ORIGINAL ARTICLE

International Dental Journal 2011; 61: 144–151

doi: 10.1111/j.1875-595X.2011.00031.x

Dental caries prevalence and treatment needs of 5- to 12-year-old children in relation to area-based income and immigrant background in Greece

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Objectives: To investigate the association between certain socio-demographic characteristics and dental health status of 5- to 12-year-old children attending public kindergarten and primary schools in Piraeus, Greece. **Methods:** Gender, age, place of residence, immigrant background and area-based income were associated with dental caries prevalence, treatment needs and oral hygiene level in 5,116 children. **Results:** The mean number of decayed, missing and filled deciduous teeth (dmft) and Unmet Restorative Treatment Needs Index (UTN) at 6-year-olds were 1.54 and 84.6% respectively, and the DMFT and UTN at 12-year-olds were 1.35 and 71.8%. Caries experience/severity significantly increased with age, whereas treatment needs and oral hygiene level decreased ($P < 0.001$). Immigrant background and low area-based income was associated with poorer oral health outcomes. The above associations retained statistical significance after multivariate analysis. Children who live in areas with lower average income present 1.20 to 2.14 greater risk of having higher caries severity and poorer oral hygiene in comparison to those living in more affluent areas, and children with an immigrant background have 1.68 to 4.34 higher likelihood to present higher dmft and DMFT values, higher unmet treatment needs, and poorer oral hygiene levels compared to their Greek counterparts above and beyond the effect of the other risk factors assessed. **Conclusions:** The present study revealed a socio-demographic gradient in oral health status and treatment needs of children in Piraeus, Greece.

Key words: *Cross-sectional study*, *dental caries*, *area-based income*, *immigrant background*, *children*, *multivariate analysis*, *Greece*

Despite the fact that a significant decline in children's dental caries has occurred in developed countries in recent decades, this disease remains the most common in childhood. The main causes of dental caries are greatly determined by behavioural factors, while various socioeconomic factors affect oral health status and behaviour of the individuals. The above suggest that dental caries encompasses an interplay of biological, behavioural, socioeconomic and cultural factors[1–3].

It has been acknowledged that family influences children's health both directly and indirectly. On one hand, children are dependent on their parents' concern in order to acquire positive oral health behaviour and have access to regular dental care. On the other, it is the social environment that may or may not support families to have access to oral health promotion strategies and dental care facilities. Moreover, parents with low income, low education, different cultural backgrounds as well as those living in rural areas present with poor oral health and oral health habits and this can be reflected on their children's oral health[3–6]. Recent studies from different countries have shown social disparities in child oral health which are related to socioeconomic background and ethnicity. According to the U.S. Surgeon General's report[7], the social impact of oral diseases in children is substantial; dental caries is a severe problem among low income minority children and is related to limited access to dental care. In Denmark, Sundby and Petersen[8], and Christensen *et al.*[9], found major inequalities in dental health between children with Danish and non-Danish family background. In Glasgow, Conway *et al.*[10] found significant differences in dental caries levels in ethnic minority children and those from deprived backgrounds compared to their white and affluent peers. Armfield[11], found pervasive social inequalities in child oral health in Australia. In the Netherlands, Jerkovic *et al.*[12] found that the high prevalence of dental caries in children from low socio-economic status (SES) schools is associated with oral health behaviour and eating habits.

In Norway, Wigen and Wang[6], found that young children of parental immigrant and low education background are at great risk of caries. In Italy, Ferro *et al.*[13,14] found that being an immigrant is a strong determinant of caries occurrence in children.

In Greece, the most recent cross-sectional national oral health survey conducted in 2005[15] revealed that the prevalence of dental caries in children has declined since the previous national pathfinder survey[16], while the number of caries free subjects has increased, following, in some respect, the epidemiologic pattern of other developed countries. Improved child oral health may be attributed to the overall lifestyle changes that lead to the adoption of better oral hygiene and nutrition habits as well as to the effective use of fluorides; yet, oral health disparities between the different socioeconomic backgrounds in urban areas as well as between urban and rural areas, still exist in children. The information concerning socio-economic status refers mainly to parental educational level and/or occupational status. Data regarding the income, an enabling factor for dental utilisation, are very limited and they are based solely on self-reports[17,18], while no information is available regarding the part played by family income as a discrete area-based measure in socioeconomic disparities in child oral health. In addition, ethnic origin, a factor of consideration when examining inequalities in oral health, is not a routinely collected category in Greek oral health surveys and there is a shortage of this kind of data[19].

