

Mapping Evidence on Early Childhood Caries Prevalence: Complexity of Worldwide Data Reporting

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ABSTRACT

Objective: This review aims to identify variances and research gaps in the early childhood caries (ECC) prevalence within countries and the global community by mapping current evidence.

Materials and methods: We performed a literature search in PubMed/MEDLINE and Web of Science to identify English-language, peer-reviewed epidemiologic studies published from January 1999 to January 2019. Abstracts and full-text articles were dual-screened based on predefined eligibility criteria. We classified outcomes by children's age and countries based on economic status. Ranges of reported caries prevalence and median values by country and age were calculated and evidence-mapped.

Results: Out of 915 studies, 59 studies met the inclusion criteria. The most significant number of reports were from the USA, Brazil, and India. The ranges of prevalence (1–96%) among the studies were large. The calculated median caries prevalence values may better estimate countries' prevalence than the reported ranges. Early childhood caries prevalence's highest median values were found for South Korea studies (54%) for children <3-year-old and from Bosnia (81%) for children 3–6 years old. No apparent difference was found in the prevalence of ECC from developed and developing countries.

Conclusion: This mapping review reflects the ranges and median values of ECC worldwide. Overall, the reported prevalence of ECC in most countries is very high. No apparent difference was found in the prevalence of ECC from developed and developing countries. Reported ranges of ECC, as well as heterogeneity and methodological issues, hamper comparisons across studies globally.

Clinical significance: The global ECC prevalence ranges are extreme. Median data may provide a structure for future epidemiological studies to optimizing healthcare resources for caries interventions globally.

Keywords: Cross-sectional studies, Dental caries, Global health, Preschool child.

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INTRODUCTION

Early childhood caries (ECC) is defined as the presence of one or more decayed (non-cavitated or cavitated lesions), missing or filled (due to caries) surfaces in any primary tooth of a child under 6 years of age.¹ Primary teeth maintain the space for the permanent teeth and are essential to a child's well-being. Early childhood caries leads to a higher risk of new carious lesions,² acute and chronic pain,³ hospitalizations and emergency room visits,⁴ delays of growth and development,^{5,6} and diminished quality of life of young children and their families.^{7,8} Early childhood caries is preventable but currently affects >600 million children worldwide and remains mostly untreated.⁹ Unquestionably, ECC's high prevalence is a worldwide burden to society, major health concerns, and health economics issues.

In the current global environment of escalating healthcare costs and resource constraints, ECC's prevalence is critical for countries to understand the necessary resources to prevent and provide services to reduce children's caries burden. At the turn of the 21st century, surprisingly, ECC epidemiology is not fully defined. In a brief overview of searching the PubMed engine using the terms "dental caries" and "children," nearly 11,000 studies are reported from different countries; however, understanding the evidence from international prevalence studies is challenging. In our literature search, only one study was found to address the global prevalence estimates for ECC. This study's data are reported by mean values with ECC prevalence for children younger than 36 months at 23.8% and children between 36 and 71 months at 57.3%.¹⁰

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The methodological variations in worldwide prevalence studies also impart barriers to a global hinder understanding of the disease. Very often, these studies: (1) have unclear study design; (2) inconsistent definition of "early childhood caries"; (3) lack reporting criteria for carious lesion identification; and (4) lack of prevalence reporting by a specific age. An analysis of ECC prevalence reported in median values for specific ages from various countries may better inform our understanding of the ECC global burden.

Hence, this mapping review aims to synthesize global dental caries prevalence data in children under 6 years of age from studies that report data by specific ages. These findings may suggest approaches to standardize methods for reporting ECC prevalence

studies and assist national and global agendas addressing the worldwide ECC burden.

