Original article

Relationship between caries, body mass index and social class in Spanish children

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ABSTRACT

Objective: To determine the association between caries, body mass index (BMI) and social class in child population of the Valencia region (Spain) at 6, 12 and 15 years, and study.
Methods: In a cross sectional study of 1326 children aged 6 (n = 488), 12 (n = 409) and 15 years (n = 433) who took part in the 2010 Oral Health Survey of the Valencia region, the ICDAS II criteria were employed for diagnosing and coding all the teeth examined. The quantitative BMI values on a continuous scale were grouped into 3 categories (normal weight, overweight, obese) based on a table adjusted for age and gender. The highest-ranking occupation of the parents was taken to indicate the social class of the child.
Results: The mean BMI was 17.21 at 6 years, 21.39 at 12 years and 22.38 at 15 years. No significant differences in caries indexes (DMFT or dft) by degree of obesity stratified by social class were found in any of the age groups studied. There was no significant correlation between BMI and DMFT-dft in any of the age groups.
Conclusions: Obesity is not associated with dental caries in schoolchildren of this population.

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Relación entre la caries, el índice de masa corporal y la clase social en niños españoles

RESUMEN

Objetivo: Determinar la asociación entre la caries, el índice de masa corporal (IMC) y la clase social en la población infantil de la Comunidad Valenciana (España) a los 6, 12 y 15 años de edad.
Método: Se realizó un estudio transversal con una muestra de 1326 niños/as de 6 años (n = 488), 12 años (n = 409) y 15 años (n = 433) de edad. Se emplearon los criterios del ICDAS II para el diagnóstico y la codificación de todos los dientes examinados. Los valores cuantitativos del IMC se agruparon en tres categorías (peso normal, sobrepeso y obesidad) según una tabla ajustada por edad y sexo. Para determinar la clase social se consideró la ocupación de mayor nivel de los padres.
Resultados: La media del IMC fue de 17,21 a los 6 años, de 21,39 a los 12 años y de 22,38 a los 15 años. No se observaron diferencias significativas en los índices de caries (DMFT o dft) por grado de obesidad y estratificado según clase social en ninguno de los grupos de edad. No hubo correlación significativa entre el IMC y el DMFT-dft en ninguno de los grupos.
Conclusiones: La obesidad no está asociada con la caries dental en los niños y las niñas de la muestra estudiada.

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Introduction

In recent decades, changes in lifestyle and diet have been accelerated by industrialization, urbanization, economic development and market globalization. Their impact on health and nutrition has been significant, notably through higher carbohydrate intake and lower physical activity levels, particularly among the younger members of the population. As a result, the prevalence of child obesity has shot up throughout the world and has become a serious public health problem with grave consequences.[1] A high body mass index (BMI) is a complex metabolic condition involving behavioral, environmental and genetic components.[2] Previous studies have shown a positive association between dental caries and BMI. Overweight or obese children have a greater likelihood of suffering dental caries than those of normal weight.[3,4] The relationship between dental caries and body weight is such that dietary interventions designed to reduce the incidence of dental caries may also reduce the development and persistence of excess weight.[5]

Other factors that might influence the association between caries and obesity, such as social class, have also been studied. When both obesity and poverty are present, caries levels may rise.[6]

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Caries and obesity are multi-faceted conditions, influenced by a diversity of factors: psychosocial, behavioral and genetic aspects, eating habits, educational level and social class all play a part.[2,7–10] Furthermore, sugar intake is a decisive factor for both.[11] The challenge in studying this association lies in measuring the confounders or effect modifiers (diet, socioeconomic status, age, and so on) fully and in a standardized manner.[12,13] Tooth decay causes in the human dentition irreversible destruction with masticatories implications and other related quality of life. Preventing tooth decay in children ages remains a priority in public health in industrialized countries.[14]

The aim of this study was to analyze the relationship between caries, body mass index (BMI) and social class in 6, 12 and 15-year-old children of the Valencia region (Spain).

Methods

Study design and study group

This was a cross-sectional study. The 6, 12 and 15-year-old child population of the Valencia region of Spain comprises around 40,000 children in each age group, who attend 1200 primary and secondary schools. To measure their BMI to a level of precision of 0.04 with an estimated standard deviation in the mean BMI of around 3 or 4 depending on the age group, at a 95% confidence level, it was estimated that the minimum sample size should be 400 children from each age group. Cluster sampling was provided by the public health authority of Valencia. From 1200 schools in the region, 79 clusters were selected at random, with between 15 and 20 children in each. The sample size was 1326. Of these children, 484 were 6 years old, 409 were 12 years old and 433 were 15 years old.

