Original Article

# Geo-Mapping of Early Childhood Caries Risk: A Community Oriented Preventive Oral Health Promotional Approach

**Pragya Pandey[1], Manish K. Singh[2], Diksha Singh[3], Sarika Gupta[4]**

*[1]Department of Conservative Dentistry and Endodontics, KGMU, Lucknow, [2]Department of Community Medicine, Dr. Ram Manohar Lohia Institute of Medical Sciences, Lucknow, [3]Departments of Oral Pathology and Microbiology, and [4]Pediatrics, KGMU, Lucknow, Uttar Pradesh, India*

## Abstract

**Context:** Given the uneven distribution of dental caries, there is an exigent need for a database of dental caries and its spatial distribution for better planning and efficient delivery of health promotional and preventive programs. Geo-mapping is a helpful tool for policy makers/administrators for efficient allocation of limited resources. **Aims:** To geo-map spatial distribution of caries risk in preschoolers of Lucknow and to identify associated predisposing factors. **Settings and design:** A cross-sectional study was done among 1000 preschool children (3-5 years of age) attending pediatrics, outpatient department at a medical college in Lucknow, Uttar Pradesh. **Methods and Material:** Children were enrolled using the systematic random sampling. Each child was geo-coded with respect to his/her residence, clinically examined for dental caries and given a Decayed Missing Filled Tooth (DMFT) index score. A pre-tested questionnaire was used to collect socio-demographic data. Caries prevalence was geo-mapped using color codes. **Statistical Analysis Used:** Median DMFT scores were compared using Mann-Whitney and Kruskal-Wallis test. QQ plot/Shapiro-Wilk's test was used to check the normality of data. **Results:** Prevalence of caries was found to be 76%. 10% children had DMFT score of 4 and more. A significant difference in distribution of DMFT score was observed for gender, income levels and between wards. Wards closer to the center of Lucknow district had a higher prevalence of caries. **Conclusions:** Geo-mapping of caries prevalence gives a quick visual glance of specific areas vulnerable to caries and help deliver specific tailor-made services.

**Keywords:** DMFT, early childhood caries, geo-map

## Introduction

Early Childhood Caries (ECC) is an aggressive and rampant form of dental caries in children aged three to five years. It is characterized by the presence of one or more decayed (non-cavitated or cavitated), missing (due to caries), or filled tooth surfaces in any primary tooth. A decayed, missing, or filled score of ≥4 (age 3), ≥5 (age 4), or ≥ 6 (age 5) constitutes Severe ECC (S-ECC).[1]

**Address for correspondence:** Dr. Manish K. Singh, Department of Community Medicine, Dr. RMLIMS, Lucknow, Uttar Pradesh, India.
E-mail: drmanishscbmc@yahoo.co.in

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Published studies have documented ECC prevalence between 36-85% in Asia, 38-45% in Africa and 22-61% in the Middle East.[2] A study from Bangalore, India, reported a caries prevalence of 27.5% among the younger age groups (8-48 months age).[3]

World Health Organization (WHO) community-oriented preventive oral health promotional approach has been emphasized and prioritized over the general curative approach worldwide and has shown impressive results in developed countries.[4-8] Socio-demographic variables such as parents educational status, occupation, cultural practices, family income



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etc., have been reported as potential determinants of oral health in young children.[1,9-11]

Geographic Information Systems (GIS) helps link healthcare, social and environmental determinants of health. The spatial representation facilitates primary care physician as well as public health specialists to arrive at quick conclusions, make fast and apt decision and plan for future care.[12] One of the most useful applications of GIS is the planning of domiciliary care. Private healthcare providers can make use of GIS to extend their reach and promote their services. They can even make predictions about some services that are in great demand in specific locations. The primary healthcare physicians can make use of GIS to direct patient quickly and efficiently to a suitable health care facility.

