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Prevalence of periodontitis in an adult population from an urban area in North Italy: findings from a cross-sectional population-based epidemiological survey.

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Abstract

Aim: There is a paucity of up-to-date data regarding prevalence and risk indicators of periodontitis in Italy. Therefore, the aim of this study was to evaluate the prevalence of periodontitis and its risk indicators among adults from an urban area in North Italy.

Material and Methods: This cross-sectional survey used a stratified two-stage probability sampling method to draw a representative sample of the adult population of the city of Turin. One thousand and six hundred individuals, 20-75 years old, were randomly selected and 736 subjects agreed to participate (47% of the sampled subjects). Clinical parameters were assessed using a full-mouth protocol. Logistic models were applied to assess associations between periodontitis and its putative risk indicators. Age was included as restricted cubic spline.

Results: Based on CDC/AAP case definition, the prevalence estimates of severe and moderate periodontitis were 34.94% (95% CI: 31.23-38.74) and 40.78% (95% CI: 36.89-44.79). The probability of periodontitis increased in smokers (adjusted OR 2.06, 95% IC: 1.26-3.37, p=0.004) and with age but leveled off in the 50+ year-old group (p<0.001).

Conclusion: Periodontitis was highly prevalent in the Turin population. The present data will enable development of appropriate public health programs and allocation of resources.

Clinical relevance

Scientific rationale for study: There is a need for epidemiological data that are representative of the general population from Italy. Most relevant data were at least 20 years ago.

Principal findings: Severe periodontitis was highly prevalent in the Turin adult population using a full-mouth-six-site recording protocol and the CDC/AAP periodontitis case definition.

Practical implications: The actual prevalence of periodontitis may be substantially higher than hitherto reported. Its underestimation is attributable to the use of partial mouth recording protocols and periodontitis case definitions which rely on only periodontal probing depth instead of clinical attachment loss.

Introduction

In Europe public health administrators are not always in a position to estimate the burden of the periodontal diseases and risk factors on the morbidity rates of the population (Bourgeois et al. 2007). This is partly attributable to the scarcity of data from epidemiological studies based on a representative sample of the population (König et al. 2010).

Another aspect to be considered is the lack of agreement in the operational definition of periodontitis and in methodologies of data collection (Kingman & Albandar 2002, Savage et al. 2009, Leroy et al. 2010). Most previously published epidemiological studies have used partial mouth recording protocols and periodontitis case definitions which rely on only periodontal probing depth (PD) instead of clinical attachment loss (CAL) (Sheiham & Netuveli 2002, König et al. 2010, Demmer & Papapanou 2010, Beltrán-Aguilar et al. 2012, Dye 2012). In 2007 the Centers for Disease Control and Prevention and the American Academy of Periodontology (CDC/AAP) recommended the definition by Page & Eke as standard case definitions for severe and moderate periodontitis in population-based epidemiological surveys and the full-mouth examination periodontal protocol as the methodology of data collection. The CDC/AAP definition combines different threshold values of PD and CAL and requires a minimum number of affected sites on separate teeth to diagnose moderate and severe periodontitis (Costa et al. 2009).

To the best of our knowledge, only two epidemiological studies used the CDC/AAP case definition to estimate the prevalence of periodontitis in Europe (Holtfreter at al. 2009, Holtfreter at al. 2010).

Data on the epidemiology and risk factors for periodontitis in the Italian population are scarce. Varying risk factors distributions and access to dental care across populations have certainly also contributed beside different epidemiological methodologies to the overall variability in prevalence estimates (Demmer & Papapanou 2010). The only epidemiological

study on a convenience sample of the Italian population was conducted by Strohmenger et al. (1991). The prevalence of the periodontal disease, recorded by means the Community Periodontal Index of Treatment Needs (CPITN) scoring method on 10 index teeth, amounted to 41% for moderate and to 10% for severe periodontitis.

Thus, the primary aim of the oral survey was to assess the prevalence of periodontitis in an urban adult population from North Italy using the case definition for population-based surveillance of periodontitis (Page & Eke 2007). The secondary aim was to explore periodontitis risk indicators.

Material and Methods

The study was conducted in accordance with the World Medical Association Declaration of Helsinki and was approved by the Research Ethics Committee of the University of Turin (Italy). Individuals who agreed to participate signed informed consent form. At the end of the examination the participants were provided with a written report about their periodontal status. Patients with diagnosed periodontal diseases were advised to seek oral health consultation.

Study design and sampling procedures

A population-based cross-sectional representative epidemiological survey was conducted by the Section of Periodontology, Department of Surgical Sciences, C.I.R. Dental School, University of Turin (Italy) between December 2009 and July 2010. The target population comprised adults, aged between 20 and 75 years, living in Turin (Italy). Turin is one of the biggest industrial and business cities located in Northern Italy. It was inhabited by 910,504 persons at the time of sampling procedures.

To obtain an estimate of severe periodontitis prevalence with a 95% confidence interval (95% CI) with a precision of 2.5% we needed to examine 800 individuals hypothesizing a disease prevalence of 15% as reported in literature (Petersen & Ogawa 2005). Considering a response

rate of 50%, 1600 individuals were randomly selected from the Health Regional Register of Piedmont using a stratified two-stage sampling design. The Health Regional Register collects demographic information of the entire population resident in Turin grouped according to the state-provided general practitioners (GPs) to whom they are assigned. In Italy all residents are covered by the National Health System, assigned a public GP and enrolled in the regional health registries.

