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Influence of oral health behavior and sociodemographic factors on remaining teeth in Korean adults

2010–2012 Korea national health and nutrition examination survey

In-Seok Song, DDS, MSD, PhD[a], Kyungdo Han, PhD[b], Yeon-Jo Choi, DDS, DMD, PhD[c], Jae-Jun Ryu, DDS, MSD, PhD[c], Jun-Beom Park, DDS, MSD, PhD[d,*]

Abstract

In this study, the number and location of remaining teeth were analyzed according to sociodemographic variables, anthropometric measurements, and oral health behavior patterns. The hypothesis was that the number and location of remaining teeth would be affected by oral health behavior and by sociodemographic factors, such as education levels, household income, and urban/rural residency.

This nationwide cross-sectional study was performed with a total of 36,026 representative Korean adults aged 19 and older. The data were taken from the 2012–2012 Korea National Health and Nutrition Examination Survey.

Men had, on average, significantly more remaining teeth than women did. Women brushed their teeth more often than men per day and were more likely to brush their teeth after meals. The participants with higher education levels or household income had significantly more remaining teeth; the number of daily tooth brushing was positively associated with the number of remaining teeth; urban residents had significantly more remaining teeth than rural residents; and elderly adults had fewer remaining teeth than younger adults had (all with $P < 0.05$). The participants were more likely to retain their incisors (especially their canines) for their entire lifetimes than do so for their molars. From the incisors to the second premolars, they had more mandibular teeth than maxillary teeth, but among molars, they had more maxillary teeth than mandibular teeth. Elementary graduates with low household income had fewer remaining teeth than did university graduates with high household income ($P < 0.0001$). Finally, participants with high socioeconomic status were more likely to lose their molar teeth than anterior teeth compared to those with low socioeconomic status.

The participants who brushed their teeth fewer times per day, those with low household incomes and/or education levels, and those who lived in rural districts had significantly higher prevalence of tooth loss than did other groups in Korean adults. Participants had more anterior and premolar teeth on mandible, but they had more molars on maxilla. In addition, participants with high socioeconomic status were more likely to lose their molar teeth than anterior teeth compared to those with low socioeconomic status.

Abbreviations: BMI = body mass index, KNHANES = Korean National Health and Nutrition Examination Survey.

Keywords: dental health surveys, epidemiology, oral health, tooth brushing, tooth loss

1. Introduction

Having more natural teeth can be an indicator of general and oral health. It is considered that having at least 20 natural teeth is required for the satisfactory function and esthetics.[1] The number of remaining teeth may be a predictor of longevity, and retaining teeth may be important to living a long life.[2] A longitudinal cohort study of 569 Japanese adults aged 70 revealed that individuals with 20 teeth or more lived longer on average than

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[a] Department of Oral and Maxillofacial Surgery, Korea University Anam Hospital, [b] Department of Biostatistics, College of Medicine, The Catholic University of Korea, [c] Department of Prosthodontics, Korea University Anam Hospital, [d] Department of Periodontics, College of Medicine, The Catholic University of Korea, Seoul, Republic of Korea.

[*] Correspondence: Jun-Beom Park, Department of Periodontics, Seoul St Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul, Republic of Korea (e-mail: jbassoonis@yahoo.co.kr).

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those with 19 teeth or fewer.[3] Also, there was a significant decrease in all-cause mortality by 4% per tooth loss. Similarly, a large-population based cohort study of adults aged 75 in 3 Nordic countries revealed that having more remaining teeth was significantly related to having a lower 7-year mortality rate.[4] One systematic review also demonstrated that tooth loss decreased health-related quality of life.[5]

Two mechanisms have been suggested for the influence of tooth loss on general health or mortality: inflammation and malnutrition.[6–8] Periodontal inflammation could increase mortality associated with cardiovascular or chronic heart disease. Tooth loss and periodontal inflammation were associated with various systemic diseases, including stroke, dementia, pneumonia, osteoporosis, cardiovascular disease, diabetes mellitus, rheumatoid arthritis, and erectile dysfunction.[9–11] A person's awareness of oral health problems may attenuate their chewing ability and food choices.[12,13] Poor dentition attenuates mastication efficiency and causes subsequent self-limiting food selection with a diet devoid of fruits, vegetables, and other foods containing key nutrients. As a result, the presence of remaining natural teeth or a well-fitting denture determines a higher quality of dietary nutrition intake.

