from16% to 92.2%. This systematic review revealed that ECC is prevalent among Indian children and highlights the need of preventive intervention and early risk assessment by its own caries risk assessment (CRA) tool. Occurrence seems to be firmly connected with age, snacking frequency, feeding and oral hygiene habits and with social determinants of health including parental education level, low socioeconomic status and number of siblings.

Keywords: *Caries risk, Early Childhood Caries (ECC), India, logistic regression, pre school child, prevalence, systematic review*

Introduction

The American Academy of Pediatric Dentistry has defined ECC as "the presence of one or more decayed (non-cavitated or cavitated lesions), missing (due to caries), or filled tooth surfaces in any primary tooth in a child under the age of six".[1] Early childhood caries (ECC) is a very complex disease, associated with frequent sugar consumption in environment of enamel adherent bacteria that does not always involve bottle feeding.[2]

There are several distinctive factors in young children, which can modify the oral biology such as the immature host defence system, the behavioural patterns associated with feeding and oral hygiene in early childhood. Cultural, genetic and socio - economic differences within a community affect the extent and gravity of the problem.[3] There is variation in prevalence of ECC in different population. Nevertheless, regardless of race, culture or ethnicity, are the disadvantaged subpopulations of children.[4]

Access this article online

Quick Response Code:

Website: www.jispcd.org

DOI: 10.4103/jispcd.JISPCD_56_22

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How to cite this article: Khan SY, Javed F, Ebadi MH, Schroth RJ. Prevalence and risk factors for ECC among preschool children from India along with the need of its own CRA tool- A systematic review. J Int Soc Prevent Communit Dent 2022;12:295-308.

202In India these disadvantaged children, mostly live in rural and urban slum areas, belong to families of low socioeconomic status (SES), have poor feeding conditions and dietary pattern, have parents with lower education levels and have less awareness regarding health. Health care facilities are beyond their reach. Hence, the burden and extent of ECC is very high among this population.[5] If left untreated, the sequelae may vary from pain, swelling, infection/abscess, disturbed sleep and even malocclusion.[6,7] These clinical outcomes ultimately have an impact on the quality of life of the child, its growth and development and in some extreme cases may even require hospitalization.[8,9] Therefore, it can be said that ECC is a social, behavioural, political, medical, psychological, economical and a dental problem.[10,11]

A number of risk factors influence caries incidence and prevalence like- age, sex, ethnicity, behaviour (dietary and oral hygiene) and SES. Scope and quality of caries preventive program and treatment are dependent on caries prevalence and risk factors information. Hence, there is a constant requirement to assess the prevalence of caries and associated risk factors.[12] The purpose of this systematic review was to identify the burden of ECC in India in pre school children (<6 years of age), specifically its prevalence, associated risk factors, and its effects on health and well-being.

Materials and Methods

The protocol for the present systematic review was registered at PROSPERO (Ref No.CRD42022306234)

Search strategy

Electronic databases were searched for published studies on ECC in India. A sensitive,systematic and separate search was done by two review authors (SYK and FJ) and then a common listing was derived from both. Keywords used alone with Boolean operator "or" and in combinations with the Boolean operator "and" was done. Terms like: "early childhood caries", ECC, dental caries, caries, caries in primary dentition, caries in deciduous dentition, infant, pre-school, toddler, "severe- early childhood caries", S-ECC, India, babies, baby, "dent_ and cavit_"were searched. The search terms were used for title and abstract. The literature search spanned the years 1993–2021 and was restricted to publication in English only. Searched electronic databases were Pub Med (Medline), Embase, Cochrane CENTRAL register, Scopus, NLM Gateway, DARE, CANCERLIT, CINAHL, LILACS; PsycINFO and Library catalogue of University of Manitoba.Apart from databases, hand search was done using Google search engine. Care was taken to include studies which could represent all the five parts of India namely Central, North, East, West and South. The PECO question was-Population;Pre-school Indian children ≤ 6 years of age,Exposure; associated risk factors,Comparison;Not applicable,Outocme;prevalence and associated risk factors.

Study selection

The search was guided by the following **inclusion criteria.** Studies involving children ≤ 6 years of age, Indian children with ECC, dmft>0, dmfs>0, caries prevalence reported in deciduous dentition, associated risk factors for ECC and those examining association between nutrition and ECC were included. In case of any discrepancy with regard to the eligibility, matter was resolved by an experienced third reviewer (RJS).

Quality assessment and data extraction

Data extraction was done by two authors –SYK and FJ as-

1) Name of authors, region where study was conducted
2) Population and age on which study was done
3) Type of study design with reported prevalence
4) Logistic regression or other statistical tests used.
5) Quality of evidence.

Those studies that used logistic regression analysis to investigate the relationship between ECC and risk factors were subsequently reviewed by third author (RJS) as full text articles, to identify whether significant /non significant association existed. **GRADE**[13] was used for quality evidence by two review authors through consensus. GRADE approach starts with study design-Randomized trials as high and Observational studies as low. This system rates the quality of evidence as high(four plus),moderate (three plus),low(two plus) and very low (one plus) on the basis of study design, risk of bias,inconsistency,indirectness,impression and publication bias.

Indian studies identified common risk factors for ECC with the variables that were assembled into 14 categories: age, education level, SES, family characteristics, eating behaviour (e.g snacking frequency), oral hygiene behaviour (e.g. brushing habits), infant feeding behaviours (e.g breastfeeding and bottle feeding), sex, dental history, fluoride exposure, nutrition, debris, belief and developmental defects. Family characteristics included number of siblings, working mother, birth order and parent's age at child birth. SES risk factors comprised of variables related to social class, occupation of parents, family income.