The primary sampling units were GPs stratified by the four districts of Turin to ensure a geographic and socioeconomic coverage over the whole of Turin. The probability to be selected was proportional to the number of subjects attending each GP. The second stage units were the subjects cared by each GP, who were sampled using a random sampling technique. Overall 20 GPs were sampled, and 1600 patients were selected and invited to participate in the study through an invitation letter, explaining the purpose of the study and including a trough description of the clinical examination. The invitation letter was accompanied by a structured questionnaire about socio-demographic and lifestyle factors (including educational level and smoking habit) and medical history comprising self-reported diabetes and cardiovascular diseases (coronary hearth disease, infarction, stroke, peripheral arterial diseases). The questionnaire was completed by each subject and collected at the time of periodontal examination.

Severe and moderate periodontitis case definitions

Periodontitis was defined as severe (individuals with ≥2 interproximal sites with CAL ≥6 mm, not on the same tooth and ≥1 interproximal site with PD ≥5 mm) or moderate (individuals with ≥2 interproximal sites with CAL ≥4 mm, not on the same tooth or ≥2 interproximal sites with PD ≥5 mm, not on the same tooth) according to the CDC/AAP case definition (Page & Eke 2007). Subjects with no evidence of severe or moderate periodontitis were defined as having no or mild periodontitis (Page & Eke 2007).

Subjects diagnosed with severe periodontitis were further stratified by extent and characterized as 'localized' (≤ 30% of sites involved) and 'generalized' (> 30% of sites involved) according to Armitage (1999).

Periodontal examination

An experienced and calibrated periodontist clinically examined each subject who accepted to participate to the study. Each clinical examination was performed using a headlight with the individuals seated on a regular chair in the GP's medical office and required on average 45 min. No radiographic examination was made.

All fully erupted teeth, excluding third molars, were examined by means of disposable mirrors and a periodontal probe with 1-mm markings (PCP-UNC 15, Hu-Friedy, Chicago, IL, USA) The following parameters were assessed at six sites per tooth: presence/absence of plaque (PI), presence/absence of bleeding on probing (BoP), PD, gingival recession (REC) and CAL. PD was calculated as distance from the cemento-enamel junction (CEJ) to the bottom of the pocket. REC was defined as the distance from the CEJ to the free gingival margin, and this assessment was assigned a negative sign if the gingival margin was located coronal to the CEJ. CAL was the algebraic sum of PD and REC. The total percentages of sites which revealed PI or BoP were expressed as full mouth plaque score (FMPS) and full mouth bleeding score (FMBS). Tooth mobility and furcation involvement were also recorded.

Measurement reproducibility

The study clinician was trained and calibrated in performing the clinical measurements before the start of the study. A total of 15 subjects were consecutively selected among patients seeking care at the medical office of a GP not involved with the study. They were examined by the study clinician and by the senior member of the Section of Periodontology who served as "reference examiner". The inter-examiner correlation coefficients for mean PD at subject level ranged between 0.88 and 0.95 and between 0.92 and 0.95 for mean CAL. The agreement on the prevalence of sites with PD ≥ 4 mm was also calculated. The weighted kappa statistic

(± 1mm) was 0.87 representing substantial agreement (95% IC 0.82-0.92).

Assessment of intra-examiner reproducibility used replicate measurements on the same patients with an interval of 24 hours between the first and the second recording. The intra-class correlation coefficients values ranged between 0.90 and 0.93 and between 0.92 and 0.99 for PD and CAL, respectively.

Data analysis

When each visit was completed, with the information on periodontal examination, socio-demographic, medical and lifestyle factors, the form was checked for completeness and correctness. The information was entered to feed a computer database specifically prepared for this study.

In order to produce estimates of severe periodontitis (and then moderate periodontitis) prevalence, each age and sex stratum was weighted for the inverse of the probability to be selected using as reference the population in Turin at 01/01/2010 (data from the National Institute of Statistics). We used the STATA survey commands in order to consider the design effect on the periodontitis prevalence.

The distributions of subjects' characteristics were summarized using percentages and frequencies. In order to evaluate differences according to the clinical examination, the chi-square test was used to compare patients periodontally screened and patients who returned the questionnaires but had no periodontal data available.

To obtain robust estimate of the effect on periodontitis of putative risk indicators, we did not distinguish between moderate and severe form of periodontal disease and we consider as dependent variables periodontitis (moderate or severe).

In order to estimate crude and adjusted effect of periodontitis risk indicators logistic regression models were performed. The risk indicators considered were age, gender, education level (categorized in 3 levels: low or primary and secondary school level; intermediate or high school diploma; and high or educational attainment beyond the high

school level), smoking status (as dichotomous) and diabetes mellitus. Subjects were classified for diabetes according to self-reported diabetic status or use of anti-diabetic medication. Age was included both in the univariate and multivariate model as a restricted cubic spline.

As explorative analysis, we performed an additional logistic regression in order to estimate odds ratio (OR) of FMPS (expressed in quartiles) adjusted by gender, age, educational level, smoking status, and diabetes.

Statistical analysis was conducted using the Statistical Package STATA/SE 10.0 (Stata Corp LP, College Station, TX, USA).

Results

The flow chart of the study is presented in the Appendix Figure 1. Among 1600 subjects invited to participate to the study, only 802 returned questionnaires. The overall response rate was 50.12%. Because 58 subjects refused the clinical examination and 8 were edentulous 736 subjects were included in the analysis (47% of the subjects sampled).

Among 802 patients no difference was detected in socio-demographic, general health and behavior variables between individuals with and without periodontal examination as reported in the Appendix Table 1.

Characteristics of the 736 subjects included in the statistical analysis according to the periodontal diagnosis are shown in Table 1.

