Oral hygiene and periodontal condition of 12- and 15-year-old Greek adolescents. Socio-behavioural risk indicators, self-rated oral health and changes in 10 years



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Abstract

Aim To investigate oral hygiene and periodontal status of 12- and 15-year-old Greek adolescents in relation to socio-demographic and behavioural indicators and identify national trends.

Materials and methods In a stratified cluster sample of 2,478 participants, the Simplified Debris Index (DI-S) and the Community Periodontal Index (CPI) were calculated. Socio-demographic/behavioural data were collected through structured questionnaires. Multivariate ordinary regression examined the effect of socio-behavioural indicators on oral hygiene and periodontal conditions.

Results 51.7% of the 12-year-olds and 56.9% of the 15-year-olds had fair and good oral hygiene, respectively. Approximately 30% of the adolescents had healthy periodontium. Bleeding on probing was detected in 23.6% and 21.6% of the 12- and the 15-year-olds, accordingly. Calculus was found in 46.2% and 44.3% of the 12- and the 15-year-old groups, correspondingly. The prevalence of periodontal pockets ≥4mm was 3.2%. Significantly higher DI-S scores were found among 12-year-olds who were males, had lower educated mothers or did not use dental floss and among adolescents who brushed their teeth <twice/day. Inferior periodontal status was found among 15-year-olds who were males, 12-year-olds with lower educated mothers, who did not brush or brushed infrequently, and among subjects who did not floss. Poor self-rated oral health was significantly related to adverse oral hygiene and periodontal health outcomes. Oral hygiene and periodontal status of Greek adolescents improved moderately in ten years.

Conclusions Periodontal health promotion strategies should target vulnerable sub-groups of adolescents to reduce future periodontal burden. Self-rated oral health may be useful for identifying unmet periodontal treatment needs.

KEYWORDS Periodontal status, oral hygiene, adolescents, national pathfinder survey, socio-behavioural indicators, self-rated oral health.

Introduction

Identifying trends in the prevalence and severity of the periodontal diseases and highlighting disparities among populations with the aim to provide efficient periodontal care reimbursement schemes is an important, although largely overlooked part of public dental services and oral health promotion planning [Jürgensen et al., 2012]. Among adolescent populations worldwide, the Community Periodontal Index (CPI) has been extensively utilised as a source of descriptive aepidemiological data on their periodontal status. Globally, plaque-induced gingivitis described by bleeding on gentle probing as well as the acquisition of calculus deposits have been identified as affecting the majority of adolescent cohorts [Jenkins and Papapanou, 2002; Albandar and Tinoco, 2001]. In contrast, shallow pockets (4-5mm) were present only in a minority of the samples that were examined [Jenkins and Papapanou, 2002]. In Greece, in the context of a national pathfinder survey that was conducted in 2004 in 12- and 15-year-old adolescents, calculus with or without bleeding was the most frequently observed condition (42.8% and 53.3%, respectively). Bleeding on probing was found in 41.5% of the 12-year-olds and in 30.0% of the 15-year-olds, whereas the prevalence of periodontal pocketing that was examined in the latter age group was very low (0.2%) [Vadiakas et al., 2012].

Inequalities in the health of adolescents pose a significant public health issue, due to magnified consequences in a period of biological, psychological and social development [Sfreddo et al., 2019]. Considering periodontal health, research has shown that extensive levels of gingival bleeding on probing could adversely affect the adolescents' perception of their oral health and daily life [Tomazoni et al., 2014], and impact negatively on their social life as the presence of gingival bleeding has been correlated with an increased number of episodes of verbal bullying [Moraes et al., 2020]. Gingival bleeding has been associated with the occurrence of systemic diseases, such as otitis media/externa and asthma in late adolescence [Abe at al., 2020a], however, abnormally overweight (obese) adolescents have been reported to present significantly less bleeding on probing than normal-weight subjects [Vallogini et al., 2017]. Furthermore, persistent gingival inflammation at a young age has shown significant association with periodontitis and tooth loss during the course of adult life [Lang et al., 2009]. Also, the presence of calculus deposits has been linked to chronic periodontitis prevalence in adolescents and young

adults [Susin et al., 2011], presumably due to the dental calculus being an ideal breeding environment for bacterial biofilm growth, inducing inflammatory reactions of the surrounding gingival tissues [Akcali and Lang., 2018].

