

# Age threshold for moderate and severe periodontitis among Korean adults without diabetes mellitus, hypertension, metabolic syndrome, and/or obesity

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## Abstract

The purpose of this study is to determine an appropriate age threshold at which to recommend the evaluation of moderate and severe periodontitis among Korean adults.

This study involved a cross-sectional analysis using data from the Korean National Health and Nutrition Examination Survey from 2012 to 2014. Incidence rates of periodontitis with the 95% confidence interval (CI) were evaluated. The predictive accuracy of age for periodontitis was determined by calculating the area under curve (AUC) on the basis of the receiver operating characteristic (ROC) curve.

The cutoff value of age was 43 years in men having periodontitis with an AUC of 0.70 with 95% CI of 0.69 to 0.72. The AUC was 0.72 (95% CI: 0.70–0.73), and the cutoff value of age (49 years) was identified for the moderate periodontitis in women. The cutoff values for age with AUCs and 95% CI for individuals with periodontitis were 46 years (0.72 [0.71–0.73]), 43 years (0.73 [0.72, 0.74]), 45 years (0.71 [0.70,0.72]), 43 years (0.73 [0.72, 0.74]), and 45 years (0.74 [0.72, 0.75]) for no obesity, no abdominal obesity, no diabetes mellitus, no hypertension, and no metabolic syndrome groups, respectively.

This study proposed the guideline for the appropriate age threshold at which to recommend the evaluation of moderate and severe periodontitis for the general population and additionally added the guideline for the individuals without systemic disease including diabetes mellitus, hypertension, metabolic syndrome, and obesity. This study suggests that the participants with certain age may be recommended for the regular periodontal evaluation.

**Abbreviations:** AUC = area under curve, BMI = body mass index, CI = confidence interval, CPI = community periodontal index, KNHANES = Korean National Health and Nutrition Examination Survey, ROC = receiver operating characteristic.

**Keywords:** age factors, epidemiology, health surveys, oral health, periodontitis

## 1. Introduction

Periodontitis is reported to be prevalent in the general adult population.<sup>[1,2]</sup> Previous reports evaluated the rate of periodontal destruction before 40 years of age and found out that without interference the periodontal lesion progresses at a relatively even

pace and that the progress is continuous.<sup>[3]</sup> Another report evaluated the rate of progress of periodontal disease in a population never exposed to any programs regarding dental diseases and it was shown that tooth mortality started after 30 years of age and increased throughout the decade in a moderate progression group.<sup>[4]</sup> It was also reported that older individuals have experienced more generalized severe loss and 50% to 75% of older adults experienced loss of attachment over relatively short periods of time.<sup>[5]</sup> Event though, detailed epidemiological data on periodontal conditions in elderly people are limited,<sup>[6]</sup> higher proportions of aged, man, and African-American individuals had established periodontitis, and it was suggested that these groups were at a higher risk for periodontitis.<sup>[7]</sup> However, in another report evaluating the periodontal conditions in 35- to 44-year-old and 65 to 74-year-old participants showed that a similar percentage of 17% of the younger and 15% of the older cohort scored a Community Periodontal Index of Treatment Needs code 4.<sup>[8]</sup>

Recommendations for evaluation and treatment of periodontitis with systemic diseases including diabetes mellitus and hypertension is generally accepted,<sup>[9,10]</sup> and the general recommendation for individuals without systemic diseases is not well established yet. It can be suggested that guidelines when patients would receive the most benefits from treatment of periodontitis considering the individual's general health, since age is an important independent predictor of periodontitis.<sup>[11]</sup> The purpose of this study is to determine an appropriate age threshold at which to recommend the evaluation of moderate and severe periodontitis among Korean adults.

