

Periodontitis Prevalence and Severity in Adults: A Cross-Sectional Study in Norwegian Circumpolar Communities

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Key findings: Periodontitis affected half of the examined population with a varying distribution across sociodemographic and behavioral variables.

Abstract

Background: The aim of this study was to describe the prevalence, severity and extent of periodontitis in the adult population of circumpolar communities in Norway using data from the study Tromstannen – Oral Health in Northern Norway.

Methods: In this cross-sectional survey, data were collected from a randomized population sample (20-79 years) in Northern Norway. Periodontal conditions were assessed for 1,911 dentate adults with a full-mouth periodontal examination. Probing depth (PD) and bleeding on probing (BoP) were measured at six sites per tooth. Radiographic bone loss (BL) was examined using orthopantomograms.

Results: According to the CDC/AAP case definition, 49.5% of participants had periodontitis and 9.1% had severe periodontitis. Periodontitis prevalence and severity increased with age. The extent of BL and PD \geq 4 mm also increased with age, but more rapidly and to a greater extent for BL. The prevalence of periodontitis was higher among men and varied between urban and rural areas. Periodontitis prevalence was positively associated with smoking, lower levels of education and income.

Conclusions: This study reveals a high burden of periodontitis among adults living in circumpolar communities in Norway. The results showed sociodemographic disparities regarding periodontitis, and highlights the importance of further investigation of factors influencing periodontal health.

Keywords: epidemiology; periodontal diseases; dental health surveys; arctic regions

Introduction

Periodontitis is a common disease among adults; its prevalence is reported by European and US studies to range from 31% to 76%.¹⁻⁶ Severe forms of the disease affect 11% of the global population.⁷ Differences in demographic characteristics and levels of exposure to various risk factors between different populations can partly explain the wide range in the prevalence of periodontal disease, but this variance can also be the result of differences in periodontal examination protocols and case definitions between studies using different measures of periodontitis.⁸⁻¹¹ To enable a comparison between populations, the Joint EU/USA Periodontal Epidemiology Working Group has proposed standards for reporting the prevalence and severity of chronic periodontitis.¹²

Periodontal disease is considered a major public health problem.¹³ It is reported to have a negative impact on oral health-related quality of life and patients' lives, including impairment, functional limitations, discomfort and disability.¹⁴⁻¹⁶ Consequently, it is important to gain knowledge about a population's periodontal conditions, and by collecting reliable and comparable periodontal data, researchers can contribute to global estimates of the burden of periodontitis.⁷

Knowledge about the prevalence of periodontal disease in the general adult population of Norway has been lacking. A nearly 40 years old study (1979) described periodontal conditions in a coastal community in Northern Norway (n=297, aged 20-69 years).¹⁷ Other studies have described periodontal conditions exclusively in age cohorts (35-year-olds) in Oslo between 1973-2003 (n=543) and in a national random sample (n=394) of elderly pensioners.^{18,19} Northern Norway has a history of low dentist-to-patient ratio, and in a national health interview survey of living conditions, it was reported that Northern Norway had the poorest self-reported dental health and the least frequent use of dental health services.²⁰ Additionally, large geographic disparities with respect to tooth loss and denture wearing have been reported in Norway.²¹ There is a need for studies estimating the burden of periodontitis and possible risk factors in the northern part of the country to aid the planning of dental health care services in the region. Furthermore, knowledge of periodontal

conditions in these northern communities could be of interest for other regions with similar living conditions, as there are few studies describing periodontal conditions.^{2, 5, 22-26} Studies of periodontitis prevalence in circumpolar countries provide only national estimates or estimates from regions south of the Arctic Circle,^{2, 5, 22-24} or they focus on indigenous populations.^{25, 26} This is the first epidemiological study in the general adult population of an entire Norwegian county. The aim was to describe the prevalence, severity and extent of periodontitis in circumpolar communities in Norway, according to the recommended standards for presenting chronic periodontitis,¹² as well as to examine differences in the sociodemographic and behavioral characteristics of people with periodontitis.

Materials and methods

Study design and data collection

To describe periodontal conditions, data from a dental health survey in Northern Norway (Tromstannen – Oral Health in Northern Norway, TOHNN) were used.²⁷ The TOHNN study is a population-based cross-sectional representative study, with a target population of adults aged 20-79 years, living in Troms County, Norway. Troms County is one of three Norwegian counties located north of the Arctic Circle. Tromsø, one of the largest cities within the Arctic Circle, surrounded by islands, fjords and mountain peaks, and the gateway to the Polar Seas, is included in the catchment area. In January 2013, 112,253 people in the selected age group inhabited the county. A power calculation, with a 95% confidence interval with a margin of error of 1.5%, indicated that we needed to examine 1,516 individuals to be able to describe the prevalence of severe periodontitis when hypothesizing a 10% prevalence as reported in the literature.⁷ The total sample (n=3,000) was based on a 50% attendance rate experienced in other epidemiological studies in Norway.^{18, 28-30} To obtain a representative selection of all regions in the county, the sample was stratified on three different areas: Tromsø (51,110 people: 46%), Southern Troms County (49,740 people: 44%) and northern Troms County (11,403 people: 10%). 3,000 individuals were randomly selected by simple random

sampling technique from the population register by Statistics Norway, resulting in 1,380 people from Tromsø, 1,320 people from Southern Troms County and 300 people from Northern Troms County.

A total of 2,909 individuals were invited to participate in the study by a letter of invitation. Initial non-responders were contacted with an additional letter. Details of the invitation procedure have been described previously.²⁷ The study included a questionnaire and a clinical dental examination, and was completed by 1,986 (68.3%) participants. The study was approved by the Regional Committees for Medical and Health Research Ethics, Norway (2013/348/REC North). All participants provided written informed consent.

