Tooth Replacement Related to Number of Natural Teeth in a Dentate Adult Population in Bulgaria: A Cross-Sectional Study

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Purpose: This study aimed to explore the relationships among tooth replacement, number of present natural teeth, and sociodemographic and behavioral factors in an adult population in Bulgaria. ***Materials and Methods:*** Quota sampling was used to recruit 2,531 dentate subjects aged 20 years and over from the capital city and four main urban centers, four towns, and seven small towns and villages of Bulgaria. Potential candidates for tooth replacement were classified as having functional dentitions (26 to 27 or 20 to 25 natural teeth present) or subfunctional dentitions (16 to 19 or 2 to 15 natural teeth present), not including third molars. Multiple logistic regression analyses were performed to determine the associations between tooth replacement and the factors of interest. ***Results:*** Of the included subjects, 37% presented with tooth replacement, while 19% presented with fewer than 20 natural teeth. Molars were replaced significantly less often ($P \leq .017$) than premolars and anterior teeth. The presence of tooth replacement was more likely in subjects with 2 to 15 teeth (odds ratio: 1.62) and less likely in subjects with 26 to 27 teeth (odd ratio: 0.29), but no significant difference was detected between subjects with 16 to 19 and 20 to 25 teeth. Tooth replacement was associated with age, occupational status, frequency of dental visits, and toothbrushing habits. ***Conclusions:*** In this Bulgarian population, the variables number of present teeth, age, dental visits, and toothbrushing were relevant factors with respect to tooth replacement. The cutoff value of 20 teeth did not discriminate high-risk from low-risk subjects. *Int J Prosthodont 2013;26:34–41. doi: 10.11607/ijp.3111*

Preservation of the dental arch via replacement of missing teeth has been a central goal of prosthodontic care.[1] In Bulgaria, this goal is still based on the traditional morphologic approach taught in dental schools and may be systematically applied in dental practice. However, this approach is neither attainable nor affordable from the perspective of public health care. Since the fall of the communist regime in 1989, the public health care sector in Bulgaria has undergone radical changes, including privatization of oral health care services.[2] Now, dentists (1 per 1,210 inhabitants) provide oral health care services in private practices either within the scope of the mandatory health insurance system or privately.[3,4] With total oral health expenditures accounting for 0.16% of the gross domestic product,[5] oral health care is severely underfinanced. The annual package for insured adult patients partially covers a clinical examination and two curative procedures (ie, fillings and extractions), whereas additional dental services are fully paid for by the patient. Despite the positive trends in economic growth, Bulgaria remains far behind most European countries in terms of income per person, with an average annual wage of €3,224 in 2008.[4,6] As such, it is expected that a substantial portion of the population cannot afford dental care, especially expensive prosthodontic services.

It has been increasingly recognized that an incomplete dentition can still satisfy functional needs.[7,8] Research shows that the demand for tooth

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replacement is primarily motivated by esthetic and social concerns as opposed to physical need.[9,10] Absent anterior and premolar teeth have been shown to have a greater impact on oral function and satisfaction than absent molar teeth.[11,12] In 1992, the World Health Organization (WHO) set the following strategic goal for oral health care: "the retention throughout life of a functional, aesthetic, natural dentition of not less than 20 teeth and not requiring recourse to a prosthesis."[13] Consequently, the presence of 20 teeth has been used in recent epidemiologic studies as the threshold for a functional dentition.[14] While the presence of 20 natural teeth has been associated with adequate function and nutrition,[15,16] the relationship between number of present teeth and tooth replacement seems to be less clear. In a review of prosthodontic restorations in Europe, it was concluded that if only a few teeth are missing, they are most likely to be either restored with fixed prostheses or not replaced at all, while the likelihood of replacement with removable prostheses increases with the number of missing teeth.[17] A recent study of tooth loss and prosthodontic rehabilitation among 35- to 44-year-old Iranians found much higher odds of prosthodontic rehabilitation in subjects with fewer than 20 teeth.[18] Additionally, several non-dental factors, eg, demographic and socioeconomic factors, are well known to be related to tooth replacement.[19–23]