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## 2. Methods

### 2.1. Survey and subjects

This study used data from the Korean National Health and Nutrition Examination Survey (KNHANES), which was performed between 2012 and 2014 under the Korean Centers for Disease Control and Prevention and the Korean Ministry of Health and Welfare, Sejong, Korea.<sup>[12,13]</sup> A total of 18,382 individuals were candidates for the KNHANES. The analysis in this study was confined to a total of 18,382 respondents over 19 years of age. Individuals without oral health values were excluded, reducing the sample to 15,747. The number of individuals was reduced to 15,170 due to insufficient data regarding the fasting time. Finally, 13,162 individuals without missing values for the outcome variables were analyzed. All participants in the survey signed an informed consent form prior to participation. This study was conducted according to the Helsinki Declaration-based Ethical Principles for Medical Research Involving Human Subjects. This study was approved by an institutional review board of the Korean Center for Disease Control and Prevention (2012-01EXP-01-2C, 2013-07CON-03-4C, and 2013-12EXP-03-5C).

### 2.2. Sociodemographic and lifestyle variables

Trained interviewers from the KNHANES performed the standardized health examination and questionnaire. Current smokers were defined as the participants who smoked currently and had smoked more than 100 cigarettes in their life time. Participants were also categorized, based on the quantity of alcohol consumed per day for the month prior to the interview and the individuals were considered heavy drinkers if they had consumed of >30g per day. Participants who performed moderate exercise at least 5 times per week for 30 minutes or more per session, or who performed vigorous exercise at least 3 times per week for 20 minutes or more per session were considered regular exercisers. In this study, education levels were categorized as university graduate or higher. If the monthly income of a participant's household was less than \$1092.40, the individuals were categorized as the lowest quartile in income.

### 2.3. Anthropometric and biochemical measurements

Trained staff members from the KNHANES performed the anthropometric measurements. Body weight was measured to the nearest 0.1 kg and height was measured to the nearest 0.1 cm. Body mass index (BMI) was calculated as body weight (kg) divided by height squared ( $m^2$ ). Waist circumference (WC) was measured in a standing position at the narrowest point between the lower border of the rib cage and the iliac crest. A BMI  $\geq 25$  kg/ $m^2$  was defined as general obesity,<sup>[14]</sup> and abdominal obesity was defined as a WC  $\geq 90$  cm in men or  $\geq 85$  cm in women.<sup>[15]</sup>

Systolic blood pressure and diastolic blood pressure were measured twice at 5-minute intervals using a standard mercury sphygmomanometer (Baumanometer; W.A. Baum Co., Inc., Copiague, NY), and the average values were used for the analysis. A blood sample was collected from the antecubital vein of each individual after fasting for more than 8 hours to measure the concentrations of serum fasting plasma glucose, total cholesterol, triglycerides, and high-density lipoprotein cholesterol.

The individuals were diagnosed as having diabetes if the individual's fasting plasma sugar was  $\geq 126$  mg/dL, if hemoglobin

A1c was 6.5% or greater, if they were currently using antidiabetic medications or if they had physician-diagnosed diabetes.<sup>[16]</sup> The individuals were considered to have hypertension if the participant's systolic blood pressure was 140 mmHg or greater, if the individual's diastolic blood pressure was 90 mmHg or greater or if the individuals were under the current use of antihypertensive medication.<sup>[17]</sup> The individuals were considered to have metabolic syndrome if the individuals sufficed 3 or more of the following criteria: waist circumference of 90 cm or greater in men and 80 cm or greater in women; fasting triglycerides  $\geq 150$  mg/dL or use of lipid-lowering medication; high-density lipoprotein cholesterol  $< 40$  mg/dL in men and  $< 50$  mg/dL in women or use of medication; blood pressure  $\geq 130/85$  mmHg or use of antihypertensive medication in a patient with a history of hypertension; and fasting blood glucose  $\geq 100$  mg/dL or current use of antidiabetic medication.<sup>[18]</sup>

### 2.4. Oral health behaviors, periodontitis, and number of natural teeth

The community periodontal index (CPI) developed by the World Health Organization was used to assess periodontal condition.<sup>[19]</sup> Participants were considered to have moderate periodontitis if their CPI was  $\geq 3$ . If the participants' CPI was  $\geq 4$ , the individuals were considered to have severe periodontitis.