Information on sociodemographic characteristics, behaviors and co-morbidities were collected by self-reported questionnaire. The questionnaire covered questions about self-perceived ethnicity, education, annual household gross income (analyzed in three categories according to the national tertiles of gross household income in 2013), diabetes, tooth-brushing frequency, frequency of dental visits, smoking and Swedish type, low-nitrosamine, smokeless tobacco (snus) use. Smoking was assessed with three questions: 1) "Do you smoke on a daily basis?" 2) "How many cigarettes do you smoke each day?" and 3) "For how many years have you been smoking?". Number of years of past smoking was also registered. Use of snus was assessed with the same questions. Age was stratified in categories 20-34, 35-44, 45-54, 55-64 and 65-79 years. To assess urban-rural disparities, municipalities were categorized into the following three groups: the municipality with the largest city (Tromsø) was classified as urban; two municipalities (Harstad and Lenvik) with smaller towns were classified as suburban; and the remaining municipalities without towns were classified as rural.

Periodontal examinations were performed on all individuals with natural teeth. Twenty-two participants were excluded because of incomplete periodontal examinations, and 51 (2.6%) were identified as edentulous; two participants had only one tooth and were excluded because of case definition criteria of measurements from two or more teeth. This resulted in 1,911 participants with complete periodontal examinations (Figure 1). Examinations were performed in a dental office by 11

calibrated dentists assisted by dental nurses. Bleeding on probing (BoP) and periodontal pocket depth (PD) were assessed at six sites per tooth for all teeth. Third molars and implants were excluded from the analysis. Periodontal pocket depth was measured to the closest millimeter with a periodontal probe with single millimeter graduations.[¶] Orthopantomograms (OPG) were used to assess the radiographic bone level.^{2, 18} Marginal bone levels of both distal and mesial surfaces of all teeth, excluding third molars, were measured linearly with a transparent plastic ruler.³¹ The alveolar bone level was measured in relation to the radiographic apex. The cemento-enamel junction (CEJ), alveolar crest (AC) and radiographically depicted root apex were used as reference points. If the CEJ was destroyed after restorative therapy, the apical margin of the restoration was used as a reference point. The AC was considered the most coronal point at which the periodontal ligament space had a constant width. If the CEJ or AC could not be determined for more than 20% of the teeth, the participant was excluded from the analysis. Bone loss (BL) was considered present at sites in which the distance from the CEJ to the AC exceeded 2 mm and was categorized in 10% intervals as 1-10, as described by Skudutyte-Rysstad et al.²⁷ A modified plaque index was used,³² recording plaque at four sites per tooth as present or not using a mouth mirror and periodontal probe.

Periodontal case definition and periodontal parameters

To estimate of the prevalence and severity of periodontitis, a categorical case definition was necessary. The Joint EU/USA Periodontal Epidemiology Working Group has suggested Centers for Disease Control and Prevention/American Academy of Periodontology (CDC/AAP) case definitions for reporting of periodontitis in epidemiologic studies.¹² These case definitions are based on PD and clinical attachment level (CAL) with the following definitions: Severe periodontitis: ≥ 2 interproximal sites with ≥ 6 mm CAL (not on the same tooth) and ≥ 1 interproximal site(s) with ≥ 5 mm PD; Moderate periodontitis: ≥ 2 interproximal sites with ≥ 4 mm CAL (not on the same tooth) or ≥ 2 interproximal sites with PD ≥ 5 mm (not on the same tooth); and mild periodontitis: ≥ 2 interproximal sites with ≥ 3 mm CAL and ≥ 2 interproximal sites with ≥ 4 mm PD (not on the same tooth) or 1 interproximal site with ≥ 5 mm PPD. In this study, CAL was unknown. To be able to define

periodontitis according to the CDC/AAP case definition in our sample, the relationship between radiographic BL and CAL was inferred from results in a complementary sample. To get a wide range of attachment levels, 8 patients visiting the periodontal clinic at the Public Dental Health Service Competence Centre of Northern Norway were examined, along with 11 patients with no or mild periodontitis (by first author, GEH). PD and CAL were measured clinically on all proximal surfaces (n=786), and proximal bone levels on OPGs were recorded. BL was measured as a proportion of the root, categorized in 10% intervals, 1-10. The CAL was measured in mm indirectly by first measuring the PD (= distance from the gingival margin (GM) to the bottom of the pocket), followed by measuring the distance from the CEJ to the GM. If the GM was coronal to the CEJ, the measurement was given a negative value and subtracted from the PD measurement. To assess the ability of measured radiographic bone loss to predict measured CAL, the following model was tested by linear regression:

$$CAL = \beta_0 + \beta_1 \cdot BL$$

In this formula, β_0 was the intercept and the value for CAL when BL = 0, and β_1 was the difference in CAL for each one-unit difference in BL. The model was statistically significant ($F(1, 786) = 1616.20$, $p < 0.001$) and explained 67% of the variance. All parameters of the model were significant ($p < 0.001$) and estimated as follows:

$$CAL = 2.0 \text{ mm} + 1.3BL$$

Using this model, measured radiographic BL was related to measured CAL with BL categories 0, 1, 2 and 3 corresponding to 2.0, 3.3, 4.6, and 5.9 ($\approx 2, 3, 5$ and 6) mm of CAL, respectively, and could be used to apply the CDC/AAP case definition. Using predicted measures of CAL to apply the CDC/AAP case definition, accurately defined 95% of cases previously defined using direct measures of CAL, with an intraclass correlation coefficient (ICC) of 0.95.