Several causal factors contributed to tooth loss, including dental caries, periodontal breakdown, and mental illness.[14–18] Recently, studies have focused on sociodemographic variables as reasons for tooth loss. These variables include education level, income level, and characteristics of residency. A longitudinal cohort study of community-dwelling elderly Italian people age 65 or older revealed that edentulous rates were higher among women who had longer menopausal periods, more children, or more solitary lives and among men who smoked, had poor nutritional status, or had a higher prevalence of edentulism.[19] Another report of older Finnish adults showed that oral health status had a significant impact on their lives who had fewer remaining teeth or who had less education.[20]

In the present study, the associations between the number/location of remaining teeth and sociodemographic variables, including anthropometric measurements or oral health behavior were investigated. This study hypothesized that the number and location of remaining teeth was affected by the frequency of tooth brushing and by sociodemographic factors such as education levels, household income, and urban/rural residency.

2. Material and methods

2.1. Overview of the survey and participants

The data from the present observational study were extracted from the 2010–2012 Korea National Health and Nutrition Examination Survey (KNHANES), a nationwide cross-sectional survey conducted by the South Korean Ministry of Health and Welfare. Trained agents inspected the study's representative population of South Koreans using well-made questionnaires, physical inspections, health interviews, and nutritional examinations.

For the present study, 36,026 total participants aged 19 and older were included in the analysis. The sample comprised 15,296 male participants and 20,730 female participants. The Institutional Review Board of the Korean Center for Disease Control and Prevention approved this study (2008-04EXP-01-C, 2009-01CON-03-2C, and 2010-02CON-21-C), and it was accomplished according to the Helsinki Declaration's Ethical Principles for Medical Research Involving Human Subjects.

2.2. Sociodemographic and lifestyle variables

Sociodemographic and lifestyle variables were evaluated through a self-administered questionnaire that addressed education level, household income, and place of residence (urban or rural). The education level was categorized based on whether the participant had the equivalent of a high school education (≥13 years). Household income was divided into quartiles based on the number of involved family members. The subjects were divided based on rural or urban residency. Thereafter, we categorized participants' residence according to administrative districts. These districts included 7 metropolitan cities and 9 provinces in South Korea.

2.3. Anthropometric measurements

Specially trained inspectors acquired the anthropometric data. The measurements followed the recommendations of the World Health Organization.[21] Height was measured to the nearest 0.1 cm. Body weight was documented (using a digital scale) to the nearest 0.1 kg; the participants wore light clothing and had bare feet. Waist circumference was measured to the nearest 0.1 cm at the narrowest midpoint between the iliac crest and the costal margin. The participants wore loose-fitting clothing, and the circumference was measured after the participant had breathed out fully. Body mass index (BMI) was calculated by dividing body weight (kg) by the square of height (m^2).

2.4. Oral health status and behavior patterns

The participants were inspected to determine the number and location of remaining teeth according to the FDI World Dental Federation two-digit notation.[22] Participants self-reported their number of dental visits within 1 year, rated their mastication and speaking difficulty, noted any dental problems left untreated, and described previous and present experiences with decayed teeth. They also reported the times of day when they typically brush their teeth from the following choices: before bedtime, after snacks, and before or after each meal (breakfast, lunch, and dinner). Participants also noted their use of secondary oral products, including floss, interdental brushes, gargling solutions, and electric toothbrushes. The frequency of daily tooth brushing was defined as the mean number of times brushing the teeth in a day. The anterior teeth were defined as incisors and canines, and the posterior teeth were defined as premolars and molars.

2.5. Statistical analyses

The data were presented as mean ± standard error for continuous variables and as percentage (standard error) for categorical variables.[23] Student's t tests for continuous variables and Rao–Scott chi-square tests for categorical variables were used to compare the differences in the number of remaining tooth with the other variables. The SAS statistical software package (version 9.3; SAS institute, Cary, NC) was used for the analysis. All the data were considered to be statistically significant at $P < 0.05$.

3. Results

Table 1 showed the baseline characteristics of the participants included in the study. There were significant differences between the sexes in terms of education level, household income, time and frequency of tooth brushing, mastication problems, speaking difficulties, dental problems left untreated, previous and present

Table 1

General characteristics of the participants.