GIS is helpful for primary healthcare physicians to get the exact location of specific medical equipment and how somebody may gain fast access to it. It is also beneficial for insurance companies to guide an insured person to the nearest empaneled health facility. GIS has application in strategic planning, research, evaluation and emergency preparedness.[13] Distribution of dental caries is uneven and hence there is a need for a database of dental caries in pre-schoolers for planning and efficient delivery of health promotional and preventive programs and directing scarce resources to where they are most needed.[3] Geo- mapping with color coding is a visual tool capable of depicting variation in distribution of any variable across different geographical regions.[14]

A recent study on application of GIS to analyze distribution of patients visiting the periodontology department at a dental college hospital in South Korea showed distribution of patients was significantly affected by the proximity, accessibility, age, gender and socioeconomic status of patients, and the patients visiting the periodontology department travelled farther distances than those visiting the other departments.[15] GIS over the years has been widely used for mapping distribution of endemic fluorosis across the globe. A recent study in Lamphun, Thailand using GIS for mapping fluoride endemic areas and places with unsafe drinking water facilities concluded that it was helpful for health policy authorities, local governments and villagers to collaborate and resolve issues.[16]

A recent study in India, used GIS maps to plot mean DMFT and caries prevalence across India, using secondary data from published articles, systematic reviews, national oral health survey and grey literature. The study revealed that among 5-year-old children, the highest and lowest mean DMFT and caries prevalence was found in Goa (5.9,86.5%) and Rajasthan (0.7,24.9%) respectively, while among 12-year-old children, the lowest was in Rajasthan (0.9,36.1%) and highest was in Chhattisgarh (4.8) and Chandigarh (93.4%) respectively.

They concluded that GIS maps were a utility tool capable of presenting complex information about common oral health diseases to dental researchers and physicians in a simple way. It was useful for estimating oral disease patterns, resource allocation etc., as per the population density thereby facilitating advocacy of oral health.[17] A recent study in Jeddah, Saudi Arabia using GIS technology to map various diseases found different clusters for each disease and concluded that it is useful for health planners in Jeddah to improve supply of health services in the resulting cluster locations.[18]

Extensive review of literature didn't yield much about the use of Geo-maps in dentistry across India, however they have been used abroad for presenting epidemiological data based on caries risk.[19] The present study was planned with an aim to geo-map spatial distribution of caries risk in pre-schoolers of Lucknow and to identify associated predisposing factors.

## Material and Methods

The present study was a cross-sectional study. The study was approved by institutional ethics committee, KGMU, Lucknow, UP wide letter no. 901/ Ethics/R-Cell-18 dated 02/07/18. The study was carried out over a period of one year. Lucknow, the capital city of Uttar Pradesh, a northern state in India has eight zones subdivided into 110 wards.[20] The study population comprised of pre-school children (3-5 years of age) accompanied by parents and residing in zone Six, that includes 17 wards attending the Pediatrics, Outpatient Department (OPD), at a medical college hospital in Uttar Pradesh.[21] Children having acute infections of oral cavity that interfered with oral examination, mentally or physically disabled children and those not accompanied by guardian/caregiver or the guardian refusing to give consent or unable to understand Hindi or English were excluded.

Guardians were explained the purpose of the study and children who fulfilled the inclusion and exclusion criteria was enrolled after taking informed consent for participation from their guardian. Children were enrolled using systematic random sampling. All children and their guardian irrespective of their participation in the study were counseled on risk factors of dental caries. Each child enrolled in the study was geo coded with respect to his/her residence in each ward of zone 6. Considering the non-zero DMFT dental caries prevalence as 50% (prevalence being not known), at 5% precision and 95% confidence interval the sample size was calculated as 384. A design effect of 2.5 was applied, that yielded a sample size of 960 which was rounded of to 1000.