Results

The search strategy resulted in 727publications. Hand search yielded 72 articles, making a total 799.Overall, 252 duplicate articles were removed and a total of 547 were reviewed by two authors independently (SYK and FJ).**A total of 428 articles were excluded**,while 119 full text articles were assessed. **Those retracted articles were excluded which lacked on relevant data of Early Childhood Caries pertaining to Prevalence, Risk factors and Age group [Chart 1]**.

Overall, 37 studies on ECC in Indian children were identified. Of the 37 studies, 11reported risk factors for ECC and two found association between severe ECC and nutritional health and well-being [Table 1]. **More than 90% of the included studies had a cross sectional study design.** A total of 13 studies were conducted on Anganwadhi children, one study included Tibetan immigrants living in India, and the remaining 23 included rural/urban/sub-urban/urban slum preschool children.

The prevalence of ECC in India varied from 16% to 92.2% [Table 1].The highest prevalence of ECC was among Tibetan immigrant preschool children living in India (92.2%).Anganwadhi children were also found to have a high rate of ECC (81.4%).By contrast the lowest rate of ECC was among semi urban and rural preschool dwelling children of Tamil Nadu (16%).Out of 37studies, three studies also reported the prevalence of S-ECC and in one study, prevalence of S-ECC was 94.3% which was higher than the highest reported prevalence of ECC. However, there was also a variation in the prevalence of S-ECC as reported by different studies, which ranged from 21%- 94.3%. Anganwadhi children were having the highest S-ECC rate whereas; preschool children in Himachal Pradesh were having the lowest rate of S-ECC.

To assess significant relationship between ECC and several associated risk factors there were only 11 studies out of 37 that performed multiple logistic regression [Table 2], three studies focused on severe ECC and two examined ECC/S-ECC association with nutritional status of children.

Risk Factors

Childhood age is one of the known risk factors of ECC and has been considered by eight reviewed Indian studies as a significant factor. [Table 3]. The

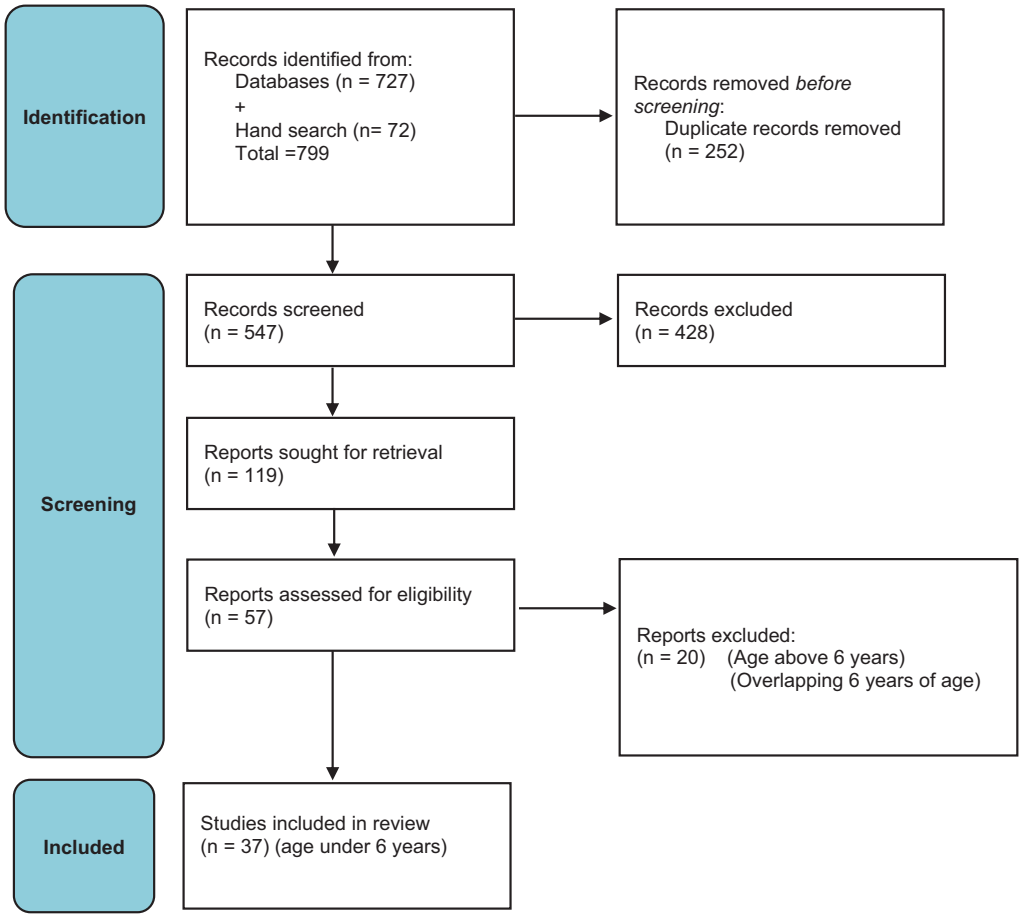

Chart 1: PRISMA flow chart

Table 1: Published studies on early childhood caries among pre-school children in India