In the target population, the prevalence estimates of severe and moderate periodontitis were 34.94% (95% CI: 31.23-38.74) and 40.78% (95% CI: 36.89-44.79), respectively. The prevalence estimates of the localized and generalized severe periodontitis amounted to 23.48% (95% CI: 20.35-26.93) and to 11.46% (95% CI: 9.29-14.09), respectively.

The prevalence of severe periodontitis increased with age as reported in Table 2. In the subjects under 30 years it was 6.25% (95% CI: 2.62-14.18) and it increased to 52.63% (95% CI: 45.51-59.65) in the 50-59-year-old group and then leveled off.

The percentage of individuals with moderate periodontitis increased among age strata up to the 30-39-year-old age group (49.14%, 95% CI: 40.15-58.19) and then decreased slightly (50-59-year-old age group 34.21%, 95% CI: 27.80-41.25). For both males and females there was a general pattern of increased prevalence and severity of periodontitis with increasing age. The distributions were similar up to the 40-49 year-old age group, thereafter the severe periodontitis was more prevalent between males than females. In contrast moderate periodontitis affected a higher percentage of females. A similar trend was observed for both localized and generalized severe periodontitis (Table 3).

Pocket depths and attachment loss increased from the incisor to the molar region, as illustrated in Figure 1. Molars had greater mean PD and CAL than premolars that in turn had greater PD and CAL than canines and incisors. Apart from third molars, the first upper molar was the most severely periodontally involved, while, regardless of the reasons for tooth loss, the first lower molar was the most frequently missing (Appendix Figure 2). As was evident in Table 4, the mean number of missing teeth based on a dentition with 28 teeth ranged from 0.65 (95% CI: 0.31-0.99) to 7.38 (95% CI: 6.39-8.36), depending on age cohort.

Table 5 shows crude and adjusted OR_s for putative risk indicators for periodontitis. Smoking habit (Adjusted OR=2.06, 95% IC: 1.26-3.37, p=0.004) and age were risk indicators for periodontitis The probability of periodontitis increased with age but leveled off in the 50+ year-old group ($p<0.001$): the crude and adjusted relationship between age and probability of periodontitis was reported in Figure 2a,b respectively.

We explored the association between FMPS and periodontitis adjusted by gender, age, education level, smoking status, and diabetes: the odds of having periodontitis was greater in patients with high FMPS values than in patients with low FMPS values (Adjusted $OR_{(Intermediate\ vs\ Low)}$= 2.96, 95% CI: 1.72-3.92; Adjusted $OR_{(High\ vs\ Low)}$= 5.47, 95% CI: 2.92-10.27; Adjusted $OR_{(Very\ high\ vs\ Low)}$= 8.68, 95% CI: 4.57-16.48).

Discussion

This is the first population-based representative epidemiological study in Italy. It reported estimates of the prevalence of severe and moderate periodontitis among the 20-75-year-old population in Turin, one of the biggest industrialized cities in the Northern part of the country. The estimates indicated that 39.94% and 40.78% of the population was affected by the severe and moderate form of periodontitis, respectively.

It is important to take into account that the response rate was about 50.12%. Thus, it is unlikely to rule out that patients suffering from periodontitis were overestimated in the examined population. Nevertheless, the sample size calculation accounted for a non-response rate of 50% and no differences were detected between patients with and without periodontal data regarding socio-demographic, lifestyle and medical health factors.

The present findings indicated a higher severity of periodontal destruction than reported in earlier epidemiologic studies from Europe (Sheiham & Netuveli 2002). The current opinion is that the prevalence of periodontitis may be substantially higher than hitherto reported (Papapanou 2012). This may be attributable to underestimation by prior population surveys due to the use of partial examination and classification systems that rely only on PD values (Burt 2005). Utilization of partial recording protocols implicates a biased estimation of disease prevalence and extent (Kingman & Albandar 2002, Kingman et al. 2008). A recent study by Eke et al. (2012) found that partial-mouth probing examinations used in the National Health and Nutrition Examination Surveys (NHANES) underestimates the prevalence of periodontitis in USA by almost 50%.

In the present study periodontal data were collected through a full-mouth six-site examination by one experienced examiner. It is important to point out that periodontal examination was carried out at the GPs' medical office and this might affect the accuracy of measurements. Nevertheless, examiner training and calibration sessions were conducted at the same medical

setting and this might have reduced the magnitude of the measurements errors.

For Europe, only few population-based representative studies reported national or regional estimates of periodontitis based on a full-mouth recording protocol. Prevalence of CAL ≥ 4 mm was 20% among 35-44-year-old adults and 64.8% among 65-74-year old seniors in Denmark (Krustrup & Petersen 2006). In United Kingdom it amounted to 42% and to 85% in the same age cohorts (Morris et al. 2001). In a French study the 75.32% of the 35-64-year-old population had attachment loss ≥4 mm (Bourgeois et al. 2007).

In the present study, due to a lack of universally accepted definition of periodontitis, the CDC/AAP suggested case definition for population-based surveillance of periodontitis was used (Page & Eke 2007). It defined severe and moderate periodontitis using the combination of different thresholds of CAL and PD. It has been emphasized that periodontitis required recording of both PD and CAL, representing current pathology and previous cumulative tissue destruction (Tonetti & Claffey 2005, Savage et al. 2009).

To the best of our knowledge, only two studies from Europe reported epidemiological data according to the CDC/AAP definition (Holtfreter at al. 2009, Holtfreter at al. 2010). The Pomerania study reported an overall prevalence of 17.60% for severe periodontitis and of 33.33% for moderate periodontitis (Holtfreter et al. 2009). In the Germany survey 17.4% of adults (35-44 years) and 41.9% of seniors (65-74 years) had severe periodontitis. In the same age groups the prevalence of moderate periodontitis was 53.5% and 45.5%, respectively (Holtfreter et al. 2010).