The purpose of this study was to examine the levels of dental caries, the dental treatment needs and the oral hygiene level of 5–12-year-old children attending public kindergarten and primary schools in the Prefecture of Piraeus (Attica region) – Greece, and to improve our understanding on the influence of certain socio-demographic characteristics such as age, gender, area of residence (urban/semi-urban), area-based income levels as well as immigrant origin, on their dental health.

MATERIALS AND METHODS

This cross-sectional study was carried out from October to May, for two consecutive years (2006/2007) as a part of the implementation of an Oral Health Promoting Program organised by the Prefecture of Piraeus, for children attending public kindergarten and primary schools. The Regional Authority of the Ministry of Education, Department of Primary Education gave legal approval for the protocol of the programme.

The Prefecture of Piraeus is an administrative division of the Region of Attica, Greece, with a population of approximately 541,504 individuals, according to the last Population Census of the National Statistical Services of Greece (2001). The capital city of Piraeus and six adjacent municipalities are inhabited by 91% of the total population; ten smaller municipalities consist of some semi-urban and a few rural settlements that are inhabited by 6% and 3% of the population, respectively.

Eighteen kindergartens and 45 primary schools were randomly selected (using a random numbers generator) from the total list of the schools, stratified by urban and semi-urban location and the registered children of the selected schools (7,774) comprised the study population. Head teachers of all the kindergartens and primary schools who were approached agreed to participate in the dental survey. Each child was given a form of consent to be completed by their parents of whom 5,674 children (72.99%) returned positive signed forms, 75 children (0.96%) returned refusals and 2,025 children (26.05%) did not return any forms at all. A total of 5,116 children 5–12 year-olds, who were present in the schools the assigned days of dental examination, formed the final study sample.

The children were examined in a fully equipped ambulant dental unit, under optimal lighting conditions, using a mouth mirror and a blunt dental probe. One of the authors (TG) and another calibrated dentist performed the oral examination and recorded dental caries using the diagnostic criteria set by WHO[20], and the simplified Debris Index (DI-s)[22]. Unmet Restorative Treatment Needs Index percentages were calculated for both dentitions [d/(d + f)]% and [D/(D + F)]%[21], while the oral hygiene level was categorised into good, moderate and poor oral hygiene level[23]. Intra and inter-examiner reproducibility of the caries diagnoses were assessed by the Kappa statistics and found to be 0.92 and 0.83 respectively.

The socio-demographic factors were assessed using individual and area-based data. Data concerning age and nationality of the children were obtained from the schools' archives. A child was recorded as having an immigrant background if his/her father or both parents were immigrants. Income data were obtained from the Ministry of Economy and Finance[24], based on the household's income statements of 2006 and were aggregated by postcode areas. The income level matches to the postcode area of each school's location.

Statistical analysis

Statistical analysis was carried out using SPSS, V16.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were generated for the prevalence of caries, dmft, DMFT, UTN and DI-s. Further statistical analysis was performed using non parametric methods. Rank correlation analysis (Spearman's rho) was used initially for the assessment of the inter-correlation between all variables, both socio-demographic factors (age, gender, ethnic background, residence area and area-based income), and oral health outcomes. In addition, in