Study	Region in india	Population	Type of study	Age	Prevalence of ecc (%)	Reported risk factors using multiple logistic regression	Reported risk factors	Quality of evidence
Mahejabeen R *et al.*[14]	Hubli, Dharwad city, Karnataka	Preschool children	cross-sectional	3-5yrs	54.1	no	Z-test and Chi sq. test were used*	⊕⊕Low
Tyagi R.[15]	Davangere city, Karnataka	Preschool children	cross-sectional	2-6yrs	19.2	no	modified questionnaire was used	⊕⊕Low
Shenoy *et al.*[16]	Manglore city	Kindergarten and Anganwadi preschool children	cross-sectional	3-5yrs	Kindergarten- 62.3%, Anganwadi- 81.4%	no	Chi sq. test was used*	⊕⊕Low
Malvania *et al.*[17]	Pipari village, Vadodra, Gujarat	Anganwadhi's preschool children	cross-sectional	1-5yrs	26.3	yes	See Table 2	⊕⊕Low
Priyadarshini *et al.*[18]	Banglore city	Anganwadhi's preschool children	cross-sectional	24-59 mnths	37.3 , S-ECC- 94.3	no	T test, ANOVA, Chi sq. test were used	⊕⊕Low
Goel *et al.*[19]	Chandigarh	Anganwadi's preschool children	cross-sectional	3-6yrs	48.3	no	Frequency, Percentages*	⊕⊕Low
Subramaniam *et al.*[3]	Banglore city	Preschool children	-	8-48 mnths	27.5	yes	See Table 2	⊕⊕Low
Prakash *et al.*[20]	Urban Banglore	Urban preschool children	cross-sectional	8-48 mnths	27.5	no	Chi sq.test was used*	⊕⊕Low
Agarwal *et al.*[21]	Mysore city, Karnataka	Preschool children	cross-sectional	3-6yrs	56.6	no	Chi sq. test was used*	⊕⊕Low
Singh *et al.*[22]	Marathahalli, Banglore	Preschool children	cross-sectional	3-5yrs	40	no	Chi sq. test was used*	⊕⊕Low
Gaidhane *et al.*[5]	Wardha district	Anganwadhischildren	cross-sectional	2-5yrs	31.81	no	Chi sq. test was used*	⊕⊕Low
Narang *et al.*[23]	Lucknow city	Preschool children	cross-sectional	2-6yrs	33.01	no	Chi sq. test and one way ANOVA were used	⊕⊕Low
Sarumathi *et al.*[24]	Chennai, Tamil Nadu	School children	cross-sectional	3-6yrs	63.4	yes	See Table 2	⊕⊕Low
Kuriakose *et al.*[25]	Trivandreum district, Kerala	Rural and Urban preschool children	cross-sectional	2-5 yrs	54	no	Chi sq. test was used	⊕⊕Low
Stephen *et al.*[26]	Salem, Tamil Nadu	Semi-Urban and Rural preschool children	cross-sectional	18-72 mnths	16	no	Student's t-test and ANOVA were used	⊕⊕Low
Sujlana *et al.*[27]	Pinjore block (Panchkula), Haryana	School children	cross-sectional	5yrs	59	yes	See Table 2	⊕⊕Low
Kaikure *et al.*[28]	Bylakuppe, Mysore	Immigrant Tibetan preschool children	cross-sectional	10-72 mnths	92.2	no	Chi sq. test and ANOVA test were used	⊕⊕Low

Table 1: Continued

Study	Region in india	Population	Type of study	Age	Prevalence of ecc (%)	Reported risk factors using multiple logistic regression	Reported risk factors	Quality of evidence
Gopal *et al.*[12]	Bhimavaram town, West Godavari district, Andhra Pradesh	School children	cross-sectional	3-6yrs	27.3	no, but Pearson's correlation analysis was used	Student 't' test and Chi sq. test were used	⊕⊕Low
Shilpashree *et al.*[29]	Banglore city	Anganwadi's preschool children	cross-sectional	3-6 yrs	31.4	yes	See Table 2	⊕⊕Low
Henry *et al.*[30]	Lalgudi taluk, Tiruchirapalli district, Tamil Nadu	Anganwadi's preschool children	cross-sectional	0-3yrs	40.6	no	Frequncy, percentages*	⊕⊕Low
Koya *et al.*[31]	West Godavari district, Andra Pradesh	School children	cross-sectional	24-71 mnths	41.9	no	Student 't' test and Chi sq. test were used	⊕⊕Low
Mangla *et al.*[32]	Sirmaur district, Himachal Pradesh	Preschool children	cross-sectional	12-36mnths	S-ECC- 21%	yes	See Table 2	⊕⊕Low
Ghanghas *et al.*[33]	Rohtak city, Haryana	Preschool children	cross sectional	3-5yrs	32	no	Chi sq. test was used	⊕⊕Low
Mahajan *et al.*[34]	Jammu city	Rural and Urban preschool children	cross-sectional	<5yrs	rural- 69% , Urban- 43%	no	Chi sq. test was used	⊕⊕Low
Dogra *et al.*[35]	Anoo village, Hamirpur, Himachal Pradesh	Anganwadi's preschool children	cross sectional	1-5yrs	55.38	no	modified questionnaire was used,Chisq.test were used*	⊕⊕Low
Chugh *et al.*[36]	Bhubaneshwar, Odisha	Anganwadi's preschool children	cross-sectional	under 6 yrs	47.29	yes	See Table 2	⊕⊕Low
Suchitra *et al.*[37]	Thiruvananthpuram, Kerala	Rural and Urban preschool children	cross-sectional	2-6yrs	59.6	no	Chi sq test *	⊕⊕Low
Vandana K *et al.*[38]	Nellore district, Andhra Pradesh	Anganwadi's preschool children	cross-sectional	2-6yrs	67 (pilot study)	yes	See Table 2	⊕⊕Low
Balraj *et al.*[39]	Goa	Kindergarten and pre-primary school children	cross-sectional	3-6yrs	64	no	Chi sq. test used	⊕⊕Low
Panwar *et al.*[40]	North East Delhi	Anganwadhi children	cross-sectional	2-6yrs	38.4, S-ECC- 22.9	yes	See Table 2	⊕⊕Low
Nagarajappa *et al.*[41]	Bhubaneshwar, Odisha	Preschool children	cross-sectional	3-6yrs	37.2	no	Chi sq. test and ANOVA with post hoc Bonferroni was used	⊕⊕Low
Krishnaswamy *et al.*[42]	North zone of Mangaluru city, Karnataka	Preschool children	cross-sectional	3-6yrs	57.5	no, but likelihood ratio was used	Chi sq. test *	⊕⊕Low