When compared with the present data, the prevalence of severe periodontitis ranked lower. It was important to point out that the periodontal parameters were recorded only at two interproximal sites on a maximum of 14 teeth (Holtfreter et al. 2009) and on 12 index teeth (Holtfreter et al. 2010). Interestingly, the CDC/AAP prevalence was calculated with a varying number of sites (Holfreter et al. 2010). Based on distolingual and mesiobuccal sites, prevalence for severe periodontitis was doubled compared with prevalence based on

mesiobuccal sites (7.8% *versus* 17.4% in the 35-44 age group), whereas the prevalence of moderate periodontits remained relatively steady. These differences emphasized the effect of underlying periodontal sites on CDC/AAP prevalence values.

As suggested by Susin et al. (2005) partial mouth recordings might result in a varying degree of bias across different levels of extent and severity of periodontitis and across different age groups. While among adults and seniors the current data were more consistent with those by Holfreter et al. (2009, 2010), greater discrepancies arised when comparing young adults. The prevalence of severe periodontitis among 35-44-year-old age group was 17.4% in Germany compared to 18.10% and 34.59% among 30-39 and 40-49-year-old age groups in the present sample. Most often, only few teeth/sites were severely affected in such age cohorts, while generalized periodontitis occurred seldom.

Another aspect to be addressed is the relevantly high prevalence of both moderate (35.00%) and severe (6.25%) periodontitis in the 20-29 year-old group observed in the current study. It should be underlined that 71% of individuals diagnosed with moderate periodontitis had a maximum of 3 interproximal sites with CAL of 4 to 5 mm mainly due to PD, and all subjects with localized severe periodontitis presented 3 to 5 interdental sites with PD of 5 mm and CAL of 6 mm. It is likely that most of these subjects would not have been identified as moderate or severe periodontitis by using partial-mouth recording protocols.

In the present investigation multivariate logistic regression analysis revealed age and smoking status to be factors significantly associated with periodontitis.

In agreement with data from the literature the prevalence of periodontitis increased with age (Albandar et al. 1999, Bourgeois et al. 2007, Holfreter et al. 2010). The age-specific increase in the prevalence and severity of the periodontitis was attributed to the cumulative effect of periodontal breakdown over time (Albandar 2002, Borrell & Papapanou 2005). A decline in edentulism and a higher retention of teeth in older age cohorts conceivably contribute to an

increase in the prevalence of periodontitis. This is particularly evident when the periodontal damage is expressed in terms of CAL.

It is interesting to underline that the relationship between age and periodontitis was not linear. As evidenced by the observational data and by the cubic restricted spline model the prevalence as well as the probability of periodontitis leveled off in the 50+ year-old groups. These findings are consistent with the pattern of periodontal disease progression described in older subjects by Albandar (1990) and Haas et al. (2012). Reasons remain controversial but as previously reported by Haas et al. (2012) might be associated to the pattern of tooth loss in different age cohorts. It is well established that tooth loss increased with age (Mundt et al. 2007) and may affect the estimates of periodontal disease (Susin et al. 2004). As would be expected, persons with greater amount of attachment loss are more likely to lose teeth over the next years (Beck et al. 1997). Haas et al. (2012) observed that individuals 50+ years old had mean tooth loss of 1.14 ± 0.17 due to CAL progression over a 5-year period compared with 0.53 ± 0.08 among subjects < 30 years old. Thus, although the reasons for tooth loss were not assessed in the current study, tooth loss probably could explain, at least in part, the leveling off in the prevalence of severe periodontitis after the age of 50.

Among behavioral factors, smoking status was strongly associated to periodontitis (adjusted OR 2.06). This finding is consistent with previous studies that reported OR values ranging between 2 and 6 (Bergström & Preber 1994, Kinane et al. 2006, Bergström 2006). It is important to highlight that, in spite of the documented dose-response effect, we did not stratify current smokers according to the daily number of cigarettes smoked (Tomar & Asma 2000) and we did not account for lifetime smoking exposure. This may have introduced an underestimation in the association between smoking and periodontitis.

It is noteworthy that lower educational level was related to increased odds of having periodontitis in the univariate analysis, but not in the multivariate model. The fact that people

with lower education had substantially greater documented periodontal disease has been reported in several epidemiological surveys (Albandar et al. 1999, Krustrup & Petersen 2006, Bourgeois et al. 2007). This influence, however, is confounded by factors such as sociocultural determinants, smoking habit, dental and general health behavior (Albandar 2002, Rathmann et al. 2006, Geyer et al. 2010). People with lower education are more likely to use tobacco and have poor lifestyle. Smokers and diabetics are at higher risk for periodontal diseases (Borrell & Papapanou 2005, Chapple et al. 2013). The present findings support the view that this association is primarily behavioral in nature.

The strengths of the present investigation include the study design, the comprehensive clinical examination, and the periodontitis case definition. These may have minimized the misclassification of periodontal disease. However, it is our opinion that CDC/AAP case definition may induce an overestimation of periodontal treatment needs among young adults.

In fact, considering the high periodontitis prevalence it may be argued the introduction of epidemiologic definitions of periodontitis that allow a differential diagnosis between active disease and past tissue loss.

