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ORIGINAL ARTICLE

Caries experience among adolescents in southeast Italy

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Abstract *Background/purpose:* According to WHO recommendations, 12-year-olds are considered an important target group for evaluating the level of dental caries among children with permanent teeth, and are often chosen for international comparisons. The aim of the present study was to evaluate the current oral health status of 12-year-old children in southeast Italy, stratified by gender and residential area.
Materials and methods: The survey was conducted on 431 children enrolled by multistage cluster sampling. A dental caries experience index (decayed, missing, and filled permanent teeth; DMFT) was recorded at schools by a team of examiners trained at the start of the study. Statistical analyses by Chi-square, Fisher's exact, and Wilcoxon tests were performed using SAS version 9.1 software for PCs. We applied the Zero-Inflated Negative Binomial regression model in the STATA package.
Results: Caries prevalence was recorded in 38.3% of the sample. Estimated means and 95% confidence intervals of the DMFT index by gender were: 1.15 (0.91—1.39) for males, 1.26 (1.02—1.5) for females, and 1.21 (1.03—1.39) for the total sample. The D component of the index was dominant. The mean number of caries found in southeast Italy was significantly higher than the national mean ($t = 3.125$, $P = 0.002$), but significantly lower than the mean for south Italy ($t = -2.125$, $P = 0.03$). Results of the regression model showed that only the mother and father's nationality and educational level contributed to the DMFT.

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Conclusions: The oral health situation of 12-year-old children from southeast Italy seems to be in line with that in other Western European countries.

Introduction

In recent years, due to the widespread use of fluoridated toothpastes, caries experience and severity have dramatically decreased in many Western industrialized countries.[1–4] This trend was particularly observed in younger age groups.[5–9]

Following WHO recommendations, the first Italian pathfinder study was designed and carried out by the Collaboration Centre for Epidemiology and Community Dentistry of Milan in collaboration with the Italian Society of Hygiene and Preventive Medicine, and called the "National Pathfinder among children's oral health in Italy".[10] Twelve-year-olds are considered an important target group for evaluating the level of dental caries among children with permanent teeth, and are often chosen for international comparisons.[10] Caries experience was observed in 43.1% (95% confidence interval (CI) 41.8–44.4%) of the population; the mean decayed, missing, and filled permanent teeth (DMFT) score was 1.09 (95% CI 0.98–1.21). Significant differences were demonstrated among geographic areas in caries prevalence (the D component). The D component of the caries index was dominant in all regions. An inverse relationship was observed between the mean DMFT score and per capita gross national product.[10]

The Pathfinder study revealed significant differences in oral health indexes in different geographic areas of Italy, and indicates that south Italy is one of the most critical areas. Therefore, the aim of the present report was to assess the current oral health status of 12-year-old children in southeast Italy, stratified by gender and residential area.

Materials and methods

A cross-sectional survey was conducted in the Apulia Region of southeast Italy, with a land surface of 19,347 km^2 and a population of 4,040,990 inhabitants (including 1,961,510 males and 2,079,480 females), 48,049 of whom were 12-year-olds (including 24,895 boys and 23,144 girls).

School attendance is compulsory up to the age of 16, and education is provided by public school systems; thus, in public schools all different socioeconomic status (SES) levels of parents are represented. In Apulia, caries-prevention policies have never been implemented at either the regional or local level. In the entire region, the water supply is provided by a single aqueduct (Acquedotto Pugliese S.p.A.); the water is not fluorinated, and the measured water fluoride content ranges from 0.1 mg/L to 0.6 mg/L (mean 0.23 mg/L) (according to the website www.aqp.it). Thus, the same exposure level to fluoride in water was hypothesized for all Apulian 12-year-olds. No data are available on the use of other forms of fluoride administration (tablets, droplets etc.).

This study was an observational survey, and no experiments were carried out on humans or human samples. The Research Ethics Committee of the University of Milan approved the study design. In order to obtain a sample representative of the regional population, multistage cluster sampling was performed, considering the five Apulian provinces as strata; in the second stage, counties of the provinces and then secondary schools were chosen at the cluster level with a proportional random selection of participants. A sample size was calculated based on an assumed prevalence of dental caries (DMFT $>$ 0) of 45% and a standard error of 0.05. According to the sampling method, 381 Apulian children attending the first grade of secondary school (the sixth/seventh year of schooling) were estimated to be required for the final sample, but to compensate for an estimated 15% dropout rate during the investigation, 447 children were enrolled. Parents or guardians were given an information leaflet explaining the aim of the study and requesting their child's participation; children were enrolled as participants only after their parents' written consent was obtained. In total, 447 children were recruited and 431 were examined (213 males and 218 females), because 13 were not present in the classroom at the time of the examination and were excluded. Data were collected at the schools by means of clinical examinations. The dental caries experience (DMFT) was recorded according to WHO criteria[9] using a plain mirror (Hahnenkratt, Königsbach, Germany) under artificial light. In addition, the number of sealed premolars and molars were recorded.