order to assess the relative effect of socio-demographic factors, and to control for confounding effects, multivariate binary and ordinal logistic regression analysis was performed. Binary logistic regression was used for the assessment of caries prevalence (presence *vs.* absence) as dependent variable, whereas ordinal logistic regression was used for the assessment of caries severity (dmft cut points 0/1/3 and DMFT cut points 0/1/2), unmet treatment needs [d/(d + f)% cut points 0%/90%, and D/(D + F)% cut points 0%/89%], and oral hygiene level (DI-s cut points 0.34/1.5) as dependent variables. For the purpose of the statistical analysis, area-based income variable was grouped in quintiles (cut points €15,133/15,245/16,148/16,846), and age variable was grouped in four categories (5–6; 7–8; 9–10; 11–12 year-olds). The age group of 11–12 was not included in the regression on deciduous dentition, whereas the age group of 5–6 was not included in the regression on permanent dentition. The variables were entered with the same sequence in the model in order to control for confounding effects. The results of the full models were presented, even if some variables failed statistical significance, to enable the assessment of the consistency of the impact of each risk factor in oral health outcomes. Parameter estimates were tested with Wald statistic for *P*-level of 0.05, and odds ratios with 95% confidence interval were computed from the results. Nagelkerke's R^2 statistic was used to measure the strength of association between the dependent variable and the explanatory variables (interpreted as an approximate measure of the variance of the dependent variable explained by the model).

RESULTS

Table 1 presents the distribution of the sample by age, gender and ethnic background; 442 children attended kindergartens (5- and 6-year-olds) and 4,674 attended primary schools (7- to 12-year-olds). In all, 739 children (14.4%) had an immigrant background. The male/female ratio was approximately 1:1 (49.6% males and 50.4% females); 4,326 children (84.6%) lived in urban and 790 (15.4%) in semi-urban areas.

Table 1 Sample distribution by age, gender and ethnic background

Age (years)	*n*	Greeks (%)		Immigrants (%)		Total (%)
		Boys (*n* = 2,194)	Girls (*n* = 2,183)	Boys (*n* = 341)	Girls (*n* = 398)	(*n* = 5,116)
5	163	3.0	3.0	5.0	3.5	3.2
6	279	5.8	5.1	5.9	5.0	5.5
7	836	16.3	16.3	17.0	16.3	16.3
8	741	14.6	14.5	14.7	13.6	14.5
9	770	15.5	14.4	13.8	17.0	15.1
10	807	15.5	16.1	16.4	14.8	15.8
11	759	15.2	15.3	11.7	13.1	14.8
12	761	14.1	15.2	15.5	16.63	14.9

Table 2 presents the oral health outcomes according to age, gender, ethnic background, residence area and area-based income as well as the statistical significance of correlation between them. Six-year-olds had 36.2% caries experience, dmft of 1.54 and 84.6% untreated caries in deciduous teeth, and 12-year-olds had 47.2% caries experience, DMFT of 1.35 and 71.8% untreated caries in permanent teeth. The mean DI-s score was 0.75 overall. Caries experience and severity significantly increased with age in the permanent dentition ($P < 0.001$), whereas in deciduous dentition, the trend was inverse after the age of 10 years. Unmet treatment needs and oral hygiene level significantly decreased with age (higher DI-s score means lower level of hygiene) ($P < 0.001$). Girls had statistically significantly lower dmft values ($P < 0.05$), higher caries experience and DMFT values ($P < 0.001$), and better oral hygiene level ($P < 0.001$) in comparison with boys. Immigrant background was significantly negatively correlated with all the assessed oral health outcomes ($P < 0.001$). The differences in dmft and DMFT between Greek and immigrant children by age are illustrated in *Figures 1 and 2*. Children in semi-urban areas had higher treatment needs ($P < 0.05$) but they presented better oral hygiene level ($P < 0.001$). Concerning area-based income, the analysis showed significant negative correlation of income-level with all the assessed oral health outcomes, except of treatment needs in permanent teeth. Strong inter-correlation was observed between area-based income and degree of urbanisation ($r_S = 0.585$, $P < 0.001$), whereas weaker correlation was observed between ethnic background and area-based income ($r_S = 0.0.046$, $P < 0.01$), and between ethnic background and gender ($r_S = 0.028$, $P < 0.05$) (data not shown).

