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# Socio-demographic and area-related factors associated with the prevalence of caries among preschool children in Greece.

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***Objective***: To assess dental caries experience in 4-6 year old children of the Athens Metropolitan Area attending public kindergartens and investigate the association of area deprivation and immigration status on dmft. ***Basic research design***: A cross-sectional study of a large area-stratified sample of 683 kindergarten children was conducted during the academic years 2009-2011. Dental caries experience and oral hygiene level were assessed using dmft and the Simplified Debris index (DI-s). Area deprivation was defined using a pre-established Geo-demographic System for Attica. Zero-inflated Poisson regression models were used to test associations between the dmft index and related factors; gender, age, immigrant background and area deprivation. Differences were reported in terms of predicted probabilities. ***Results***: Caries prevalence was 20.8% (95% CI17.8,24.0%). The mean dmft and DI-s scores were 0.67 (95% CI0.61,0.74) and 0.16 (95% CI0.14,0.18) respectively. The mean predicted probability of having no detectable caries experience was 79% (95% CI75, 83%), while the probability of having dmft=1 or 2 was 6% (95% CI5,8%) and 2% (95% CI1,3%) respectively. The predicted probability of having no caries experience was substantially lower for males, those from the least affluent areas and non-Greeks by 5%, 18% and 31% respectively. Regarding dmft scores, deprived children were more likely to have 1 or 2 teeth with caries experience by 9% (95% CI4,13%) and 6% (95% CI2,10%) respectively, while the corresponding differences for non-Greeks were 10% (95% CI7,14%) and 12% (95% CI7,15%). ***Conclusions*:** Socio-demographic and area-related variations in oral health exist among kindergarten children in Athens.

**Key words:** *socio demographic factors, prevalence of dental caries, pre-school children, Greece*

## Introduction

Several studies have documented the association between socioeconomic disparities with the oral health of young children; area and ethnic characteristics are considered important determinants of oral health (Petersen *et al*., 2005). Disease distribution and health outcomes are greatly affected by the places where people live and there is clear evidence that there is a strong association between health and area of residence (Tunstall *et al*., 2004). On the other hand, immigrant status has a marked relationship to dental caries among preschool populations where children with an immigrant background have greater experience of the disease (Ferro *et al*., 2010; Gatou *et al*., 2011; Pine *et al.,* 2003; Wigen and Wang, 2010).

In Greece, like most European countries, an influx of economic migrants has occurred over the last three decades. According to the 2001 Greek census, the majority of documented migrants in Greece are Albanian (63.7%), followed by migrants from the Balkans, Eastern Europe and some Asian and African countries (HSA, 2001). Although several Greek epidemiological studies have investigated the association of dental caries with socio-economic factors in various native populations, the scientific evidence regarding more ethnically diverse groups of preschool children is limited (Boka *et al*., 2013; Gatou *et al*., 2011; Kalyvas *et al*., 2006). Moreover, there are no epidemiological data on the association of area deprivation with the oral health of young children living in Greece.

The purpose of this study was to examine dental caries prevalence in preschool children attending public kindergartens in the Athens metropolitan area and to investigate the impact of area deprivation and immigration status on the dmft score.

## Method

This study uses data collected between 2009 and 2011 during a larger cross-sectional investigation into the effects of socioeconomic factors and deprivation on the oral health and dental service use by preschool children in Attica, Greece. For that survey, a random cluster sample of 4-6-year old children was selected from public kindergartens (84% of all the area's kindergartens) in Attica (Athens and surrounding districts)**.** Kindergarten attendance in Greece is compulsory only for 5-year-olds, according to their year of birth. A sample size of about 600 children was required to assess the associations proposed for a significance level of 0.05, a power of 0.80 and correction of continuity. That power analysis was based on the results of a previous study of Attica children (Oulis *et al.,* 2012), assuming a difference of 0.75 in dmft means between deprived and non-deprived children. For the selection of the kindergartens, the 120 municipalities of the Attica prefecture were stratified into three area-based income clusters representative of the national socioeconomic structure according to mean annual family income (GSIS,

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2007). Targeting the estimated sample size, and following the regional socio-economic pattern, 13 municipalities were randomly selected and 35 public kindergartens chosen (using a random number generator) without replacement from the complete list of kindergartens in the selected municipalities. The Ethical Committee of the University of Athens Dental School and the Ministry of Education approved the study. The heads of the selected kindergartens were informed by mail and agreed to participate. All the children in selected kindergartens were included and information letters and consent forms were distributed through the teachers to the parents. Dental visits were pre-arranged and the parents forewarned. Information on age and national origin of the children were obtained from schools' records. A child was recorded as non-Greek or immigrant if his/her father was born in Southeastern or Eastern Europe, Asia or Africa (HSA, 2001).