Seven examiners undertook clinical visits. In order to avoid inter-cluster variability attributable to inter-examiner variability, each school selected was visited by all seven examiners at the same time, and each examiner looked at an equal proportion of children. The team received training, and intra- and inter-examiner reliability was assessed before the start of the study; the sensitivity, specificity, percentage agreement, and kappa statistics were recorded. Percent agreement ranged from 98.0% to 99.2%, and kappa statistics ranged from 0.92 to 0.97.[11]

Categorical variables were summarized as the count and percentage, and comparisons were performed using Chi-square and Fisher's exact tests where appropriate. Percentages of healthy teeth, decayed non-filled teeth, and filled teeth were determined as the number of teeth divided by the total number of effective teeth present. P values for paired comparisons of the percentages of healthy, decayed, and filled teeth were adjusted for multiple comparisons with a permutational procedure.

Mean values of decayed teeth (DT), missing teeth (MT), filled teeth (FT), and DMFT, and 95% CIs were calculated by

gender and for the overall sample. Comparisons between independent groups were performed by means of the Wilcoxon test.

The level of significance was set to 0.05 for all statistical analyses. Multiple comparisons were performed by means of Fisher exact test, adjusted for gender.

Assessment of the significance of differences in the means for DT, MT, FT, and DMFT found at the regional level was also made, and these were compared to corresponding values of national and southern-Italian levels, using Student *t* test. Data were processed and analyzed using SAS version 9.1 software for PC (SAS, Cary, NC, USA).[10] To estimate the contribution of individual and/or behavioral variables to the DMFT index, which was not normally distributed (Shapiro–Wilk test: $z = 8.25$, $P < 0.0001$), a Zero-Inflated Negative Binomial (ZINB) regression model was applied.

In fact, when applied to skewed distributions, this model showed a better fit of the observed data than other regression models that do not rely on a normal distribution of the dependent variable.[12] In order to choose which regression model would better fit our data, we used the Akaike information criterion (AIC) as a guide.[13] The lowest AIC value was observed for the ZINB model (Poisson: 3.39; negative binomial: 2.96: zero-inflated Poisson: 2.95; and ZINB: 2.91), which indicates that this model best fits the present study data (Fig. 1).

The ZINB model expresses the DMFT index as a function of various explanatory variables: gender, parent nationality (Italian vs. other), educational level (high-school or higher vs. lower than high school), preterm birth, prolonged breast feeding (> 1 year), and tooth-brushing habits (brushing at least three times per day for at least 3 minutes each time). However, only the variables that contributed to the DMFT with a P value of < 0.10 were used in the final model.

The zero-inflated regression model can be interpreted as a splitting device that subdivides individuals into two groups: subjects not at risk for caries with a probability $P = 0$ on the DMFT index for their demographic/behavioral risk profile characteristics, and another group of subjects at risk for dental decay at $P = 0$ only by chance at the moment of the observation, but with a probability of $1 - P$. On the basis of this assumption, the influence of covariates may move individuals from the former to the latter group and the probability of scoring > 0 in the ZINB model was estimated by a logistic regression ($1 - P$). This statistical analysis was performed using the STATA package (StataCorp LP, College Station, Tx, USA).

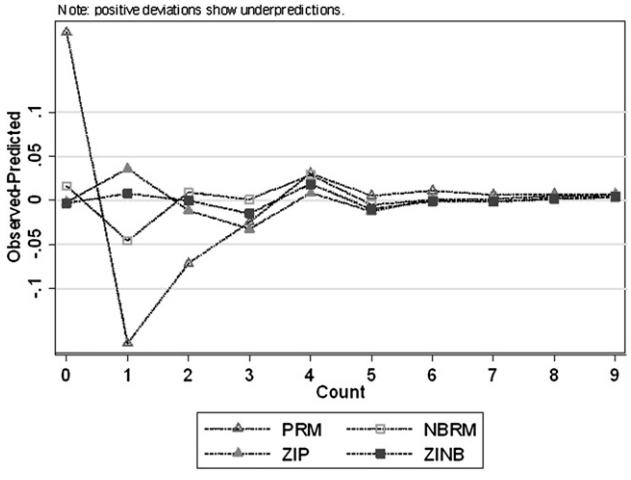

Figure 1 Differences of DMFT index between observed and predicted proportions from Poisson (PRM), Negative Binomial (NBRM), Zero Inflated Poisson (ZIP) and Zero inflated Negative Binomial (ZINB) regression models.