Clinical examination

The three examiners were calibrated for ICDAS II caries criteria. First they carried out a calibration online (https://www.icdas.org/icdas-e-learning-course), then they performed an exercise with 10 children. The reliability of their measurements was assessed by reference to a gold standard (an experienced examiner). The weighted Kappa values of the 3 examiners all exceeded 0.85.

The World Health Organization (WHO) recommendations were followed during the clinical examinations in the schools. A 60 W lamp was used as the light source. The intraoral examinations were performed with a no. 5 plain mouth mirror and a WHO type periodontal probe, both sterilized. They were carried out in November and December 2010.[15]

Parental consent

Permission to conduct the study was obtained from the school authorities and from the head teachers of the schools involved. Signed informed consent to examine the children and to obtain information was also obtained from the parents of the children prior to the oral health examination. The study was approved by the Human Research Ethical Committee of the University of Valencia (approval #H1352114553202) and complied with the recommendations of the Declaration of Helsinki.

Caries

The ICDAS II criteria were employed for diagnosing and coding all the teeth examined.[16] The ICDAS II codes classify each decayed tooth in 6 stages of caries, ranging from sound (code 0) to extensive cavity with visible dentin (code 6).

The outcome quantitative variables of caries indexes considered in temporary dentition at 6 years of age were:

- d_{1-6} ft: decayed codes ICDAS II 1 to 6 and filled teeth count.
- d_{4-6} ft: decayed codes ICDAS II 4 to 6 and filled teeth count.

The outcome quantitative variables of caries indexes considered in permanent dentition at 12 and 15 years were:

- D_{1-6} MFT: decayed codes ICDAS II 1 to 6, missing and filled teeth count.
- D_{4-6} MFT: decayed codes ICDAS II 4 to 6, missing and filled teeth count.

Body mass index

To measure the BMI, the height and weight of each child were recorded at the same time of the clinical examination. The BMI was calculated by dividing the weight in kilograms by the height in meters squared: $BMI = weight\ (kg)/height\ (m)^2$. The measurements were performed by three examiners previously trained with the completion of weighing and calculation of BMI with a standardized procedure. The children wore lightweight clothes and no footwear while being weighed. Two consecutive weightings were made and a weighted average was recorded. Height was also measured without footwear. The instruments used were a SECA Robusta 813® weighing scale and a height measuring rod from the same manufacturer. BMI was expressed as quantitative variable and also the BMI values on a continuous scale were grouped into 3 categories–taking the percentiles 85 and 97 as indicative of overweight and obesity respectively (http://www.who.int/growthref/who2007_bmi_for_age/en/).

Social class

In addition to age and gender, information was obtained on social status, using the classification based on parental occupation validated in Spain.[17] The highest-ranking occupation of the parents was taken to indicate the social class of the child. The classifications were:

I: professionals, senior management and senior technical grades.
II: other executives, middle-level technical grades, small employers and self-employed without higher education.
III: middle management.
IVa: skilled manual workers.
IVb: partly-skilled manual workers.
V: unskilled workers.

The social classes were recoded, classifying classes I and II as high social class, class III as middle class and classes IVa. IVb and V as low social class.

Statistical analysis

The data were analyzed with the SPSS 22.0® statistics application. Descriptive statistics with means and 95% confidence intervals were calculated for quantitative variables: BMI and caries indexes. Student's t-test, ANOVA and linear trend test were used to study differences between means in bivariate statistics. The Pearson correlation coefficient was used to test for linear relationships between quantitative variables. The significance level was set at $p < 0.05$. Prior to the use of means comparison tests, the normal distribution was tested by the Kolmogorov-Smirnov test.

Table 1
Caries indexes, body mass index, gender and social class by age (6, 12 and 15 years).