The children were examined in their school settings, according to the standard method described by the World Health Organization (WHO, 1997) for oral health surveys. Dental examinations were performed by one dentist (MM) using a mouth mirror, the WHO periodontal probe (for confirmation of diagnosis in doubtful tooth areas) and a lightweight portable examination light (Daray lamp). Oral hygiene level was recorded first using the Simplified Debris Index (DI-s, Greene and Vermillion, 1964). The teeth were then cleaned or dried using cotton rolls. Dental caries experience was assessed using the WHO criteria and summarized as decayed, missing and filled teeth (dmft index). Dental caries was diagnosed at the cavitation level (d3) threshold using a visual method. Treatment needs were assessed by the UTN index (Walsh, 1970: number of decayed teeth ÷ number of obviously decayed, missing and filled teeth × 100%). The examiner was trained using written instructions and slides and calibrated on patients by a gold standard examiner. Intra-examiner reproducibility for dental caries at the child level after re-examination of 5% of the sample one month later was 0.94 (Kappa statistic).

Area deprivation was defined using the segmentation analysis Geo-demographic System of Attica (GSA), developed by Geoinformation SA. This descriptive classification system that divides the prefecture of Attica into 12 categories based on 52 demographic, economic and lifestyle variables derived from the Hellenic Statistical Authority and MRB SA. The final categories were defined using GIS technology and Fuzzy clustering techniques. The spatial unit of the variables uses postal codes, 285 in the study area (Grekousis and Hatzichristos, 2012). The children of the present study were classified into six of the GSA categories using their school postcodes (Table 1).

Statistical analysis was carried out using STATA v.12 (StataCorp LP, TX, USA). Descriptive statistics and frequency distributions were provided. For the study of associations, multivariate regression analysis was performed between the outcome variable (dmft values) and predictors (gender, ethnicity and area deprivation). Age and dental plaque accumulation (DI-s index) were also considered. As dmft score distribution was heavily skewed with many zero counts, a zero-inflated Poisson (ZIP) regression model was performed (Gilthorpe *et al*., 2009; Lewsey and Thomson, 2004; Long and Freese, 2006). The ZIP regression model is a generalized linear model (GLM) for non-negative dependent variables and consists of two separate models: a logit (binary) model for the 'excess zero' cases predicting whether a child is at risk of dental caries (always/certain zero dmft) and a Poisson model estimating the counts (expected dmft values) for those children who are susceptible to the disease (not certain zeros). These two processes are then combined into a final regression model of main effects (predictive effect of each variable when the rest of the variables in the model were held constant at their means). Likelihood-ratio (LR) and Vuong tests were used to evaluate the relative fits of the ZIP model over other GLM models and the standard Poisson having the specified predictors and Wald test ascertained the overall fit of the predictors (Long and Freese, 2006). Adjusted standard errors for clusters by school (cluster standard errors) were obtained to control intraclass-correlation [correlation of observations (cases) within the same school]. The interpretation of regression outcomes (for no detectable caries experience and for having 1-2 carious teeth) was based on mean predicted probabilities obtained by post-estimation techniques with the results presented in probability functions graphs (Long and Freese, 2001). For this reason, the tables with the full regression analysis results were not included, but data are presented as Odds Ratios (OR) for the logit model of the ZIP regression and Incidence Rate Ratios (IRR) for the Poisson model. An alpha level of 0.05 and 95% confidence intervals (CI) indicated statistical significance.