Tooth brushing frequency and use of secondary oral products were used for the evaluation of oral health behaviors. The frequency of tooth brushing was calculated by the total number of tooth brushing per day. Secondary oral products included dental floss, mouthwash, interdental brushes, electric toothbrushes, irrigation devices, tongue cleaners, end-tufted brushes, and special devices for dentures. Presence of tooth pain, experience of orthodontic treatment, and dental checkup within a year were obtained. Self-reported oral state, chewing ability, and speech ability were categorized into favorable, average, and problematic.

### 2.5. Statistical analysis

Results are presented as percentages (standard error) for categorical variables. Differences between nominal variables were compared using a chi-square test. Incidence rates of periodontitis were calculated by dividing the number of events by person-time at risk, with the 95% CI estimated by exact binomial probabilities. The predictive accuracy of age for periodontitis was calculated by calculating the *c*-index on the basis of the receiver operating characteristic (ROC) curve. The cutoff age value in the prediction of periodontitis was defined as the cutoff point having the highest Youden index (sensitivity + specificity - 1). Statistical significance was set at a *P* value of  $< .05$ .

## 3. Results

Table 1 shows the baseline characteristics of the studied individuals according to their age groups. Moderate and severe periodontitis seemed to increase with age. The percentage of waist circumference  $\geq 90$  cm in men and  $\geq 80$  cm in women increased with age. The percentage of man in whole population decreased with increasing age. The percentage of current drinking decreased with increasing age. The percentage of diabetes mellitus, hypertension, and metabolic syndrome increased with age. Interestingly, the percentage of diabetes mellitus increased >3 times in the 45 to 49 age group when compared with the 30 to 44 age group. Similarly, the percentage of hypertension increased

**Table 1**

**The baseline characteristics of the studied individuals according to the age groups.**

	Age (y)					P*
	19-29	30-44	45-59	60-74	75-	
Unweighted n	1661	3776	3816	3193	716	
Moderate periodontitis (CPI ≥3)	3.32 (0.54)	17.36 (0.84)	38.34 (1.16)	43.76 (1.33)	45.71 (2.27)	<.0001
Severe periodontitis (CPI ≥4)	0.87 (0.22)	7.19 (0.56)	18.44 (0.91)	21.82 (1.10)	28.30 (2.49)	<.0001
Sex (male)	53.44 (1.38)	50.65 (0.82)	49.05 (0.80)	46.33 (0.92)	39.10 (1.92)	<.0001
Diabetes mellitus (yes)	0.84 (0.25)	3.02 (0.31)	10.59 (0.58)	22.28 (0.89)	25.88 (2.21)	<.0001
Hypertension (yes)	3.97 (0.62)	11.58 (0.66)	30.52 (0.98)	51.76 (1.10)	69.00 (2.23)	<.0001
Metabolic syndrome (yes)	6.04 (0.76)	17.63 (0.81)	33.12 (0.88)	49.65 (1.06)	58.01 (2.06)	<.0001
Body mass index ≥25 (kg/m <sup>2</sup> )	22.89 (1.23)	33.31 (0.89)	34.06 (0.87)	37.45 (1.04)	32.54 (2.34)	<.0001
Waist circumference ≥90 cm in men and ≥80 cm in women	15.63 (1.08)	26.52 (0.86)	33.16 (0.95)	47.10 (1.16)	48.15 (2.35)	<.0001
Current smoker (yes)	21.00 (1.37)	26.84 (0.89)	21.49 (0.82)	12.58 (0.68)	6.30 (0.96)	<.0001
Current drinking (yes)	70.08 (1.25)	65.20 (0.95)	57.38 (1.01)	41.75 (1.07)	32.25 (2.01)	<.0001
Regular exercise (yes)	24.78 (1.45)	18.71 (0.95)	19.28 (0.87)	14.07 (0.83)	9.31 (1.58)	<.0001
University graduate or higher	38.07 (1.49)	56.69 (1.24)	26.27 (1.13)	11.00 (0.83)	6.72 (1.12)	<.0001
Income (lowest quartile)	9.32 (1.10)	4.84 (0.45)	9.59 (0.72)	31.19 (1.24)	63.57 (2.24)	<.0001