The acceptance of a functionally oriented approach to dental care means that the clinician's definition of the "need" for prosthodontic services must take into account that there are no clear indications for treatment.[24] According to the WHO statement,[13] a functional dentition should not require prosthodontic replacement of missing teeth. However, this aspect of the WHO statement has received little attention in the dental literature and has never been studied in Bulgaria. The aim of this study was to describe tooth replacements in a dentate adult population in relation to the number of present natural teeth and several sociodemographic and behavioral factors. It was hypothesized that subjects with fewer than 20 natural teeth are more likely to undergo tooth replacement than subjects with 20 or more natural teeth. A second hypothesis was that missing teeth in the molar region are replaced less often than missing teeth in the premolar and anterior regions.

Materials and Methods

This study was part of a cross-sectional survey conducted in Bulgaria between October 2006 and January 2010. The sample size calculation set a minimum of 2,400 subjects to allow for multiple logistic regression analysis with at least 12 independent variables, stipulating no fewer than 120 observations of the least prevalent part of a dichotomous variable at a 5% prevalence rate. A quota sampling method was applied to draw subjects aged 20 years and over. Quota units were established with regard to demographic (type of settlement), social (occupational status), and dental (dentition) characteristics. Four groups of settlements were defined based on their population size and administrative functions: capital city, main urban centers, towns, and rural settlements (ie, a small town or village). Occupational status was expressed in terms of three groups of occupational categories (professionals, intermediate, and workers), with a separate fourth category for retired subjects. Dentitions were classified as complete, interrupted, or shortened on the basis of morphologic characteristics. Recruitment of participants continued until the predetermined conditions for sample size and completion of quota units had been fulfilled.

A total of 16 settlements were selected for the survey: Sofia (the capital city), four main urban centers, four towns, and seven small towns and villages. Within the settlements, employed subjects were recruited from factories and institutions, whereas retired subjects were recruited from local health care centers and a home for elderly people. Of all eligible subjects available for examination, 313 refused participation and 2,644 were examined. Following exclusion of 113 totally edentulous subjects, data from 2,531 dentate subjects were analyzed. The Ethical Committee of the Medical University-Sofia approved this study (no. 299/15.05.2007). The research was carried out in compliance with the Helsinki Declaration. Verbal consent was obtained from each subject prior to data collection. Data were collected using a structured interview, self-administered questionnaire, and oral examination.

The interview and questionnaire contained items regarding a number of background variables, including demographic (age, sex, and place of residence), sociocultural (educational attainment, occupational status, and household income), and behavioral (dental attendance and toothbrushing patterns) factors. Educational attainment was defined as the years of education completed and classified as low (9 years or fewer), middle (10 to 12 years), or high (more than 12 years). Combined household income was self-rated by the subjects on a five-point scale, and subjects were assigned to three income categories: high (income rated as "excellent" or "very good"), middle (income rated as "good"), or low (income rated as "fair" or "poor"). Dental visits were considered as regular if subjects reported visiting a dentist at least once a year and as irregular if subjects reported less frequent dental visits. Frequency of toothbrushing

was scored as follows: two or more times a day, once a day, or less than once a day.

Following the interview and completion of the questionnaire, subjects received an oral examination, and the status of each tooth was recorded as present or absent. Present teeth (TP) were recorded as sound, decayed, filled, or crowned. Absent teeth were recorded as missing and replaced (TMR) or as missing and not replaced (TMNR). A tooth root was considered as an absent tooth, indicating a potential site for tooth replacement. A tooth replacement was recorded as involving a fixed dental prosthesis (FDP) or a removable dental prosthesis (RDP).

Oral examinations were performed by one calibrated examiner in natural light using a mirror and dental probe, with the subject seated in an ordinary chair. A headlight was used when the natural light was deemed to be insufficient. The examiner was calibrated against experienced researchers at the beginning of and halfway through data collection by examining convenience samples of 10 subjects in each calibration session. The interexaminer agreement was very good in both sessions (Cohen kappa ≥ 0.95).