Table 3 presents odds ratios (OR) and 95% confidence intervals (CI) derived from multivariate binary logistic regression analysis with caries experience as dependent variable (results shown only for the full model). Higher age, immigrant background, and living in lower income areas was consistently associated with higher odds of caries prevalence, both in the deciduous and permanent dentitions with odds ratios ranging from 2.65 to 4.40 for the ethnic background, and from 1.34 to 1.72 for the income level. Gender preserved its predictive value on the caries experience in the permanent dentition, through the modelling, with girls having higher odds of caries experience than boys (OR = 1.31). The residence area revealed predictable value in the multivariate analysis, with children living in urban areas having higher odds of experiencing caries in the deciduous dentition (OR = 1.50). The full models accounted for approximately 0.121 and 0.167 of the variance of caries experience in deciduous and

Table 2 Oral health outcomes according to age, gender, ethnic background, residence area and area-based income, along with statistical significance of correlations between them (Spearman's rho, r_s)

Risk factors	Oral health outcomes						
	Deciduous dentition			Permanent dentition			
	Caries experience, *n* (%)	dmft, x ± SE (*n* = 4,658)	d/(d + f)%, x ± SE (*n* = 2,329)	Caries experience, *n* (%)	dmft, x ± SE (*n* = 4,775)	D/(D + F)%, x ± SE (*n* = 1,397)	DI-s, x ± SE (*n* = 5,116)
Age (years)	r_s = 0.069***	r_s = 0.020 NS	r_s = −0.102***	r_s = 0.315***	r_s = 0.327***	r_s = −0.088**	r_s = 0.066***
5	41 (25.2)	0.94 ± 0.18	92.0 ± 4.1	0 (0.0)	0.00 ± 0.00	Uncountable	0.33 ± 0.04
6	101 (36.2)	1.54 ± 0.18	84.6 ± 3.2	3 (2.0)	0.05 ± 0.03	100.0 ± 0.0	0.64 ± 0.04
7	378 (45.2)	1.92 ± 0.10	81.6 ± 1.8	68 (8.9)	0.16 ± 0.02	85.3 ± 4.1	0.68 ± 0.03
8	388 (52.4)	2.29 ± 0.11	77.1 ± 1.8	129 (17.5)	0.34 ± 0.03	74.0 ± 3.8	0.73 ± 0.03
9	456 (59.3)	2.44 ± 0.10	74.1 ± 1.7	217 (28.3)	0.59 ± 0.04	74.8 ± 2.8	0.84 ± 0.03
10	479 (61.6)	2.21 ± 0.09	75.4 ± 1.7	288 (35.7)	0.77 ± 0.04	79.7 ± 2.2	0.85 ± 0.03
11	322 (52.1)	1.48 ± 0.08	68.8 ± 2.3	336 (44.3)	1.04 ± 0.05	69.8 ± 2.3	0.79 ± 0.03
12	188 (39.6)	1.00 ± 0.07	73.1 ± 3.0	359 (47.2)	1.35 ± 0.68	71.8 ± 2.1	0.72 ± 0.03
Gender	r_s = 0.021 NS	r_s = 0.033*	r_s = −0.003 NS	r_s = −0.061***	r_s = −0.067***	r_s = 0.040 NS	r_s = 0.071***
Boys	1,209 (51.6)	2.00 ± 0.05	75.7 ± 1.1	624 (26.5)	0.59 ± 0.02	76.2 ± 1.6	0.80 ± 0.02
Girls	1,144 (49.4)	1.81 ± 0.05	76.4 ± 1.1	776 (32.0)	0.78 ± 0.03	72.8 ± 1.5	0.69 ± 0.02
Ethnic background	r_s = −0.200***	r_s = −0.249***	r_s = −0.161***	r_s = −0.148***	r_s = −0.153***	r_s = −0.108***	r_s = −0.102***
Greeks	1,861 (46.5)	1.61 ± (0.04)	72.8 ± 0.9	1,084 (26.5)	0.61 ± 0.02	71.8 ± 1.3	0.72 ± 0.01
Immigrants	492 (75.2)	3.68 ± (0.13)	88.5 ± 1.2	316 (45.7)	1.14 ± 0.06	83.0 ± 1.9	0.94 ± 0.03
Residence area	r_s = −0.015 NS	r_s = −0.012 NS	r_s = 0.046*	r_s = 0.023 NS	r_s = 0.027 NS	r_s = 0.035 NS	r_s = −0.062***
Semi-urban	360 (48.8)	1.85 ± 0.09	79.6 ± 1.9	233 (31.8)	0.78 ± 0.05	77.9 ± 2.5	0.65 ± 0.03
Urban	1,993 (50.8)	1.91 ± 0.04	75.4 ± 0.8	1,167 (28.9)	0.67 ± 0.02	73.6 ± 1.2	0.76 ± 0.01
Area-based income	r_s = −0.034*	r_s = −0.030*	r_s = −0.061**	r_s = −0.064***	r_s = −0.066***	r_s = −0.007 NS	r_s = −0.027*
Low 1	723 (52.1)	1.94 ± 0.07	78.8 ± 1.3	448 (31.1)	0.74 ± 0.04	76.1 ± 1.9	0.77 ± 0.02
Low 2	287 (55.6)	2.18 ± 0.12	79.0 ± 2.1	209 (40.2)	1.02 ± 0.07	72.2 ± 2.9	0.84 ± 0.04
Low 3	488 (48.2)	1.78 ± 0.08	72.3 ± 1.8	290 (27.4)	0.60 ± 0.04	68.7 ± 2.6	0.69 ± 0.03
Low 4	449 (50.6)	1.92 ± 0.09	79.2 ± 1.8	234 (27.3)	0.65 ± 0.04	82.0 ± 2.3	0.85 ± 0.03
High 5	406 (47.5)	1.82 ± 0.09	70.1 ± 2.0	219 (24.4)	0.53 ± 0.04	72.2 ± 2.8	0.64 ± 0.02
Total	4,658 (50.5)	1.90 ± 0.04	76.1 ± 0.78	4,775 (29.3)	0.69 ± 0.02	74.3 ± 1.08	0.75 ± 0.01