An important shortcoming of the study is the moderate response rate, which is in line with that previously reported by Holfreter et al. (2010). Moreover, predictors of periodontitis that have been reported in previous studies, such as stress and lifestyle factors (such as alcohol consumption, and physical activity) were not analyzed in this study. Finally, socio-demographic characteristics and attitudes towards oral hygiene of this urban population should be carefully considered when extrapolating the present findings to the other European populations.

In conclusion, the analysis of the overall data collected from this survey demonstrated a high burden of periodontitis in the Turin adult population. The present data will enable proper development of guidelines, allocation of resources and development of appropriate public health programs.

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Table 1. Characteristics of subjects according to the severity of periodontitis

Variables	No/Mild periodontitis N (%)	Moderate Periodontitis N (%)	Severe Periodontitis N (%)	Total N (%)
Gender				
Female	108 (25.06)	179 (41.53)	144 (33.41)	431 (58.56)
Male	60 (19.67)	110 (36.07)	135 (44.26)	305 (41.44)
Age (years)				
20-29	47 (58.75)	28 (35.00)	5 (6.25)	80 (10.87)
30-39	38 (32.76)	57 (49.14)	21 (18.10)	116 (15.76)
40-49	34 (21.38)	70 (44.03)	55 (34.59)	159 (21.60)
50-59	25 (13.16)	65 (34.21)	100 (52.63)	190 (25.82)
60-75	24 (12.57)	69 (36.13)	98 (51.30)	191 (25.95)
Education				
Low	49 (16.07)	120 (39.34)	136 (44.59)	305 (41.44)
Middle	71 (25.00)	111 (39.08)	102 (35.92)	284 (38.59)
High	48 (32.65)	58 (39.46)	41 (27.89)	147 (19.97)
Smoking status				
Non-smoker	141 (25.04)	224 (39.79)	198 (35.17)	563 (76.49)
Smoker	27 (15.61)	65 (37.57)	81 (46.82)	173 (23.51)
Comorbidity				
No	106 (29.28)	149 (41.16)	107(29.56)	362 (49.18)
Yes	62 (16.58)	140 (37.43)	172 (45.99)	374 (50.82)
Cardiovascular diseases				
No	164 (23.50)	271 (38.83)	263 (37.67)	698 (94.84)
Yes	4 (10.53)	18 (47.37)	16 (42.10)	38 (5.16)
Diabetes				
No	164 (23.67)	272 (39.25)	257 (37.08)	693 (94.16)
Yes	4 (9.30)	17 (39.54)	22 (51.16)	43 (5.84)
FMPS (%)				
0-25	54 (56.84)	33 (34.74)	8 (8.42)	95 (12.91)
25-50	65 (27.90)	115 (49.36)	53 (22.74)	233 (31.66)
50-75	26 (15.03)	68 (39.31)	79 (45.66)	173 (23.50)
75-100	23 (9.79)	73 (31.06)	139 (59.15)	235 (31.93)
FMBS (%)				
0-25	101 (43.35)	94 (40.34)	38 (16.31)	233 (31.65)
25-50	46 (17.90)	120 (46.69)	91 (35.41)	257 (34.92)
50-75	15 (10.64)	48 (34.04)	78 (55.32)	141 (19.16)
75-100	6 (5.71)	27 (25.71)	72 (68.58)	105 (14.27)
Total	168 (22.82)	289 (39.27)	279 (37.91)	736 (100)

Comorbidity: occurrence of one or more self-reported systemic disorders including endocrine disorders, blood vascular disorders, orthopedic diseases (arthritis, rheumatoid arthritis), hypertension and allergy; FMPS: full-mouth plaque score; FMBS: full-mouth bleeding score.

Table. 2 Prevalence of periodontitis by age and gender

	Overall		Females		Males	
	Prev	**95% CI**	**Prev**	**95% CI**	**Prev**	**95% CI**
Severe periodontitis (years)						
20-29	6.25	(2.62, 14.18)	2.17	(0.30, 13.94)	11.76	(4.48, 27.50)
30-39	18.10	(12.1, 26.2)	15.58	(9.06, 25.50)	23.08	(12.45, 38.76)
40-49	34.59	(27.6, 42.32)	33.33	(24.75, 43.18)	36.67	(25.49, 49.49)
50-59	52.63	(45.51, 59.65)	46.90	(37.89, 56.13)	61.04	(49.75, 71.26)
60-75	51.31	(44.23, 58.34)	46.88	(37.12, 56.87)	55.79	(45.68, 65.44)
Moderate periodontitis (years)						
20-29	35.00	(25.36, 46.04)	34.78	(22.50, 49.49)	35.29	(21.23, 52.47)
30-39	49.14	(40.15, 58.19)	49.35	(38.37, 60.39)	48.72	(33.61, 64.06)
40-49	44.03	(36.49, 51.84)	42.42	(33.07, 52.35)	46.67	(34.48, 59.26)
50-59	34.21	(27.8, 41.25)	38.94	(30.39, 48.23)	27.27	(18.49, 38.27)
60-75	36.13	(29.61, 43.19)	40.63	(31.27, 50.72)	31.58	(23.03, 41.59)

Table. 3 Prevalence of localized and generalized severe periodontitis by age and gender