MATERIALS AND METHODS

Initially, an electronic literature search was performed on studies between January 1999 and December 2014 with a primary search term “early childhood caries” using Embase, PubMed, MEDLINE, Science Direct databases, Google Scholar, and World Health Organization (WHO) library databases and gray literature. Another review was performed from January 2014 through January 2019. A total of 915 studies of ECC prevalence studies were retrieved from these two searches. Two reviewers screened titles and abstracts for relevance and obtained full-text articles of publications.

Because of the methodological focus of this review, studies were excluded if: (1) they were not a controlled trial, cohort, case-controlled or cross-sectional study; (2) the sample size <100 children; (3) the diagnostic criteria used for assessing dental caries in the primary dentition was not clearly stated; (4) the country where the children were assessed was not clear; and, (5) the study did not list caries prevalence by age, i.e., 1 year old (12–23 months), 2 years old (24–35 months), 3 years old (36–47 months), 4 years old (48–59 months), and 5 years old (60–71 months). Flowchart 1 illustrates the search process for the study.

From the initially identified 915 studies, 59 withstood the exclusion criteria and were abstracted to include: (1) the number of children per age, (2) country, (3) study type, (4) caries criteria, and (5) prevalence by age. We also calculated each country's ECC prevalence range and median values by age. Median values were calculated to observe data distribution not affected by outliers when skewed data are present.¹¹ Data also were categorized by the 2014 United Nations classification of developed and developing countries based on their economic status.¹² Data compilation, analysis, and graphing were accomplished using Microsoft Excel for Mac, Version 16.14.1, 2018, and Tableau 2020.3.

RESULTS

The 59 studies worldwide estimated overall ECC prevalence are shown in Table 1 and Figure 1. The studies were predominantly

conducted in developing countries (38/59). On a country-by-country basis, the United States of America, India, and Brazil have contributed eight studies each. Regarding global contribution, 18 of 27 countries had only one study eligible to be included in this review. Early childhood caries prevalence ranges from these studies were highly variable, with no apparent differences in prevalence between developed and developing countries.

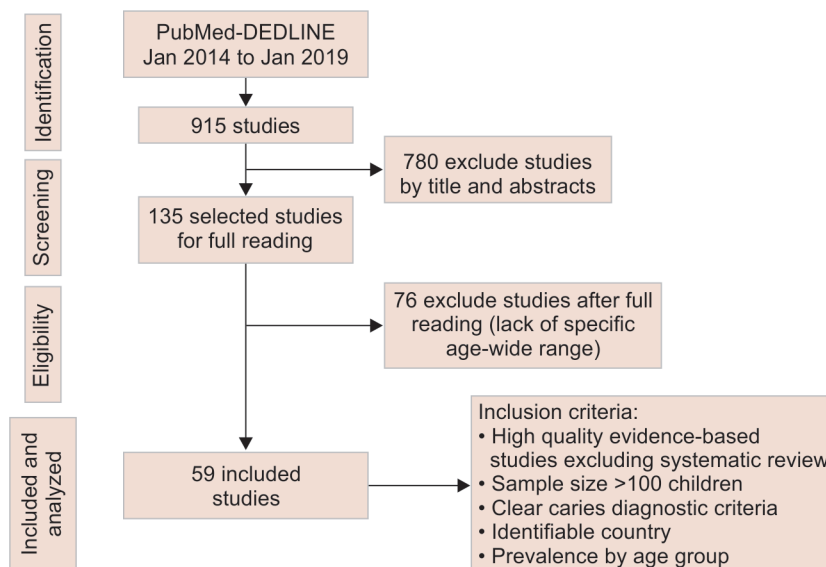
Table 1 shows that the range of ECC prevalence among the reported studies countries was extreme. For instance, the range of caries prevalence for 1 year olds was between 1% and 96% derived from reports from the United States and Brazil, respectively; for 2 years old, the range was 6–88%, derived from Nigeria and Brazil, respectively; for 3 years old, the range was 4–80% derived from the United States and Salvador, respectively; for 4 years old, the range was 12–80% derived from France and Salvador, respectively; and for 5 years old, the range was 21–97%, derived from Nigeria and Salvador, respectively.