Table 1: Continued

Study	Region in india	Population	Type of study	Age	Prevalence of ecc (%)	Reported risk factors using multiple logistic regression	Reported risk factors	Quality of evidence
Sharma *et al.*[43]	Mandi, Himachal Pradesh	Preschool children	cross-sectional	2-6yrs	rural- 71.1% , Urban- 42%	no	Pearson's Chi-square and Student's t-test were used*	⊕⊕Low
Rathod *et al.*[44]	UkkaliVijayapura district, Karnataka	Anganwadi's preschool children	cross-sectional	1-5yrs	23.9	no	Chi sq. test *	⊕⊕Low
Barjatya *et al.*[45]	Indore, Madhya Pradesh	Preschool children	cross-sectional	3-5yrs	64	yes	See Table 2	⊕⊕Low
Yavagal *et al.*[46]	Devangere city, Karnataka	Anganwadi's preschool children	cross sectional	2-5yrs	52.9	no	Chi sq. test, Kruskall Wallis and Mann Whitney U test for dmft score	⊕⊕Low
Athavale *et al.*[47]	Mumbai	Urban slum community children	-	6mnths-6yrs	50	yes	See Table 2	⊕⊕Low

* Statistical tests not given in the Abstract

study conducted in 2012 showed that caries prevalence increases with increase in the age. In 8–13 month old age group only one child was found to have caries. The reason that they stated was less number of erupted teeth in this age group.[3] Another study done in 2013 reported an increase in caries prevalence with increasing age ($X_2$for trend = 29.89, p= .0001) which is in support of the above study.

Thirnganamurthy S *et al.* stated that in 4 years old, the odds ratio of caries occurrence was 1.73, in 5 years old- it increased to 3.24 and in 6 years old, it went to as high as 3.6.[24] Hence, increase in age, increased the association of developing caries to age. Similarly, another study done in 2018 stated greater caries prevalence of 46% in older age group of 61–72 months (5–6 year) when compared to younger age group of 36–48 months (3–4 year) with prevalence of 21% and in 49–60 months(4–5 year) a prevalence of 33% respectively.[36] Recently, Barjatya *et al.*[45] and Athavale *et al.*[47] also found a significant association of ECC with age. A multivariate analysis using logistic regression showed a statistically significant association of age with S-ECC$P < 0.0001$, with an odds ratio as high as OR=7.059.[32]

Sex was another risk factor studied by four different Indian studies but none reported it as a significant risk factor [Tables 2, 3].[3,17,36,38]

Socioeconomic factors like social status/class, occupation and family income were also related to increase the risk of caries development. There were seven studies out of which four reported SES as a significant risk factor [Table 3]. Two of these studies showed low socioeconomic status as a marker for caries occurrence,[24,45] one study stated low income as a risk factor for ECC(p<0.001, Adj OR=0.35)[3] and another study showed relationship between occupation and ECC with an OR=2.68.[38] Six studies also investigated the level of education of parents/caregivers. Five studies reported significant association between low education level and ECC.[3,24,27,32,38] Only one study reported the association between ECC and education level of parents as insignificant.[17]

Family characteristics (family size, birth order) were also taken into account for assessing if there was any significant association with ECC [Table 3]. Three studies found significant relationship with ECC. One study showed higher number of siblings to be related to higher occurrence of ECC (P = 0.046, Adj OR= 1.4),[27] another research related birth-order to ECC (P = 0.001, Adj OR= 2.70)[36] and one study considered busy family life as a marker of ECC.[47]