The distribution of tooth replacements in the sample population and per arch and tooth type as well as the percentage of subjects with 20 or more teeth were calculated for all subjects based on a 32-tooth dentition (ie, including third molars). Subjects with both fixed and removable restorations were counted as subjects with an RDP. Tooth replacements were related to the number of natural teeth in subjects with an incomplete dentition. An incomplete dentition was defined as the presence of a least 1 tooth in each arch but no more than 27 teeth in the whole dentition, based on a 28-tooth dentition (ie, not including third molars). Incomplete dentitions were considered as functional if 20 to 27 natural teeth were present or as subfunctional if 2 to 19 natural teeth were present. To increase specificity with regard to the association of tooth replacements with number of present teeth, subjects with functional incomplete dentitions were further subdivided into subjects with 26 to 27 teeth and subjects with 20 to 25 teeth, based on the assumption that tooth replacement is not necessarily required when only 1 or 2 teeth are missing. The subdivision of subfunctional incomplete dentitions aimed at approximately equal distribution of subjects between subgroups because no assumptions could be derived from the dental literature. This resulted in one subgroup of subjects with 16 to 19 teeth and another with 2 to 15 teeth.

For all subjects with an incomplete dentition, the replacement ratio (Rratio) was calculated separately for the whole dentition and for each of the three dental regions (anterior, premolar, and molar). The Rratio was calculated by dividing the number of replaced missing teeth by the total number of potential sites for tooth replacement: Rratio = TMR / (TMR + TMNR + tooth roots). Differences in the replacement of missing teeth between the dental regions were expressed as differences in the replacement ratios. The mean fractions of replaced teeth per dental region were compared in pairs in subjects who showed missing teeth in at least two dental regions. Differences in Rratio between the dental regions were tested by paired *t* tests with 95% confidence intervals (CIs).

Multiple logistic regression analyses were performed to determine the associations between tooth replacement (dependent variable) and the number of present natural teeth, controlling for demographic, sociocultural, and behavioral factors (independent variables). Odds ratios (ORs) were calculated with 95% CIs for the dependent variable after dichotomization (tooth replacement vs no tooth replacement). Subjects with missing data for the background variables (n = 32) were excluded from the analyses.

Categoric data are presented as counts and percentages. Continuous data are presented as means ± standard deviations (SDs). $P \leq .05$ was considered as statistically significant. The Statistical Package for Social Sciences for PCs (version 16, IBM) was used for the analyses.

Results

Table 1 shows the distribution of dentate subjects according to sociodemographic and behavioral characteristics. Of the total sample (n = 2,531), a minority (37%) had received tooth replacement (Table 2). Tooth replacements were seen more often in the oldest age group (73%) compared to younger age groups (≤ 63%), in women (42%) compared to men (33%), and in subjects living in rural settlements (49%) compared to urban residents (≤ 40%). Of all subjects with tooth replacement (n = 928), 76% presented with an FDP only, 16% with an RDP only, and 8% with both. Of all subjects with an RDP, the majority (n = 159) presented with a partial RDP. Forty-seven subjects had a complete maxillary RDP in the maxilla, while 16 subjects had a complete mandibular RDP (both groups excluded from further analyses). The distribution of RDPs was approximately even between the arches, whereas slightly more FDPs were seen in the maxilla (Fig 1). The fraction of nonreplaced missing teeth (TMNR) was higher in molar teeth than in premolar and anterior teeth in both arches (Fig 2).

Slightly more than 19% (n = 489) of all dentate subjects presented with a subfunctional dentition comprising fewer than 20 natural teeth; 413 subjects were

Table 1 Distribution of Dentate Subjects According to Sociodemographic and Sociobehavioral Characteristics