Adolescents (subjects between 10 and 19 years of age) face heightened risks, because they may no longer benefit from the care provided to children or the protections associated with adulthood [World Health Organization, 2005]. During that period of life, inequalities in periodontal health have been consistently correlated with material factors, such as the socio-economic position of the parents [Tadakamadla et al., 2020; Sfreddo et al., 2019; Kumar et al., 2017; Tomazoni et al., 2017; Susin et al., 2011], gender [Abe et al., 2020b; Olczak-Kowalczyk et al., 2019; Paduano et al., 2018; Furuta et al., 2011] and rural/urban place of residence [Olczak-Kowalczyk et al., 2019], which may influence dental plaque levels through pathways such as the adoption of adequate or inadequate behaviours in terms of oral hygiene practices [Abe et al., 2020b; Sfreddo et al., 2019; Furuta et al., 2011], and/or the determination of the social environment in which individuals live and work [Tomazoni et al., 2017].

The aim of the present study, which was part of the second national pathfinder survey (2014) assessing the oral health status of the Greek population through the examination of targeted age groups, was to estimate the oral hygiene status and periodontal condition of 12- and 15-year-old Greek children in relation to socio-demographic and behavioural parameters. Furthermore, trends in the oral hygiene levels and periodontal condition the of the 12- and 15-year-old children were identified, by comparing the results of the 2014 survey with those of a survey conducted in 2004.

Materials and methods

A stratified cluster sample was selected according to the WHO guidelines for national pathfinder surveys [World Health Organization, 1997] in the same age groups and from the same areas as in the 2004 survey [Vadiakas et al., 2012], for comparison purposes. Specifically, the survey covered three urban communities of different socio-economic backgrounds from the two larger metropolitan areas of Greece (Athens and Thessaloniki) and one urban and one rural community from each of six mainland counties and three islands. Therefore, the survey was conducted in 15 urban and 9 rural sites and around 50 subjects were examined at each site. Stratified random sampling was used to select three schools from each city. The sample comprised of 2478 12- and 15-year-old adolescents of Greek nationality. Permission from the Ministry of Education, ethical approval from the Research Ethics Committee of the School of Dentistry of the University of Athens and parental consent were obtained before the clinical examinations. (permission number: 201/21/03/2013 for the 12-year-old children and 202/21/03/2013 for the 15-year-old children).

Calibration of the participating examiners took place against a reference examiner that was considered as the 'gold standard', during a clinical session where each of the ten trainees and the reference examiner examined ten 12-15-year-old children. Inter-examiner agreement as described by Pearson's correlation coefficient levelled off at 0.575 (max), regarding the simplified debris index (DI-S) configuration. The examinations were held in the classrooms, using reclining chairs and portable lights, using dental mirrors and the WHO CPI periodontal probe. Each calibrated examiner was accompanied by a chairside assistant, who was a dental practitioner that completed the examination forms. Cotton rolls and gauze were available for moisture control.

Clinical examination collected data describing gingival bleeding on probing, presence of calculus (with or without bleeding) and periodontal pocketing (only for the 15-year-old age group) on teeth 11, 31, 16/17, 26/27, 36/37 and 46/47 according to the WHO recommendations [World Health Organization, 1997]. Based on the clinical information, the Community Periodontal Index (CPI) [World Health Organization, 1997] was calculated. Furthermore, the proportion of the buccal surface coverage of teeth 11, 31, 16 and 26, as well as the lingual surface coverage of teeth 36 and 46 with soft debris was recorded, and the corresponding simplified debris index (DI-S) was calculated.

Socio-demographic and behavioural data were collected through a structured questionnaire that was completed face-to-face at the time of the clinical examination. Indicators of periodontal and oral hygiene status were analysed in relation to socio-demographic and behavioural variables. For analysis purposes, demographic characteristics (gender, urban or rural area of residence) and socio-economic status parameters (parental level of education) were recorded. Parental education was assessed by the completion of certain education milestones by the father and the mother of each subject, and was categorised into three levels: Up to lower secondary, upper secondary/non-university tertiary and university. Periodontal health-related behaviours were described by dental attendance pattern (dental visit when in pain or for other emergencies/for treatment/for a check-up and preventive procedures), toothbrushing frequency (never or occasionally/once per day/twice per day), use of dental floss (no/yes), and tobacco use (no/yes, for the 15-year-old adolescents only). Also, the 12- and 15-year-old participants were asked to self-rate their oral health as good, moderate or poor.

Regarding missing data, no correction for non-participation or non-response was applied. Due to the skewed distribution of the DI-S index data, the corresponding analyses were based on the following subgroups:

a) Good (score 0.0–0.6);
b) Fair (score 0.7–1.8);
c) Poor (score 1.9–3.0).

