ORIGINAL RESEARCH

Early Childhood Caries in a Preschool-based Sample in Northeast Italy: Socioeconomic Status and Behavioral Risk Factors

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Abstract

Aim: To assess the relationship among caries and age, gender, immigrant condition, socioeconomic status (SES), and a behavioral risk factor (toothbrushing) in a sample of 3–5-year-old children.

Materials and methods: We performed a random cross-sectional survey from January to December 2017, carrying out clinical examinations to estimate the decayed, missing, and filled teeth (dmft) score. Parents filled in a questionnaire reporting their education level (SES) and the daily frequency of children's toothbrushing. The multivariate analysis assessed the association between caries occurrence and the independent variables. The dmft score was assessed by zero-inflated negative binomial regression (ZINBR).

Results: Out of 1,441 children in the sample, 357 (26.0%) presented at least one caries-affected tooth. Caries risk significantly increased with age and irregular toothbrushing, and it was significantly higher in children with lower SES levels. We modeled caries risk by means of ZINBR. The degree of caries experience increased in children from lower SES positions, immigrant status, and of older age; regular toothbrushing (twice a day) is a predicting factor to belong to the "zero caries" group.

Conclusion: Dental caries represent a significant burden in preschool children and can be regarded as an early marker of social disadvantage.

Clinical significance: The confirmation of the earliest preventive approach as the only chance to grant a "caries free" dentition in all ages and the first target for a pediatric dentist.

Keywords: Early childhood caries, Preschool children, Prevalence, Risk factors, Toothbrushing.

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Ethical Policy and Institutional Review Board Statement

The design of the study was reviewed and approved by the Local Ethic Committee of Padua (approval no. 256, approval date 04.20.2017). All the procedures were performed following the ethical guidelines laid down by the Declaration of Helsinki (2013).

Patient Declaration of Consent

Inclusion criteria were the year of birth (2012–2014) and parents' signed consent. A self-submitted information form (along with a consent form) was given to be completed by the children's parents.

Data Availability Statement

All data generated or analyzed during this study are included in this article. Further inquiries can be directed to the corresponding author.

The data that support the findings of this study are not publicly available due to their containing information that could compromise the privacy of research participants but are available from the corresponding author (Alberto Besostri).

Introduction

The World Health Organization data suggest that caries prevalence declined in high and middle-income countries. In the United States of America and in the Western and Nordic European Countries, the decline started in the mid-1970s of the previous century after fluoride toothpaste became widely available and used.[1–3] Despite this, some authors have reported that the burden of untreated dental caries in primary dentition has not decreased or even augmented in recent years, particularly in countries with low caries prevalence in primary dentition.[4–8] Tooth decay is the single most common chronic childhood disease,[9,10] yet it is largely preventable, and carious dentine lesions are now concentrated in a minority of children.[3] The last resolution on the oral health of the World Health Assembly remarks upon the burden of poor oral health among the most vulnerable and highlights the importance of preventive interventions with a life course approach.[11]

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Caries affects mainly the poor. Untreated caries in deciduous teeth affects more likely preschool children from low-income families.[12,13] This association might be stronger in developed countries,[14,15] while a nonapparent difference was found comparing the prevalence of early childhood caries (ECC) in developed and developing countries.[16]

However, when children from higher-income families develop caries, the severity of the disease is comparable to that of low-income children.[17] For this reason, we chose the population-based approach according to the "prevention paradox"—a large number of people exposed to a small risk may generate many more cases than a small number exposed to high-risk, which was also reported for the onset of dental caries.[18,19]

In our area, kindergartens provide an ideal setting for an oral health promotion program and a source of recurrent survey-based data to allow the monitoring of decay trends.[7]

The aim of this study was to assess, in a sample of children aged 3–5 years, the relationship between caries experience and age, gender, immigrant condition, SES, and a behavioral risk factor (toothbrushing).

Materials and Methods

The present study was carried out as a random cross-sectional survey (conforming to the Strengthening the Reporting of Observational Studies in Epidemiology guidelines) from January to December 2017. The design of the study was reviewed and approved by the Local Ethic Committee of Padua (approval no. 256, approval date 24th April 2017). Within the framework of a Community Oral Health Promotion Program developed by our team, we randomly selected 25 nursery schools (out of 88) in our Health District (Veneto Region—North East Italy). Children aged 3–5 years (born in 2012–2014) attending these schools were the target of our Oral Health Promotion Program. The number of schools selected represents the best performance over 1 year our team can work. No power calculation was carried out as the number of schools selected represents the best performance over 1 year our team can work—we decided to work with a random sample of schools to get a better description and representation of the children population in our area. Inclusion criteria were the year of birth (2012–2014) and parents' signed consent. The study population consisted of 1,573 individuals (12.3% over a population of 12.819 born in the same years). Exclusion criteria—15 children (0.9%) were excluded as they were not of the same year cohort; we missed information about 107 fellows (information form not completed by their parents), so our final sample consisted of 1,441 children (710 males and 731 females).