		Sex		
	Total	Male	Female	
N	36,026	15,296	20,730	*P**
Age, y	45.13 ± 0.17	44.09 ± 0.19	46.15 ± 0.19	<0.001
BMI, kg/m^2	23.68 ± 0.03	24.11 ± 0.04	23.25 ± 0.04	<0.001
Waist circumference, cm	80.95 ± 0.09	84.06 ± 0.11	77.91 ± 0.12	<0.001
Remaining teeth, n	24.73 ± 0.05	24.97 ± 0.06	24.5 ± 0.07	<0.001
Ant.-Post. teeth	6.8 ± 0.1	5.4 ± 0.1	8.2 ± 0.1	<0.001
Education level, years of education				<0.001
Elementary: ≤6	19 (0.4)	12.3 (0.4)	25.5 (0.5)	
Middle: 7–9	10 (0.2)	10 (0.3)	9.9 (0.3)	
High: 10–12	39.2 (0.4)	42 (0.6)	36.5 (0.5)	
University: ≥13	31.8 (0.5)	35.7 (0.6)	28 (0.5)	
Household income, Q				<0.001
Q1	16.2 (0.4)	14.2 (0.4)	18.1 (0.4)	
Q2	26.1 (0.5)	25.5 (0.5)	26.6 (0.5)	
Q3	28.8 (0.4)	30 (0.5)	27.7 (0.5)	
Q4	28.9 (0.6)	30.3 (0.7)	27.6 (0.6)	
Place, urban	80.8 (1.1)	80.7 (1.2)	80.9 (1.1)	0.47
Tooth brushing per day, n	2.47 ± 0.01	2.37 ± 0.01	2.56 ± 0.01	<0.001
≤1	12.6 (0.3)	16.1 (0.4)	9.1 (0.3)	
2	43.2 (0.4)	44.2 (0.6)	42.3 (0.5)	
≥3	44.2 (0.5)	39.7 (0.6)	48.6 (0.6)	
Tooth brushing time				
Before breakfast	28.5 (0.4)	31.4 (0.6)	25.8 (0.5)	<0.001
After breakfast	69.1 (0.4)	63.5 (0.6)	74.6 (0.4)	<0.001
Before lunch	1.3 (0.1)	1.2 (0.1)	1.4 (0.1)	0.18
After lunch	42.6 (0.4)	39 (0.5)	46.2 (0.5)	<0.001
Before dinner	2.8 (0.1)	3.3 (0.2)	2.4 (0.1)	<0.001
After dinner	62.9 (0.4)	61.5 (0.5)	64.2 (0.5)	<0.001
After snack	2.6 (0.1)	2.1 (0.1)	3.2 (0.2)	<0.001
Before bedtime	36.6 (0.5)	34.8 (0.6)	38.3 (0.6)	<0.001
Use of secondary oral products	35 (0.4)	31 (0.5)	39 (0.5)	<0.001
Mastication				0.03
Very uncomfortable	5.2 (0.2)	4.8 (0.2)	5.6 (0.2)	
Uncomfortable	19.9 (0.3)	19.9 (0.4)	20 (0.4)	
So-so	15.8 (0.3)	15.5 (0.4)	16 (0.3)	
Not uncomfortable	24.8 (0.5)	24.9 (0.6)	24.6 (0.5)	
Never uncomfortable	34.3 (0.5)	34.9 (0.6)	33.8 (0.6)	
Speaking				<0.001
Very uncomfortable	1.4 (0.1)	1.2 (0.1)	1.6 (0.1)	
Uncomfortable	6.8 (0.2)	6.4 (0.2)	7.2 (0.2)	
So-so	8.4 (0.2)	8 (0.3)	8.7 (0.3)	
Not uncomfortable	23.8 (0.6)	24.1 (0.6)	23.5 (0.6)	
Never uncomfortable	59.7 (0.6)	60.3 (0.7)	59 (0.7)	
Dental visit within a year	26.1 (0.4)	26.6 (0.5)	25.7 (0.5)	0.14
Refusal of dental treatment	39.4 (0.4)	37.1 (0.5)	41.6 (0.5)	<0.001
Presence of dental caries	33.5 (0.4)	36.8 (0.5)	30.3 (0.5)	<0.001
Experience of dental caries	90.1 (0.2)	87.1 (0.4)	93 (0.2)	<0.001

Data are presented as means ± standard error or percentages (standard error).

Ant-Post teeth = number of anterior teeth minus number of posterior teeth; BMI = body mass index.

* *P*-values were obtained by independent t test for continuous variables or chi-square test for categorical variables.

experiences with decayed teeth, and use of secondary oral products (P-value < 0.05 in all cases). Men had significantly more remaining teeth than women. Women brushed their teeth more often than men and were more likely to brush their teeth after meals. Men were more likely to brush their teeth than women before breakfast and before dinner, and women were more likely to brush their teeth than men after breakfast, after lunch, after dinner, after snacks, and just before bedtime (P-value < 0.001 in all cases).