Community Periodontal Index data were also ordered, thus, for both indices the ordinal nature of the data was taken into account in all analyses. Descriptive analysis of DI-S and CPI categories by each socio-demographic/behavioural variable was performed with the use of non-parametric tests (Mann-Whitney and Kruskal-Wallis tests). Multivariable ordinal logistic regression analysis was performed to investigate the relationship between the DI-S and CPI indices and the various socio-demographic and behavioural factors. Only the univariably significant factors ($p \leq 0.05$) were included in the final models. All regression models used robust standard errors to account for the potential clustering of children within the same school. Results were presented with odds ratios (OR) and 95% confidence intervals (CI) adjusted for all included independent variables, with the level of significance set at $p \leq 0.05$. In all regression analyses the comparisons were estimated against one of the categories that was considered as reference. Data were processed and analysed with IBM SPSS Statistics (PC version 26.0).

Results

Table 1 shows how the oral hygiene status of adolescents was

	12-year-olds				15-year-olds			
	Oral hygiene level of adolescents (%)				Oral hygiene level of adolescents (%)			
	N*	Good (0.0-0.6)	Fair (0.7-1.8)	Poor (1.9-3.0)	N*	Good (0.0-0.6)	Fair (0.7-1.8)	Poor (1.9-3.0)
Area of Residence								
Rural	426	41.3	54.0	4.7	438	52.7	42.7	4.6
Urban	825	45.2	50.5	4.2	789	59.2	38.9	1.9
	NS†				*p<0.05*†			
Gender								
Male	612	34.8	59.0	6.2	569	50.4	45.9	3.7
Female	630	52.7	44.6	2.7	657	62.6	35.3	2.1
	p-value<0.001†				*p-value<0.001*†			
Father's education								
Up to lower secondary	285	34.4	60.4	5.3	276	50.0	47.5	2.5
Upper secondary/Non-university tertiary	580	44.3	51.4	4.3	544	56.1	40.6	3.3
University	381	50.4	45.7	3.9	403	62.5	35.0	2.5
	p-value<0.001‡				*p-value<0.01*‡			
Mother's education								
Up to lower secondary	235	34.9	57.0	8.1	213	50.2	46.0	3.8
Upper secondary/Non-university tertiary	612	41.0	54.7	4.2	589	55.0	41.9	3.1
University	399	53.6	43.9	2.5	423	62.9	35.0	2.1
	p-value<0.001‡				*p-value<0.01*‡			
Self-assessed oral health								
Good	368	52.4	43.2	4.3	368	64.7	34.0	1.4
Moderate	579	45.3	51.4	3.3	577	58.4	39.3	2.3
Poor	301	30.9	62.8	6.3	281	43.8	50.2	6.0
	p-value<0.001‡				*p-value<0.001*‡			
Reason for dental visit								
Pain/Acute problem	226	39.8	53.5	6.6	225	52.9	43.1	4.0
Treatment	316	36.4	60.1	3.5	366	54.4	42.6	3.0
Check-up/Prevention	664	49.8	46.5	3.6	608	60.0	37.7	2.3
	p-value<0.001‡				*NS*‡			
Toothbrushing frequency								
No/Occasionally	147	25.2	64.6	10.2	138	33.3	58.7	8.0
Once per day	536	39.9	55.4	4.7	432	50.7	44.7	4.6
Twice per day	565	52.7	44.8	2.5	655	66.0	33.4	0.6
	p-value<0.001‡				*p-value<0.001*‡			
Use of dental floss								
No	847	40.0	54.9	5.1	851	54.2	42.9	2.9
Yes	400	52.3	45.0	2.8	375	63.2	34.1	2.7
	p-value<0.001†				*p-value<0.01*†			
Smoking								
No	N/A	N/A	N/A	N/A	1117	57.9	39.3	2.8
Yes	N/A	N/A	N/A	N/A	107	46.7	50.5	2.8
					p-value<0.05†			
Total	1251	43.9	51.7	4.4	1227	56.9	40.2	2.9

**Number of observations may be less than total for some variables due to missing data. †Mann-Whitney test. ‡Kruscal-Wallis test. NS: Not Significant*

TABLE 1 Observed oral hygiene status of 12- and 15-year-old adolescents measured using the simplified Debris Index (DI-S) according to socio-demographic and behavioural parameters.

distributed according to the various socio-demographic and behavioural parameters that were examined. Good oral hygiene levels were recorded in 43.9% and 56.9% of the 12- and the 15-year-olds, accordingly. The percentage of the adolescents with poor oral hygiene levels was low (<4.5%) in both age groups. Urban-residing 15-year-old adolescents presented significantly better oral hygiene status than their rural-residing age-mates. The DI-S score, at both ages, was significantly better in the females, in those with higher parental educational achievement, in those who adopted optimal oral health behaviours in relation to the toothbrushing frequency and the use of dental floss, and in the adolescents whose self-rated oral health score was higher. The 12-year-old adolescents who visited the dentist primarily for prevention exhibited significantly higher oral hygiene than their age-mates who paid dental visits mainly when in pain or for treatment purposes. Furthermore, 15-year-old adolescents who were engaged to tobacco use, demonstrated significantly worse oral hygiene levels compared to their age-mates who had not adopted that habit.