To provide a detailed description of periodontal status, the prevalence and extent (proportion of sites and teeth affected) of threshold values (PD ≥ 4 mm and ≥ 6 mm, and BL $> 0\%$ and $> 10\%$) were

presented. For case definitions, mild and moderate periodontitis were combined into one category, labeled “non-severe” periodontitis.^{5,34} Total periodontitis was defined as the presence of either severe or non-severe periodontitis, reported as “periodontitis”. BoP and plaque index (PI) were presented according to periodontitis severity and age group.

Examiner reliability

The examiners were trained under supervision of a periodontist (NO), prior to data collection to reduce measurement bias. Inter-examiner agreement in PD measurements between the 10 examiners and the periodontist (NO), was assessed at site-level. Congruency was compared to the nearest millimeter. The median ICC of agreement was 0.81 (range: 0.43-0.94). One examiner (GEH) performed all measurements of radiographic BL on OPGs. Test-retest agreement of site-level measurements was assessed on two occasions with two sets of duplicate examinations of 10 OPGs. In the first case, examinations performed at the beginning of the examination period were re-examined after three months, with ICC 0.78. In the second case, a second set of OPGs examined at the end of the examination period were re-examined after one week, with ICC 0.88.

Statistical analysis

Data were analyzed using statistical software.[¶] Demographic and socioeconomic characteristics are presented as means (standard deviation, SD) or numbers (proportions) for the total study population stratified by age. Differences in background characteristics between age groups were assessed with Pearson χ^2 test or one-way analysis of variance (ANOVA). Radiographic BL and PD are presented as means (standard error, SE) and proportions (SE) of affected sites and teeth per mouth for the total study population and by age group. PD is presented using measurements from all six sites per tooth. Tests of linear trend across age groups of BL and PD were estimated using linear regression models for continuous variables and logistic regression for binary variables. The prevalence of periodontitis is presented as proportions (SE). Overall estimates of total, severe and non-severe periodontitis were standardized to the age distribution of the 2013 Troms County population. The group with the lowest

prevalence of periodontitis served as a referent group within each category, and the absolute difference from this group in percentage points was calculated. Differences between groups were assessed with z-tests, with a significance level set at 0.05. Additionally, BoP and PI are presented as means (SD) for the total study population and for subpopulations stratified by severity of periodontal disease according to the CDC/AAP case definition. The Lorenz curve was created with a spreadsheet software[#] and used to describe the distribution of PD \geq 4 mm in the population,³⁵ as the cumulative proportion of total population is plotted against the cumulative proportion of PD \geq 4 mm. A straight diagonal line would depict perfect equality, where every person would have the same number of PD \geq 4 mm. The extent to which the curve sags below the straight diagonal line indicates the degree of inequality of distribution. The Gini coefficient represents the area between the line of equality (diagonal) and the Lorenz curve, calculated using the Riemann sum estimate (middle sum). The higher the Gini coefficient, the more unequal the distribution is.

Results

Study population

The mean age was 47.3 (\pm 15.3) years, and 51% were women (Table 1). About 45% of participants resided in urban areas and 42% reported having a university level education. Approximately 20% of the examined population was categorized in the highest income group. The prevalence of diabetes was 3.8%. For oral hygiene habits, the majority reported brushing their teeth \geq 2 times per day. Fifteen percent were current smokers. The mean number of teeth present was 25.0. Fifty-two participants (2.7%) reported ethnicities other than Norwegian.

Radiographic bone level and periodontal probing depth

In Table 2, the prevalence and extent of radiographic BL and PD are presented by selected thresholds. Prevalence of radiographic BL spiked from the age of 35 years, reaching almost 100% in the 65-79-year-old age group. The extent of BL also increased rapidly with age. Prevalence of PD \geq 4 mm was high across all age groups. The extent of PD \geq 4 mm increased with age, but to a lesser

degree than BL. Figure 2 presents the distribution of PD \geq 4 mm in the population stratified by age group. The number of sites with PD \geq 4 mm was unequally distributed in the population for all age groups. While more than four in five 65-79-year-olds had some sites with PD \geq 4 mm, the majority (80%) of all sites with PD \geq 4 mm was found in the top 20% of the age group. Disparities in the distribution of sites with PD \geq 4 mm increased with decreasing age; the top 20% of 20-34-year-olds accounted for 94% of all sites with PD \geq 4 mm.

Prevalence and severity of periodontal disease

The estimated prevalence and distribution of periodontitis by age and gender, as well as socioeconomic status, oral health-related behaviors and tobacco use are presented in Table 3. According to the CDC/AAP case definition,¹¹ the prevalence of total periodontitis was estimated to be 49.5% (SE \pm 1.1%), with 9.1% severe periodontitis and 40.4% non-severe periodontitis (mild and moderate periodontitis combined). The prevalence of periodontitis increased with age; in the oldest age group, it was five times higher than in the youngest age group. Periodontitis was more prevalent among men (56.7%) than women (42.6%). When comparing the prevalence of periodontitis in urban and rural municipalities, there was a higher prevalence in suburban and rural municipalities than in urban areas. In addition, prevalence increased with lower education and income and current smoking habit. Prevalence of severe periodontitis was highest in the 65-79 year age group and in current smokers (Table 3).

Bleeding on probing and plaque index

Mean BoP was 30.0% and this was consistent across age groups (Table 4). BoP increased with level of severity of periodontitis, with a mean of 25.4% for persons with no periodontitis, 33.2% for persons with non-severe periodontitis and 41.7% for persons with severe periodontitis. Stratified by severity of periodontitis, BoP varied more across age groups. The mean PI was 44.2%, and increased with the severity of periodontitis and age.