The clinical examinations were carried out by two examiners (Alberto Besostri and Roberto Ferro) using a portable light, a mouth mirror, and a dental probe. Diagnosis of dental caries at the tooth level (dmft index) was, according to the criteria recommended by the British Association for the Study of Community Dentistry,[20] mainly made visually and confirmed with a probe when necessary. Dental caries was diagnosed at caries into dentine (d3) threshold. No X-rays were taken.

Data from clinical examinations were coded and then put into an *ad hoc* performed database. Data were analyzed using Stata rel. 14.0 (Stata Corporation, College Station, Texas, United States of America, 2004).

The dmft score was the primary outcome of the study. Each child was furthermore classified as having caries (with dmft >0) or being caries free (with dmft = 0)—a dichotomous variable 1/0 was defined to record this information. A self-submitted information form (along with a consent form) was given to be completed by the children's parents. It contained questions about mother's and father's education level and the mother's place of birth; a further item requested the daily frequency of the children's toothbrushes. Education level has been classified into four categories. Low (primary education), medium-low (lower secondary education), medium-high (upper secondary education), and high (bachelor's degree).

For each child, the social class position (SES) was assessed according to the best education level observed between father and mother's status.[21] A child was defined "immigrant" if his/her mother was born in a "Non-Western Country" (Eastern Europe, Asia, Africa, Turkey, South, and Central America); otherwise, a "nonimmigrant" status was assigned.[22]

Toothbrushing frequency has been categorized as "irregular/once a day," "twice a day."

Means and standard deviations were calculated for continuous variables, for categorical variables, and the results were provided as proportions. Comparisons between groups were made using the Pearson Chi-squared test. A p-value of <0.05 was considered significant.

Multivariate analysis has been performed to evaluate the association between caries occurrence (dichotomous variable) and the independent variables (age, sex, family class of social position, and frequency of toothbrushing)—those variables which showed a statistically significant association with the outcome in univariate analysis, were evaluated by means of a binomial logistic regression model.

Moreover, as dmft was highly positively skewed by a high proportion of zero scores modeling data was assessed by NBR and ZINB models to account for such a distribution.

Results

Overall, 1,441 children (50.7% females) were examined, 280 (19.4%) of immigrant background. The distribution of all the variables in our study sample is displayed in Table 1. Because of its very small amount (12 subjects, 0.83%) "low category" in education level was joined to the "medium-low" one. Of 1,441 children in the sample, 357 (26.0%) presented with at least one caries-affected tooth (dmft ≥ 1). Overall mean dmft was 1.05 (median 0, range 0–16). Accounting for the age-group, we observed mean dmft of 0.58 (3-year-old), 1.12 (4-year-old), and 1.39 (5-year-old). Caries experience increased with age and was more severe in children of lower SES families (Table 2). Lifestyles, like toothbrushing twice a day, played a role in protecting against caries onset.

Results from the binomial logistic regression model showed that caries risk significantly increased with age [odds ratio (OR) = 2.30 95% and confidence interval (CI) = 1.64–3.22 by children 4-year-old, OR = 2.85 95%, and CI = 2.05–3.96 by 5-year-old ones), and irregular toothbrushing (OR = 1.62 95% and CI = 1.24–2.11), and it was significantly higher in children of lower SES levels (OR = 2.66 95% and CI = 1.75–4.05) (Table 3).

Given that the dmft distribution was positively skewed by a high proportion of zero scores (74.0%) modeling data were assessed using an NBR and ZI models accounting for such a distribution. The dispersion parameter (α) was significantly different from zero (α = 5.23 95% and CI = 4.49–6.08); the NBR model is therefore more appropriate than a Poisson model. Vuong test suggests that the

ZI model is a significant improvement over a standard negative binomial model (z = 6.44 and $p = 0.0000$).

Table 4 provides a display of covariate-adjusted estimates from the ZINB count equation and from the inflate equation. In the negative binomial section (first part of the outcome), caries experience is modeled as an incidence rate ratio (IRR), adjusted for caries-free, and estimates the association of the covariates with an increase of caries incidence—sex, immigrant status, and SES had a significant effect on the severity of caries experience. The second part in the outcome of the ZINB regression describes caries-free subjects in excess of those expected, modeling for each covariate the probability of being without caries. Children of younger age showed a higher probability of being an extra zero, nonimmigrant status, high SES category, and toothbrushing twice a day worked in the same way.