Figure 2 illustrates the ECC prevalence in three developed and three developing countries with sufficient data, to show the ranges and median values for ECC prevalence in children <3 years old and between 3 years and 6 years old. The median prevalence values in many of the ranges are closer to one side of the range, indicating that the median data for prevalence may give a different understanding of each country's data than the reported ranges in caries prevalence.

Figure 3 illustrates the change in caries prevalence in developed and developing countries as reported by the year of study publication date. There is no clear trend in the increase or decrease of ECC prevalence over the 20 years. It should be noted that since 2013, reports have been exclusive from developing countries.

The ECC ranges and median values of the three countries with the largest number of reports, India, the United States, and Brazil, are presented in Figure 4 that shows the variances within and between countries. The median values of ECC prevalence from USA studies have the most significant increase (approximately 20%) in children between ages 3 and 4. Median values in caries prevalence from Brazil were higher in all the ages than the USA's median values. There was no evident caries prevalence by age group for India's studies.

Flowchart 1: Flowchart of the search and screening strategy



ECC Prevalence Studies

Table 1: Ranges of caries prevalence (%) reported among different age-groups in developed and developing countries

<i>Developed countries</i>			<i>Developing countries</i>		
<i>Country (no. of studies) (ref. no.)</i>	<i>Specific age (no. of studies)</i>	<i>ECC prevalence range (%)</i>	<i>Country (no. of studies) (ref. no.)</i>	<i>Specific age (no. of studies)</i>	<i>ECC prevalence range (%)</i>
USA (8) ²⁷⁻³⁴	1 y/o-(5)	1-21	India (8) ³⁵⁻⁴²	1y/o-(1)	8
	2 y/o-(7)	6-44		2 y/o-(3)	31-39
	3 y/o-(7)	4-61		3 y/o-(5)	8-46
	4 y/o-(5)	29-70		4 y/o-(5)	15-51
	5 y/o-(6)	27-75		5 y/o-(5)	24-61
Japan (3) ⁴³⁻⁴⁵	1 y/o-(2)	3-5	Brazil (8) ^{19-23,46-48}	1 y/o-(4)	2-96
	2 y/o-(2)	21-23		2 y/o-(7)	15-88
	3 y/o-(4)	21-65		3 y/o-(5)	33-76
		4 y/o-(4)		44-59	
				5 y/o-(2)	63-70
Canada (2) ^{25,49}	1 y/o-(2)	30-47	China (4) ⁵⁰⁻⁵³	2 y/o-(1)	28
	2 y/o-(2)	55-56		3 y/o-(2)	44-57
	3 y/o-(2)	67-78		4 y/o-(2)	53-72
	4 y/o-(2)	75-78		5 y/o-(3)	62-85
	5 y/o-(2)	78-84			
Lithuania (2) ^{54,55}	3 y/o-(1)	51	Nigeria (3) ⁵⁶⁻⁵⁸	1 y/o-(1)	3
	4 y/o-(2)	71-82		2 y/o-(2)	6-27
	5 y/o-(2)	85-90		3 y/o-(2)	23-30
		4 y/o-(2)		31-39	
				5 y/o-(2)	21-35
Italy (1) ⁵⁹	2 y/o-(1)	80	Jordan (1) ⁶⁰	1 y/o-(1)	13
	3 y/o-(1)	15		2 y/o-(1)	21
	4 y/o-(1)	25		3 y/o-(1)	34
	5 y/o-(1)	32		4 y/o-(1)	52
Bulgaria (1) ⁶¹	1 y/o-(1)	21		Turkey (2) ^{62,63}	2 y/o-(1)
	2 y/o-(1)	40	3 y/o-(2)		22-40
	3 y/o-(1)	56	4 y/o-(2)		40-50
		5 y/o-(1)	69		
Belgium (1) ⁶⁴	3 y/o-(1)	22	Taiwan (1) ⁶⁵	1 y/o-(1)	0
	5 y/o-(1)	41		2 y/o-(1)	9
				3 y/o-(1)	58
				4 y/o-(1)	77
				5 y/o-(1)	91
Denmark (1) ⁶⁶	3 y/o-(1)	5	South Korea (1) ⁶⁷	1 y/o-(1)	44
				2 y/o-(1)	64
				3 y/o-(1)	79
				4 y/o-(1)	91
France (1) ⁶⁸	4 y/o-(1)	12	Israel (1) ⁶⁹	1 y/o-(1)	0
				2 y/o-(1)	33
Austria (1) ⁷⁰	5 y/o-(1)	43	El Salvador (1) ⁷¹	1 y/o-(1)	10
				2 y/o-(1)	40
				3 y/o-(1)	80
				4 y/o-(1)	80
				5 y/o-(1)	97
			Sudan (1) ⁷²	3 y/o-(1)	46
				4 y/o-(1)	52
				5 y/o-(1)	56
			Chile (1) ⁷³	2 y/o-(1)	20
				4 y/o-(1)	53