Table 2: Identified risk factors for ECC in Indian studies

S.no.	Study	Risk factors for ECC or S-Ecc from multiple logistic regression analysis	Association with undernutrition
1	Malvania *et al.*[17]	**SIGNIFICANT:** Weaning at a later age (p<0.01) **(Belief)** Frequency of consuming snacks (p<0.01)**(Snacking Behaviour)** **NOT SIGNIFICANT:** Sex (p>0.05)**(Sex)** Educational qualification of mother (p>0.05)**(Education level)** Feeding habits (p>0.05)**(Feeding behaviour)** Oral hygiene habits (p>0.05)**(Oral hygiene behaviour)**	
2	Subramaniam *et al.*[3]	**SIGNIFICANT:** On-demand breast feeding (Feeding habits)(p=0.001, Adj OR= 1.55)(Reference-breastfeeding)**(Infant Feeding behaviour)** Bottle feeding at night (Feeding habits)(p<0.001,AdjOR=2.31)(Reference-breastfeeding)**(InfantFeeding behaviour)** In-between meal snacks (p=0.001,Adj OR=1.68)(Reference- breastfeeding)**(Snacking Behaviour)** No nutritional supplements (Feeding habits)(p<0.001,Adj OR=0.23)(Reference-breastfeeding)**(Infant Feeding behaviour)** Child cleaning under no supervision (Oral hygiene)(p<0.001,Adj OR=0.43) (Reference- child cleaning)**(Oral behaviour)** Non- fluoridated dentrifice used (Oral hygiene)(p<0.001,Adj OR=2.66)(Reference-fluoridated dentrifice)**(Fluoride exposure)** Increase in Age in years (p<0.001, Adj OR=1.05)**(Age)** Low education of mother (p<0.001)**(Education level)** Low Family income (>$4000)(p<0.001,Adj OR=0.35)(Reference-<$1000)**(Socioeconomic status)** **NOT SIGNIFICANT:** Bottle feeding (Feeding habits)(p=0.154, Adj OR=0.73)(Reference-breastfeeding)**(Infant Feeding behaviour.)** Bottle feed + Breast feed (Feeding habits)(p=0.362, Adj OR= 0.87)(Reference-breastfeeding)**(Infant Feeding behaviour)** Tooth cleaning at night (Oral hygiene)(p=0.380, Adj OR=0.87)**(Oral behaviour)** Sex(p=0.604, Adj OR= 1.07)(Reference- female)**(Sex)**	
3	Sarumathi *et al.*[24]	**SIGNIFICANT:** Finger Mode of cleaning (p=0.038, OR= 1.89)**(Oral hygiene behaviour)** No. of sweets taken (p=0.0001, OR= 4.762)**(Snacking Behaviour)** Low Socioeconomic status (p=0.0001,OR= 4.762)**(SES)** Low Mother's education level (p=0.0001, OR= 3.606)**(Education level)** Low Father's education level (p=0.0001, OR=3.571)**(Education level)** Age =3 years (p<0.0001, OR=1)**(Increase in Age)** Age =4 years (p<0.0001, OR=1.73) Age =5 years (p<0.0001, OR=3.24) Age =6 years (p<0.0001, OR=3.60)	
4	Sujlana *et al.*[27]	**SIGNIFICANT:** Low Mother education level(p=0.001, Adj. OR= 1.3)**(Education level)** Higher no. of siblings(p=0.046,Adj OR= 1.4)**(Family characteristics)** Snacking frequency >3 (p=0.001, Adj.OR=2.0)**(Snacking Behaviour)** Ability to control child's sugar consumption(p<0.0001,Adj OR=1)**(Behaviour)** Brushing frequency of child (p<0.004, Adj OR=1.5)**(Oral hygiene behaviour)** Parental laxness about the child's tooth brushing (OR=1.5)**(Behaviour)** Do you assist your child when brushing? (p<0.001, Adj OR= 1.8)**(Behaviour)** Do you brush twice daily? (p<0.001, Adj OR= 2.0)**(Behaviour)** **NOT SIGNIFICANT:** Father's education level **(Education level)** Parent's dental seeking behavior**(Behaviour)** Irrelevant to go to the dentist for regular visits **(Behaviour)**	

Table 2: Continued

S.no.	Study	Risk factors for ECC or S-Ecc from multiple logistic regression analysis	Association with undernutrition
		Occupation of the parents**(SES)** Child order in the family or family structure (**SES)** Family income **(SES)** Parents attitude towards dental decay **(Behaviour)**	
5	Shilpashree *et al.*[29]	**SIGNIFICANT:** Bed time bottle feed at night(p=0.001, Adj OR=1.32) **(Infant Feeding behaviour)** Bottle fed only(p=0.657, Adj OR= 1.10)**(Infant Feeding behaviour)** Snacking in between meals(p<0.001, Adj OR= 1.24) (**Snacking Behaviour)** Method of brushing other than brush(p=0.006, Adj OR= 1.38)**(Oral hygiene Behaviour)** Frequency of brushing teeth once (p= 0.006,Adj OR= 1.83)**(Oral hygiene Behaviour)** **NOT SIGNIFICANT:** Duration of breast feedind(p=0.551, Adj OR=0.78)**(Infant Feeding behaviour)** Frequency of breast feeding(p=0.397, Adj OR= 1.83)**(InfantFeeding behaviour)** Breast fed only(p= 0.426, Adj OR= 0.89)**(Infant Feeding behaviour)** Breast fed on demand(p= 0.610, Adj OR= 0.98)**(InfantFeedingbehaviour)** Semisolid food consumption(p=0.007, Adj OR= 0.74)**(Feeding behaviour)** Drinking with cup (p= 0.480,Adj OR= 0.94)**(Infant Feeding behaviour)** Snacking frequency (p= 0.863, Adj OR= 0.96)**(SnackingBehaviour)** Age at which child started brushing (p= 0.088, Adj OR= 0.75)**(Oral hygiene Behaviour)** Person responsible for child brushing(p= 0.204, Adj OR= 0.49)**(Oral hygiene Behaviour)** Tooth powder usage (p= 0.407, Adj OR= 0.91)**(Oral hygiene behaviour)** Brushing at night (p= 0.397, Adj OR= 0.89)**(Oral hygiene Behaviour)**	
6	Mangla *et al.*[32]	**SIGNIFICANT:** (**S-ECC logistic regression model Variables**) Increase in Age group (p<0.0001, OR=7.059)(**Age)** Mother's low education level (p=0.001, OR= 0.571)**(Education level)** Prolonged Duration of bottle-feeding (p=0.018, OR= 0.508) **(Infant Feeding behaviour)** Unsupervised toothbrushing(p= 0.003,OR= 0.367)**(Oral hygiene behaviour)** Frequency of consumption of sweet and sticky food >2 per day(p=0.010, OR=1.552)**(Snacking Behaviour)** **NOT SIGNIFICANT:** Mother working or nonworking (p=0.312,OR= 1.401)(**Family characteristics)** Income (p=0.494,OR= 1.049)(**SES)** Father's education level (p=0.083,OR= 1.347)(**Education level)** Socioeconomic status (p=0.885, OR= 1.042) **(SES)** Bottle-feeding done on demand (p=0.510, OR= 2.347)(**Infant Feeding behaviour)** Bottle sipping during the day (p=0.237,OR= 4.043)**(Infant Feeding behaviour)** Bottle fed to sleep(p= 0.702,OR= 1.901)**(Infant Feeding behaviour)** Contents of bottle-feeding (p=0.992,OR= 0.998)**(InfantFeeding behaviour)** Any sugar added to milk(p= 0.289,OR= 1.609)**(Feeding behaviour)** Age of commencement of solids (p=0.873,OR= 0.964)**(Feeding behaviour)** Whether sweets are given as reward to the child (p=0.737,OR= 0.833)**(Behaviour)**	
7	Chugh *et al.*[36]	**SIGNIFICANT:** 49 to 60 months (p=0.002, Adj OR=2.53)(Age, Ref-36-48 months)**(Age) Increase in age** 61 to 72 months (p=0.001, Adj OR=5.39)(Age, Ref-36-48 months) **(Age)** 3rd child in family (p=0.001, Adj OR= 2.70)(Child birth order in a family, Ref- 1st child)**(Family characteristics)** Breastfed for >24 months (p=0.001, Adj OR=5.41)(Ref-0-12 months)**(InfantFeeding behaviour)**	