Discussion

The results suggested that half of adults in the target population had periodontitis; approximately four of 10 had non-severe periodontitis, and only one of 10 had severe periodontitis. That severity and extent of the disease increased with age was expected, as periodontitis often is seen as a chronic disease and cumulative over time.³⁶ Prevalence of periodontitis was highest among people with lower education and current smoking habit.

The majority of the study population was healthy, educated and reported making regular dental visits and practicing good oral hygiene. The participants had a high educational level; 42% had university level education compared with nationwide 35%.³⁷ Educational level was highest in the largest municipality,²⁷ where the Arctic University of Norway and University Hospital of North Norway is located, contribution to the high number of persons with university level education. The proportion of persons with university level education in sub-urban and rural municipalities was equivalent to the national average.²⁷ Smoking and diabetes had the same rates as the national averages and estimates, with 15% and 4%, respectively.^{38, 39}

Periodontitis in Europe and USA

Comparing the findings in this study with previous findings in Norway is not straightforward because different measures of periodontitis have been used. The prevalence of PD ≥ 6 mm (Table 2) was in the range of the results from the Oslo study in comparable age groups (8%),¹⁸ while the prevalence of BL was considerably higher in the present study than among 35-year-olds in Oslo in 2003 (24%). In the study of Norwegian elderly pensioners (≥ 67 years), the prevalence of ≥ 1 tooth PD ≥ 6 mm was reported to be 33%,¹⁹ consistent with the results in the current study for the same age group. Conversely, the prevalence of severe periodontitis was only half of what was found in the current study. One explanation could be the case definition used for severe periodontitis (≥ 3 periodontal pockets ≥ 6 mm) by Norderyd and colleagues in 2012 and possibly the partial-mouth recording (one site per tooth), which could have provided biased estimates of periodontitis.^{19, 40-42}

Our findings were comparable with the prevalence reported in a Swedish study: 39% for periodontitis of any severity and 11% for severe periodontitis.² However, a different case definition for periodontitis was used, and direct comparison should be made with caution. In comparison with studies applying the CDC/AAP case definition, the prevalence of periodontitis in this study concurred with the prevalence reported for US adults: 46% for periodontitis of any severity and 9% for severe periodontitis.⁵ The prevalence reported in German and Italian studies evaluating periodontitis with the CDC/AAP case definition was considerably higher. For German adults (35-44 years), prevalence of periodontitis and severe periodontitis were reported to be 71% and 17%, respectively.⁴ For adults aged 20-75 years in Northern Italy, estimated prevalences of periodontitis and severe periodontitis was 76% and 35%, respectively.⁶ These discrepancies between studies could partly be explained by differences in the underlying characteristics of the study populations. There was a larger proportion of current and former smokers in the German and Italian studies compared with the present study,^{4, 6} and the proportions of people with middle and high levels of education were greater in the present study compared with other countries.

Differences in periodontal health

The present study showed differences in the population regarding the distribution of periodontitis, which was in accordance with other reported data.^{4, 5, 43} These discrepancies could be explained by differences in oral health-related behavior, in access to dental health care and norms for seeking treatment. However, in bivariate analysis, persons making annual dental visits did not have less periodontitis than persons with less frequent dental visits; rather, it was the opposite. This could be a result of neglected important aspects of prevention dentistry, under-treatment or under-diagnosis or that people categorized with yearly dental visits also include those undergoing treatment, e.g. periodontal treatment.

The most notable differences in periodontitis was across age groups, with more than 80% of persons ≥ 65 years old affected (Table 4). Although a large number of seniors had periodontitis, the burden of PD ≥ 4 mm was not equally distributed in the population (Figure 2). A small proportion of

the senior population accounted for the majority of PD ≥ 4 mm, meaning that there was a subgroup of seniors with more extensive periodontitis. The number of natural teeth in seniors is increasing.⁴⁴ Based on an estimate that every fifth person in Norway will be at least 70 years old in 2060,⁴⁵ it is important for dental health care services to be capable of detecting individuals with periodontitis at an early stage and for preventive measures to be implemented. Clinicians should be trained in and adopt methods that have been reported to be effective in improving oral health-related behaviors,⁴⁶⁻⁴⁸ and the role of dental hygienists and dentists with special knowledge of prevention and oral health promotion should be emphasized in all parts of the country.

Strengths and limitations

There were some limitations to note. Only slightly more than half (57.3%) of adults ≥ 65 years old responded, which could have caused biased results for this age group. The most common reasons for not participating were health issues in combination with travel difficulties and no subjective need or interest in participating (e.g., wearing dentures).²⁷ Additionally, more men than women ≥ 65 years old participated, which might have resulted in overestimation of periodontitis prevalence for men.

The indirect approach to CAL by predicting CAL from BL could have led to errors in case definitions and possible underestimation of periodontitis. Variance in the ability of BL to predict CAL increased with increasing values of CAL. However, the use of threshold values of CAL ≥ 4 and ≥ 6 mm to define cases, minimized errors of high measures of CAL. Finally, geographical disparities, including the low periodontist-to-patient ratio in Northern Norway, different living conditions, culture and attitudes towards health, should be considered when extrapolating estimates to other regions and countries.

The study also had several strengths, including the high participation rate and full-mouth examination protocol. Furthermore, to the best of our knowledge, this was the first study to apply the recommended standards for reporting chronic periodontitis, enabling future comparisons across studies and contributing to the understanding of the global burden of periodontitis.