		Education (%)*	Income (%)*			Dental visits (%)*	Toothbrushing (%)*		
	n (%)	> 12 y	High	Middle	Low	Irregular	< 1/d	1/d	≥ 2/d
Total	2,531 (100)	37	9	39	52	55	8	37	55
Age (y)									
20–44	1,102 (44)	31	6	33	61	59	11	42	47
45+	1,429 (56)	41	11	44	45	53	5	33	62
Sex									
Male	1,516 (60)	31	9	40	51	60	11	44	45
Female	1,015 (40)	46	7	39	54	49	3	26	71
Settlement									
Capital	397 (16)	39	8	41	51	49	7	31	62
Urban center	716 (28)	46	12	46	42	48	3	33	64
Town	704 (28)	23	9	35	56	60	13	41	46
Rural	714 (28)	40	5	37	58	62	8	39	53
Occupational status									
Professional	832 (33)	81	11	49	40	44	2	33	65
Intermediate	1,034 (41)	17	9	38	53	60	8	37	55
Worker	559 (22)	10	6	31	63	67	14	44	42
Retired	78 (3)	22	0	18	82	46	14	28	58
Unknown	28 (1)	61	11	50	39	40	7	25	68

*Subjects with missing data (3 for education, 19 for income, 1 for dental visits, and 12 for toothbrushing) were not considered in the percentage calculation.

Table 2 Distribution of Prostheses According to Age, Sex, and Residence

		% of subjects		
	No. of subjects	No replacement	FDP only	RDP ± FDP
Total	2,531	63	28	9
Age (y)				
20–29	468	95	5	< 1
30–39	649	82	18	< 1
40–49	609	58	35	7
50–59	606	37	47	16
≥ 60	199	27	36	37
Sex				
Male	1,516	67	27	6
Female	1,015	58	30	12
Settlement				
Capital	397	67	22	11
Urban center	716	78	19	3
Town	704	60	33	7
Rural	714	51	35	14

FDP = fixed dental prosthesis; RDP = removable dental prosthesis.

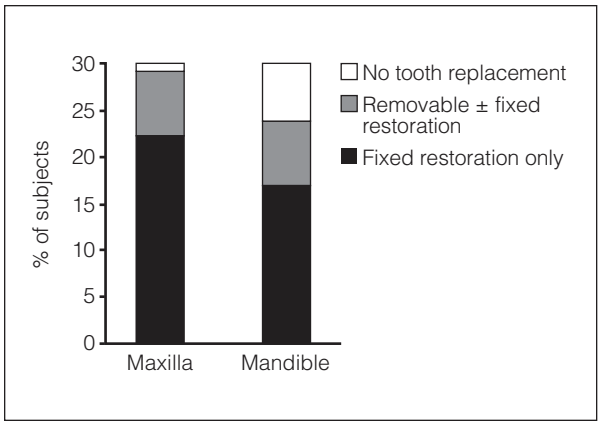

Fig 1 Distribution of tooth replacements per arch.

dentate in both arches (Table 3) and 76 were dentate in one arch only. The percentage of subjects with a functional dentition dropped from approximately 90% at the age of 40 years to 50% at 65 years of age (Fig 3). When tooth replacements were considered, the majority of subjects at all ages presented with dentitions comprising 20 or more natural plus replaced teeth.

In subjects with incomplete dentitions (n = 1,811), the percentage of subjects who had received tooth replacement increased as the number of present natural teeth decreased (Table 3). Fixed restorations were more frequent in subjects with 20 to 25 or 16 to 19 natural teeth, while RDPs were more frequent in subjects with 2 to 15 natural teeth. The mean number of replaced teeth in subjects with only FDPs ranged from 1.2 (± 0.4) to 4.6 (± 2.8). The mean number of replaced teeth in subjects with RDPs ranged from 0.7 (± 0.6) to 13.8 (± 5.4). Molar regions in both arches showed significantly smaller mean fractions of replaced teeth compared to premolar and anterior regions (Table 4). In contrast, no significant differences were found in mean Rratio between premolar and anterior regions.