**Table 1.** Sample distribution (%) in the Geodemographic Categories of Attica

| *Category* | | *Summary description* | *%* |
|---|---|---|---|
| 1 | Striving | Craftsmen, machine operators, typically with many children | 7.9 |
| 2 | Blue collars | Low income, small industries, unskilled workers | 12.6 |
| 3 | Middle class | Moderate income and education | 11.7 |
| 4 | White collared | Moderate income, living in central of Athens | 11.8 |
| 5 | Urban prosperity | Higher income executives or employees | 40.4 |
| 6 | Affluent achievers | High education and income, comfortable residencies | 15.6 |

## Results

Some 744 parents (58%) agreed to participate in the study and data were obtained for 683 children who presented for the dental examination. The sample consisted of 340 boys (49.8%) and 343 girls (50.2%), with a mean age of 5.1 years (SD 0.5, range 4-6). Most children were of Greek origin. Of the 78 (11.4%) with an immigrant background, 66.7% were of Albanian origin while the rest were from East European countries, Middle East and India. Most children belonged to the urban prosperity group and affluent achievers, while 20% were from the most deprived categories (blue collar and striving).

The prevalence of dental caries (having at least one tooth affected) was 20.8% (95% CI17.8%, 24.0%), while the prevalence for having three or more carious teeth was 9.8%. More than half of the non-Greek and over a third of the deprived children were affected. Caries prevalence was higher in non-Greeks, deprived children (striving and blue collars categories) and boys by 34.4 % and 23.9%, 3.7% in comparison to Greeks, affluent children and girls (Table 2). Among the children with caries, 80.3% had untreated caries and in 31% had filled teeth. No missing teeth were observed.

**Table 2.** Dental caries experience (dmft>0) of children, demographic characteristics and area deprivation

| | | *Caries experience* | |
|---|---|---|---|
| | | *%* | *95%CI* |
| Gender | Boys | 22.7 | 18.3-27.5 |
| | Girls | 19.0 | 14.9-23.5 |
| Age | 4-5 years | 18.4 | 12.5-25.6 |
| | 5-6 years | 21.5 | 18.1-25.2 |
| Ethnicity | Greeks | 16.9 | 14.0-20.0 |
| | Non- Greeks | 51.3 | 39.7-62.8 |
| Area deprivation (GSA categories) | Striving | 38.9 | 25.9-53.1 |
| | Blue collars | 30.6 | 21.1-41.5 |
| | Medium class | 18.6 | 10.9-29.0 |
| | White collars | 19.6 | 11.7-30.1 |
| | Urban class | 17.4 | 13.1-22.4 |
| | Affluent | 15.0 | 8.8-23.1 |
| Overall | | 20.8 | 17.8-24.0 |

The UTN Index was 74.1% (95% CI72.7%, 7 5.6%), following the socioeconomic gradation of the sample. Mean DI-s score was 0.16 (95% CI0.14,0.18) and IQR was 0.2 (data not shown). Most children had good oral hygiene levels (DI-s scores 0.0-0.6) and only 8.2% showed poor oral hygiene (DI-s scores 1.9-3.0).

The number of teeth affected by carues varied between 0 and 16 showing a heavily skewed distribution with a mean dmft of 0.67 (95% CI0.61, 0.74) and a zero IQR. Stratified analysis revealed that caries had ethnic, socio-economic and demographic characteristics: mean dmft for Non-Greeks was 2.13 (95% CI1.82, 2.48), for the least affluent backgrounds was 1.56 (95% CI1.24, 1.93) and for males 0.70 (95% CI0.61, 0.79). Accordingly, dmft IQRs for the above groups were 3, 2 and 0 respectively.

The association of area deprivation, ethnicity and demographic factors with dmft index was investigated in multivariate form using a ZIP regression model. No detectable caries experience was associated with living in affluent rather than deprived areas (OR=1.23, $p<0.05$), being female (OR=1.40, $p<0.05$) and non-Greek (OR=2.50, $p<0.001$). Only immigrant status was significantly related to higher dmft scores (IRR=1.36, $p<0,05$). The overall effect of area deprivation on caries severity was not statistically significant, but when the variable was separated into the six deprivation categories, statistically significant differences in dmft scores were found for categories 5 (IRR=0.67, $p<0.05$) and 6 (IRR= 0.49, $p<0.001$) in comparison to the reference group (striving) over and above all the other factors.