*P < 0.05, **P < 0.01, ***P < 0.001.

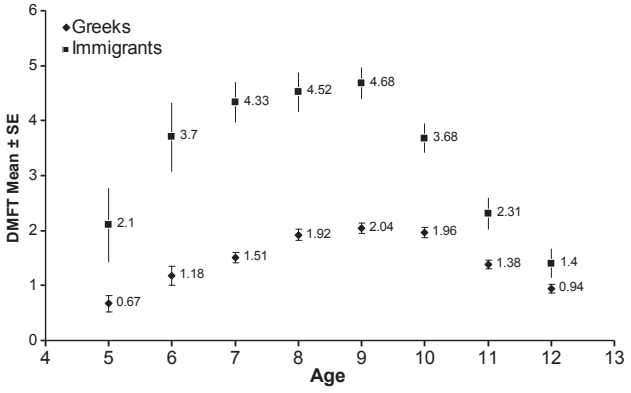

Figure 1. Mean dmft by age comparing Greek and immigrant children.

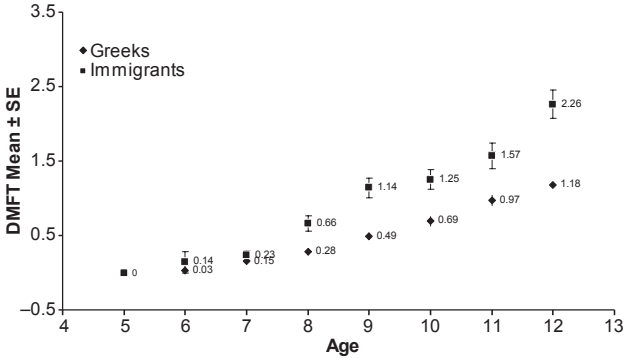

Figure 2. Mean DMFT by age comparing Greek and immigrant children.

permanent dentition, respectively, according to the Nagerlerke's R^2 value.

The results of the multivariate ordinal logistic regression analysis with dmft, DMFT, [d/(d + f)]%, [D/(D + F)%], and DI-s as dependent variables are presented in *Table 4*. Through the modelling process age, gender, ethnic background and area-based income retained independent significant predictive values in the same direction to that observed in the bivariate analysis, whereas residence area did not show a stable association. Children with an immigrant background had a higher likelihood of presenting higher dmft and DMFT values, higher unmet treatment needs, and poorer oral hygiene levels compare to Greek children. The estimates (OR) for the effect of an immigrant background became stronger with the consecutive introduction of the independent variables, especially with the introduction of income (for example OR for the effect on dmft raises from 4.05 in the reduced to 4.34 in the full model). Gender maintained its ambivalent effect on the assessed oral health outcomes, after adjustment for all the other risk factors. Girls had higher odds of scoring higher DMFT (OR = 1.33),