Conclusions

In conclusion, this study reveals a high burden of periodontitis in circumpolar communities in Norway, with half the adult population affected. Sociodemographic disparities regarding periodontitis was shown, highlighting the importance of further investigation of factors influencing periodontal health. The results from this study contributes new knowledge and will be valuable in planning dental health care and population-based preventive actions.

Footnotes

|| UNC 15, American Eagle Instruments, Inc., Missoula, MT.

¶ SPSS, Version 24.0, IBM, Armonk, NY.

Excel 2013 for Windows, Microsoft, Redmond, WA.

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Figure legends

Figure 1. Flow chart of study participants, presented in numbers.

Figure 2. Proportional distribution of sites with $PD \geq 4$ mm in different age groups. Each point of the curves denotes the proportion of the population (x-axis) responsible for the proportion of the total burden of $PD \geq 4$ mm (y-axis) in respective age groups. E.g. in 65-79-year-olds the top 20% of the population accounted for 80% of the total burden of $PD \geq 4$ mm, while in 20-34-year-olds the top 20% of the population accounted for 94% of the total burden of $PD \geq 4$ mm.

Table 1. Characteristics of Study Participants with Periodontal Examination (N = 1,911) Stratified by Age and in Total.

Characteristics	Age groups, years					p value*	Total
	20-34	35-44	45-54	55-64	65-79		
Number of participants	461	385	392	373	300		1,911
Proportion of target population, %	1.5	1.7	1.8	1.9	1.6		1.7
Male gender, n (%)	203 (44.0)	187 (48.6)	190 (48.5)	194 (52.0)	162 (54.0)	0.062	936 (49.0)
Ethnicity, n (%)						0.780	
Norwegian	445 (96.5)	377 (98.2)	379 (96.7)	364 (97.6)	292 (97.7)		1,857 (97.3)
Sámi	7 (1.5)	3 (0.8)	5 (1.3)	6 (1.6)	3 (1.0)		24 (1.3)
Other	9 (2.0)	4 (1.0)	8 (2.0)	3 (0.8)	4 (1.3)		28 (1.5)
Education, n (%)						<0.001	
University level	190 (41.4)	222 (58.0)	171 (43.8)	133 (36.2)	79 (26.8)		795 (42.0)
High school	245 (53.4)	141 (36.8)	168 (43.1)	165 (45.0)	107 (36.3)		826 (43.6)
Secondary school	24 (5.2)	20 (5.2)	51 (13.1)	69 (18.8)	109 (36.9)		273 (14.4)
Household income‡, n (%)						<0.001	
≥105,499 USD	69 (15.8)	122 (32.4)	101 (26.1)	65 (18.0)	13 (4.7)		370 (20.1)
52,750-105,498 USD	179 (41.1)	194 (51.5)	208 (53.7)	214 (59.3)	114 (41.3)		909 (49.5)
<52,750 USD	188 (43.1)	61 (16.2)	78 (20.2)	82 (22.7)	149 (54.0)		558 (30.4)
Demographic status, n (%)						<0.001	
Urban	226 (49.0)	194 (50.4)	187 (47.7)	142 (38.1)	117 (39.0)		866 (45.3)
Suburban	133 (28.9)	108 (28.1)	129 (32.9)	134 (35.9)	88 (29.3)		592 (31.0)
Rural	102 (22.1)	83 (21.6)	76 (19.4)	97 (26.0)	95 (31.7)		453 (23.7)
Tooth brushing frequency, n (%)						<0.001	
≥2 times/day	314 (68.9)	279 (73.0)	301 (77.0)	282 (77.0)	182 (62.1)		1,358 (71.9)
1 time/day	121 (26.5)	92 (24.1)	81 (20.7)	77 (21.0)	87 (29.7)		458 (24.3)
<1 time/day	21 (4.6)	11 (2.9)	9 (2.3)	7 (1.9)	24 (8.2)		72 (3.8)
Frequency of dental visit, n (%)						<0.001	
Yearly	145 (31.5)	183 (48.2)	232 (59.2)	249 (67.3)	196 (66.2)		1,005 (53.0)
Every other year	85 (18.2)	61 (16.1)	53 (13.5)	36 (9.7)	20 (6.8)		255 (13.4)
Less often	81 (17.6)	47 (12.4)	34 (8.7)	28 (7.6)	24 (8.1)		214 (11.3)
Only for acute problems	149 (32.4)	89 (23.4)	73 (18.6)	57 (15.4)	56 (18.9)		424 (22.3)
Smoking status, n (%)						0.003	
Never smoker	402 (87.6)	309 (81.3)	311 (79.7)	291 (78.4)	259 (86.9)		1,572 (82.8)
Former smoker	10 (2.2)	9 (2.4)	6 (1.5)	10 (2.7)	8 (2.7)		43 (2.3)
Current smoker	47 (10.2)	62 (16.3)	73 (18.7)	70 (18.9)	31 (10.4)		283 (14.9)

Smokeless tobacco use‡, n (%)						<0.001	
Never user	321 (69.8)	324 (85.3)	353 (90.5)	343 (93.0)	291 (99.3)		1,632 (86.3)
Former user	4 (0.9)	4 (1.1)	3 (0.8)	0 (0)	0 (0)		11 (0.6)
Current user	135 (29.3)	52 (13.7)	34 (8.7)	26 (7.0)	2 (0.7)		249 (13.2)
Diabetes mellitus, n (%)	3 (0.7)	5 (1.3)	10 (2.6)	20 (5.4)	34 (11.8)	<0.001	72 (3.8)
Tooth count in dentate (28), mean (SD)	27.2 (1.6)	26.9 (1.7)	26.1 (2.3)	24.0 (4.6)	19.1 (7.0)	<0.001†	25.0 (4.7)

Data are presented as means (standard deviation, SD) or as numbers with percentages given in parentheses.