		6 years n = 484 Mean (95%CI)	12 years n = 409 Mean (95%CI)	15 years n = 433 Mean (95%CI)
Caries index d_{1-6} ft/D_{1-6} MFT		2.13 (1.88–2.38)	3.44 (3.08–3.80)	4.74 (4.37–5.11)
Caries index d_{4-6} ft/D_{4-6} MFT		0.98 (0.79–1.17)	0.87 (0.73–1.02)	1.08 (0.91–1.24)
BMI	Normal weight	57.3%	55.2%	53.0%
	Overweight	25.6%	26.8%	37.0%
	Obese	17.1%	18.0%	9.70%
Gender	♂	50.0%	46.9%	47.8%
	♀	50.0%	53.1%	52.2%
Social class	Low	45.6%	53.2%	35.7%
	Middle	43.6%	35.7%	40.9%
	High	10.8%	11.1%	23.4%

95%CI: confidence interval of 95%; BMI: body mass index.

Table 2
Distribution of body mass index by gender and social class.

		Age groups		
		6 years Mean BMI (95%CI)	12 years Mean BMI (95%CI)	15 years Mean BMI (95%CI)
Gender	♂	17.33 (17.01–17.65)	21.88 (21.35–22.45)	22.42 (21.93–22.90)
	♀	17.16 (16.83–17.49) Student's t test p = 0.466	20.96 (20.44–21.48) Student's t test p = 0.021	22.32 (21.86–22.78) Student's t test p = 0.786
Social class	Low	17.57 (17.17–17.97)	21.73 (21.15–22.31)	22.64 (22.64–23.23)
	Middle	17.17 (16.79–17.54)	21.22 (20.60–21.83)	22.13 (21.62–21.64)
	High	16.66 (16.14–17.18) ANOVA test p = 0.076	20.70 (19.78–21.61) ANOVA test p = 0.203	22.33 (21.65–23.01) ANOVA test p = 0.203

95%CI: confidence interval of 95%; BMI: body mass index.

Results

The schoolchildren examined numbered 1326: 484 aged 6 years (242 boys and 242 girls), 409 aged 12 years (193 boys and 216 girls) and 433 aged 15 years (207 and 226 respectively). By social class, 42.5% were of low social class, 37.7% middle class and 14.5% upper class. By weight categories, 50.8% were of normal weight, 30.9% overweight and 18.3% obese. The mean body mass index (BMI) was 17.21 (17.02–17.48) at 6 years, 21.39 (21.01–21.79) at 12 years and 22.38 (22.08–22.69) at 15 years.

Table 1 shows the distribution by age of caries (dft/DMFT), BMI, gender and social class within the sample.

Table 2 shows the BMI distribution by gender and social class. No significant differences in BMI by social class were found at any of the three ages.

Significant differences and linear trends in caries indexes by social class were found in the three age groups studied. These differences were found among lower social class groups against high social class. A clear linear relationship between worsening social class and increased tooth decay was observed (Table 3).

No significant differences in caries indexes (DMFT or dft) by degree of obesity stratified by social class were found in any of the age groups studied (Table 4).

There was no significant correlation between BMI and DMFT-dft in any of the age groups.

Discussion

Child obesity and dental caries in children constitute two major health problems in a large majority of countries nowadays and present great challenges for public health. In developed countries, child caries has remained stable, at low rates, since the early 21st century. The previous epidemiological study of oral health in children in the Valencia region of Spain —carried out in 2004 using the WHO diagnostic criteria[18]— estimated a caries prevalence of 32% in primary dentition and dft 1.08 at 6 years of age, and 42.5% caries prevalence in permanent teeth and DFMT 1.07 at 12 years of age. The caries data obtained in the present study are comparable. Moreover, the Spain-wide study of 2011 (the Aladino study) shows a high prevalence of obesity in the child population.[19]

Obesity and dental caries in children have been associated, although the results obtained in different studies are inconsistent and inconclusive. It is not clear whether they really are associated or whether they merely coexist simultaneously, as they share a common etiology and/or similar contributing factors. A number of authors have found an association between dental caries and obesity in young children and adolescents.[10,20–26] However, not all the studies show the same strength of association, as some recognize that high weight is not *per se* an etiological factor in the development of caries,[27] or that the association between overweight and caries prevalence is weak.[3] Other authors show that overweight or

Table 3
Distribution of caries indexes by social class.