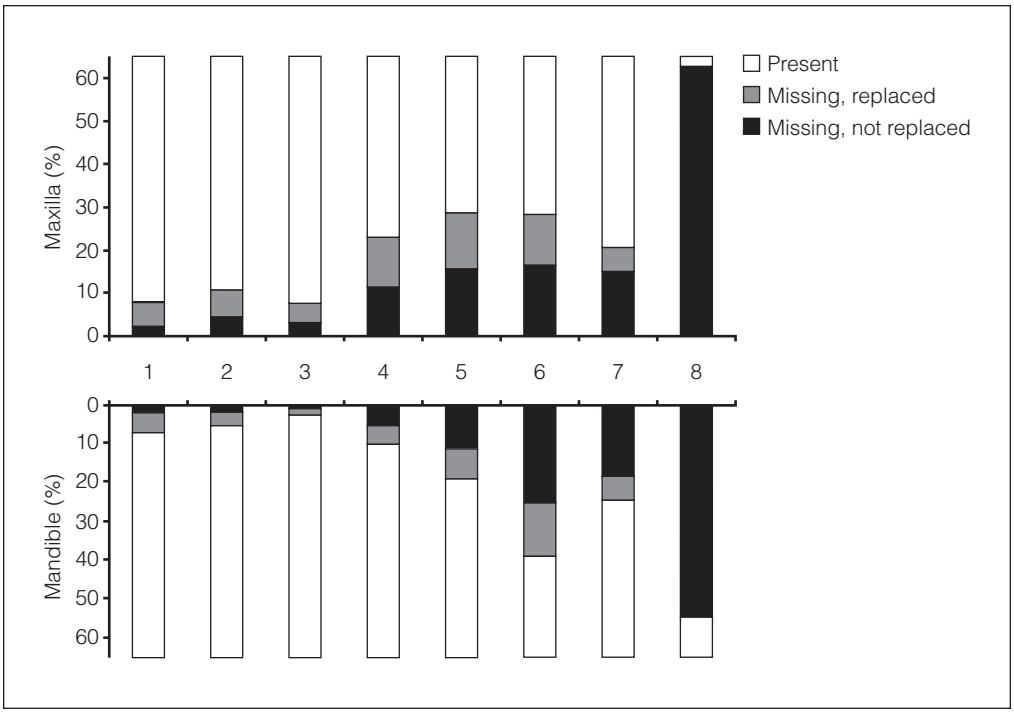

Fig 2 Distribution of replaced and nonreplaced missing teeth per tooth type (universal tooth-numbering system).

Table 3 Mean No. of Natural Teeth (T_P) and Replaced Teeth (T_{MR}) According to Presence and Type of Restoration in Subjects with Incomplete Dentitions (n = 1,811)

No. of present teeth (no. of subjects)	No replacement		FDP only			RDP ± FDP		
	Subjects (%)	T_P (SD)	Subjects (%)	T_P (SD)	T_{MR} (SD)	Subjects (%)	T_P (SD)	T_{MR} (SD)
Functional dentition								
26–27 (635)	75	26.6 (0.5)	25	26.4 (0.5)	1.2 (0.4)	< 1	26.7 (0.6)	0.7 (0.6)
20–25 (763)	45	23.3 (1.6)	52	22.8 (1.7)	2.9 (1.6)	3	21.8 (1.3)	3.2 (2.6)
Subfunctional dentition								
16–19 (212)	37	17.9 (1.0)	49	18.1 (1.0)	4.5 (2.4)	14	17.6 (1.1)	7.9 (2.7)
2–15 (201)	28	11.1 (3.3)	21	12.6 (2.5)	4.6 (2.8)	51	10.5 (2.9)	13.8 (5.4)

FDP = fixed dental prosthesis; RDP = removable dental prosthesis; SD = standard deviation.