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Developed countries			Developing countries		
Country (no. of studies) (ref. no.)	Specific age (no. of studies)	ECC prevalence range (%)	Country (no. of studies) (ref. no.)	Specific age (no. of studies)	ECC prevalence range (%)
			Albania (1) ⁷⁴	5 y/o-(1)	84
			Saudi Arabia (1) ⁷⁵	5 y/o-(1)	75
			Laos (1) ⁷⁶	3 y/o-(1)	82
			Tanzania (1) ⁷⁷	2 y/o-(1)	2
				3 y/o-(1)	12
			Uganda (1) ⁷⁷	2 y/o-(1)	12
				3 y/o-(1)	54
			Bosnia/Herzeg (1) ⁷⁸	3 y/o-(1)	59
				4 y/o-(1)	86
				5 y/o-(1)	98

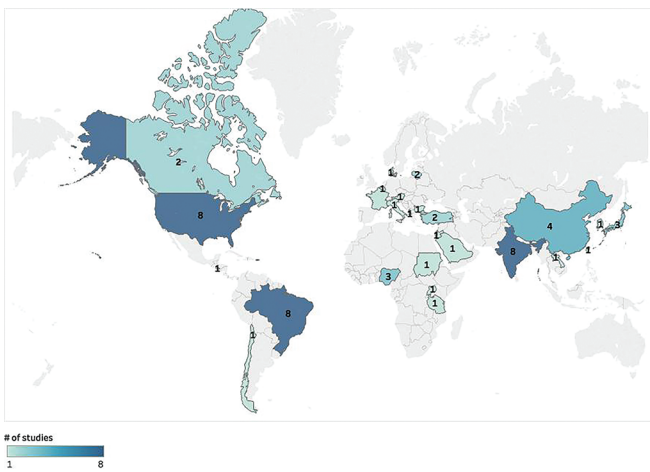


Fig. 1: Worldwide geographical distribution of the ECC studies that met the criteria for this report

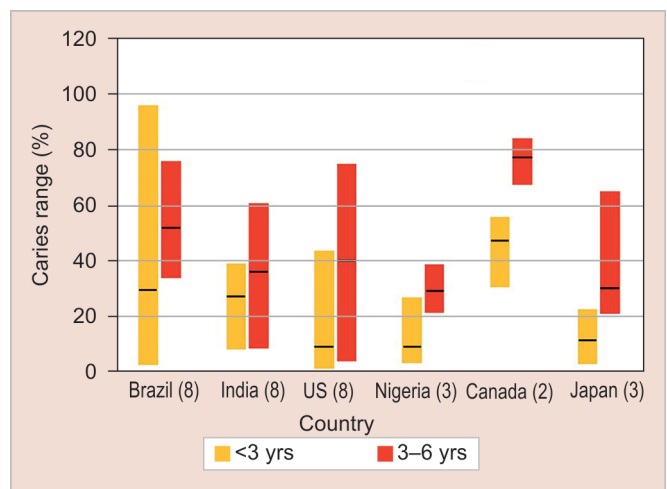


Fig. 2: The range and median values of early childhood caries prevalence among selected developing and developed countries in children <3 years and a 3–6-year-olds. The number next to countries represents the number of studies; horizontal lines within the ranges represent the median values