Age groups	Caries indexes	Social class			ANOVA test p-value	Post-hoc ANOVA test Bonferroni p <0.05	Linear trend test p-value
		Low	Middle	High			
6 years	d_{1-6} ft	2.54 (2.09–2.98)	1.73 (1.56–2.53)	1.28 (0.66–1.91)	0.012	Low vs high	0.002
	d_{4-6} ft	1.36 (0.94–1.73)	0.68 (0.46–0.91)	0.46 (0.10–0.83)	0.007	Low vs high Low vs middle	0.009
12 years	D_{1-6} MFT	4.01 (3.52–4.49)	3.06 (2.48–3.65)	2.18 (1.44–2.91)	0.001	Low vs high	0.001
	D_{4-6} MFT	0.95 (0.75–1.14)	0.77 (0.56–0.98)	0.51 (0.22–0.78)	0.107	-	0.046
15 years	D_{1-6} MFT	5.45 (4.81–6.10)	4.62 (4.03–5.19)	3.92 (3.19–4.64)	0.008	Low vs high	0.002
	D_{4-6} MFT	1.28 (0.95–1.62)	0.96 (0.73–1.18)	1.03 (0.68–1.37)	0.229	-	0.259

Table 4
Distribution of caries indexes by body mass index categories, stratified by social class.

Age group	Caries indexes	Social class	BMI categories			ANOVA test p-value
			Healthy weight Mean (95%CI)	Overweight Mean (95%CI)	Obese Mean (95%CI)	
6 years n = 484	d_{1-6} ft	Overall	2.04 (1.67–2.40)	2.27 (1.82–2.72)	2.14 (1.65–2.74)	0.736
		Low	2.42 (1.77–3.07)	2.74 (1.85–3.63)	2.55 (1.66–3.45)	0.853
		Middle	1.86 (1.30–2.41)	2.18 (1.51–2.85)	1.89 (1.10–2.69)	0.784
		High	1.56 (0.61–2.50)	0.73 (0–1.52)	1.60 (0–4.83)	0.456
	d_{4-6} ft	Overall	1.05 (0.76–1.33)	0.85 (0.56–1.14)	0.96 (0.55–1.36)	0.697
		Low	1.37 (0.82–1.92)	1.34 (0.67–2.01)	1.36 (0.59–2.13)	0.997
		Middle	0.77 (0.40–1.13)	0.60 (0.28–0.92)	0.56 (0.21–0.91)	0.719
		High	0.68 (0.04–1.31)	0.20 (0–0.51)	0.22 (0–0.75)	0.431
12 years n = 409	D_{1-6} MFT	Overall	3.39 (2.86–3.93)	2.92 (2.37–3.48)	4.25 (3.39–5.11)	0.065
		Low	3.92 (3.13–4.73)	3.75 (2.87–4.64)	4.60 (3.47–5.72)	0.465
		Middle	3.14 (2.28–4.01)	2.19 (1.42–2.96)	4.23 (2.49–5.97)	0.053
		High	1.95 (0.77–3.12)	1.94 (0.68–3.20)	2.25 (0.21–4.28)	0.954
	D_{4-6} MFT	Overall	0.97 (0.74–1.18)	0.73 (0.50–0.95)	0.89 (0.56–1.22)	0.374
		Low	1.00 (0.70–1.29)	1.02 (0.62–1.40)	1.03 (0.51–1.55)	0.991
		Middle	1.11 (0.71–1.53)	0.61 (0.28–0.84)	0.73 (0.31–1.14)	0.126
		High	0.33 (0.00–0.75)	0.55 (0.00–1.12)	0.63 (0.00–1.39)	0.707
15 years n = 433	D_{1-6} MFT	Overall	4.72 (4.24–5.20)	4.78 (4.13–5.42)	4.73 (3.38–6.09)	0.991
		Low	5.37 (4.45–6.30)	5.62 (4.55–6.68)	5.25 (3.16–7.33)	0.922
		Middle	4.33 (3.67–4.99)	4.94 (3.76–6.12)	5.27 (2.69–7.85)	0.489
		High	4.48 (3.44–5.51)	3.60 (2.43–4.77)	2.50 (0.55–4.44)	0.272
	D_{4-6} MFT	Overall	1.01 (0.79–1.23)	1.14 (0.84–1.44)	1.24 (0.75–1.71)	0.646
		Low	1.12 (0.69–1.57)	1.38 (0.76–1.99)	1.75 (0.93–2.56)	0.506
		Middle	0.87 (0.62–1.13)	1.17 (0.68–1.65)	0.83 (0.08–1.58)	0.465
		High	1.17 (0.61–1.73)	0.87 (0.39–1.34)	1.12 (0.00–2.42)	0.693