Table 1: Study sample: variables distribution

Sample characteristics	*N (1,441)*	*%*
Gender		
Male	710	49.3%
Female	731	50.7%
Age (years)		
3	459	31.9%
4	466	32.4%
5	516	35.8%
Ethnicity		
Nonimmigrant	1161	80.6%
Immigrant	280	19.4%
Education level (social class position)		
Low/medium-low	155	10.8%
Medium-high	873	60.6%
High	413	28.7%
Toothbrushing frequency		
Irregular—1 time/day	875	60.7%
2 times/day	566	39.3%
Caries experience		
dmft = 0	1066	74.0%
dmft ≥ 1	375	26.0%

Discussion

In this work, we studied ECC experience in a sample of children 3–5-year-old. One in four (26%) in our sample showed at least one caries-affected tooth. We observed that caries experience was mainly affected by increasing age and social status (more severe in children of lower SES families and immigrant status), while lifestyles, like toothbrushing, played a role in protecting against caries onset. We modeled caries risk by means of two subsequent approaches. In the first one, a traditional/classical binomial logistic regression model, a significant risk of caries experience was associated with age, irregular toothbrushing, lower SES levels, and immigrant condition. Overdispersion of caries-free children (dmft = 0) and a highly skewed distribution suggested a reduced utility of such class of multivariate analysis and, as a consequence, we choose a ZINB model.

Zero-inflated models analyze the risk factors of dental caries in a "susceptible" subpopulation of children said to be at risk for a disease or condition and a subpopulation of "non-susceptible" children with only zero counts who are considered to be not at risk.

In the first part of the outcome of that regression, the negative binomial section, the caries experience is modeled as an IRR, adjusted for caries-free, and estimates the association of the

Table 2: Study population and caries occurrence according to age, gender, immigrant status, SES, and toothbrushing

Characteristics	*dmft = 0 (n = 1,066)*	*%*	*dmft ≥ 1 (n = 375)*	*%*	*p-value*
Gender					0.698
Male	522	49.0%	188	50.1%	
Female	544	51.0%	187	49.9%	
Age (years)					<0.001
3	388	36.4%	71	18.9%	
4	329	30.9%	137	36.5%	
5	349	32.7%	167	44.5%	
Ethnicity					<0.001
Nonimmigrant	918	86.1%	243	64.8%	
Immigrant	148	13.9%	132	35.2%	
Social class position					<0.001
Low/medium-low	87	8.2%	68	18.1%	
Medium-high	648	60.8%	225	60.0%	
High	331	31.1%	82	21.9%	
Toothbrushing frequency					0.001
Irregular—1 time/day	620	58.2%	255	68.0%	
2 times/day	446	41.8%	120	32.0%	

Table 3: Odds ratios for caries occurrence by the binomial logistic regression model, adjusted for age, gender, immigrant status, SES, and toothbrushing

Characteristics		*OR*	*95% CI*		*p-value*
Gender	Male	1.00			
	Female	0.96	0.75	1.24	0.776
Age (years)	3	1.00			
	4	2.30	1.64	3.21	<0.001
	5	2.85	2.05	3.96	<0.001
Ethnicity	Nonimmigrant	1.00			
	Immigrant	3.24	2.44	4.31	<0.001
Social class position	High	1.00			
	Medium-high	1.39	1.03	1.87	0.030
	Low/medium-low	2.66	1.75	4.05	<0.001
Toothbrushing frequency	2 times/day	1.00			
	Irregular—1 time/day	1.61	1.24	2.11	<0.001

covariates with an increase of caries incidence—we can refer to that result as a measure of severity of the condition. Sex, immigrant status, and SES had a significant effect on the severity of caries experience. The second part in the outcome of the ZINB regression describes caries-free subjects in excess of those expected, modeling for each covariate the probability of being without caries. The probability of being an extra zero was statistically significantly higher for caries-free in children of younger age, nonimmigrant status, high SES category, and toothbrushing twice a day.

Social class position, immigrant status, and age were significant in both parts of the ZINB regression model, implying that the degree of caries experience increases in children from lower SES positions, immigrant status, and of older ages, while the excess of caries-free among those children decreases.

The behavior of lifestyle such as toothbrushing could be regarded as counterfactual, nevertheless, we can observe that the caries distribution (values of dmft greater than zero) is not statistically different between children in both categories of daily frequency of toothbrushing. Such observation suggests that regular toothbrushing (twice a day) is a predicting factor to belong to the "zero caries" group (not at risk)—when the caries process begins, its severity (e.g., increase of caries incidence) is no longer due only to regular toothbrushing among children which could be interpreted as "caries subject to."