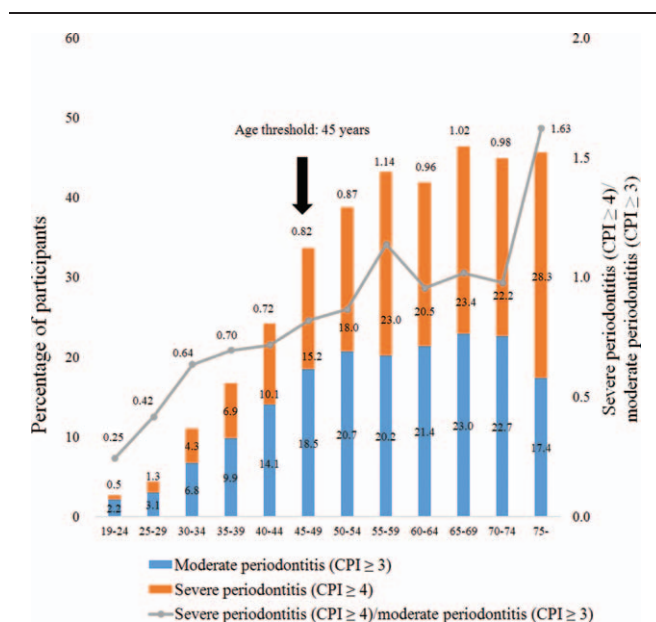
Data are presented as percentages (standard error). CPI = community periodontal index.  
\*P-values were obtained by chi-square tests for categorical variables.

2.6 times in the 45 to 49 age group when compared with the 30 to 44 age group. The percentage of metabolic syndrome increased 1.9 times in the 45 to 49 age group when compared with the 30 to 44 age group.

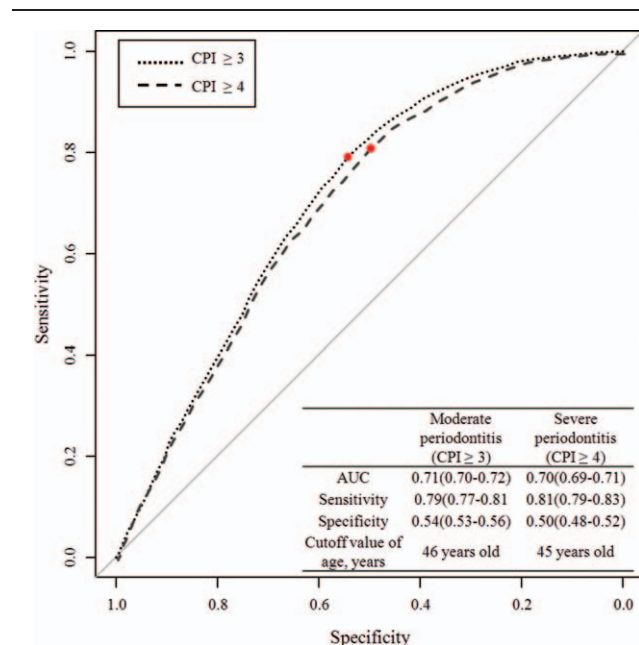
The prevalence of moderate and severe periodontitis is shown in Figure 1. The percentage of periodontitis (moderate periodontitis + severe periodontitis) increased from 24.2% (age group of 40-44 years) to 33.7% (age group of 45-49 years). Figure 2 shows the ROC curve on the basis of age for the prediction of moderated and severe periodontitis. AUC for age was 0.71 (95% confidence of interval [CI]: 0.70-0.72), and the cutoff value for age (46 years) was identified for the moderate periodontitis on the basis of the highest Youden index. The c-index for age was 0.70 (95% CI: 0.69-0.71), and the cutoff value for age (45 years) was identified for the severe periodontitis on the basis of the highest Youden index. The sensitivity, specificity,

and Youden index in predicting for moderated and severe periodontitis for different cutoff values of age are shown in Supplementary Table 1, <http://links.lww.com/MD/B833>.