* *P*-value for differences between groups using the χ^2 test or one-way ANOVA†.

‡ Average household income in Norway for 2013: 85,665 USD

§ Swedish type low-nitrosamine smokeless tobacco

Table 2. Prevalence and Extent of BL and PD and Overall Mean BL and PD by Age Group and in Total.

Measure of periodontitis	Age groups, years					P for trend*	Total
	20-34	35-44	45-54	55-64	65-79		
Bone loss (BL), % (SE)							
Prevalence							
BL >0%	28.0 (2.1)	68.1 (2.4)	84.7 (1.8)	97.1 (0.9)	99.3 (0.5)	<0.001	72.4 (1.0)
BL >10%	4.8 (1.0)	20.3 (2.1)	35.5 (2.4)	66.2 (2.5)	78.3 (2.4)	<0.001	37.7 (1.1)
Bone loss (BL), mean (SE)							
Proportion of sites/mouth (%)							
BL >0%	1.7 (0.2)	7.3 (0.6)	18.8 (1.1)	38.5 (1.5)	52.7 (1.6)	<0.001	21.5 (0.6)
BL >10%	0.2 (0.04)	0.8 (0.1)	3.8 (0.5)	10.8 (1.0)	17.8 (1.3)	<0.001	5.9 (0.3)
Proportion of teeth/mouth (%)							
BL >0%	2.9 (0.04)	11.1 (0.8)	25.1 (1.3)	48.1 (1.5)	63.0 (1.6)	<0.001	27.4 (0.7)
BL >10%	0.3 (0.1)	1.4 (0.2)	5.4 (0.7)	14.6 (1.1)	23.6 (1.5)	<0.001	8.0 (0.4)
Mean BL (%)	0.2 (0.03)	0.8 (0.07)	2.5 (0.20)	5.8 (0.34)	8.8 (0.50)	<0.001	3.2 (0.13)
Probing depth (PD), % (SE)							
Prevalence							
PD ≥4 mm	54.9 (2.3)	65.7 (2.4)	71.4 (2.3)	80.2 (2.1)	81.0 (2.3)	<0.001	69.5 (1.1)
PD ≥6 mm	5.9 (1.1)	12.7 (1.7)	17.6 (1.9)	30.6 (2.4)	33.0 (2.7)	<0.001	18.7 (0.9)
Probing depth (PD), mean (SE)							
Proportion of sites/mouth (%)							
PD ≥4 mm	2.9 (0.3)	4.2 (0.4)	6.1 (0.5)	9.3 (0.7)	10.3 (0.8)	<0.001	6.2 (0.2)
PD ≥6 mm	0.1 (0.1)	0.3 (0.1)	0.7 (0.2)	1.1 (0.2)	1.3 (0.2)	<0.001	0.6 (0.1)
Proportion of teeth/mouth (%)							
PD ≥4 mm	10.0 (0.8)	14.3 (1.0)	18.0 (1.1)	25.4 (1.4)	27.4 (1.6)	<0.001	18.3 (0.5)
PD ≥6 mm	0.5 (0.2)	1.1 (0.2)	2.4 (0.4)	4.0 (0.5)	4.2 (0.5)	<0.001	2.3 (0.2)
Mean PD (mm)	2.0 (0.02)	2.1 (0.02)	2.1 (0.02)	2.2 (0.03)	2.3 (0.04)	<0.001	2.1 (0.01)

Values are given as means or percentages with standard error in parentheses.

Bone loss (BL) of >0% and >10% relating to degree of clinical attachment loss (AL) ≥3 and ≥5 mm, respectively

* P-value for linear trend across age groups

Table 3. Distribution of Participants Classified According to the CDC/AAP Case Definition by Sociodemographic, Behavioural and Co-morbidity Variables; Proportions

Characteristics	Periodontitis (CDC/AAP Case Definition) ¹¹									
	n	Non-severe			Severe			Total		
		%	(SE)	Absolute difference (pp)	%	(SE)	Absolute difference (pp)	%	(SE)	Absolute difference (pp)
Total	1,911	40.4	(1.1)		9.1	(0.7)		49.5	(1.1)	
Total, Age standardized*		39.2	(1.1)		8.8	(0.6)		48.2	(1.1)	
Age group (yrs.)										
20-34	461	15.8	(1.7)	Ref. _a	0.2	(0.2)	Ref. _a	16.1	(1.7)	Ref. _a
35-44	385	33.0	(2.4)	17.2 _b	1.6	(0.6)	1.4 _a	34.6	(2.4)	18.5 _b
45-54	392	46.4	(2.5)	30.6 _c	7.4	(1.3)	7.2 _b	53.8	(2.5)	37.7 _c
54-64	373	57.9	(2.6)	42.1 _d	18.0	(2.0)	17.8 _c	75.9	(2.2)	59.8 _d
65-79	300	57.7	(2.9)	41.9 _d	23.7	(2.5)	23.5 _c	81.3	(2.3)	65.2 _d
Gender										
Female	975	35.7	(1.5)	Ref. _a	6.9	(0.8)	Ref. _a	42.6	(1.6)	Ref. _a
Male	936	45.2	(1.6)	9.5 _b	11.4	(1.0)	4.5 _b	56.7	(1.6)	14.1 _b
Ethnicity										
Norwegian	1,857	40.3	(1.1)	7.0 _a	9.0	(0.7)	4.8 _a	49.4	(1.2)	11.9 _a
Sámi	24	33.3	(9.8)	Ref. _a	4.2	(4.2)	Ref. _a	37.5	(10.1)	Ref. _a
Other	28	46.4	(9.6)	13.1 _a	14.3	(6.7)	10.1 _a	60.7	(9.4)	23.2 _a
Education										
University	795	35.2	(0.7)	Ref. _a	4.7	(0.7)	Ref. _a	39.9	(1.7)	Ref. _a
High School	826	41.8	(1.1)	8.3 _b	10.4	(1.1)	5.7 _b	52.2	(1.7)	12.3 _b
Secondary School	273	50.6	(2.3)	6.2 _c	17.6	(2.3)	12.9 _c	68.1	(2.8)	28.2 _c
Annual household income†										
≥105,499 USD	370	34.3	(2.5)	Ref. _a	4.6	(1.1)	Ref. _a	38.9	(2.5)	Ref. _a