Table 2: Continued

S.no.	Study	Risk factors for ECC or S-Ecc from multiple logistic regression analysis	Association with undernutrition
		Children who did not brush teeth under parent's supervision (p=0.001, Adj OR= 2.70)(**Oral hygiene behaviour)** **NOT SIGNIFICANT:** Female(p=0.596, Adj OR=1.15)(Gender, Ref- male) (**Sex)** Muslim (p=0.839, Adj OR= 0.90) (Religion, Ref- Hindu)**(Religion)** Christian (p=0.416, Adj OR= 1.97) (Religion, Ref- Hindu)(**Religion)** OBC (p=0.820, Adj OR=1.08)(Caste, Ref- General)**(Caste)** SC (p=0.671,Adj OR= 0.85)(Caste, Ref- General)**(Caste)** ST (p= 0.547, Adj OR=0.71)(Caste, Ref-General)(**Caste)** Middle class(p=0.876, AdjOR=0.79)(Socioeconomic class, Ref- Upper class) **(SES) - Social Class** Lower class(p=0.269, AdjOR=2.19)(Socioeconomic class, Ref- Upper class)**(SES)**	
8	Vandana *et al.*[38]	**SIGNIFICANT:** Low SES (p= 0.00001) **(SES)** Increase in Age (OR=0.87) (**Age)** Mother's Occupation (non-professionals) (OR=2.68) **(SES)** Plaque scores (p=0.00001) **(Debris)** Mother's schooling at child's birth (p= 0.0025) (**Education level)** Duration of using bottle (p=0.0024)(**InfantFeeding behaviour)** Enamel hypoplasia **(Developmental defects)** Bottle feeding while sleeping (p= 0.0499)**(Infant Feeding behaviour)** Sweet consumption (p= 0.0301) **(Behaviour)** **NOT SIGNIFICANT:** Sex (p= 0.122) **(Sex)** Mother's age at child's birth (p= 0.6841)**(Family characteristics)** Father's age at child's birth (p=0.0676)(**Family characteristics)** Father's schooling at child's birth (p=0.0388) (**Education level)** Duration of breastfeeding (p=0.1663)**(Infant Feeding behaviour)** Frequency of using bottle (p=0.4455)(**InfantFeeding behaviour)** Eating before going to bed (p=0.1906)(**Behaviour)** Soft drink (p= 0.0952)**(Feeding behaviour)** Frequency of tooth brushing (p=0.2669**) (Oral hygiene behaviour)** Use of toothpaste (p= 0.4488) **(Oral hygiene behaviour)** Dental visit before (p= 0.8213) (**Dental history)**	
9	Panwar *et al.*[40]	**SIGNIFICANT:** Increase in Age (OR=1.89, p= 0.0001)**(Age)** Low Birth weight (OR=1.97, p= 0.05)(**Malnutrition)** Maternal sharing of utensils(OR= 6.41, p= 0.0001)(**Behaviour)** Fell asleep with nipple of milk bottle in the mouth (OR=3.66, p= 0.01)**(Infant feeding Behaviour)** Increase in Frequency of between meal snacking (OR=2.62,p= 0.001) (**SnackingBehaviour)** Increase in Frequency of eating sweets and chocolates (OR=1.78,p= 0.0001)**(Snacking Behaviour)** **NOT SIGNIFICANT:** Manner of feeding (OR=0.79,p=0.36)**(Infant Feeding behaviour)** Duration of bottle feeding (OR=0.85,p=0.33)**(Infant Feeding behaviour)** Bottle feeding at night (OR=2.54,p=0.08)(**Infant feedingBehaviour)** Teeth cleaning (OR=1, p= 0.96)**(Oral hygiene Behaviour)** Initiation of teeth cleaning (OR=1.26, p= 0.34)(**Oral hygiene Behaviour)** Method of cleaning (OR= 1.13, p= 0.80)(**Oral hygiene Behaviour)**	Yes- significant
10	Barjatya *et al.*[45]	**SIGNIFICANT:** Increase in Age-3 years (p<0.001, Adj OR= 0.33)**(Age)** Increase in Age-4 years (p<0.001, Adj OR= 0.15)(**Age)**	