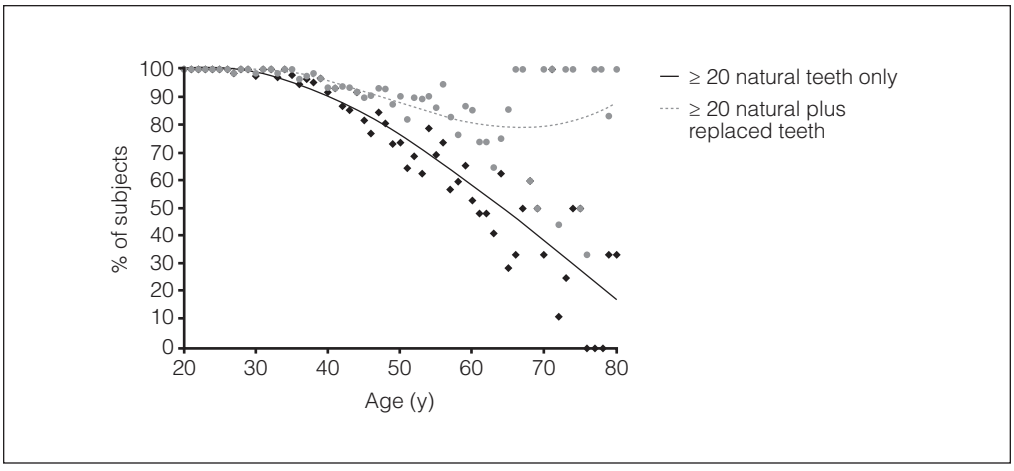

Fig 3 Percentage of subjects with ≥ 20 natural teeth only and ≥ 20 natural and replaced teeth combined according to age.

The multiple logistic regression analyses revealed that subjects with functional dentitions comprising 26 to 27 natural teeth had significantly lower odds of tooth replacement than those with functional dentitions comprising 20 to 25 teeth (Table 5). In contrast, the difference in odds ratios between subjects with 16 to 19 teeth (subfunctional) and subjects with 20 to 25 teeth (functional) was not significant. Subjects with 2 to 15 natural teeth were more likely to have undergone tooth replacement. Each additional year of age significantly increased the chance of tooth replacement. Sex, place of residence, educational attainment, and household income did not reveal significant associations. Professionals were more likely to have replaced teeth than the other occupational categories. With respect to oral health behavior, regular dental attendants and those who brushed their teeth more frequently were more likely to have tooth replacements than their respective counterparts (Table 5).

Discussion

In this study, tooth replacement was found to be associated with the number of present natural teeth, but the cutoff of 20 natural teeth did not discriminate high-risk from low-risk groups of subjects. The universal applicability of the 20- to 21-teeth threshold has been previously discussed.[25] Earlier studies on the effect of tooth loss on oral health impact and quality of life have demonstrated that the number of existing natural teeth associated with reduced oral health impact scores fluctuates between different countries[25] and age groups.[26] In the present study, tooth replacement was more likely in subjects with 2 to 15 teeth, but the odds of having tooth replacement did not differ significantly between subjects with 16 to 19 teeth and those with 20 to 25 teeth. Therefore, the hypothesis that tooth replacement is more likely for subjects with fewer than 20 natural teeth could not be accepted.

In contrast, the outcomes support the hypothesis that molars are replaced less often than other tooth types. This is in line with a previous study on the laboratory production of prosthetic restorations in Bulgaria, which found that most of the provided restorations were not intended to replace all missing posterior teeth.[27] In that study, the majority of the restorations were FDPs, although the mean price of a three-unit FDP (€75) was 2.5-times higher than the price of an RDP. Obviously, FDPs replace fewer missing teeth at a higher cost, whereas RDPs offer a low-cost alternative for the replacement of numerous missing teeth. In the present study, RDPs were more frequently seen in older age groups, women, and rural residents.

Table 4 Mean Difference in Replacement Ratios Between Anterior, Premolar, and Molar Regions

Region	Mean difference	95% CI	*P*
Maxilla			
A-PM	0.001	−0.03–0.03	.943
A-M	0.09	0.06–0.12	< .001
PM-M	0.11	0.09–0.13	< .001
Mandible			
A-PM	−0.01	−0.04–0.01	.319
A-M	0.03	0.01–0.06	.017
PM-M	0.03	0.01–0.04	.002

A = anterior; PM = premolar; M = molar; CI = confidence interval.