Table 2 showed the mean number of remaining teeth according to the variables. The subjects showed significantly more remaining teeth if they had a high education level, a high household income, or a high frequency of tooth brushing (all with P-value < 0.001). The remaining teeth of the subjects were described according to the administrative districts in 7 metropolitan cities and 9 provinces (all with P-value < 0.001).

Figure 1 showed participants' mean remaining teeth according to the administrative districts they lived in. Urban individuals had

Table 2

Remaining teeth according to oral health behaviors and sociodemographic variables.

Category	Total	Sex	
	Remaining teeth (n)	Male	Female
Education level, years of education			
Elementary: ≤6	21.33±0.12	21.41±0.19	21.33±0.13
Middle: 7–9	24.29±0.1	23.63±0.16	24.9±0.12
High: 10–12	24.37±0.06	23.98±0.09	24.72±0.07
University: ≥13	24.77±0.06	24.83±0.07	24.59±0.08
P	<0.001	<0.001	<0.001
Household income, Q			
Q1	21.84±0.1	21.94±0.14	21.81±0.13
Q2	23.66±0.07	23.68±0.1	23.64±0.09
Q3	24.2±0.06	24.19±0.08	24.22±0.07
Q4	24.48±0.05	24.48±0.08	24.48±0.07
P	<0.001	<0.001	<0.001
Tooth brushing per day, n			
0	16.54±0.51	17.61±0.68	15.27±0.7
1	22.77±0.11	23.1±0.13	22.32±0.19
2	23.94±0.05	23.98±0.07	23.97±0.07
3	23.9±0.06	24.06±0.08	23.77±0.07
4	23.8±0.08	23.91±0.11	23.71±0.1
P	<0.001	<0.001	<0.001
Residence			
Seoul Special City, Capital	24.06±0.06	24.03±0.09	24.11±0.08
Busan Metropolitan City	23.61±0.16	23.56±0.2	23.68±0.19
Daegu Metropolitan City	23.6±0.13	23.6±0.18	23.63±0.17
Incheon Metropolitan City	24.1±0.12	24.06±0.19	24.16±0.15
Gwangju Metropolitan City	24.23±0.14	24.28±0.22	24.2±0.21
Daejeon Metropolitan City	24.11±0.17	23.99±0.22	24.23±0.21
Ulsan Metropolitan City	23.18±0.3	23.35±0.26	23.06±0.48
Gyeonggi-do Province	23.95±0.08	24.03±0.1	23.9±0.09
Gangwon-do Province	23.15±0.26	23.05±0.32	23.36±0.24
Chungcheongbuk-do Province	22.86±0.2	23.42±0.28	22.3±0.27
Chungcheongnam-do Province	23.28±0.15	23.42±0.22	23.19±0.18
Jeollabuk-do Province	23.14±0.24	23.33±0.29	23±0.35
Jeollanam-do Province	23.53±0.21	23.72±0.23	23.38±0.3
Gyeongsangbuk-do Province	22.64±0.18	22.98±0.28	22.35±0.26
Gyeongsangnam-do Province	22.96±0.21	23.22±0.23	22.74±0.27
Jeju Special Self-Governing Province	23.65±0.19	24.1±0.27	23.22±0.25
P	<0.001	<0.001	<0.001

Data are presented as the means±standard error.

significantly more remaining teeth than did rural individuals (Fig. 1A). The urbanites in Seoul (the capital), Busan, Daegu, Incheon, Gwangju, Daejeon, and Ulsan Metropolitan City showed dark shades, and the adjacent provinces showed light shades. Male subjects seemed to have more remaining teeth than female subjects in 8 provinces, except Gangwon-do Province (Fig. 1B and C).

Table 3 showed the mean number of remaining teeth according to gender and age group. Men had more remaining teeth than women in their 20s, 70s, or older, whereas women had more remaining teeth than men in their 40s and 50s. The mean number of remaining teeth decreased from the youngest age group to the oldest age group.

The survival rates of individual teeth (from anterior incisors to posterior molars) were designated in Fig. 2. The participants were more likely to retain their anterior teeth (especially their canines) for their entire lifetimes than do so for their molars. The participants had more anterior and premolar teeth on maxilla, but they had more molars on mandible. There were significant differences between the number of remaining teeth by side (right and left) (*P*-value=0.018), although the difference (0.017 tooth) was very small.