Table 2: Continued

S.no.	Study	Risk factors for ECC or S-Ecc from multiple logistic regression analysis	Association with undernutrition
		Lower status(p<0.001, AdjOR=3.56)**(Socioeconomic status)** Breastfed for> 1 year (p<0.001, Adj OR= 0.19) **(Duration of breastfeeding)(Infant Feeding behaviour)** Bottlefeeding for >2 years (p= 0.009, Adj OR= 2.95)**(Duration of bottlefeeding) (Infant Feeding behaviour)** Cow milk - bottle content other than water (p= 0.007, Adj OR= 2.29)**(Feeding behaviour)** **NOT SIGNIFICANT:** Not breastfed (p=0.525, Adj OR= 0.74)**(Duration of breastfeeding) Infant Feeding behaviour** Night feeding practice (p= 0.164, Adj OR= 1.52) **(Infant Feeding behaviour) - Time of feed-day or night** Day feeding practice (p= 0.443, Adj OR= 0.80)**(Infant Feeding behaviour)** Introduction of drinking via cup >1 year (p= 0.302, Adj OR= 0.80)**(Feeding behaviour)** Time of starting solids **(Behaviour)** Frequency of snacking **(Snacking Behaviour)** Regularity of meals **(Feeding Behaviour)**	
11	Athavale *et al*.[47]	**SIGNIFICANT: S ECC** Children ≥ 3years**(Increase in age)** Undernutrition (OR=1.10) **(Malnutrition)** Busy family life **(Family characteristics)** Limited dental care **(Dental history)** Presence of deep decay, d3 (continuous) (p<0.05, Adj OR= 1.1) **(Dental history)** Junk Food (p<0.05, Adj OR= 0.80)**(Behaviour)** **NOT SIGNIFICANT:** Children < 3 years **(Age)**	Yes- siginificant

Table 3: Indian studies using Logistic Regression to assess Caries riskfactors

S.no.	Risk factors	Number of studies assessing risk factor type	Number of studies reported significant associations with risk factor type
1	Age	8	8(100%)
2	Education level	6	5(83.3%)
3	Socioeconomic status(SES)	7	4(57.1%)
4	Family characteristics	5	3(60%)
5	Behaviour	6	4(66.6%)
6	Feeding behaviour	5	1(20%)
7	Infant feeding behaviour	7	7(100%)
8	Snacking behaviour	8	7(87.5%)
9	Oral hygiene behaviour	9	6(66.7%)
10	Sex	4	None (0%)
11	Dental History	2	1(50%)
10	Fluoride exposure	1	1(100%)
11	Nutrition	2	2(100%)
12	Debris	1	1(100%)
13	Belief	1	1(100%)
14	Developmental defects	1	1(100%)

Different behavioural factors were identified and assessed for their association with ECC. Six studies assessed the association and four reported significant association between ECC and behaviour. One study investigated parent's dental seeking behaviour as a possible risk indicator for ECC and stated it to be of significance in the onset of ECC [Table 2].[27] Out of eight studies, seven reported significant association between snacking behaviour and ECC. Six studies showed relationship between snacking frequency/number of sweets intake with

ECC and found it to be significantly associated,[3,17,24,27,32,40] three studies investigated in between meal snacking as a possible risk indicator for ECC.[3,29,40] Seven studies investigated association of infant feeding behaviour with ECC and all of them found significant association between ECC and feeding behaviour [Tables 2, 3]. Bottle-feeding at night was observed to be significantly associated with ECC occurrence.[3,29,32,38] Duration of breastfeeding was also one of the risk indicator which was significantly associated with ECC.[36,45] Similarly, on-demand breastfeeding was significantly associated with ECC.[3] Feeding behaviour was examined by five studies and only one study found it to be significantly associated with ECC [Table 3].

Oral hygiene behaviour was reported by nine studies and six studies found significant association with ECC [Table 3]. Three studies reported significant association between child brushing under no supervision and ECC,[3,32,36] two reported frequency of brushing as potential risk indicator of ECC and found it to be significantly associated with ECC.[27,29] On the contrary, one study found no relation between frequency of brushing and ECC,[38] two studies reported cleaning at night to be non-significant and showed no association with ECC.[3,29]

Dental history (visit to dentist) was examined by two studies as a possible risk indicator for occurrence of caries [Tables 2, 3]. Out of the two studies, one reported it to be significantly associated with ECC[47] while the other reported no significant association.[38]

Only one study showed association between debris score and ECC [Table 3] and reported it to be significantly associated with the ECC ($P = 0.00001$).[38]

Another factor recognised as a potential risk indicator for caries development is enamel hypoplasia. Only one study had reported it and shown its association with ECC occurrence to be of significance.[38]

One study has viewed beliefs of the parent/caregiver and its influence on ECC [Table 3].According to the study weaning at a later stage is significantly associated with development of caries($P < 0.01$).[17]

Exposure of fluoride was investigated by Subramanian *et al.* in 2012 [Table 3] which showed significant association between use of non-fluoridated dentifrice and ECC development.[3] According to the study, children who were using fluoridated dentifrice had a significantly lower percentage (18.3%) of caries.