95%CI: confidence interval of 95%; BMI: body mass index.

obese adolescents have 1.6 times more interproximal caries than those of normal weight,[23] although this is not the case in all age groups.[20,23] Parental overweight has been considered a risk factor for the development of conditions such as obesity or caries in children.[21] The children's predilection for particular foods, particularly sweets, sugar-rich foods —which have high levels of rapidly metabolized carbohydrates— and soft drinks, may explain the co-occurrence of child obesity and dental caries in many of the sample populations studied, since confounding risk factors such as frequency of intake, potentially cariogenic diets or poor oral hygiene are shared by both conditions.[24]

Among the systematic reviews and meta-analyses that have examined this association, Hooley et al.[28] consider that there is evidence of an association between dental caries and BMI, although a clearer understanding of this association is needed.

The study by Hayden et al.[26] indicates that when standardized definitions for the assessment of child obesity are used, a small overall association between obesity and level of caries in the permanent dentition is encountered: caries is more prevalent in obese children than in normal weight children. They find no association between obesity and caries in primary dentition.

The considerable heterogeneity of the studies could limit their external validity and the generalization of their results. Assessment of child weight status was not uniform across studies, and this variation in measurements may partly explain the inconclusive reports on the relationship between dental caries and obesity in the literature to date.[26]

The existence of studies conducted with similar methods to the present study supports its results concerning the absence of any relation between obesity and dental caries among schoolchildren in the Valencia region of Spain. Macek and Mitola,[29] published the most heavily-weighted study based on participant numbers, and found no association between age-specific body mass index and increased dental caries prevalence and severity among US children. Nor did Sadeghi et al.[30] find such an association in Iranian children. In the present study, the lack of association between dental caries and obesity could be influenced by factors related to the regular exposure of Valencian children to fluorine in toothpaste and to their being included in a weekly fluorinated mouthwash program at school. Additionally, the absence of such an association may relate to the fact that BMI in children changes substantially with age, and the changes are not correlated strictly with body fat.

Another confounding variable that may have influenced this relation is socio-economic class. Social class is considered an associated factor in the relation between BMI and dental caries.[2–4,6,7,9,20–23,26,31,32] The factors that contribute to the two problems of caries and child obesity are both psychosocial and nutritional.[9] The environment in which children spend their early years has an impact on their future oral health.[23] Attending state rather than private schools has been shown to be a disadvantageous factor for caries prevalence, missing teeth and DMFT,[7] as has residing in countries with a different level of development.[4] These differences have been reflected in the conclusions of a recent meta-analysis: compared with normal weight children, obese children

from industrialized countries have a significant relationship with caries, in contrast to those from non-industrialized countries.[26]

Family income has been considered a reliable predictor for child caries.[3,22] Children with caries come from families with lower incomes, with parents of low educational levels and overweight mothers.[21] Children of higher socioeconomic status who brush their teeth more often show a significantly lower prevalence and extent of DMFT, irrespective of weight status.[2] The findings of the present study agree with numerous other studies in that decreasing socioeconomic status is associated with increasing development of caries,[33] as has also been found in previous studies of the child population of Valencia.[18] Recently, the latest epidemiological study of oral health in Spain, has shown a relationship between social disadvantage and presence of dental caries in both children and adults. Also observed a concentration of the disease in certain groups of individuals that suggest a change prevention strategies targeted specifically at risk groups.[34]

Gerdin et al.[3] consider that there are two potential sources of bias in studies that examine the association between obesity and caries: the samples used and the role of socioeconomic status. As regards the former, the present study examined a representative random sample of the child population with appropriate sample sizes in each of the age groups, giving high power as well as highly reliable measurement of the different variables. A stratified statistical analysis was performed to check for the latter —possible socioeconomic bias. Analysis of the influence of social class on the relationship between caries and obesity found a lack of association in each of the three classes (high, middle and low), analyzed independently. Nevertheless, authors such as Marshall et al.[21] did find caries and obesity coexisting in children of low social class.

In view of our outcomes, it may be concluded that there is no relation between obesity and caries in the child population, and social class does not influence this relationship. Future longitudinal studies could shed more light on the influence of social factors in the aetiology of both processes.[35]

Controlling overweight/obesity and caries in children needs to be approached as a public health problem and tackled through prevention, both in the school and in the family, by promoting health education in healthy lifestyle habits, paying particular attention to food. Strategies that address both diseases need to be considered, irrespective of whether or not there is really is an association between them.