Table 3 Odds ratios (OR) and 95% confidence intervals (CI) derived from multivariate binary logistic regression analysis with caries experience (presence *vs.* absence) as dependent variable

Independent variables	Caries experience Deciduous dentition, OR (95% CI)	*P*	Caries experience Permanent dentition, OR (95% CI)	*P*
Age (years)				
5–6	0.28 (0.22–0.36)	<0.001	–‡	
7–8	0.61 (0.52–0.70)	<0.001	0.17 (0.14–0.21)	<0.001
9–10	1.0*		0.55 (0.47–0.64)	<0.001
11–12	–†		1.0*	
Gender				
Girls	0.91 (0.79–1.04)	NS	1.31 (1.14–1.49)	<0.001
Boys	1.0*		1.0*	
Ethnic background				
Immigrants	4.40 (3.51–5.52)	<0.001	2.65 (2.21–3.18)	<0.001
Greek	1.0*		1.0*	
Residence area				
Urban	1.50 (1.16–1.94)	<0.01	0.89 (0.70–1.13)	NS
Semi-urban	1.0*		1.0*	
Area-based income				
Low 1	1.72 (1.34–2.20)	<0.001	1.34 (1.06–1.69)	<0.01
Low 2	1.25 (0.75–1.64)	NS	2.07 (1.61–2.66)	<0.001
Low 3	1.14 (0.95–1.41)	NS	1.21 (0.97–1.50)	<0.10
Low 4	1.23 (0.99–1.55)	NS	1.21 (0.96–1.52)	NS
High 5	1.0*		1.0*	
Nagelkerke R^2	0.121		0.167	

*Reference category.
†Age group 11–12 not included in the analysis.
‡Age group 5–6 not included in the analysis.

lower dmft (OR = 0.87) and lower DI-s values (OR = 0.77) in comparison with boys, while no association of gender was observed concerning the unmet treatment needs. The degree of urbanisation preserved a negative association with oral hygiene level (OR = 1.66) through the modelling, and though it revealed a positive association with experience and severity of deciduous caries (OR = 1.50 and 1.37 respectively), lost the association with treatment needs, when income variable was introduced in the model. Area-based income preserved statistical significance on all oral health outcomes, except of treatment needs in the permanent dentition. The strength of the association (OR) increased through the consecutive adjustment for the other risk factors, especially with the introduction of immigrant background variable in the model. Living in areas with lower income significantly increased the odds of having higher caries severity in both deciduous and permanent teeth, poorer oral hygiene and higher treatment needs in deciduous teeth, in comparison to those living in the more affluent areas (OR ranging from 1.20 to 2.14), above and beyond all the other assessed factors.

DISCUSSION

It is important to determine whether the socio-economic level of the area where a child lives affects its oral health and is differentiated by demographic characteristics such as age, gender and ethnic background. The results of this study revealed that the neighbourhood, as well as the individual-level social gradient affect caries experience, severity and treatment needs of children living in Piraeus.

Caries prevalence and severity outcomes of the present study agree with the results obtained from the national Greek oral health survey[15] regarding the comparable age group (Greek kindergarten children living in Athens); caries experience, mean dmft values of Greek kindergarten children living in Athens was found 32.5%, 1.22 respectively, while the corresponding findings in the present study (Greek kindergartens, who live in urban areas) were 33.0%, 1.18 respectively. Nevertheless, our results, regarding mixed population are lower (dmft = 1.54, UTN = 84.6%) compared to those found in a previous study conducted in kindergarten children of mixed ethnical background in Athens and Piraeus (dmft = 2.6, UTN = 92%)[19]. These differences can be attributed to the greater percentage of immigrants in the previous study (up to 40%) compared to that in the present study (14.4%).