Results

At least one decayed tooth was recorded in 38% of the sample. Table 1 shows the frequency of children with at least one decayed, filled, missing, or sealed tooth stratified by gender. No differences were found for gender or geographical area.

Estimated means and 95% CIs of the DMFT index by gender adjusted for the design effect were 1.15 (0.91–1.39) for males, 1.26 (1.02–1.5) for females, and 1.21 (1.03–1.39) for the total sample (Table 2).

No differences were found between the genders. The D component of the index was dominant. The Wilcoxon test did not show significant differences between genders for mean DT (0.95 for males, 0.97 for females, and 0.96 for the total), mean FT (0.17 for males, 0.28 for females, and 0.23 for the total), or mean MT (0.03 for males, 0.01 for females, and 0.02 for the total). A significant difference by gender was found for the mean number of sealed teeth (0.3 for males, 0.46 for females, and 0.38 for the total). The same difference was observed when comparing percentages of sealed teeth between males and females: 16% in females (35/218) versus 9% in males (18/213) (Chi-square = 5.78, $P = 0.016$).

The percentage of healthy upper right incisors was significantly higher than right upper molars ($P < 0.0001$), first left upper and lower molars ($P < 0.0001$), second left lower molars ($P = 0.003$), and second left upper molars ($P = 0.006$).

The percentage of decayed upper left incisors was significantly lower than first upper right molars ($P < 0.0001$), first upper left molar ($P < 0.0001$), first lower right molar ($P < 0.0001$), second lower right molar ($P = 0.006$), and first and second lower left molars ($P < 0.0001$). The upper right incisors were significantly less decayed than the second upper right molar ($P = 0.024$), and first and second right and left lower molars ($P < 0.0001$). The upper right canines were significantly less decayed than the second upper right molar ($P = 0.027$).

The upper right incisors were significantly less-often filled than the first right lower molar ($P = 0.01$) and first left lower molar ($P = 0.042$). The upper right canines were significantly less-often filled than the first upper right molar and first upper left molar ($P < 0.01$). The upper right premolars were less-often filled than the first molars (both right and left, upper or lower; $P < 0.0001$).

Comparisons of the regional, southern-Italian, and national DT, MT, FT and DMFT values showed that the mean number of caries in Apulia was significantly higher than the national mean ($t = 3.125$, $P = 0.002$), but significantly lower than the southern-Italian mean ($t = -2.125$, $P = 0.03$).

The mean number of filled teeth in Apulian children was significantly lower than both the national mean ($t = -4.33$,

Table 1 Frequency of children with at least one tooth decayed, filled, missing and sealant.

	Female ($n = 218$)			Male ($n = 213$)			Total ($n = 431$)			Chi-square	P
	n	%	95% CI	*n*	%	95% CI	*n*	%	95% CI		
Decayed	87	40	30–50	78	37	26–47	165	38	31–46	0.49	0.48
Filled	36	17	4–29	26	12	0–25	62	14	6–23	1.62	0.2
Missing	2	1	0–3	6	3	1–6	8	2	1–4		0.17*
DMFT	109	50	41–59	96	45	35–55	205	48	41–54	1.05	0.3
Sealant	35	16	4–28	18	9	6–12	53	12	3–21	5.78	0.02

*Fisher exact test.
95% CI: confidence interval at 95% level.

$P < 0.0001$) and the southern-Italian mean ($t = 4$, $P = 0.0002$). In contrast, the mean number of missing teeth did not significantly differ from either the national or southern-Italian means.

Overall, it was concluded that the mean Apulian DMFT value did not significantly differ from the national Italian mean, but was significantly lower than the southern-Italian mean.

In the regression model, only sociodemographic variables (mother and father's nationality and educational level) contributed to the DMFT according to the selection criterion, and so these were entered into the final model.

Table 3 gives the results of the final ZINB model for both the negative binomial estimates (left side) and logistic estimates (right side). Only the educational level of the father reached statistical significance in both parts of the model; the signs of the coefficients diverged in the two parts. This means that in the negative binomial part, where the coefficient is negative (−0.35, $P = 0.049$), children with a highly educated father tended to have lower DMFT values (i.e., 5.98 adjusted DMFT compared to the constant 8.45). Conversely, from the inflated part, children with a highly educated father showed a high probability of scoring > 0 (0.30).

Table 2 Estimations of means and 95% confidence intervals of DT, FT, MT, DMFT stratified by gender.