	Overall		Females		Males	
	Prev	**95% CI**	**Prev**	**95% CI**	**Prev**	**95% CI**
Localized severe periodontitis (years)						
20-29	5.00	(1.88, 12.60)	2.17	(0.30, 13.94)	8.82	(2.87, 24.09)
30-39	12.07	(7.27, 19.37)	10.39	(5.27, 19.45)	15.38	(7.07, 30.30)
40-49	25.16	(19.01, 32.49)	27.27	(19.40, 36.88)	21.67	(13.33, 86.00)
50-59	32.63	(26.33, 39.63)	27.43	(19.99, 36.39)	40.26	(29.92, 51.55)
60-75	34.55	(28.14, 41.59)	36.46	(27.45, 46.53)	32.63	(23.96, 42.68)
Generalized severe periodontitis (years)						
20-29	1.25	(0.18, 8.37)	0.00		2.94	(0.41, 18.21)
30-39	6.03	(2.90, 12.14)	5.19	(1.96, 13.06)	7.69	(2.50, 21.34)
40-49	9.43	(5.76, 15.07)	6.06	(2.74, 12.86)	15.00	(7.98, 26.42)
50-59	20.00	(14.90, 26.31)	19.47	(13.16, 27.83)	20.78	(13.12, 31.29)
60-75	16.75	(12.09, 22.75)	10.42	(5.69, 18.31)	23.16	(15.75, 32.7)

Table 4. Mean number of missing teeth, based on 28 teeth, by age cohort and gender

Years	Overall		Females		Males	
	Teeth lost	95% CI	Teeth lost	95% CI	Teeth lost	95% CI
20-29	0.65	(0.31, 0.99)	0.72	(0.23, 1.20)	0.56	(0.12, 1.00)
30-39	1.65	(1.21, 2.08)	1.66	(1.13, 2.19)	1.62	(0.87, 2.36)
40-49	3.12	(2.51, 3.73)	2.54	(1.92, 3.15)	4.08	(2.86, 5.31)
50-59	5.39	(4.59, 6.20)	5.93	(4.81, 7.05)	4.61	(3.51, 5.71)
60-75	7.38	(6.39, 8.36)	7.02	(5.74, 8.30)	7.74	(6.24, 9.23)

Table 5. Crude and adjusted effects on periodontitis

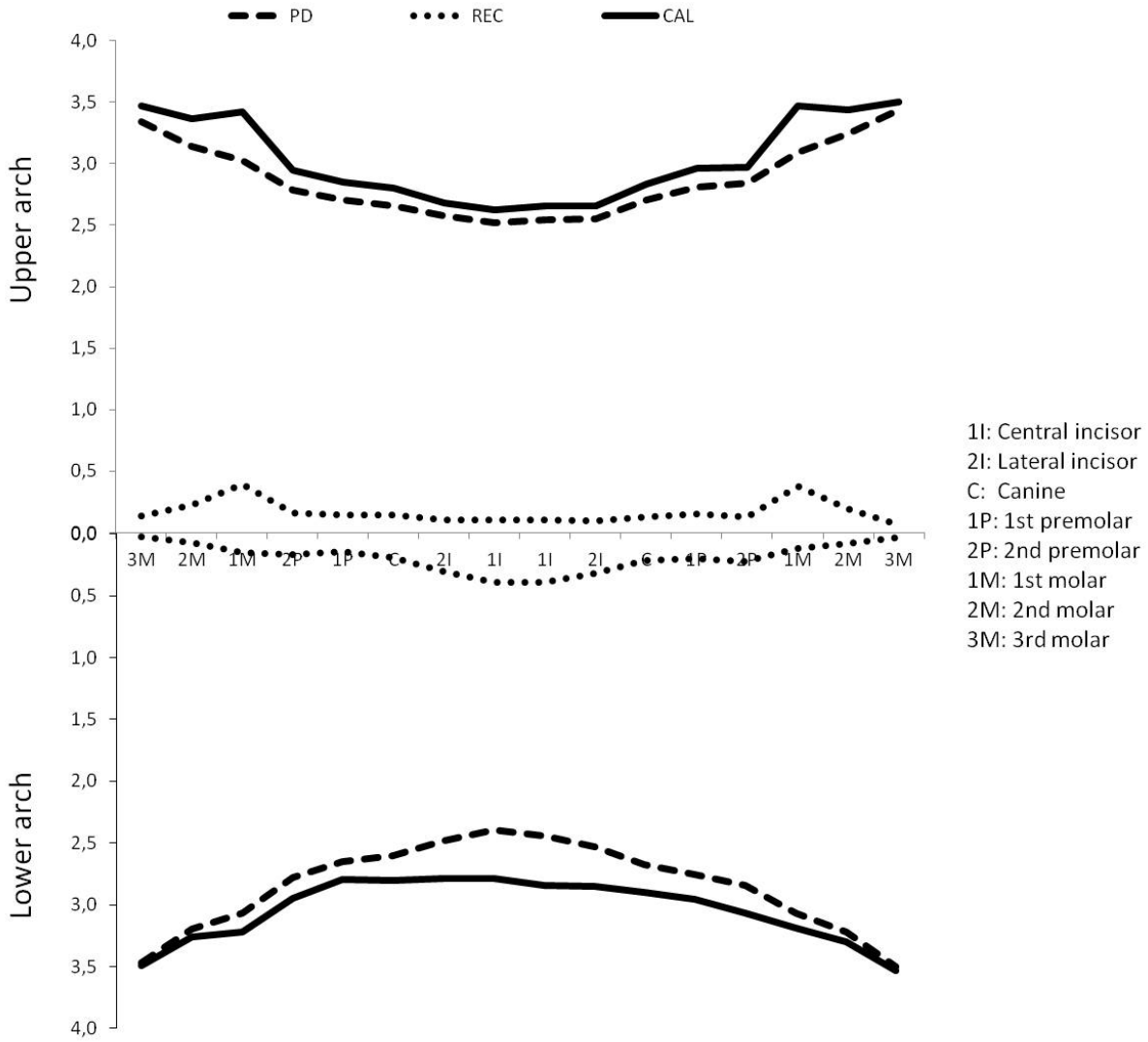
	Crude effect			Adjusted effect		
	OR	95% CI	p-value	OR	95% CI	p-value
Gender						
Female	1.00			1.00		
Male	1.37	(0.95, 1.95)	0.088	1.27	(0.86, 1.87)	0.236
Education						
Low	1.00			1.00		
Middle	0.57	(0.38, 0.86)	0.008	1.03	(0.65, 1.65)	0.890
High	0.39	(0.25, 0.63)	<0.001	0.66	(0.41, 1.07)	0.091
Smoking status						
Non-smoker	1.00			1.00		
Smoker	1.81	(1.14, 2.84)	0.011	2.06	(1.26, 3.37)	0.004
Diabetes mellitus						
Non-diabetic	1.00			1.00		
Diabetic	3.02	(1.06, 8.61)	0.038	2.00	(0.64, 6.24)	0.233