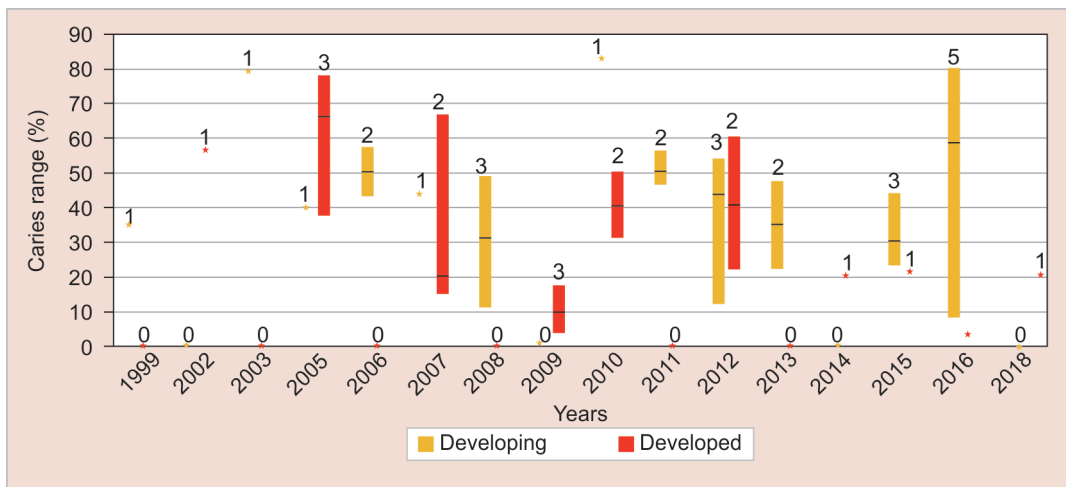


Fig. 3: The ranges of early childhood caries prevalence chronologically from 1999 to 2019 among developing and developed countries in children for 3-year-olds. No studies on 3 years old children in 2019. The number on top of the bars represents the number of studies; *denotes none or too few studies for a median and range; horizontal lines represent the median values

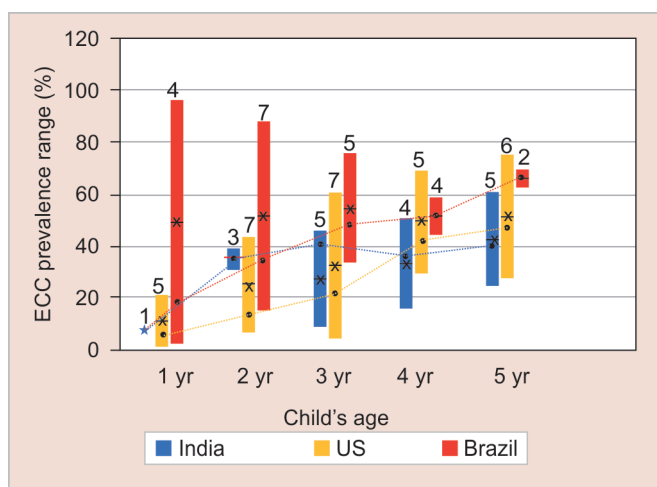


Fig. 4: The ranges, median and mean values of early childhood caries prevalence among children of different age-groups in three selected countries having numerous ECC reports. The black bars dots within the ranges represent the median values; the horizontal lines represent the means. The median values of each age group from each country are connected. The number on top of the bars represents the number of studies. *denotes none or too few studies for a median and range

DISCUSSION

Reported ECC prevalence ranges present extreme geographical and age variations that can be lessened by displaying the findings graphically and by using summary statistics. Accordingly, using median values, this mapping review found higher ECC prevalence in 3–6 years old; no differences in ECC prevalence associated with countries' economic status; and greater numbers studies from developed countries in the past 7 years.