In a similar way, girls show a greater probability of being an "extra zero."

Our data strengthen the results found in international[23–26] and national[27–30] literature on the association among caries and age,[31] ethnic origins,[32] and toothbrushing habits.[15,33]

The social determinants of oral health disparities will not be eliminated by dental treatment and clinical prevention alone but could be controlled by a common lifelong risk approach targeting the root cause of oral diseases.[11,33,34]

To this extent, we examined the immigrant/no immigrant status of the mother's and parents' education levels also as a proxy of the family income.

Our results are sustained by several studies—on mothers' immigrant status,[26,32,35] also referring to the expectant mother's oral health as a predictive factor on caries onset in the child,[36] on the association among ECC, parents' education levels,[27,37] and family income.[38]

A strength of our study is the approach in modeling caries risk—in the presence of excess zeros, ZI models are currently regarded as the preferable model choice.[39]

In Italy, kindergartens provide either a 3- or 4-year-old preschool program. Although attendance is not compulsory, the comprehensive services offered in this area result in parents of all socioeconomic levels sending their children to kindergarten. Thus, kindergarten populations represent the preschool population, making them an appropriate source for studies.

Within this approach, the most important result in the analysis is that the earliest preventive approach is the fundamental chance to grant a "caries free" dentition in all ages and the first target for a pediatric dentist because the onset of decay involves a derailment from the "caries free" trajectory, so sustaining the thesis that the longer a site survives without cavitation, the less likely it is that a lesion will form.[40]

The use of dmft score is a possible limitation of this analysis. This selected criterion for disease detection reduces the incidence of false positive findings, however, resulting in an increased number of false negative findings.[41]

Another limitation of this study is that in obtaining information about the daily toothbrushing habits from parents, they could inflate their answers for this type of socially acceptable behavior, so the accuracy of the information cannot be completely assumed. Finally, the cross-sectional nature of this study could not completely

Table 4: ZINB regression: caries risk-adjusted for age, gender, immigrant status, SES, and toothbrushing

Count component (negative binomial section)		*IRR*	*95% CI*		*p-value*
Gender	Male	1.00			
	Female	0.74	0.61	0.89	0.002
Age (years)	3	1.00			
	4	0.96	0.73	1.27	0.786
	5	1.14	0.87	1.49	0.331
Ethnicity	Nonimmigrant	1.00			
	Immigrant	1.46	1.20	1.78	<0.001
Social class position	High	1.00			
	Medium-high	1.49	1.15	1.92	0.002
	Low/medium-low	1.84	1.35	2.50	<0.001
Toothbrushing frequency	2 times/day	1.00			
	Irregular—1 time/day	0.98	0.80	1.21	0.854
Inflate component (logit section, modeling dmft = 0)		*OR*	*95% CI*		*p-value*
Gender	Male	1.00			
	Female	0.93	0.70	1.23	0.621
Age (years)	3	1.00			
	4	0.41	0.28	0.59	<0.001
	5	0.34	0.24	0.49	<0.001
Ethnicity	Nonimmigrant	1.00			
	Immigrant	0.31	0.23	0.43	<0.001
Social class position	High	1.00			
	Medium-high	0.81	0.58	1.15	0.238
	Low/medium-low	0.43	0.27	0.70	0.001
Toothbrushing frequency	2 times/day	1.00			
	Irregular—1 time/day	0.59	0.44	0.80	<0.001

IRR, incident risk ratio; OR, odds ratio; ZINB, zero-inflated negative binomial

inform about an exposure associated with an outcome since the optimum study design to investigate it is a longitudinal study.

Conclusion

The recorded ECC prevalence was similar to other Western Countries, and SES and behavioral habits influenced the development of ECC.

In the aim to grant a comprehensive prevention system based on a population-based approach to involve the "hard to reach" children and according to the "preventive paradox," the free dental screening offered to each kindergarten (with a written response to the parents), including an oral health education session with the children, is completed by a free of charge oral treatment at the local Health District Dentistry Unit.

Oral health isn't yet considered a leading health indicator, but in the Universal Health Coverage framework, in which the importance of oral health has been recognized,[42] an early multidisciplinary

approach involving primary care providers can facilitate access to appropriate oral health prevention and care.[37] Within this perspective, quoting Professor Watt, ECC could be a "canary in a coal mine" that is an early marker of social disadvantage.[34]

Author Contributions

- Roberto Ferro: Study conception, data collection, and data interpretation.
- Alberto Besostri: Data collection, data interpretation, and writing the manuscript.
- Armando Olivieri: Study conception, data acquisition and analysis, data interpretation, and writing the manuscript.
- Luca Benacchio: Study conception, data acquisition and analysis, data interpretation, and writing the manuscript.

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