The distribution of adolescents by CPI scores and socio-demographic and behavioural characteristics is presented in Table 2. As can been seen, approximately one third of the 12- and the 15-year-old adolescents (30.2% and 31%, respectively) presented with a healthy periodontium. Bleeding on probing, indicative of gingival inflammation, was reported as the worst CPI score in about one fifth to one fourth of the 12- (23.6%) and the 15-year-olds (21.6%), whereas calculus deposits were found in 46.2% and 44.3% of the 12- and the 15-year-old subjects, accordingly. Gingival pockets, which were recorded only in the 15-year-olds, were detected in 3.2% of the examined participants. Urban-located 15-year-olds exhibited significantly better periodontal health level than their rural-located age-mates. In both age groups, females, those with higher educated parents, those who had adopted optimal oral health behaviours in terms of toothbrushing frequency and the use of dental floss, as well as the adolescents whose self-rated oral health score was higher, demonstrated significantly better periodontal health status. Also, 12-year-old adolescents who visited the dentist primarily for preventive purposes, presented significantly better periodontal condition than their age-mates who paid mainly treatment-oriented dental visits, either in an emergency situation or not.

The results of the multivariable ordinal regression analysis for DI-S (Table 3, 4) revealed that the self-rated oral health status and the toothbrushing frequency remained significant predictors of the oral hygiene level for both age groups. Furthermore, solely for the 12-year-olds, the gender, the mother's education level and the use of dental floss were found to significantly affect the oral hygiene status of the subjects. Adolescents who rated their oral health as poor, or brushed their teeth less than twice per day, exhibited lower oral hygiene status compared to their age-mates who self-rated their oral health as good or moderate, or performed toothbrushing two times per day. Moreover, considering the 12-year-old group, males, adolescents with low educated mothers and those who did not use dental floss, presented with a significantly increased probability for low oral hygiene.

Table 5 and Table 6 demonstrate the results of multivariable ordinal regression analysis for the periodontal status of the examined adolescents, as described by the CPI index scores. In both age groups, the assessment of the own oral health status, as well as the use of dental floss parameters remained significantly associated with the periodontal condition of the adolescents. Adolescents who rated their oral health as poor and those who did not use dental floss, presented significantly higher odds of being recorded with worse periodontal status. Additionally, 12-year-olds with lower educated mothers or those who did not brush their teeth or brushed occasionally, as well as the 15-year-old males demonstrated significantly higher probability of being assigned with worse periodontal status.

Discussion

The objective of the present study was to present the periodontal and the associated oral hygiene status of a non-random but adequately illustrative sample of the 12- and 15-year-old Greek adolescent population, to aid policymakers identify and justify prioritisation in terms of targeted preventive interventions and oral health promotion planning. Periodontal health was assessed by means of the Community Periodontal Index (CPI) that measures the prevalence and severity of periodontal diseases [World Health Organization, 1997]. Among adolescent cohorts worldwide, the CPI index has been used as a major source of descriptive aepidemiological evidence on their periodontal condition, allowing international comparisons, although the validity of its hierarchical design has received criticism [Jenkins and Papapanou, 2002]. Moreover, the use of a partial protocol for clinical recordings underestimates to some extent the true prevalence of most common periodontal outcomes; however, it has been shown to gather sufficient information to measure the association of periodontal diseases and socio-behavioural factors among adolescent populations. Also, its use significantly reduces time, cost, participant's discomfort and examiner's fatigue [Peres et al., 2012].

The results of the present national pathfinder survey revealed an improvement in the oral hygiene of the 12- and the 15-year-old adolescents during a decade; specifically, mean DI-S values decreased from 0.92 and 0.74 in 2004 [Vadiakas et al., 2012] to 0.74 and 0.55 in 2014 (data not shown), for the younger and the older age group, respectively. Furthermore, the percentage of subjects with good oral hygiene levels increased by 51% and by 34.6% for the 12- and the 15-year-old age group, respectively (Fig. 1). Oral hygiene levels presumably reflect the adequacy of toothbrushing frequency and/or performance; during the decade 2004-2014, the percentage of the 12- and the 15-year-olds who brushed their teeth twice per day increased from 31.3% and 40.4% [Vadiakas et al., 2011] to 42.5% and 52.6%, respectively (data not shown). Therefore, although having improved, the oral hygiene condition of Greek adolescents cannot be considered as satisfactory. Oral hygiene status has been positively associated with the presence and the extent of gingivitis in childhood populations [Díaz-Rosas et al., 2018, Kumar et al., 2017; Chiapinotto et al., 2013], as well as with the presence of chronic periodontitis in adolescents and young adults [Susin et al., 2011]. Furthermore, as oral hygiene behaviours established during early adolescence often continue throughout life [Saied-Moallemi et al., 2009], it is important to stress the need for targeted intervention in the Greek adolescent population for the provision of oral hygiene instructions, aiming at raising the frequency and the efficiency of their toothbrushing habits.