Every child was clinically examined by two trained dentists on the dental chair using mouth mirrors, illumination and ball-ended WHO CPI probes. DMFS index was used to record the dental caries experience of the primary dentition of the child ['D' stands for decayed tooth, 'M' denotes missing tooth due to decay, and 'F 'represents filled tooth]. Diagnosis of decay in tooth was made, according to the criteria recommended by the WHO i.e. when a lesion in a pit or fissure or on a smooth tooth surface, had an unmistakable cavity, undermined enamel or a detectably softened floor or wall.[22] The parent/guardian of children enrolled for the study were administered a pre-tested questionnaire, based on WHO-Oral Health Questionnaire for children in Hindi and English to collect socio-demographic data i.e. gender, age, place of residence, family income, literacy level of parents, child's oral health and hygiene related behaviors, dental visit pattern; and parent's dental knowledge etc., by an interviewer, particularly trained for the job. DMFT >0 was considered as the primary caries outcome.

Caries risk was geo-mapped with a color code as per the severity of caries risk. Data was analyzed using MS Excel and R software version 4.0.2. Median scores/distributions were compared using Mann-Whitney and Kruskal-Wallis test. To check the normality of the data QQ plot/Shapiro-Wilk's test was used.

## Results

A total of 1000 study subjects were enrolled for the study. Table 1 shows the socio-demographic distribution of study participants and their DMFT scores. About 57% enrolled children were male with median DMFT score of 2. Female children had a median DMFT score of 1. Maximum observed DMFT score was 5 and 6 respectively in male and female children. Mann-Whitney U test, showed a significant difference in the distribution of DMFT score over gender.

Majority of participants were in the age group 4+ and from families with average monthly income of less than Rs 10,000. Mother was the main caregiver for majority of the children. Maximum DMFT score observed was lower in children from families with average monthly income of more than Rs 20,000 (Maximum DMFT score = 3) and Kruskal-Wallis test showed a significant difference for income levels. *Post hoc* Dunn's test revealed significant difference in the distribution of DMFT between income level 2 and income level 1 (*P* value: <0.0001) and income level 2 and income level 3 (*P* value: 0.0022).

Table 2 shows the multiple logistic regression analysis for non-zero DMFT score. Male children were found to have a higher likelihood for occurrence of non-zero DMFT score compared to girl child. Female children had about 50% lesser chance of having non zero DMFT score and the difference was found to be significant.

Children from families having average monthly income between Rs 10,000-20,000 were less likely to have a non-zero DMFT score compared to children from families with lower average family income. The difference was also found to be significant. Figure 1 shows the distribution of DMFT score among study participants. Only 10% children had DMFT score of 4 and more (only 1% children had a score of 6). About 50% children had DMFT score of less than equal to 1 and about one fourth of children had score of 0.

Figure 2 shows the median DMFT score of children across different wards of Zone 6, Lucknow district varied from 0 to 4. Three wards: Hyderganj, Balak Gaanj and Kanahiya Madhopur reported a median DMFT score of 4. In Chowk and Bazarkhala, all the children had a DMFT score of zero. The difference in the distribution of median DMFT scores between wards was found to be significant on applying the Kruskal-Wallis test.

Figure 3 shows the geo-map of prevalence of non-zero DMFT score in children aged 3-5 years in zone 6 of Lucknow city. The grey borderlines delimit the wards in Lucknow city and the