Overweight, obesity and caries share aetiopathogenic factors that lead to their exhibiting a significant association in some populations but not in others. Consequently, BMI should not be used as a predictor variable in the different multi-variant models for caries. The multi-factor aetiology and considerable complexity of the interactions that occur during the two processes call for more profound research into lifestyle-related aspects, adopting a longitudinal rather than a cross-sectional perspective.

Editor in charge

Laura I. González Zapata.

Transparency declaration

The corresponding author on behalf of the other authors guarantee the accuracy, transparency and honesty of the data and information contained in the study, that no relevant information has been omitted and that all discrepancies between authors have been adequately resolved and described.

What is known about the topic?

Dental caries is a high prevalent multifactorial disease. The approach strategy should be based on the prevention of common risk factors with other prevalent diseases such as obesity and diabetes in developed countries. However, the association between caries and obesity is inconclusive in the literature.

What does this study add to the literature?

The multifactorial etiology of caries implies difficulty to find a clear association between obesity and dental caries in children and young people of the Spanish population even stratifying by social class.

Authorship contributions

Conception and design of study: José Manuel Almerich-Silla, José María Montiel-Company. Acquisition of data: Teresa Almerich-Torres, Carlos Bellot-Arcís, José María Montiel-Company. Analysis and/or interpretation of data: Teresa Almerich-Torres, Carlos Bellot-Arcís, José María Montiel-Company, José Manuel Almerich-Silla. Drafting the manuscript: Carlos Bellot-Arcís, José María Montiel-Company, José Manuel Almerich-Silla. Revising the manuscript critically for important intellectual content: Teresa Almerich-Torres, Carlos Bellot-Arcís, José María Montiel-Company, José Manuel Almerich-Silla. Approval of the version of the manuscript to be published: Teresa Almerich-Torres, Carlos Bellot-Arcís, José María Montiel-Company, José Manuel Almerich-Silla.

Conflict of interests

None.

References

1. Cole TJ, Bellizzi MC, Flegal KM, et al. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ. 2000;320:1240–3.
2. Alves LS, Susin C, Damé-Teixeira N, et al. Overweight and obesity are not associated with dental caries among 12-year-old South Brazilian schoolchildren. Community Dent Oral Epidemiol. 2013;41:224–31.
3. Gerdin EW, Angbratt M, Aronsson K, et al. Dental caries and body mass index by socio-economic status in Swedish children. Community Dent Oral Epidemiol. 2008;36:459–65.
4. Vázquez-Nava F, Vázquez-Rodríguez EM, Saldívar-González AH, et al. Association between obesity and dental caries in a group of preschool children in Mexico. J Public Health Dent. 2010;70:124–30.
5. Hooley M, Skouteris H, Millar L. The relationship between childhood weight, dental caries and eating practices in children aged 4–8 years in Australia, 2004–2008. Pediatr Obes. 2012;7:461–70.

6. Jamelli SR, Rodrigues CS, de Lira PI. Nutritional status and prevalence of dental caries among 12-year-old children at public schools: a case-control study. Oral Health Prev Dent. 2010;8:77–84.

7. Moreira PV, Rosenblatt A, Severo AM. Prevalence of dental caries in obese and normal-weight Brazilian adolescents attending state and private schools. Community Dent Health. 2006;23:251–3.

8. Alm A, Fåhraeus C, Wendt LK, et al. Body adiposity status in teenagers and snacking habits in early childhood in relation to approximal caries at 15 years of age. Int J Paediatr Dent. 2008;18:189–96.

9. Spiegel KA, Palmer CA. Childhood dental caries and childhood obesity. Different problems with overlapping causes. Am J Dent. 2012;25:59–64.

10. Sakeenabi B, Swamy HS, Mohammed RN. Association between obesity, dental caries and socioeconomic status in 6- and 13-year-old school children. Oral Health Prev Dent. 2012;10:231–41.

11. de Silva-Sanigorski AM, Waters E, Calache H, et al. Splash!: a prospective birth cohort study of the impact of environmental, social and family-level influences on child oral health and obesity related risk factors and outcomes. BMC Public Health. 2011;11:505.