Considering the changes in the periodontal status of the Greek adolescents during the period 2004-2014, an increase in the percentage of subjects with healthy periodontium was observed, specifically by 47.7% and 46.5% for the 12- and the 15-year-old group, respectively. Furthermore, the percentage

	12-year-olds				15-year-olds				
	CPI (%) with highest score				CPI (%) with highest score				
	N*	0	1	2	N*	0	1	2	3
Area of Residence									
Rural	426	26.3	24.6	49.1	437	24.3	16.5	55.4	3.9
Urban	826	32.2	23.1	44.7	790	34.7	24.4	38.1	2.8
	NS†				*p-value<0.001*†				
Gender									
Male	612	26.6	23.7	49.7	569	25.3	20.7	50.6	3.3
Female	631	33.8	23.9	42.3	657	35.9	22.4	38.7	3.0
	p-value<0.01†				*p-value<0.001*†				
Father's education									
Up to lower secondary	286	24.8	20.3	54.9	275	20.7	19.3	56.7	3.3
Upper secondary/Non-university tertiary	580	31.7	22.1	46.2	545	33.9	21.5	44.4	2.8
University	381	32.0	28.3	39.6	403	33.7	26.1	36.5	3.7
	p-value<0.01‡				*p-value<0.001*‡				
Mother's education									
Up to lower secondary	236	21.6	18.2	60.2	213	21.1	19.7	57.3	1.9
Upper secondary/Non-university tertiary	612	28.3	25.0	46.7	590	32.0	19.8	45.1	3.1
University	399	38.3	24.6	37.1	422	34.4	24.9	36.7	4.0
	p-value<0.001‡				*p-value<0.001*‡				
Self-assessed oral health									
Good	368	39.4	21.5	39.1	368	44.0	21.7	31.3	3.0
Moderate	579	30.7	26.8	42.5	577	30.5	21.7	44.2	3.6
Poor	301	16.9	20.6	62.5	281	14.9	21.4	61.2	2.5
	p-value<0.001‡				*p-value<0.001*‡				
Reason for dental visit									
Pain/Acute problem	226	25.7	20.4	54.0	225	28.0	20.0	48.0	4.0
Treatment	316	27.5	30.1	42.4	365	32.6	23.8	40.8	2.7
Check-up/Prevention	665	33.5	22.1	44.4	609	31.9	20.5	44.3	3.3
	p-value<0.05‡				*NS*‡				
Toothbrushing frequency									
No/Occasionally	147	20.4	15.0	64.6	138	20.3	21.0	57.2	1.4
Once per day	537	27.9	25.0	47.1	433	26.1	23.6	48.3	2.1
Twice per day	565	34.5	24.8	40.7	654	36.4	20.5	38.8	4.3
	p-value<0.001‡				*p-value<0.001*‡				
Use of dental floss									
No	848	27.0	21.6	51.4	852	27.7	9.7	48.9	3.6
Yes	400	36.5	28.0	35.5	374	38.5	25.9	33.4	2.1
	p-value<0.001†				*p-value<0.001*†				
Smoking									
No	N/A	N/A	N/A	N/A	1117	31.6	21.4	43.8	3.2
Yes	N/A	N/A	N/A	N/A	107	25.2	24.3	47.7	2.8
					NS†				
Total	1252	30.2	23.6	46.2	1227	31.0	21.6	44.3	3.2

**Number of observations may be less than total due to missing data. †Mann-Whitney test. ‡Kruscal-Wallis test. NS: Not Significant*

TABLE 2 Observed periodontal conditions of 12- and 15-year-old Greek adolescents using the Community Periodontal Index (CPI: 0-Healthy, 1-Bleeding, 2-Calculus, 3-Pocket depth≥4mm) according to socio-demographic and behavioural parameters.