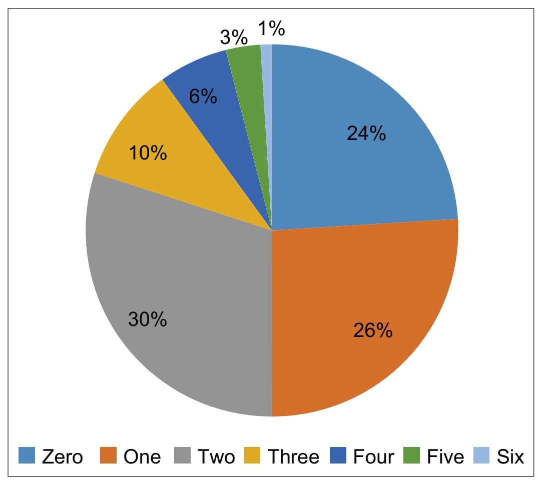


**Figure 1:** DMFT Score distribution of study participants

**Table 1: Socio Demographic Distribution of Study Participants and Their DMFT Scores**

| Variable | | Number of Subjects (%) | Median DMFT score (Minimum, Maximum Score) | *P* |
|---|---|---|---|---|
| Gender | Male | 573 (57.3) | 2 (0,5) | <0.00001MW* |
| | Female | 427 (42.7) | 1 (0,6) | |
| Age (in completed years) | 3 | 171 (17.1) | 1 (0,6) | |
| | 4 | 499 (49.9) | 1 (0,4) | 0.05784KW** |
| | 5 | 330 (33) | 2 (0,5) | |
| Monthly Family Income (INR) | <10,000 [Level-1] | 686 (68.6) | 2 (0, 5) | |
| | 10,000-20,000 [Level-2] | 284 (28.4) | 1 (0,6) | <0.0001KW** |
| | More than 20,000 [Level 3] | 30 (3) | 2 (1,3) | |
| Child caregiver | Mother | 985 (98.5) | 2 (0,6) | 0.07345MW* |
| | Others (Father/Grand Parents/Domestic Help) | 15 (1.5) | 1 (1,1) | |

*MW-Mann Whitney U test ** Kruskal-Wallis test

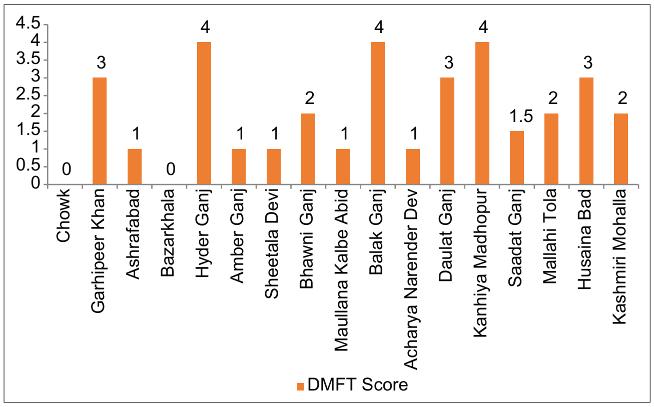


**Figure 2:** Distribution of median DMFT Score across different wards of Zone 6, Lucknow district

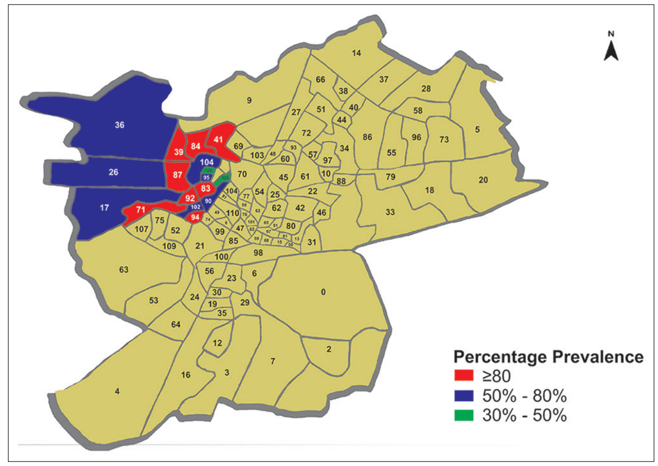


**Figure 3:** Geomap of prevalence of early childhood caries (non Zero DMFT score)

**Table 2: Logistic Regression Analysis for Non-Zero DMFT Score**

| Variable | | Estimate | *P* | OR (CI) |
|---|---|---|---|---|
| (Intercept) | | | | - |
| Gender | Male | | Reference | |
| | Female | -0.7404 | <0.0001 | 0.4769 (0.3412, 0.6644) |
| Income | Level 1 | | Reference | |
| | Level 2 | -0.4581 | 0.00945 | 0.6324 (0.4478, 0.8951) |
| | Level 3 | 17.0932 | 0.98094 | - |