Fig. 3 showed number (Fig. 3A) and location (Fig. 3B) of remaining teeth according to the socioeconomic status. Participants with high income and university graduate had significantly more remaining teeth compared to those with low income and elementary graduate (*P*-value=<0.001). The numeric difference between posterior and anterior remaining teeth (baseline=4) was smaller in participants with high income and university graduates than those with low income and elementary graduate (*P*-value=<0.001). This result implied that participants with high socioeconomic status were more likely to lose their molar teeth than anterior teeth compared to those with low socioeconomic status.

4. Discussion

This study showed that men were more likely to brush their teeth before meals and that women were more likely to brush their teeth after meals. Women brushed their teeth more often than

Figure 1. Topography of participants by mean remaining teeth according to administrative districts: (A) all Korean adults, (B) male adults, (C) female adults.

men did, but men retained more natural teeth than women. In both genders, subjects with a high frequency of tooth brushing had significantly more remaining teeth. The participants had more mandibular teeth from the incisors to the second premolars, but they had more maxillary teeth among molars. For socioeconomic and demographic variables, urban residents had significantly more remaining teeth than rural residents. Individuals with high household incomes or high education levels had significantly more remaining teeth, and those with high socioeconomic status were more likely to lose their molar teeth than anterior teeth compared to those with low socioeconomic status.

In this study, maxillary or anterior teeth remained longer than did mandibular or posterior teeth. Similar results were found in other studies. A 10-year longitudinal study of Chinese population indicated that molar teeth were more likely to be lost than incisors, canines, or premolar teeth—in both maxilla and mandible.[24] The German National Oral Health Survey also revealed a higher prevalence of tooth loss in the posterior maxilla than in the anterior mandible.[25] Meanwhile, a study of a young Brazilian population (aged 14–29) demonstrated that first molar teeth were most likely to be missing and that mandibular incisors and canines were the least likely to be missing.[26]

Aging or less frequent tooth-brushing might decrease number of remaining teeth in this study. A positive association between aging and tooth loss was found in other studies.[14,25,27] Individuals aged >60 had fewer remaining teeth than did younger individuals in several European countries.[25] The present study also showed that almost 87% of adults brushed their teeth more than twice daily. Participants who brushed less often had significantly fewer remaining teeth on average. Although it is difficult to achieve plaque-free surfaces on all teeth through adequate duration, skill, and perseverance in tooth brushing, previous studies still recommended brushing the teeth twice daily.[28–30] Recently, a systematic review and meta-analysis suggested that optimal tooth brushing should occur twice daily and involve a fluoride toothpaste for caries prevention and periodontal disease control.[31] Due to improving oral hygiene care programs in recent decades, 80% to 90% of populations in industrialized countries brush their teeth 1 or 2 times a day.[28]

Several reports have shown that having an urban residence is superior to having a rural residence in terms of remaining dentition in populations of Norwegian adults,[32] Swedish men,[25] Western Australian adults,[33] Brazilian women,[34] and Iranian adults.[35] The present study also demonstrated that urban residents had significantly more remaining teeth than rural residents. These urban and rural differences in tooth loss can be generally explained by rural culture.[36] Rural residents are prone to less-nutritious diets, less exercise, and more smoking and drinking; these behaviors are reinforced by negative health. This rural-urban difference was partly explained by the neighborhood effects of health education within a community. Furthermore, the rural individuals were less likely to have functional dentition because those who were illiterate or had low-level education had no money for high-cost prosthodontic rehabilitations.[35]

This study revealed that socioeconomic inequality was positively associated with tooth loss. Similarly, individuals with low education levels or low household incomes had higher prevalence of tooth loss than did other individuals in many studies, including ones from Sweden,[25,37] Brazil,[38,39] Germany,[40] Norway,[41] the USA,[42–46] Australia,[33] and Jordan.[47] One longitudinal comparative study from Brazil revealed that an increase in income inequality (measured by the Gini Index) from 1991 through 2003 led to an increase in the prevalence of both severe tooth loss (fewer than 9 remaining teeth) and loss of functional dentition (fewer than 20 natural teeth).[38] A Brazilian cross-sectional study of 5349 subjects aged 65 to 74 indicated that female and those of a low education level were significantly associated with an increasing prevalence of edentulism.[39] In the Norwegian population, the prevalence of losing at least 1 tooth during the past year was lower among subjects who had more than a high school degree (more than 12 years of education) than it was among subjects with less education.[41]