	DI-S		
	OR	95% CI	p-value
Gender: Female	1		
Male	1.75	1.33-2.29	<0.001
Parents' education			
Father: University	1		
Father: secondary/Non-university tertiary	0.85	0.58-1.25	NS
Father: Up to lower secondary	1.02	0.65-1.58	NS
Mother: University	1		
Mother: Upper secondary/Non-university tertiary	1.50	1.06-2.13	0.021
Mother: Up to lower secondary	1.81	1.21-2.72	0.004
Self-assessed oral health			
Good	1		
Moderate	1.06	0.81-1.38	NS
Poor	1.56	1.10-2.20	0.013
Reason for dental visit			
Check-up/Prevention	1		
Treatment	1.32	0.98-1.79	NS
Pain/acute problem	1.10	0.82-1.49	NS
Toothbrushing frequency			
Twice per day	1		
Once per day	1.37	1.09-1.71	0.006
No/occasionally	2.21	1.50-3.25	<0.001
Use of dental floss: Yes	1		
No	1.34	1.06-1.70	0.015

TABLE 3 Odds ratios and 95% confidence intervals (C.I) derived from multivariable ordinal logistic regression with simplified Debris Index (DI-S) scores as the dependent variable in 12-year-old Greek adolescents (n=1189).

NS: Not Significant.

	DI-S		
	OR	95% CI	p-value
Area of Residence: Rural	1		
Urban	0.87	0.56-1.35	NS
Gender: Female	1		
Male	1.30	0.99-1.72	NS
Parents' education			
Father: University	1		
Father: Upper secondary/Non-university tertiary	1.05	0.81-1.37	NS
Father: Up to lower secondary	1.18	0.85-1.63	NS
Mother: University	1		
Mother: Upper secondary/Non-university tertiary	1.17	0.85-1.63	NS
Mother: Up to lower secondary	1.24	0.88-1.75	NS
Self-assessed oral health			
Good	1		
Moderate	1.09	0.80-1.48	NS
Poor	1.65	1.10-2.47	0.015
Toothbrushing frequency			
Twice per day	1		
Once per day	1.72	1.30-2.28	<0.001
No/occasionally	3.00	1.80-5.01	<0.001
Use of dental floss: Yes	1		
No	0.91	0.67-1.24	NS
Smoking: No	1		
Yes	0.99	0.63-1.57	NS

TABLE 4 Odds ratios and 95% confidence intervals (C.I) derived from multivariable ordinal logistic regression with simplified Debris Index (DI-S) scores as the dependent variable in 15-year-old Greek adolescents (n=1218).

NS: Not Significant.

of subjects who demonstrated bleeding on probing as the highest CPI score diminished by 43.1% and 28% for the 12- and the 15-year-old adolescents, accordingly. Moreover, calculus deposits were detected less frequently in the 15-year-old age group, but were slightly more frequent among the 12-year-olds in 2014, compared to 2004 (-16.9% and +7.4%, respectively). In contrast to these findings, the percentage of 15-year-olds who presented with periodontal pocketing raised considerably, from 0.2% in the 2004 survey to 3.2% in the 2014 survey (Fig. 2). The reduction in the percentage of adolescents presenting with gingivitis can be attributed to the concomitant optimisation of their oral hygiene behaviours and dental plaque scores; besides, dental plaque is considered as the principal aetiologic factor for periodontal diseases, thus, it is expected to have a

	CPI		
	OR	95% CI	p-value
Gender: Female	1		
Male	1.21	0.97-1.52	NS
Parents' education			
Father: University	1		
Father: Upper secondary/Non-university tertiary	0.80	0.55-1.18	NS
Father: Up to lower secondary	0.88	0.50-1.55	NS
Mother: University	1		
Mother: Upper secondary/Non-university tertiary	1.50	1.09-2.08	0.014
Mother: Up to lower secondary	2.20	1.27-3.82	0.005
Self-assessed oral health			
Good	1		
Moderate	1.14	0.87-1.50	NS
Poor	2.22	1.57-3.13	<0.001
Reason for dental visit			
Check-up/Prevention	1		
Treatment	0.85	0.69-1.06	NS
Pain/acute problem	1.03	0.66-1.61	NS
Toothbrushing frequency			
Twice per day	1		
Once per day	1.09	0.82-1.44	NS
No/occasionally	1.54	1.04-2.28	0.033
Use of dental floss: Yes	1		
No	1.43	1.09-1.88	0.010

TABLE 5 Odds ratios and 95% confidence intervals (C.I) derived from multivariable ordinary logistic regression with Community Periodontal Index scores as the dependent variable in 12-year-old Greek adolescents (n=1190).

NS: Not Significant.