52,750- 105,498 USD	909	42.6	(1.6)	8.3 _b	8.1	(0.9)	3.5 _a	50.7	(1.7)	11.8 _b
<52,750 USD	558	40.5	(2.1)	6.2 _{a,b}	14.0	(1.5)	9.4 _b	54.5	(2.1)	15.6 _b
Demographic status										
Urban	866	34.0	(1.6)	Ref. _a	8.0	(0.9)	Ref. _a	41.9	(1.7)	Ref. _a
Suburban	592	46.1	(2.1)	12.1 _b	10.3	(1.3)	2.3 _a	56.4	(2.0)	14.5 _b
Rural	453	45.0	(2.3)	11.0 _b	9.7	(1.4)	1.7 _a	54.8	(2.3)	12.9 _b
Frequency of dental visits										
Yearly	1,005	46.2	(1.6)	20.3 _b	9.8	(0.9)	2.9 _a	55.9	(1.6)	24.1 _b
Every other year	255	25.9	(2.7)	Ref. _a	6.9	(1.5)	Ref. _a	31.8	(2.9)	Ref. _a
Less often	214	29.4	(3.1)	3.5 _a	8.9	(1.9)	2.0 _a	38.3	(3.3)	6.5 _a
Only for acute problems	424	40.6	(2.4)	11.2 _b	9.7	(1.4)	2.8 _a	50.2	(2.4)	18.4 _b
Smoking status										
Never smoker	1,572	37.9	(1.2)	Ref. _a	7.4	(0.7)	Ref. _a	45.4	(1.3)	Ref. _a
Former smoker	43	46.5	(7.7)	8.6 _{a,b}	11.6	(4.9)	4.2 _{a,b}	58.1	(7.6)	12.7 _{a,b}
Current smoker	283	51.6	(3.0)	13.7 _b	18.4	(2.3)	11.0 _b	70.0	(2.7)	24.6 _b
Smokeless tobacco use [‡]										
Never user	1,632	42.0	(1.2)	23.8 _a	9.6	(0.7)	4.4 _a	51.6	(1.2)	24.3 _a
Former user	11	18.2	(12.2)	Ref. _{a,b}	9.1	(9.1)	3.9 _a	27.3	(14.1)	Ref. _{a,b}
Current user	249	28.1	(2.9)	9.9 _b	5.2	(1.4)	Ref. _a	33.3	(3.0)	6.0 _b

Differences between groups were assessed with z-test. Different subscript letters denotes significant differences in periodontitis prevalence between characteristics at the 0.05 level.

* Standardized to age distribution of the 2013 Troms County population.

† Average household income in Norway for 2013: 85,665 USD

‡ Swedish type low-nitrosamine smokeless tobacco

Table 4. Bleeding on Probing (BoP) and Plaque Score by Severity of Periodontitis Stratified by Age Group and in Total.

Measures of gingival inflammation and dental plaque	Age, years					Total
	20-34	35-44	45-54	55-64	65-79	
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Mean BoP (%)	31.9 (18.3)	27.2 (16.2)	28.6 (16.7)	30.3 (20.1)	32.4 (21.6)	30.0 (18.6)
No periodontitis	29.4 (16.6)	23.2 (13.9)	22.7 (13.3)	20.6 (13.9)	23.2 (21.1)	25.4 (15.7)
Non-severe periodontitis	45.0 (21.2)	34.8 (17.3)	32.0 (17.4)	31.2 (20.1)	31.0 (20.1)	33.2 (18.8)
Severe periodontitis	-	30.8 (25.0)	43.7 (16.4)	40.5 (21.1)	43.0 (21.5)	41.7 (20.6)
Total periodontitis	44.8 (21.1)	34.6 (17.6)	33.6 (17.7)	33.4 (20.7)	34.5 (21.2)	34.8 (20.0)
Mean plaque score (%)	45.2 (22.9)	40.0 (21.0)	42.6 (21.5)	44.3 (22.4)	49.7 (23.4)	44.2 (22.4)
No periodontitis	43.4 (22.5)	38.4 (21.2)	39.0 (19.9)	38.7 (21.2)	45.7 (25.3)	40.9 (21.8)
Non-severe periodontitis	54.5 (22.7)	43.7 (20.3)	44.6 (22.2)	45.2 (21.6)	47.5 (22.1)	46.2 (21.9)
Severe periodontitis	-	31.3 (19.0)	51.6 (23.3)	49.1 (25.0)	58.2 (23.1)	52.7 (24.2)
Total periodontitis	54.6 (22.6)	43.1 (20.3)	45.6 (22.4)	46.1 (22.5)	50.6 (22.9)	47.4 (22.5)