We did not find differences in the prevalence of ECC between developed and developing countries. According to previous reports, countries with universal health care coverage were more likely to have lower ECC prevalence;^{13,14} countries with higher gross national income reported a higher prevalence of ECC;^{15,16} income inequality measures were reported to be inversely related to caries prevalence in 5–6 years old children countries with more remarkable economic growth have higher ECC prevalence,¹⁷ and a higher percentage of caries were reported in children living in poor social conditions such as in urban slums due to high sugar consumption in their diet.¹⁸ In a recent report, Folyan et al.¹⁴ noted a significant variation in the percentage of 3- to 5-year-olds with ECC in low and middle-income countries using the indicator for monetary poverty. However, from the 59 included studies in this study, we did not find sufficient data to support the concept that ECC prevalence was associated with socioeconomic factors, reinforcing the need for further research in this area.

The considerable variation in reported ECC prevalence that we found, perhaps, can be attributed to differences in the epidemiological study methods, variation in ECC diagnosis criteria, thresholds, and examination conditions. Additionally, there have been only a few comparative studies to evaluate global variations.¹⁰

Early childhood caries prevalence data were explored by ranges and calculated median values for each country and age group in the present study. Median values instead of means were

used because of the highly skewed values within each range. The findings between ranges and median values showed different sensitivities and possibly different inferences. For instance, the median prevalence value for children under 3 years old calculated from Brazil's studies is 27, ranging from 2 to 96%.^{19–23} Perhaps, the report of ECC prevalence by median values rather than ranges may better reflect the caries prevalence for a country and age group more accurately.

The 59 included studies' findings were arranged chronically from 1999 to 2019 to explore whether ECC prevalence temporally has changed temporally. Although it is evident that there are more reports of ECC caries prevalence after 2012, there is no clear pattern of change in the range of prevalence data over the 19 years examined. This finding can be compared to the US National Health and Nutrition Examination Survey (NHANES) surveys of children aged 2–5, collected from six surveys showing that the mean decayed and filled surfaces (dfs) were consistent between 2 and 3 between 1988 and 2012.²⁴

This review has certain limitations, resulting from both the methodology and the nature of evidence. The review may be open to bias since it combined two literature searches and only included English reports. Most importantly, ECC prevalence studies results may not be generalizable, even for a specific country, since populations may have been selected from high prevalence areas that would increase the possibility of over-estimating ECC prevalence.¹⁰ For example, Canada's two ECC prevalence studies^{25,26} refer to indigenous populations that may not represent the true ECC prevalence for preschool children in Canada. Another limitation is that ECC prevalence studies often are convenience samples and may have vastly different sample sizes. We only included studies reporting >100 subjects, yet the data in the present and the included studies do not factor in the sample sizes. Lastly, many of the included studies do not address the training and calibration of examiners, standard methods, or diagnostic criteria, limiting the reports' validity.

CONCLUSION

This mapping review of the global prevalence of ECC, between 1999 and 2019, found extreme ranges in caries prevalence that could be better understood by calculating the median prevalence values for countries. The differences in ECC's prevalence for developed and under-development countries were not evident. Many of the included studies appear to have issues regarding generalizability, use of convenience samples, lack of reporting of training and calibration of examiners, and variations in diagnostic criteria. This mapping review may guide ECC's global prevalence and provide some understanding of the resources and services to reduce preschool children's caries burden.

CLINICAL SIGNIFICANCE

The global ECC prevalence ranges are extreme. Median data may provide a structure for future epidemiological studies to optimizing healthcare resources for caries interventions globally.

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