	CPI		
	OR	95% CI	p-value
Area of Residence: Rural	1		
Urban	0.61	0.33-1.14	NS
Gender: Female	1		
Male	1.46	1.18-1.82	<0.001
Parents' education			
Father: University	1		
Father: Upper secondary/Non-university tertiary	1.00	0.69-1.45	NS
Father: Up to lower secondary	1.40	0.92-2.14	NS
Mother: University	1		
Mother: Upper secondary/Non-university tertiary	0.93	0.71-1.22	NS
Mother: Up to lower secondary	1.09	0.72-1.64	NS
Self-assessed oral health			
Good	1		
Moderate	1.54	1.20-1.97	<0.001
Poor	2.53	1.76-3.62	<0.001
Toothbrushing frequency			
Twice per day	1		
Once per day	1.06	0.80-1.42	NS
No/occasionally	1.00	0.62-1.59	NS
Use of dental floss: Yes	1		
No	1.51	1.19-1.92	<0.001

TABLE 6 Odds ratios and 95% confidence intervals (C.I) derived from multivariable ordinal logistic regression with Community Periodontal Index scores as the dependent variable in 15-year-old Greek adolescents (n=1220).

NS: Not Significant.

moderate effect on gingival bleeding [Sfreddo et al., 2019]. As for the increase in the percentage of 15-year-old subjects with periodontal pocketing that was observed, it appears that no straightforward explanation exists; it should be stressed though, that periodontal pocketing during the period of adolescence continues to remain an infrequent finding. Globally, low levels

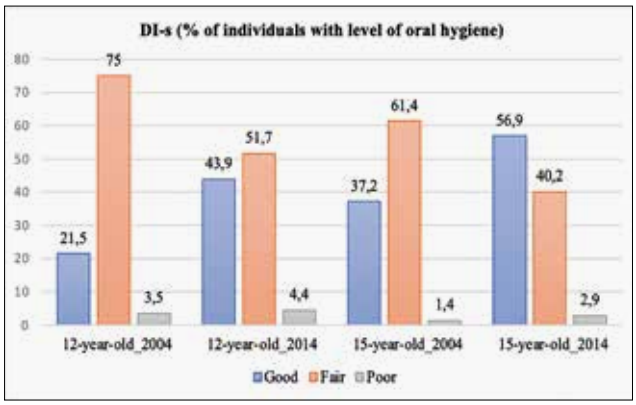


FIG. 1 Oral hygiene level (DI-S) of 12- and 15-year-old Greek adolescents in 2004 (n12=1224, n15=1257) and 2014 (n12=1251, n15=1227).

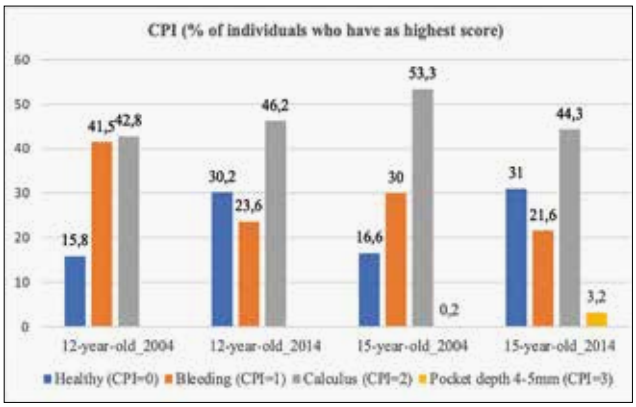


FIG. 2 Periodontal status (CPI scores) of 12- and 15-year-old Greek adolescents in 2004 (n12=1223, n15=1257) and 2014 (n12=1252, n15=1227).

of loss of periodontal bone support and/or loss of probing attachment have been reported among Caucasian Western European adolescent populations (1%-3%) [Albandar and Tinoco., 2001], and the results of the present survey corroborate this trend.

The percentage of 15-year-old Greek adolescents that presented with bleeding on probing, with or without the presence of calculus deposits was estimated to be 47.7%, according to a modification of the original CPI index configuration [World Health Organization, 2013] (data not shown). Compared with other European countries that provided relevant data recently, 15-year-old Greek adolescents appear to have higher levels of gingivitis, as the corresponding percentage for England, Wales and Northern Ireland was estimated to be 40% [Children's Dental Health Survey 2013, 2015a], whereas for Poland was calculated to be 37.4% [Olczak-Kowalczyk et al., 2019]. Considering periodontal pocketing levels, the percentage of 15-year-old Greek adolescents demonstrating at least one tooth with pocket depth ≥4mm (3.2%) was found to be higher than the corresponding percentage of Poland's (2.8%), but lower than England's, Wale's and Northern Ireland's age-mates (4.0%).