To explain the different occurrences of tooth loss, some researchers have reported that unequal access to dental care between social strata, and both dietary and cultural differences are all likely to contribute.[33,48–50] Similarly, as suggested in the study of African Americans in Florida, inequalities in health care availability, dental insurance coverage, and service receipt indicated the effects of socioeconomic status on tooth loss.[42] The subjects with low incomes and low education levels were prone to extracting their diseased teeth rather than having root canals or prosthodontic treatments. Furthermore, the subjects with low incomes who were frustrated with their dental care or who did not have regular dental visits were more significantly more likely to lose 1 or more teeth.[46]

Table 3

Mean remaining teeth (n) according to the sex and age group.

Age	Male	Female	*P*
19–29	27.6+0.0	27.4+0.0	<0.0001
30–39	27.3+0.0	27.3+0.0	0.0854
40–49	26.4+0.1	26.7+0.0	<0.0001
50–59	23.9+0.1	24.7+0.1	<0.0001
60–69	20.3+0.2	20.8+0.2	0.057
≥70	15.2+0.2	13.7+0.2	<0.0001

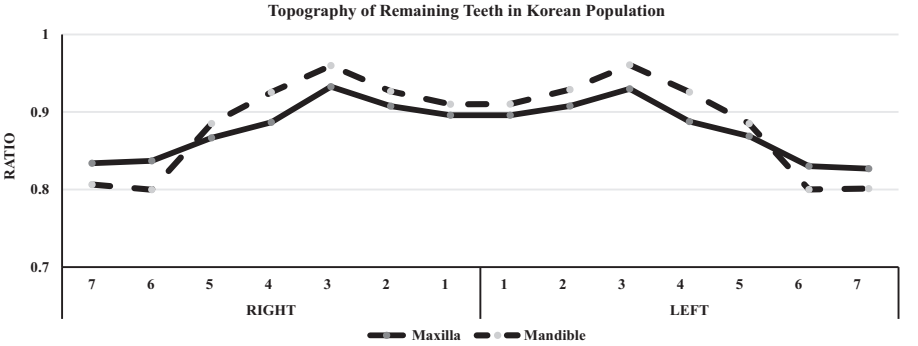

Figure 2. Individual tooth survival rates from the anterior incisors to the posterior molars.

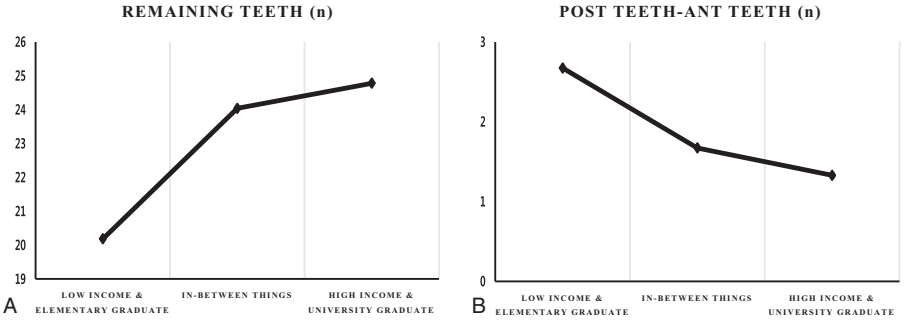

Figure 3. The number and location of remaining teeth according to socioeconomic status.

The present study had several limitations. The first is that this study was based on a cross-sectional survey; it is thus difficult to demonstrate a causal relationship between oral health behavior, sociodemographic variables, and the number of remaining teeth based on the study. Second, this study was performed in only 1 Asian country. Multicenter and longitudinal cohort studies are required to ensure the high-level reliability of the results. This study also has some strengths, though. This study analyzed a representative sample of the entire Korean adult population, and to the best of our knowledge, this is the first report to investigate number of remaining teeth among the administrative districts of South Korea. Moreover, this study revealed that location of remaining teeth had pattern according to socioeconomic status. This study also investigated the timing of tooth brushing in detail, from before breakfast to before bedtime.

In conclusion, participants who brushed their teeth fewer times per day, those with low household incomes and/or education levels, and those who lived in rural districts had significantly higher prevalence of tooth loss than did other groups in Korean adults. The participants had more anterior and premolar teeth on mandible, but they had more molars on maxilla. In addition, participants with high socioeconomic status were more likely to lose their molar teeth than anterior teeth compared to those with low socioeconomic status.

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