For the interpretation of zip regression outcomes mean predicted probabilities were calculated for the children: with no detectable caries experience (dmft=0) and with 1-2 carious teeth (dmft=1, dmft=2). The main results are presented in the following three figures.

Figure 1 represents the mean predicted probability and confidence intervals of having no detectable caries (dmft=0) in the whole sample in relation to the GSA categories, when all the other factors held fixed in their means and DI-s in the IQR. The mean predicted probability varied from 66% in the striving category to 89% in the affluent achievers category, with a mean value of 79% (95%CI 75%,83%). The probability increased from the deprived areas on the left to the affluent ones on the right. The difference between the most and least deprived areas was 18%.

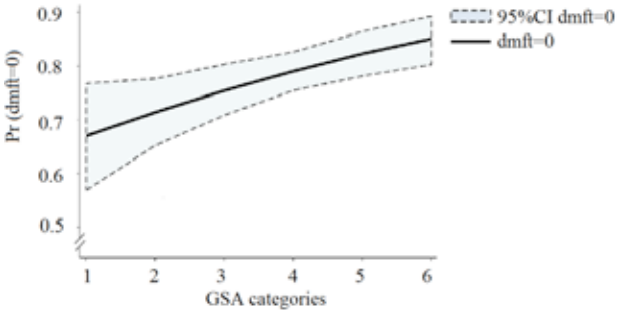
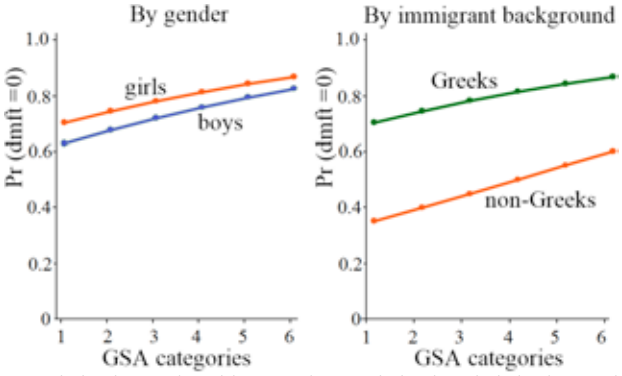



**Figure 1.** *Mean Predicted Probabilities and Confidence Intervals for no detectable caries (dmft=0) according to area deprivation (GSA categories) in the whole sample when age, gender and immigrant background were held at their means and DI-s at IQR*
*Note the vertical axis does not start at zero*

The influence of gender is illustrated in Figure 2. The mean predicted probabilities for boys varied between 63% (95% CI51%, 74%) in the striving category and 82% (95% CI77%, 89%) in the affluent achievers. The respective probabilities for girls were 71% (95% CI60%, 80%) and 87% (95% CI82%, 91%). The overall mean difference in the probabilities between genders was 5%, with girls more likely to be caries free.



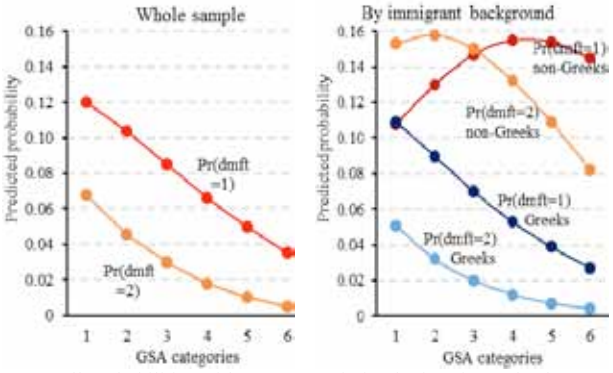

Variation by gender with age and immigrant background held at their means, DI-s at IQR

Variation by ethnic background with age and gender held at their means and DI-s at IQR

**Figure 2.** *Mean Predicted Probabilities for no detectable caries (dmft=0) by gender and immigrant background according to area deprivation (GSA categories)*

Figure 2 illustrates the more pronounced difference between Greek and immigrant children. Overall, immigrant children had a 31% lower probability of no detectable caries experience than Greeks, a difference that remained constant across all deprivation categories. More specifically, the mean predicted probabilities for the immigrants varied between 35% (95% CI22%, 49%) in the striving category and 60% (95% CI45, 72%) among affluent achievers, while the respective probabilities for Greeks were 71% (95% CI60%, 80%) and 87% (95% CI83%, 91%).