Oral hygiene status and periodontal health outcomes in adolescent populations have been linked to various socio-demographic and behavioural factors, such as the gender [Olczak-Kowalczyk et al., 2019; Vadiakas et al., 2012; Paduano et al., 2018; Furuta et al., 2011], the socio-economic status, commonly described by parental income and/or education [Sfreddo et al., 2019; Kumar et al., 2017; Tomazoni et al., 2017; Vadiakas et al., 2012], and the adopted oral hygiene practices, such as the toothbrushing habits [Olczak-Kowalczyk et al., 2019; Vadiakas et al., 2011] and the use of dental floss [Olczak-Kowalczyk et al., 2019]. The results of the present study confirmed the parameters mentioned above, as being significantly associated with the oral hygiene and periodontal health outcomes.

Specifically, in the present survey, 12-year-old males exhibited lower oral hygiene level than females, and furthermore, 15-year-old male adolescents demonstrated worse periodontal conditions than their female age-mates. Relevant studies have consistently reported that young males have a considerably higher probability of presenting with inferior periodontal status than females, this gender difference being mainly attributed to the former showing poorer oral hygiene behaviours, which are influenced by lifestyle, knowledge and attitude [Abe et al., 2020b; Paduano et al., 2018; Furuta et al., 2011]. Indeed, in the present study, regular toothbrushing (twice per day) was reported by 33% of the boys and 52% of the girls aged 12 years, and by 38% of the boys and 65% of the girls aged 15 years (data not shown).

In the present study, the socio-economic status of the 12-year-old adolescents, as described by the mother's education level, was significantly associated with the oral hygiene and the periodontal health outcomes. Specifically, 12-year-old adolescents whose mothers exhibited lower educational attainment presented with worse oral hygiene and periodontal health status. The socio-economic status of the family has been consistently reported to produce robust gradients of periodontal diseases' levels in diverse populations of children and adolescents [Tadakamadla et al., 2020]. Furthermore, reports based on the analysis of longitudinal data proposed that the parental socio-economic level influences the periodontal status of adolescent cohorts primarily through a direct neo-materialistic pathway, but also by determining their oral hygiene status, that acts as mediator [Sfreddo et al., 2019].

The adoption of optimal oral hygiene practices, such as regular toothbrushing, has been associated with a better periodontal health of adolescent populations in several studies [Olczak-Kowalczyk et al., 2019; Children's Dental Health Survey 2013, 2015a; Vadiakas et al., 2011]. In the present study, non-optimal toothbrushing frequency (less than twice per day) was a strong indicator of worse oral hygiene in both age groups. Furthermore, 12-year-olds who did not brush or brushed occasionally, demonstrated worse periodontal status compared to their age-mates who brushed regularly. Also, adolescents who did not use dental floss were significantly more likely to present with increased dental plaque deposits at age 12 and demonstrated lower periodontal heath status at both ages. Dental flossing is generally considered as being a surrogate oral hygiene measure, promoting a lifestyle where oral health is highly prioritised; however, there is evidence indicating that teenagers who use dental floss most likely have been recommended to do so by dental personnel [Wigen and Wang, 2020].

Self-perception of oral health status is a multidimensional construct that includes oral disease, tissue damage, modified functional capacity, pain and aesthetics – psychological and psychosocial components [Banu et al., 2018]. Poor self-rated oral health has been associated with periodontal disease in adult cohorts [Cascaes et al., 2009], with the presence of

fluorotic teeth in adolescent populations [Astrøm and Mashoto, 2002] and untreated decayed teeth in prepubertal children [Banu et al., 2018], and has been reported to affect the well-being and quality of life of individuals [Children's Dental Health Survey 2013, 2015b]. In the present study, approximately one fourth of the adolescents of both ages rated their oral health as 'poor', a proportion which appears to be higher than similar studies' observations [Banu et al., 2018; Children's Dental Health Survey 2013, 2015b]. Furthermore, poor self-rated oral health performed as a significant indicator of the presence of worse oral hygiene and periodontal health status in both age groups. Self-rated oral health has been suggested as being a relatively simple, easy and low-cost method of assessment, which can be routinely collected and has several uses, such as the effective targeting of sub-populations with potentially higher unmet treatments needs, and the monitoring of oral health promotion interventions [Banu et al., 2018].

Conclusions

In conclusion, oral hygiene and periodontal status of Greek adolescents have shown improvement during the decade 2004-2014, however, they cannot be considered as satisfactory, as the majority of the 12- and the 15-year-old teenagers exhibited bleeding on probing or had calculus deposits with or without bleeding. Worse oral hygiene and periodontal health conditions were found among males, 12-year-old adolescents with less educated mothers, those who had not adopted optimal oral hygiene practices and those who rated their oral health as poor. Therefore, community-level periodontal health promotion interventions of the professional bodies and the Ministry of Health should focus on these vulnerable groups to improve their periodontal health throughout their adult lives and potentially reduce future periodontal disease burden. Self-assessed oral health appears to be a promising tool for the identification of sub-groups of adolescents with unmet periodontal treatment needs.

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