Comparing the values of caries prevalence and severity indices in the present study with the corresponding values obtained from similar population groups in other countries, it was found to be about the same in children living in central Italy[13,25], in Spain[26,27], in England[28] – for caries in deciduous teeth, in the Netherlands[12], in Germany[29], and in Australia – Queensland[5]. However, the results of the present study are lower than those obtained from similar population groups of Scottish[10,28], Polish[30], Brazilian[31,32], and Jordanian[33] children but higher compared with children

Table 4 Odds ratios (OR) and 95% confidence intervals (CI) derived from multivariate ordinal logistic regression analysis with dependent variables: dmft, d/(d + f)%, DMFT, D/(D + F)%, and DI-s

Independent variables	dmft, OR (95% CI)	*P*	d/(d + f) %, OR (95% CI)	*P*	DMFT, OR (95% CI)	*P*	D/(D + F)% OR (95% CI)	*P*	DI-s, OR (95% CI)	*P*
Age (years)										
5–6	0.31 (0.25–0.39)	<0.001	2.34 (1.51–3.63)	<0.001	–		–		0.57 (0.46–0.70)	<0.01
7–8	0.70 (0.61–0.80)	<0.001	1.32 (1.08–1.62)	<0.001	0.16 (0.14–0.20)	<0.001	1.70 (1.19–2.43)	<0.01	0.95 (0.84–1.09)	
9–10	1.0*		1.0*		0.52 (0.45–0.60)	<0.001	1.45 (1.14–1.86)	<0.01	1.27 (1.113–1.45)	<0.001
11–12	–		–		1.0*		1.0*		1.0*	
Gender										
Girls	0.87 (0.77–0.98)	<0.05	0.99(0.81–1.20)	NS	1.33 (1.17–1.52)	<0.001	0.84 (0.67–1.05)	NS	0.77 (0.69–0.85)	<0.001
Boys	1.0*		1.0*		1.0*		1.0*		1.0*	
Ethnic background										
Immigrants	4.34 (3.63–5.21)	<0.001	2.44 (1.86–3.18)	<0.001	2.63 (2.22–3.11)	<0.001	1.68 (1.26–2.25)	<0.001	1.72 (1.48–1.99)	<0.001
Greek	1.0*		1.0*		1.0*		1.0*		1.0*	
Residence area										
Urban	1.37 (1.09–1.73)	<0.01	0.95 (0.66–1.35)	NS	0.85 (0.67–1.06)	NS	0.86 (0.57–1.28)	NS	1.66 (1.37–2.01)	<0.001
Semi-urban	1.0*		1.0*		1.0*		1.0*		1.0*	
Area-based income										
Low 1	1.52 (1.22–1.90)	<0.001	1.60 (1.15–2.22)	<0.001	1.32 (1.05–1.66)	<0.01	1.26 (0.84–1.84)	NS	1.76 (1.47–2.12)	<0.001
Low 2	1.30 (1.02–1.66)	<0.05	1.26 (0.87–1.83)	NS	2.14 (1.69–2.72)	<0.001	1.05 (0.71–1.59)	NS	1.59 (1.30–1.94)	<0.001
Low 3	1.13 (0.93–1.38)	NS	1.11 (0.82–1.49)	NS	1.20 (0.97–1.48)	<0.10	0.95 (0.66–1.36)	NS	1.12 (0.95–1.32)	NS
Low 4	1.15 (0.93–1.41)	NS	1.43 (1.04–1.96)	<0.001	1.23 (0.99–1.54)	<0.10	1.66 (1.10–2.49)	<0.05	1.67 (1.40–1.98)	<0.001
High 5	1.0*		1.0*		1.0*		1.0*		1.0*	
Nagelkerke R^2	0.114		0.055		0.151		0.038		0.045	

*Reference category.

living in Tennessee, USA[34], in the UK[35] – for caries in permanent teeth, and in Norway[6].

The percentage of untreated caries in Greek children in the present study is extremely high in both dentitions (76.1% and 74.3%). The increased dental treatment needs found in the present study may be attributed to the Greek oral health care system which is primarily delivered by the private sector, and in combination with the high cost of dental treatment and the extremely low public sector dental expenditure, has significant implications in the use of dental services[36]. Similar percentages of untreated caries are usually found in developing countries[31,32,37], or in certain regions within developed countries associated mainly with geographic, economic and cultural barriers to dental care[38–40]. Nevertheless, in some European countries high levels of untreated caries have been also reported[26,28].