	Gender	Mean	S.D.	CI 95%	P
Decayed	Total	0.96	1.64	0.80–1.12	
	Female	0.97	1.63	0.75–1.19	0.83
	Male	0.95	1.65	0.72–1.17	
Filled	Total	0.23	0.65	0.17–0.29	
	Female	0.28	0.72	0.18–0.38	0.17
	Male	0.17	0.56	0.09–0.25	
Missing	Total	0.02	0.16	0.00–0.04	
	Female	0.01	0.15	0.00–0.03	0.15
	Male	0.03	0.17	0.01–0.05	
DMFT	Total	1.21	1.77	1.03–1.38	
	Female	1.26	1.78	1.02–1.49	0.35
	Male	1.15	1.76	0.91–1.38	
Sealant	Total	0.37	1.25	0.24–0.50	
	Female	0.46	1.33	0.27–0.64	0.02
	Male	0.3	1.19	0.14–0.46	

S.D.: standard deviation. 95% CI: confidence interval at 95% level.

Discussion

The present study confirms previous data indicating significant differences in DMFT values among different Italian geographical areas.[10] In particular, some markers of dental decay (DT and FT) in Apulian citizens showed levels that were significantly higher than the national mean. This disease pattern is probably correlated with the socioeconomic status of the population. In fact, in Italy, primary dental health services are based on private healthcare providers, so dental care is mainly directly paid for by the patient or, to a lesser extent, through public or private insurance schemes. For this reason, in Apulia, where the *per capita* GNP is significantly lower than that in other parts of Italy, people have less access to dental care and consequently a higher level of disease. Nevertheless, overall, the Apulian DMFT did not statistically differ from the national score (1.21 vs. 1.09), while it was significantly lower than elsewhere in south Italy (1.21 vs. 1.5), indicating that conditions in this region are nearer to the national average than to that of south Italy. Moreover, the level of dental caries recorded in Apulian 12-year-olds is consistent with the value fixed by the WHO-EURO as the goal for 2020 (DMFT ≤ 1.5).[14]

Note that this is the first study conducted in south-east Italy on the frequency of dental caries in 12-year-olds, so it is not possible to compare the present data with previous reports that could reveal a rise or fall in dental caries in our population. For this reason and others, a close monitoring of dental caries epidemiology is an indispensable aspect of dental public health. It would be useful to set up periodical surveillance systems of public dental health, like those already in existence in some other European countries.[15] In any case, comparison of our data with those of previous Italian studies shows evident improvement in the Italian oral-health status. In fact, over the past two decades, the mean DMFT has fallen dramatically from over 5 to approximately 2 in 1996 and then to the present level.[9,16]

From a European perspective, the Apulian results are comparable to those described in other Western-European countries,[6,9] where there are well-organized dental public health services for children and adolescents.[8,15] Moreover, the mean DMFT value in Apulia is lower than those reported for other European countries where oral healthcare systems are similarly limited.[5,17]

Table 3 Outcome of zero-inflated negative binomial modeling (ZINB) for DMFT index.

	Negative binomial regression coefficients	P	Adjusted DMFT	Logit	P	Probability of being an extra zero
Intercept	2.13	< 0.001	8.45	−0.19	0.82	0.83
Mother of Italian nationality	1.70	0.023	1.54	14.58	0.99	0.00
Father of Italian nationality	−2.83	0.001	0.50	−15.33	0.99	0.00
Mother of high education level	−0.36	0.032	5.91	−0.37	0.34	0.57
Father of high education level	−0.35	0.049	5.98	1.02	0.001	0.30

The present study did not investigate the role of dental services in decreasing caries levels of 12-year-olds; nevertheless, previous studies stated that it plays a minor role, as the main contributors are broad socioeconomic factors and the widespread use of products with added fluoride.[18,19]

Among Apulian 12-year-olds, the D component was dominant, as in all Italian geographical regions, indicating a need for better dental care and an insufficient control of oral disease.[10]

The contribution of sociodemographic variables to the DMFT index indicates that differences in prevention may occur among different groups of the population, owing to characteristics associated with this condition. We speculated that the higher the sociodemographic status of a family (i.e., a high educational level and non-immigrant status), the higher the probability of having access to preventive dental care. In particular, the high probability of scoring > 0, which was associated with a higher educational level of the father, indicates that a protective effect is observable among this group of children. The "zero-inflated model" only could explain this score, which is likely to be increasingly useful for epidemiological studies into dental caries.

In conclusion, the oral health situation of Apulian 12-year-old children seems to be in line with that in other Western-European countries, even though no school-based promotional or preventive programs have been established at a national level. Even though this result seems encouraging, efforts should be made to further improve oral-hygiene practices and reduce dental caries by setting up preventive programs, especially at the school level.

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