Table 2 shows the AUC, sensitivity, and specificity of the studied individuals categorized by sex, presence of obesity, and the presence of systemic diseases. The cutoff value of age was 43 years in men having periodontitis with an AUC of 0.70 with 95% CI of 0.69 to 0.72. The AUC was 0.72 (95% CI: 0.70-0.73), and the cutoff value for age (49 years) was identified for the moderate periodontitis in women. The AUC of the individuals with systemic diseases for periodontitis was 0.67 for obesity, 0.64 for



**Figure 1.** The prevalence of moderate and severe periodontitis.



**Figure 2.** ROC curve of age in predicting moderate and severe periodontitis. The AUC on the basis of the AUC for age in predicting moderate periodontitis and severe periodontitis are 0.71 and 0.70, respectively. The cutoff values of ages (46 years for moderate periodontitis and 45 for severe periodontitis) were identified on the basis of the highest Youden indices. AUC=area under the curve, ROC=receiver operating characteristic. \*Youden index = [Sensitivity + Specificity - 1].

**Table 2**

**Area under the curve, sensitivity, and specificity of the studied individuals categorized by sex, presence of obesity, and the presence of systemic diseases.**

	Moderate periodontitis (CPI $\geq 3$ )				Severe periodontitis (CPI $\geq 4$ )			
	AUC (95% CI)	Sensitivity	Specificity	Cutoff value of age, years	AUC (95% CI)	Sensitivity	Specificity	Cutoff value of age, years
Sex								
Male	0.70 (0.69,0.72)	0.84	0.51	43	0.69 (0.67,0.70)	0.79	0.53	46
Female	0.72 (0.70,0.73)	0.76	0.58	49	0.72 (0.70,0.73)	0.75	0.57	49
Obesity								
No	0.72 (0.71,0.73)	0.79	0.56	46	0.72 (0.70,0.73)	0.80	0.52	45
Yes	0.67 (0.65,0.69)	0.81	0.47	45	0.67 (0.65,0.69)	0.83	0.46	45
Abdominal obesity								
No	0.73 (0.72,0.74)	0.82	0.55	43	0.72 (0.71,0.74)	0.82	0.52	43
Yes	0.64 (0.62,0.66)	0.84	0.39	46	0.64 (0.62,0.66)	0.87	0.36	45
Diabetes mellitus								
No	0.71 (0.70,0.72)	0.78	0.55	45	0.71 (0.69,0.72)	0.83	0.49	43
Yes	0.54 (0.51,0.57)	0.93	0.15	46	0.54 (0.50,0.57)	0.93	0.15	46
Hypertension								
No	0.73 (0.72,0.74)	0.77	0.59	43	0.72 (0.70,0.73)	0.77	0.56	43
Yes	0.57 (0.55,0.59)	0.72	0.39	56	0.59 (0.56,0.61)	0.91	0.20	47
Metabolic syndrome								
No	0.74 (0.72,0.75)	0.75	0.62	45	0.73 (0.71,0.74)	0.79	0.55	43
Yes	0.59 (0.57,0.60)	0.88	0.26	46	0.58 (0.56,0.61)	0.90	0.24	45

AUC=area under the curve, CI=confidence of interval.

abdominal obesity, 0.54 for diabetes mellitus, 0.57 for hypertension, and 0.59 for metabolic syndrome. The cutoff values for age with AUCs and 95% CI for individuals with periodontitis were 46 years (0.72 [0.71–0.73]), 43 years (0.73 [0.72, 0.74]), 45 years (0.71 [0.70, 0.72]), 43 years (0.73 [0.72, 0.74]), and 45 years (0.74 [0.72, 0.75]) for no obesity, no abdominal obesity, no diabetes mellitus, no hypertension, and no metabolic syndrome groups, respectively.