Periodontitis categories according to the CDC/AAP Case Definitions.¹¹

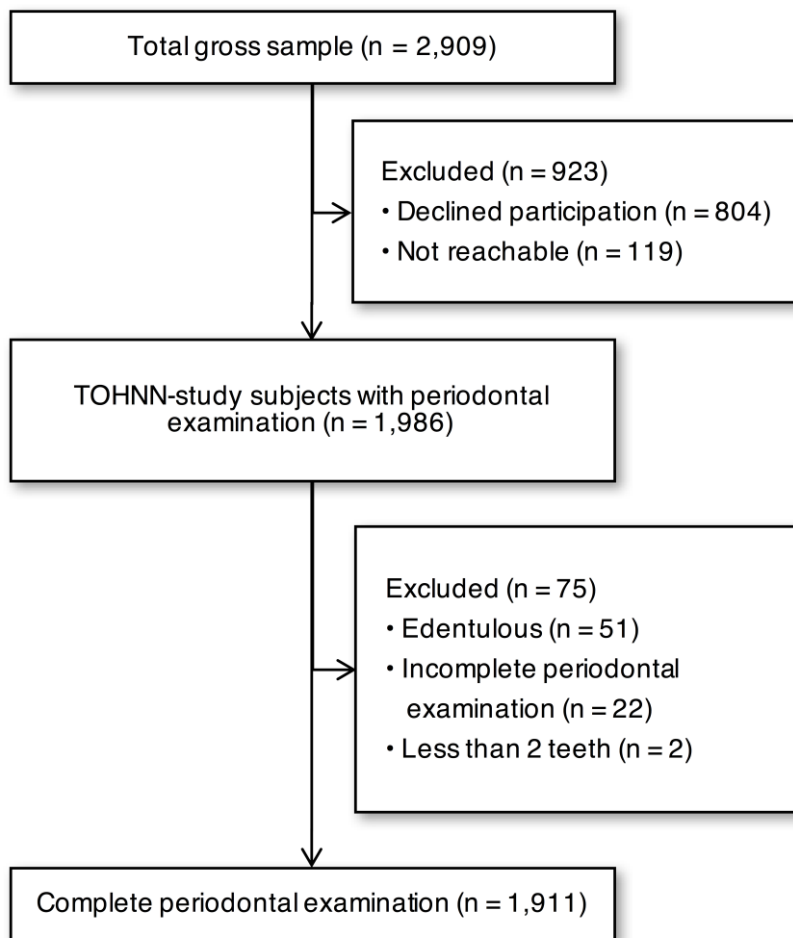


Figure 1. Flow chart of study participants, presented in numbers.

Lorenz curve

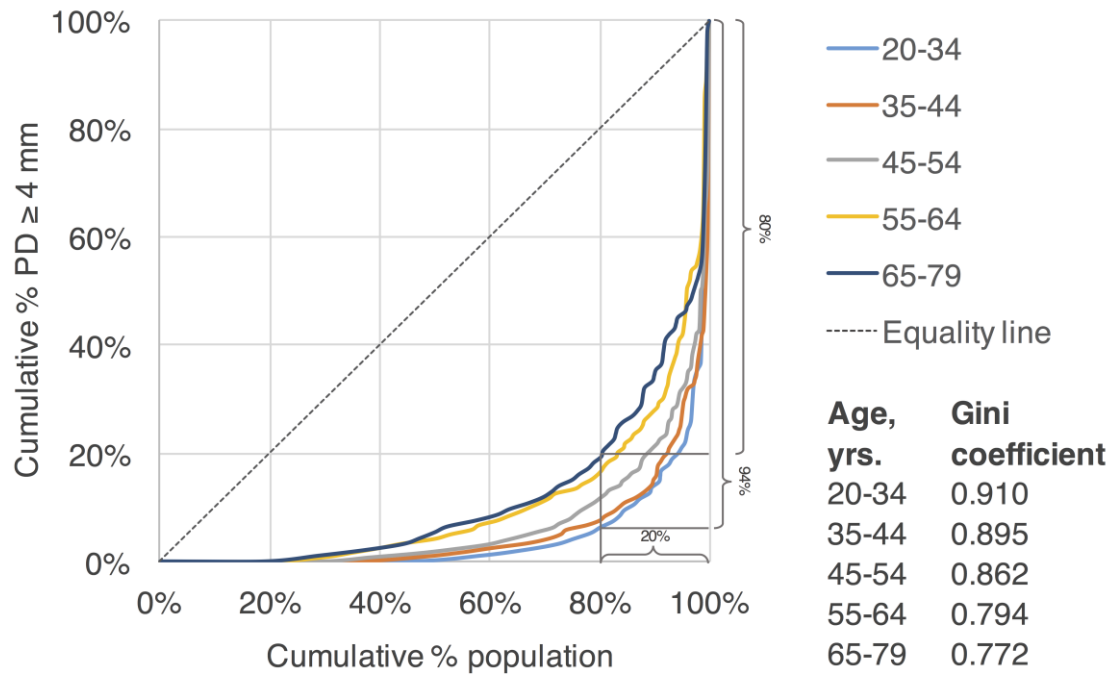


Figure 2. Proportional distribution of sites with PD ≥ 4 mm in different age groups. Each point of the curves denotes the proportion of the population (x-axis) responsible for the proportion of the total burden of PD ≥ 4 mm (y-axis) in respective age groups. E.g. in 65-79-year-olds the top 20% of the population accounted for 80% of the total burden of PD ≥ 4 mm, while in 20-34-year-olds the top 20% of the population accounted for 94% of the total burden of PD ≥ 4 mm.