12. Pinto A, Kim S, Wadenya R, et al. Is there an association between weight and dental caries among pediatric patients in an urban dental school? A correlation study. J Dent Educ. 2007;71:1435–40.

13. Wu L, Chang R, Mu Y, et al. Association between obesity and dental caries in Chinese children. Caries Res. 2013;47:171–6.

14. Bravo M, Cortés J, Casals E, et al. Basic oral health goals for Spain 2015/2020. Int Dent J. 2009;59:78–82.

15. Almerich-Silla JM, Boronat-Ferrer T, Montiel-Company JM, et al. Caries prevalence in children from Valencia (Spain) using ICDAS II criteria, 2010. Med Oral Patol Oral Cir Bucal. 2014;19:e574–80.

16. Pitts N. ICDAS – an international system for caries detection and assessment being developed to facilitate caries epidemiology, research and appropriate clinical management. Community Dent Health. 2004;21:193–8.

17. Domingo Salvany A, Marcos Alonso J. Proposal of an indicator of social class based on the occupation. Gac Sanit. 1989;3:320–6.

18. Almerich-Silla JM, Montiel-Company JM. Oral health survey of the child population in the Valencia Region of Spain (2004). Med Oral Patol Oral Cir Bucal. 2006;11:E369–81.

19. Pérez-Farinós N, López-Sobaler AN, Dal Re MA, et al. The ALADINO Study: a national study of prevalence of overweight and obesity in Spanish children in 2011. Bio Med Res Int. 2013;2013:163687.

20. Willershausen B, Moschos D, Azrak B, et al. Correlation between oral health and body mass index (BMI) in 2071 primary school pupils. Eur J Med Res. 2007;12:295–9.

21. Marshall TA, Eichenberger-Gilmore JM, Broffitt BA, et al. Dental caries and childhood obesity: roles of diet and socioeconomic status. Community Dent Oral Epidemiol. 2007;35:449–58.

22. Hong L, Ahmed A, McCunniff M, et al. Obesity and dental caries in children aged 2-6 years in the United States: National Health and Nutrition Examination Survey 1999-2002. J Public Health Dent. 2008;68:227–33.

23. Alm A. On dental caries and caries-related factors in children and teenagers. Swed Dent J Suppl. 2008;195:7–63.

24. Sharma A, Hegde AM. Relationship between body mass index, caries experience and dietary preferences in children. J Clin Pediatr Dent. 2009;34:49–52.

25. Alm A, Isaksson H, Fåhraeus C, et al. BMI status in Swedish children and young adults in relation to caries prevalence. Swed Dent J. 2011;35:1–8.

26. Hayden C, Bowler JO, Chambers S, et al. Obesity and dental caries in children: a systematic review and meta-analysis. Community Dent Oral Epidemiol. 2013;41:289–308.

27. Heinrich-Weltzien R, Monse B, Benzian H, et al. Association of dental caries and weight status in 6- to 7-year-old Filipino children. Clin Oral Investig. 2013;17:1515–23.

28. Hooley M, Skouteris H, Boganin C, et al. Body mass index and dental caries in children and adolescents: a systematic review of literature published 2004 to 2011. Syst Rev. 2012;1:57.

29. Macek MD, Mitola DJ. Exploring the association between overweight and dental caries among US children. Pediatr Dent. 2006;28:375–80.

30. Sadeghi M, Lynch CD, Arsalan A. Is there a correlation between dental caries and body mass index-for-age among adolescents in Iran. Community Dent Health. 2011;28:174–7.

31. Cinar AB, Murtomaa H. Interrelation between obesity, oral health and lifestyle factors among Turkish school children. Clin Oral Investig. 2011;15:177–84.

32. Norberg C, Hallström Stalin U, Matsson L, et al. Body mass index (BMI) and dental caries in 5-year-old children from southern Sweden. Community Dent Oral Epidemiol. 2012;40:315–22.

33. Watt R, Sheiham A. Inequalities in oral health: a review of the evidence and recommendations for action. Br Dent J. 1999;187:6–12.

34. Bravo Pérez M, Almerich Silla JM, Ausina Márquez V, et al. Encuesta de salud oral en España 2015. RCOE. 2016;21:8–48.

35. Lempert SM, Froberg K, Christensen LB, et al. Association between body mass index and caries among children and adolescents. Community Dent Oral Epidemiol. 2014;42:53–60.