Ageing is associated with higher odds of poor oral hygiene and with higher caries experience and severity in both dentitions. It is also associated with lower percentages of treatment needs. The latter finding may reflect delayed caries detection, or delayed treatment demand, as a consequence of urgent treatment needs demand rather, than regular attendance to the dentist.

Concerning the gender factor, boys had poorer oral hygiene levels, lower dmft and higher DMFT values in comparison to girls. The odds ratios for the effect of gender are more robust in the permanent dentition (OR = 0.76, $P < 0.001$), than in deciduous dentition (OR = 1.15, $P < 0.01$). The above findings were expected since girls have 2–10 months earlier onset of eruption of the permanent dentition than boys[41,42] and usually they exhibit better oral hygiene levels and report more frequent and regular tooth brushing than boys[43].

The investigation of the impact of place of residence on children's dental health revealed that children living in urban areas have 1.37 to 1.66 the odds of those living in semi-urban areas to have poorer oral hygiene, to experience deciduous caries and to score higher dmft. These differences may be interpreted by the particular characteristics of the semi-urban population of the Prefecture of Piraeus, who live in the islands surrounding the mainland city, which is a type of suburban settlement, with touristic/commercial rather than rural/agricultural economic orientation. Children living in these areas, with lower population density and better quality of life compared to the city centre, may be less affected by unhealthy behavioural patterns related to contemporary lifestyle.

The ethnic background of the children was the most strongly affecting risk factor for all the oral health variables assessed in the present study. Our results revealed that children from a disadvantaged social background, such as those whose parents are immigrants, have higher caries rates and more unmet treatment needs than their Greek counterparts. After

adjustment for the effect of all other assessed risk factors, children with an immigrant background still have more than four times the odds of Greek children of experiencing caries and for scoring higher dmft, and about 2.5 times the odds of Greek of experiencing caries and scoring high DMFT (*Figures 1 and 2*). They also have 1.7 to 2.3 times the odds of Greek children of having higher treatment needs and poorer oral hygiene. Our findings are in accordance with those obtained from studies of other countries confirming that oral health problems are more prevalent in children with an immigrant background[4,6–10,14].

In the present study, the effect of income on children's oral health was assessed using aggregated data measured at a relatively small area level (neighbourhood). It has been argued that the correlation between health outcomes and aggregated income measures is statistical artefact[44]. Nevertheless, other researchers[45] suggested that the association between population-level income inequality and health outcomes is considerably stronger over and above anything that could be accounted for by statistical artifact. In addition, Hanley and Morgan[46], exploring the validity of area-based income measures to proxy household income, found that the use of the two alternatives in multivariate analysis does not have a significant effect on the other coefficients in the model. On the other hand, the use of self-reported information to proxy socio-economic status introduces a significant amount of response bias, particularly among lower socio-economic groups, that could mask the income gradient of the oral health outcomes[47]. The results of this study revealed that area-based income is a consistent independent predictor of all oral health outcomes, except of the treatment needs in permanent dentition. Moreover, the predictive value of the income not only persists, but also increases after adjustment for confounders. These findings show that children living in wealthier areas have 1.2 to 2.1 higher odds to have better oral health in comparison with those living in poorer areas, above and beyond any difference that could be attributed to the effect of age, gender, ethnic background and area of residence. These findings are in accordance with similar findings from studies conducted in various countries; however, the regression estimates found are hardly comparable with ours due to methodological differences between the studies[11,33,34,48–50].

CONCLUSIONS

The results of the present study revealed a socio-demographic gradient in dental health status of children in Piraeus. Children who live in areas with lower income present significantly greater risk of having higher caries levels and poorer oral hygiene compared to those living in more affluent areas. Moreover, children with an immigrant background have a higher likelihood of presenting with poorer dental health compared to their Greek peers. Oral health promotion strategies and preventive programmes should consider these differentiations in order to improve efficacy and effectiveness.

Acknowledgements

We would like to thank the Administrative Authorities of the Prefecture of Piraeus, for providing continuous support to the Oral Health Promoting Program, as well as Ms Karadimou Dimitra, DDS, for her helpful assistance in the field.

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