wards of zone 6 are marked in different colors depending on the prevalence. Mean prevalence of caries (non-zero DMFT score) was found out be 74%. Among the 17 wards in the zone 6; 9 wards were found to have a prevalence of non-zero DMFT score above 74% (8 had a mean prevalence above 80%). Minimum reported mean prevalence was 33% and 34% in ward numbers 105 and 106 respectively. Highest prevalence was reported from ward numbers 94, 87, 83 and 92. Most of these wards were situated closer to the center of Lucknow district. The wards towards the periphery of Lucknow city reported a comparatively lower prevalence.

## Discussion

The present study found that the non-zero DMFT score was not uniformly distributed across different wards in Lucknow and the difference in distribution was also found to be significant. This highlights the utility of geo map to help design differential focused interventions across different geographic regions with proportionate allocation of resources. A previous study in Holland, on application of geo-maps had documented use of geo-maps as a convenient tool for evaluating the effectiveness of tailored health promotion and preventive care in the child populations.[21]

In the present study a maximum DMFT score of 5 and 6 respectively was reported in male and female children. Male children were found to have a significantly higher likelihood for occurrence of non-zero DMFT score compared to girl children. A previous study in Hong Kong also reported a statistically significant difference in prevalence of caries with respect to gender [Male child had a higher DMFT score compared to female child].[23] Similar findings were reported by a previous study at Mandi, Himanchal Pradesh with boys having significantly higher caries prevalence and mean DMFT score compared to girls.[24]

In our study, children from families in the lowest average monthly income group had a higher likelihood of non-zero DMFT score. The difference in distribution of DMFT score was also significant. Children from families with average monthly income in the highest bracket had lower maximum DMFT score. A previous study in urban Bangalore had also reported that children belonging to low socioeconomic group had higher caries prevalence.[3] A systematic review assessing the oral health status of eighty three developed countries and sixty six developing countries indicated that poor socio-economic status (SES) was significantly associated with high risk of dental caries.[25]

In our study the mean prevalence of caries (non-zero DMFT score) was found out to be 74%. Minimum reported mean prevalence was 33% and maximum reported prevalence was 95%. Wards with a high prevalence were situated closer to the center of Lucknow district. Mean DMFT score was 1.61 [SD = 1.4]. As per the last National Oral Health Survey [2002–2003], DMFT score for Indian children was around 2 and caries prevalence showed an increasing trend with age from 52% to 63% in 5–15 years age group.[22] As per a previous study in Chandigarh mean prevalence of caries was 53% (higher among males).[23] A meta-analysis of the prevalence of dental caries in India reported mean prevalence of dental caries as 49%.[24]

In our study a significant difference in distribution of DMFT score was observed between wards and wards closer to the center of Lucknow district had a higher prevalence of caries. A recent study at a dental college hospital in South Korea also found that the distribution of patients was significantly affected by proximity and the patients visiting the periodontology department travelled farther distances than those visiting the other departments.[15]

## Conclusion

To conclude prevalence of caries in the present study was found to be 76% and 10% children had DMFT score of 4 and more. A significant difference in distribution of DMFT score was observed for gender, income levels and between wards. Wards closer to the center of Lucknow district had a higher prevalence of caries. Geo-mapping is a utility tool that gives a quick visual glance of specific areas/wards vulnerable to caries and other oral health problems of public health importance, and can be used to provide need specific services to improve outcomes and reduce prevalence of ECC.

## Recommendation

To improve primary care and preventive health services, cost cutting and improved access to health care is vital. GIS helps assess patterns of healthcare utilization and community-level attributes to identify geographic regions most in need of primary care access. Given the uneven distribution of dental caries and other oral health diseases, geo-mapping of prevalence and predictors gives a quick visual glance of specific areas vulnerable to caries and helps design specific tailor-made services.

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## Conflicts of interest

There are no conflicts of interest.

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