Figure Legends

Fig. 1 Mean PD, REC and CAL of tooth for all subjects in the study (including third molars).

Fig. 2 Relationship between age and probability of periodontitis in univariate (A) and multivariate (B) models.

Fig. 1


PD
REC
CAL
Upper arch
Lower arch
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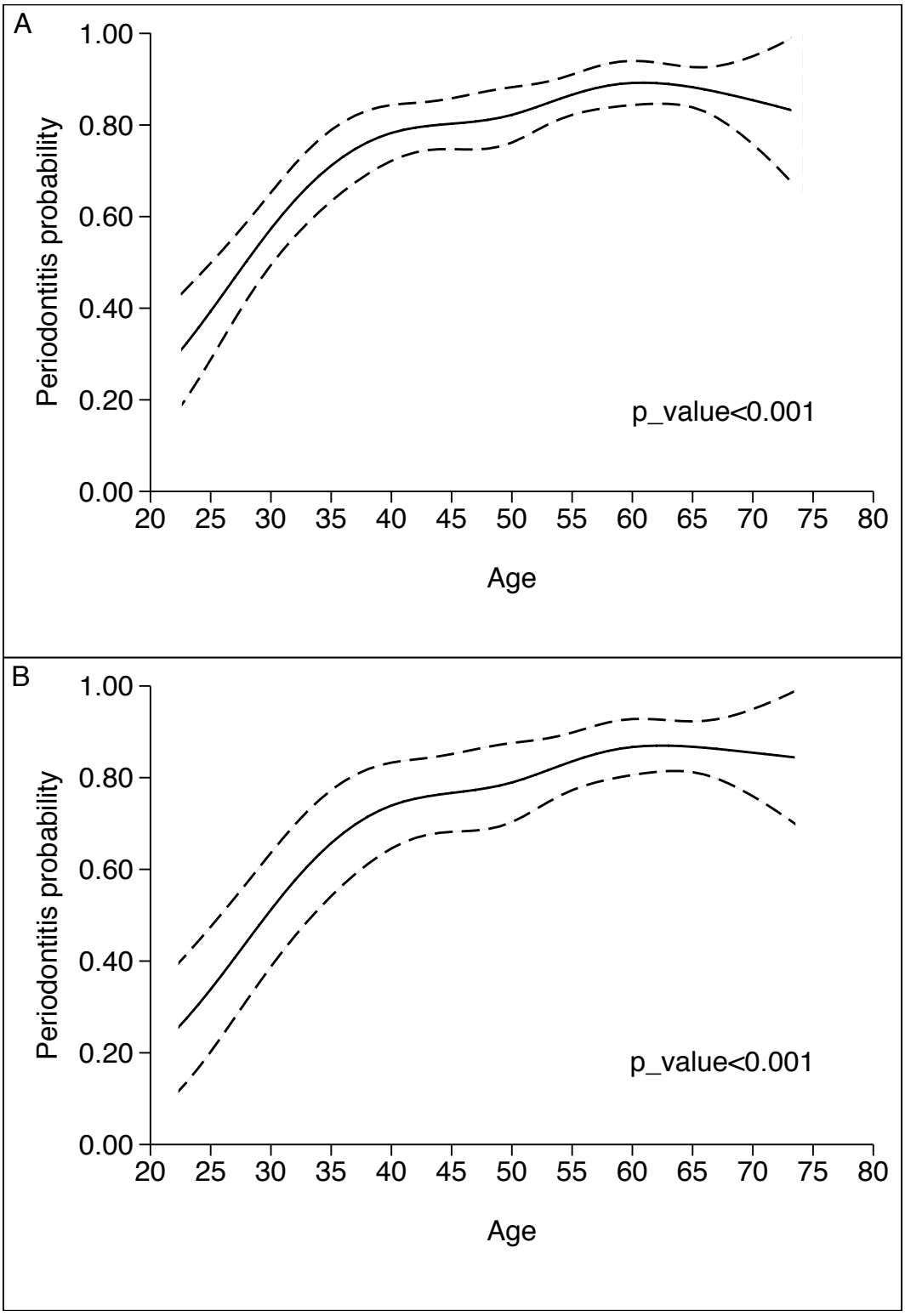
3,0
2,5
2,0
1,5
1,0
0,5
0,0
3M 2M 1M 2P 1P C 2I 1I 1I 2I C 1P 2P 1M 2M 3M
1I: Central incisor
2I: Lateral incisor
C: Canine
1P: 1st premolar
2P: 2nd premolar
1M: 1st molar
2M: 2nd molar
3M: 3rd molar