Figure 3 presents the predicted probabilities for having one or two teeth affected by dental caries according to area deprivation (GSA categories) in the whole sample and by immigrant status. The overall mean predicted probabilities were 6% (95% CI5%, 8%) for one tooth affected and 2% (95% CI1%, 3%) for 2 teeth. The probability decreased with increasing affluence, and differences across the whole scale were 9% in the first case and 6% in the second case.




Overall probabilities with age, gender and immigrant background held at their means, DI-s at IQR

Variation by immigrant background with age and gender held at their means and DI-s at IQR

**Figure 3.** *Mean Predicted Probabilities for dmft=1 and dmft=2 in the whole sample and by immigrant background according to area deprivation (GSA categories)*

Immigrant status was strongly associated with dmft score with the mean predicted probability for non-Greek children having 1-2 carious teeth was 16% (95% CI12%, 19%) and 13% (95% CI8%, 17%) respectively. Non-Greek children were 10% (95% CI7%, 14%) more likely to have one carious tooth, than Greek children, while the difference in the probability for two carious teeth was 12% (95% CI7%, 15%).

## Discussion

This cross-sectional study focused on the influence of certain socio-demographic factors on dental caries experience among kindergarten children in Attica, Greece. This was the first study in Greece using a Geo-demographic System to describe area deprivation and detect social inequalities in oral health. A different presentation was attempted, charting the results of predicted probabilities. Predicted probabilities have been used in several oral health studies (Li *et al*., 2011; Long *et al*., 2012; Polk *et al.,* 2014) to communicate likely associations is and overcome the difficulties in interpreting Odds Ratios as estimates of effect size. Unlike traditional single summary scores of effect, predicted probabilities are calculated for specific values of the outcome variable (dmft scores) and so are more intuitive (Long and Freese, 2006; Newcombe, 2006).

This study recorded a caries prevalence of 20.9% and a mean of 0.67 (SD 1.8) affected teeth. Although the results of epidemiological studies are hardly comparable because of differences in populations, sampling techniques and examination dates, a review of recent research showed that higher rates of caries experience were reported in the adjacent prefecture of Piraeus, where 48.4% of kindergarten children (40% immigrant) in 2001 had some caries experience (Kalyvas *et al*., 2006), while caries experience in Piraeus' 5-year olds was 25% in 2006-2007 (Gatou *et al.,* 2011). On the other hand, similar results to the present study were found in other recent studies: caries prevalence in 3 to 5½-year-olds was 22.6% in Thessaloniki (Boka *et al*., 2013) and 24.8% in Lausanne, Switzerland (Baggio *et al*., 2015). The 5-year-olds' caries prevalence was 26% in Flanders, Belgium (Leroy *et al*., 2012), 26.2% in the Westphalia, Germany (Grund *et al*., 2015) and 34% in Southern Italy (Nobile *et al*., 2014). Lower caries prevalence was observed in Oslo, Norway for the years 2007-2008 at 11% (Wigen *et al*., 2011).

The 74.1% untreated dental caries underlines the unmet dental needs. High rates of dental treatment need (over 75%) are reported in several studies (Ferro *et al*., 2010; Gatou *et al*., 2011; Grund *et al*., 2015; Kalyvas *et al*., 2006) and comprise a serious dental public health problem affecting children's quality of life (Petersen *et al*., 2005). This phenomenon may not be attributed only to the characteristics of dental care provision and prevention programs in each country, as low rates of dental attendance are observed in countries with preventive programs and free dental visits for children (Gallagher *et al*., 2009). Other factors such as information availability, parents' perceptions of dental treatment, education level and social/cultural factors should be considered as well (Badri *et al*., 2014; Gallagher *et al*., 2009; Leroy *et al.,* 2012).