The oral health characteristics of the studied individuals according to the presence of periodontitis are shown in Supplementary Table 2, <http://links.lww.com/MD/B833>. Individuals with moderate periodontitis experienced more tooth pain, chewing problems, and speech problems. Participants with periodontitis had less dental checkups ( $P < .05$ ). The participants with frequent tooth brushing habits made up a smaller portion of participants with periodontitis. The individuals with periodontitis flossed less and performed less interdental brushing ( $P < .05$ ).

Supplementary Table 3, <http://links.lww.com/MD/B833> shows the oral health characteristics of the studied individuals according to age groups. The percentage of favorable chewing decreased from 73.97% in age 30 to 44 group to 59.87% age 45 to 59 group. The percentage of individuals with 28 teeth dropped from 63.58% in the age 30 to 44 group to 38.34% in the age 45 to 59 group. The percentage of individuals with floss use dropped from 30.21% in the age 30 to 44 group to 18.59% in the age 45 to 59 group.

#### 4. Discussion

This study suggests that for general population, the evaluation of periodontitis should be recommended for all men and women above the ages of 43 and 49, respectively. For subgroup analysis, the evaluation of periodontitis should be routinely be considered at the age of 45 or above for the individuals without diabetes mellitus, 43 or above for individuals without hypertension, 45 or above for individuals without metabolic syndrome, and 46 or above for individuals without obesity.

It should be addressed that continuous destruction may be noted if optimal treatment is not performed at appropriate time point.<sup>[20]</sup> Predictors of destructive periodontal disease incidence and progression were evaluated in Chinese adults, and it was suggested that age was 1 factor in predicting for pressing disease.<sup>[21]</sup> In a previous report from a province in Europe, the prevalence of periodontitis increased significantly with age and remained constant after the age of 50 to 59.<sup>[22]</sup> This study proposed 45 years to be the cutoff value for the evaluation of the need of treatment of periodontitis. This report can be of great importance for making the strategy for the general population as well as individuals without systemic diseases.

Many definitions of periodontitis have been used in the previous researches for population-based studies.<sup>[23]</sup> The clinical diagnosis of periodontitis is based on measurements of periodontal probing depth, clinical attachment level, presence of gingival inflammation, radiographic evaluation, and loss of alveolar bone.<sup>[24]</sup> Some authors suggested that a combination of moderate and severe periodontitis may not be sufficient to determine the total prevalence of periodontitis in a population, and they proposed a definition for mild periodontitis.<sup>[25]</sup> However, this study used partial mouth recording protocols of CPI for the definition of moderate periodontitis as CPI  $\geq 3$  and severe periodontitis as CPI  $\geq 4$ , because there were limited resources including funding, the number of dental practitioners, and time.<sup>[26]</sup> It must also be noted that there is limitation of possible underestimation of the prevalence of periodontitis with partial mouth recordings.<sup>[19,27]</sup>

In spite of these limitations, this study had several strengths. The KNHANES is composed of nationally representative samples and the data were obtained using a systematic sampling method that was adjusted for the number of members in households while accounting for administration district, region, and type of residence in the Republic of Korea.<sup>[28]</sup> The protocol of sampling uses a stratified, multistage, probability-cluster survey of the non-institutionalized civilian population in the Republic of Korea.<sup>[29]</sup> Trained interviewers visited the subjects in their homes and performed the standardized health examination and



questionnaire.<sup>[30,31]</sup> Moreover, this study assessed the effects of systemic diseases by subgroup analysis. Diagnostic accuracy was evaluated by the AUC in the ROC curve in this study, and it was shown that the diagnostic accuracy was good if the AUC was 0.70 to 0.80, poor for 0.60 to 0.70, and a failure for 0.50 to 0.60.<sup>[32,33]</sup> In this study, the AUC of subgroups without systemic disease was >0.70, indicating good diagnostic accuracy.

Conclusively, this study proposed the guideline for the appropriate age threshold at which to recommend the evaluation of moderate and severe periodontitis for the general population and additionally added the guideline for the individuals without systemic disease including diabetes mellitus, hypertension, metabolic syndrome, and obesity. This study suggests that the participants with certain age may be recommended for the regular periodontal evaluation.

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