Fig. 2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0.80
0.60
0.40
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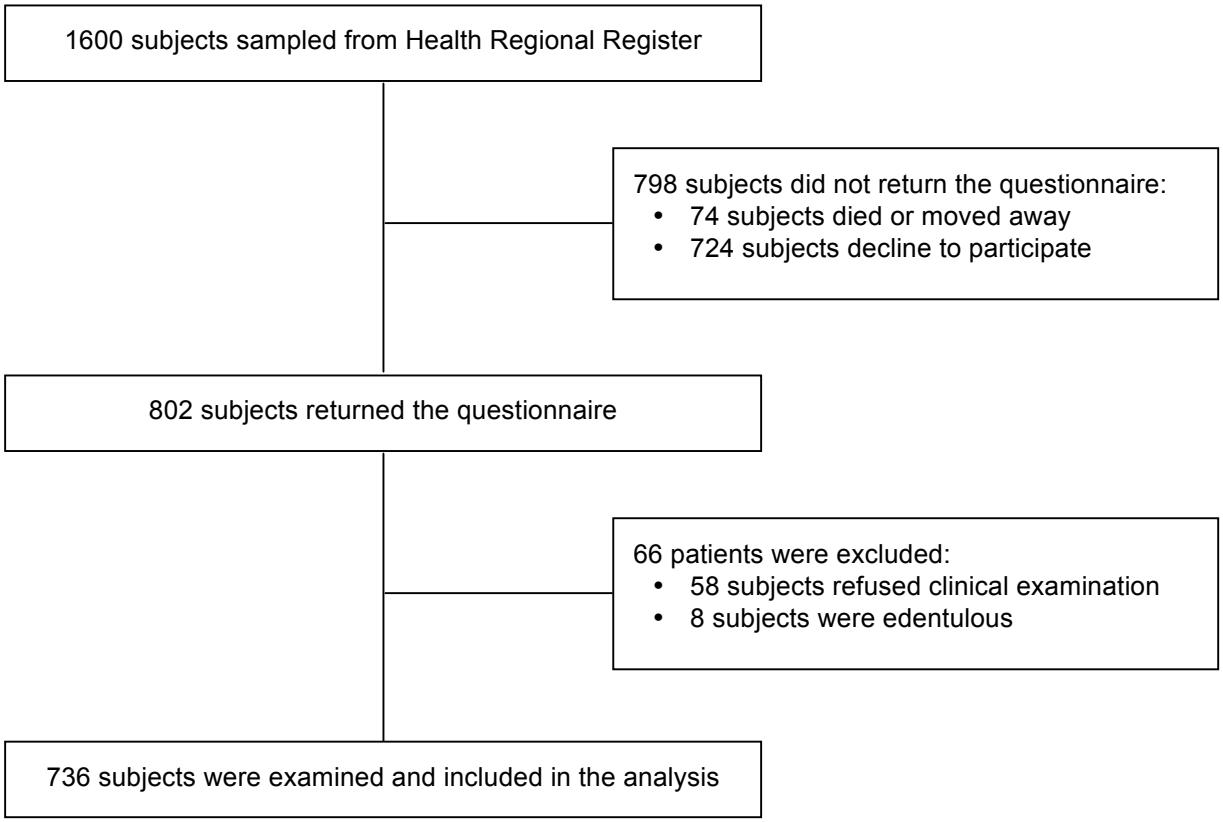
0.00
Periodontitis probability
p_value<0.001
20 25 30 35 40 45 50 55 60 65 70 75 80
Age
B
1.00
0.80
0.60
0.40
0.20
0.00
Periodontitis probability
p_value<0.001
20 25 30 35 40 45 50 55 60 65 70 75 80
Age

Appendix Fig. 1 Flow chart of the study



Appendix Table1. Characteristics of subjects according to periodontal examination

	Subjects with periodontal examination		Subjects without periodontal examination		Total		p-value
	No.	%	No.	%	No.	%	
Gender							0.933
Female	431	58.56	39	59.09	470	58.60	
Male	305	41.44	27	40.91	332	41.40	
Age							0.871
20-29	80	10.87	9	13.63	89	11.10	
30-39	116	15.76	11	16.67	127	15.83	
40-49	159	21.60	13	19.70	172	21.45	
50-59	190	25.82	14	21.21	204	25.44	
60-75	191	25.95	19	28.79	210	26.18	
Education							0.044
Low	305	41.44	17	25.76	322	40.15	
Middle	284	38.59	33	50.00	317	39.53	
High	147	19.97	16	24.24	163	20.32	
Smoking status							0.491
Non-smoker	563	76.49	48	72.73	611	76.18	
Smoker	173	23.51	18	27.27	191	23.82	
Comorbidity							0.285
No	362	49.19	37	56.06	399	49.75	
Yes	374	50.81	29	43.94	403	50.25	
Infarction							
No	719	97.69	65	98.48	784	97.76	0.676
Yes	17	2.31	1	1.52	18	2.24	
Stroke							0.173
No	728	98.91	64	96.97	792	98.75	
Yes	8	1.09	2	3.03	10	1.25	
Cardiovascular diseases							0.179
No	698	94.84	60	90.91	758	94.51	
Yes	38	5.16	6	9.09	44	5.49	
Diabetes							0.044
No	693	94.16	66	100.00	759	94.64	
Yes	43	5.84	0	0.00	43	5.36	
Total	736	100.00	66	100.00	802	100.00	

Comorbidity: occurrence of one or more self-reported systemic disorders including endocrine disorders, blood vascular disorders, orthopedic diseases (arthritis, rheumatoid arthritis), hypertension, and allergy.

Appendix Fig. 2 Distribution of missing teeth for all subjects in the study (including third molars)