The distribution of dental caries in the study population was rather polarized according to gender, deprivation and ethnic factors. More specifically, girls were less likely than boys to have visible dental caries (zero dmft group), but severity of the disease (dmft scores) was not associated with gender. This may be because disease onset and progression have different pathogenetic mechanisms and potentially different underlying risks (Holst, 2006) and gender factors may be implicated in this process. Studies on the effect of gender in dental caries present conflicting results. Some find no associations in bivariate (Baggio *et al*., 2015; Nobile *et al*., 2014) nor multivariate analysis (Boka *et al*., 2013; Ferro *et al*., 2010; Wigen *et al*., 2011), while others argue that girls have higher dmft scores when caries is present (Declerck *et al*., 2008; Gatou *et al*., 2011). These conflicting results may be related either to the methodological differences between studies or to sample sizes and statistical power.

In the analysis using the geographic information system, differences were observed in the absence of dental disease among children of different deprivation categories. Small differences for having 1-2 teeth affected by caries, were found only between the most deprived and most affluent children (6-9%). Although statistically significant, these

differences were less striking than expected, perhaps because of the low rate of caries prevalence (21%). Many studies using various measures have demonstrated the relation between dental caries experience in 5-year-olds and deprivation and there is strong evidence that the socio-economic characteristics of the area in which people live affects their oral health (Locker, 2000). Nevertheless, data on the effectiveness of geo-demographic systems in interpreting the differences in caries morbidity are scarce and not comparable. Furthermore, researchers disagree about whether these measures detect real differences in oral health or whether they have a direct or contextual effect compared to individual measures (Pereira *et al*., 2010; Stafford *et al*., 2005).

Finally, children's ethnic background is considered a strong determinant of oral health. Half of the non-Greek children of this study had dental caries with an IQR of three teeth affected. However, immigrant children had a 31% lower probability for no detectable caries and approximately 11% greater probability of having about 1-2 carious teeth. There were no differences in the probabilities among the categories of GSA and a small increase in the probability for the non-Greek children, according to area deprivation illustrated in the graph, occurred by chance as the number of non-Greek children in each category was small. Ethnic background was the most significant risk factor in Piraeus, with children with immigrant backgrounds more than four times more likely than Greek children to experience caries after controlling for other factors (Gatou *et al.,* 2011). Also, in Norway, children with parents of non-western origin were 3.4 times as likely to have dentine caries (Wigen *et al*., 2011). In Italy, 43% of immigrant children had caries and were 3.3 times as likely to have dental caries than native children (Ferro *et al*., 2010). Furthermore, there is evidence that the effect of ethnicity in children's oral health is independent of deprivation (Pine *et al.,* 2003). An explanation for this phenomenon may lay in the poor economic status and low educational level of the parents, social exclusion, language barriers and cultural characteristics. Immigrant status has an independent effect on caries experience and differences are observed in parental indulgence, attitude to hygiene and attitude to diet between immigrants and western native parents (Skeie *et al*., 2006). According to Wigen and Wang (2010), having controlled for other factors, the variable of ethnic background incorporates cultural factors linked with dental caries. Even in a western society with little isolation of ethnicities and equal opportunities to access of health information, cultural characteristics strongly affect the way people of different ethnicities prioritize their resources as well as how they receive and evaluate health messages in order to adopt healthy dental behaviors (Gao *et al*., 2010).

In this study a contextual (area-based) variable (GSA) was used as an indicator of area deprivation. The use of aggregated data in assessing individual characteristics for statistical inferences evokes the ecological fallacy. However, contextual variables have been used in several studies and can be a useful analytic tool in investigating differentiations in health outcomes and behaviors of individuals, addressing a geographic dimension of socio-economic status and restrict the amount of response bias when self-reported information is requested, especially when they are combined with individual measures (Greenland, 2001; Locker, 2000). Another limitation of the present study was related to the sampling procedure; the children were initially selected using the three area-based income clusters (see Method) and subsequently classified in the GSA categories, so they were not equally distributed within the GSA categories.

## Conclusions

The prevalence and severity of dental caries in preschool children from Attica has declined since the last epidemiological reports. However, low rates of dental treatment still remain. Statistical analysis revealed differences in the experience of caries and the number of carious teeth in relation to demographic factors, ethnic characteristics and area-deprivation.

Oral health promotion strategies including preventive measures, dietary guidelines, health education and community empowerment should focus on disadvantaged children. Interventions in the provision of dental care are also needed for all children, promoting access to dental care and encouraging dental treatment.

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