Nutrition and Well-being

In 2018, a cross-sectional study was conducted by Panwar *et al.* involving 401 Anganwadhi children. They showed that children having low birth weight <2.5kg were affected significantly with ECC when compared with those having birth weight >2.5kg (53.3% vs. 34%; $P = 0.001$). The logistic regression analyses conducted by them, showed low birth weight as one of the risk factors for ECC.[40] Another study conducted by Athavale *et al.* in 2020 also reported significant relationship between occurrence of ECC and under nutrition. According to the study, 56% of total children were undernourished, 42% had stunted growth, 36% were underweight and 21% were wasted [Tables 2, 3].[47]

Discussion

The aim of this review was to determine the prevalence and the associated risk factors of ECC in Indian preschool children. If the risk factor happens to be modifiable such as feeding behaviour, exposure to fluoride, timing and snacking frequency, then they have the potential to mitigate the risk of developing caries. A total of 37 studies were included in this review which met the criteria of ECC (i.e children of ≤6 years of age and have reported prevalence of ECC too)

In the past few years, several studies have been conducted in India on ECC. Populations considered at high risk for caries were Anganwadhi children, preschool children from slum or rural areas, immigrants have been discussed at length in the aforementioned studies. It is sad to state that despite so many studies, no study can represent the true status of prevalence of ECC in the entire Indian population. The reasons behind this can be that there is no true national representative sample available and there is also underreporting of ECC from certain states. Therefore, we must rely on available regional studies to measure the burden and extent of the disease in the preschool children in India.[3,32] Further, oral health is a sector greatly neglected by Indian health care system and is viewed as an integral part of childhood health and well being.

Among the reviewed Indian studies on ECC, SES is a well-established risk factor and has been reported by many studies. Low family income, lower social strata and occupation play an important role in increasing the risk of ECC as they limit the access to primary dental care and prevention.[3,24,38,45] Lower economic strata population experience financial, material and social limitations which create a barrier in achieving necessary oral health care and leads to occurrence of oral diseases as described by Jose and King.[48] Parental level of education also influences caries development as low education level is significantly associated with increased risk of ECC.[3,24,27] Education is a primary

determinant of a person's labour market position, which in turn influences income, housing and other material resources and makes them aware to use the available services. Studies done by Zhou *et al.*,[49] Jose and King,[48] Hallet and O'Rourke,[50] Livny and Sgan-Cohen[4] have revealed a strong association between caries presence and education level of mother.

Debris score has also now been shown to be significantly associated with ECC occurance.[38] Plaque acts as a reservoir of nutrients for bacteria and regulates ionic flow across membrane through buffering of acids, thereby increasing caries progression.[51] One study reported enamel hypoplasia as a significant risk factor for ECC.[38]Future research is warranted in this area, to better understand the association between the two. There are several studies which have shown significant correlation between nocturnal bottle feeding and ECC.[3,29,32,38] Hallet and O'Rourke,[50] Ghanim *et al.*,[52] Creedon and O'Mullane[53] stated that the reason behind this might be the contact of fermentable contents of bottle for a longer duration with teeth. Breastfeeding >24 months has been reported as a risk indicator of ECC.[36] In this current review,statistically significant association was found between ECC and age.[3,24,32,36,38,47] With increasing age, there was an increase in development of ECC as well.[38,40,45]

Few studies have investigated role of nutrition and well-being with ECC and found significant association between the two.[40,47] Similarly other studies also found association between ECC and low birth weight.[54,55] The reason behind this as stated by these studies might be the predisposition of preterm and low birth weight children to colonization by streptococci in high levels, favouring salivary disorders and enamel hypoplasia development.[56] On the other hand, few studies reported no association between birth weight and ECC.[20,57]

In order to reduce the likelihood of developing ECC, the population under study should be categorized as low, moderate and high risk and preventive and health promotion program should be directed accordingly. Caries Risk Assessment (CRA) tool has made this approach simple and convenient. Several dental and Paediatric organizations in differentcountries, have developed CRA tools, to help the professionals (dental /non dental) in determining children's likelihood for ECC.

CRA, is an essential key element for decision making and should always precede the treatment undertaken. It serves as a guide in designing of public health intervention, time and resource allocation to those with the greatest need. As the protective and causative risk factors are different and peculiar for a particular country, as evident from the current literature search, so even the CRA tool cannot be same for all countries and hence should be modified accordingly to bring out the true picture.

Conclusion

Findings from this systematic review reveal that ECC is prevalent in India. Strong association between low socioeconomic status, low level of education, increase in age, no of siblings, birthorder, enamelhypoplasia, beliefs of parents and nutritional status were associated with ECC development.Early access to preventive care and implementing CRA may assist in improving the oral health status of Indian children from caries risk group. As the protective and causative risk factors are different and peculiar for a particular country, as evident from the current literature search, so even the CRA tool cannot be same for all countries and hence should be modified accordingly.

This systematic review provides evidence that ECC is prevalent in India, which highlights the need for early caries risk assessment (CRA) and preventive interventions for high risk groups in India. Completing CRA with parents, can reveal important risk factors, including ones which are modifiable and which are not. CRA- can help uncover risk factors during clinical visits and can lead to tailored anticipatory guidance that may ultimately assist parents in reducing their child's future risk of developing caries.

Risk factors can differ between and within countries, as evident from the current systematic review. Therefore consideration should be given to modifying CRA tools for different countries in order to identify important risk factors.

Acknowledgment

Saima Yunus Khan holds International Association for Dental Research John Clarkson Fellowship for her training in Public health. Operating funds for this research and related research were provided through this fellowship.

Financial support and sponsorship

This research did not receive any specific grant.

Conflicts of interest

All authors declare that there is no conflict on interest.

Authors contributions

NA; concept, design, acquisition, interpretation, critical analysis, draft preparation, and editing.

Ethical policy and institutional review board statement

Not applicable.

Patient declaration of consent

Not applicable.

Data availability statement

Available on reasonable request.

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