Table 5 Odds Ratios for Tooth Replacement in Subjects with Incomplete Dentitions (n = 1,779)*

	OR	95% CI	*P*
No. of present teeth			
26–27	0.29	0.23–0.38	< .001
20–20‡			
16–19	1.36	0.96–1.92	.083
2–15	1.62	1.10–2.40	.015
Age†			
Per year	1.06	1.05–1.08	< .001
Sex			
Male‡			
Female	1.24	0.98–1.57	.075
Settlement			
Capital	1.17	0.81–1.68	.397
Urban center	0.94	0.69–1.29	.698
Town	1.09	0.82–1.44	.564
Rural‡			
Education			
High	1.25	0.91–1.71	.169
Middle‡			
Low	0.63	0.37–1.08	.096
Occupational status			
Professional	1.40	1.00–1.95	.047
Intermediate‡			
Worker	1.04	0.80–1.37	.763
Retired	0.54	0.23–1.24	.144
Income			
High	1.23	0.80–1.90	.342
Middle‡			
Low	1.10	0.87–1.38	.424
Oral health behavior			
Irregular dental visits‡			
Regular dental visits	2.15	1.70–2.71	< .001
Toothbrushing†	1.28	1.06–1.54	.010

OR = odds ratio; CI = confidence interval.
*Subjects with missing data (n = 32) were excluded from the analyses.
†Numeric variables.
‡Reference group.

It should be noted that this quota sample was mainly drawn from a working population aged 20 years and over. Disadvantaged groups, such as unemployed people and ethnic minorities, could not be included in the sample or remained underrepresented. Consequently, the prevalence data may be overestimated and cannot be used to make inferences about the general population. Nonetheless, the sampling strategy ensured broad geographic representation and covered a wide spectrum of socioeconomic groupings. Geographic disparity is known to be considerable in Bulgaria, both in terms of living conditions and the provision of oral health care services. Rural areas, comprising 30% of the population, are twice as poor as the capital city[28]; further, the dentist-to-population ratio exceeds 1:2,000 in rural areas, whereas the capital city and some main urban centers show a ratio of less than 1:1,000.[3] The sampling strategy reflected the uneven distribution of dentists by including settlements with different levels of urbanization, such as three rural settlements with no available dental services. Drawing the present sample from a working population did not exclude the "working poor," since more than half of the participants rated their own income as "fair" or "poor." It has been shown that nonmonetary dimensions of well-being in Bulgaria do not improve to the same extent as monetary poverty indicators.[5] In summary, the sociodemographic characteristics of the study participants, together with the large sample size, were considered adequate to assess associations between the factors of interest and tooth replacement since these associations are not likely to be sensitive to imbalances in the study sample.

The multiple regression analyses confirmed the influence of age, whereas sex, residence, and most of the sociocultural factors failed to establish significant relations. Compared to the variables number of present teeth, age, frequency of dental visits, and toothbrushing habits, all other independent variables seemed to be of minor importance. Both regular dental visits and more frequent toothbrushing were associated with a higher chance of tooth replacement. Levin and Shenkman[29] found a higher frequency of filled teeth among subjects with favorable toothbrushing practices and proposed that proper oral hygiene could indicate a better attitude toward oral health, which in turn may result in more dental visits and more filled teeth. Health behavior is shaped by social and cultural factors that influence individual decisions.[30,31] As such, personal behaviors should be seen as indicators of other factors that are the true etiologic agents.[32] In the present study, older subjects, women, and subjects living in the capital city and urban centers reported more frequent dental visits and toothbrushing.

Tooth loss can be a disabling condition with profound physical and emotional effects.[33,34] Nevertheless, the magnitude of these effects is culturally dependent and may vary considerably.[35] As long as fatalism, ie, the conviction that life is dependent on forces beyond one's control, is a typical feature of the Bulgarian post-totalitarian culture,[36] tooth loss may continue to have widespread acceptance and tolerance among certain population groups. In the present study, more than 50% of subjects above 65 years of age presented with fewer than 20 natural teeth. Even when including tooth replacements, 10% to 20% of subjects had fewer than 20 natural and replaced teeth. With this in mind, strategies aiming at retention of at least 20 natural teeth to preserve acceptable function and esthetics, as proposed by the WHO,[13] may be appropriate in Bulgaria. Applying more functionally oriented approaches in Bulgaria would require revision of the role of prosthodontic care in a collective effort to maintain functional dentitions for life. In this study, a substantial proportion of dentitions comprising at least 20 teeth—commonly labeled by epidemiologic literature as "functional"—presented with tooth replacement. Whether these dentitions were actually functional cannot be judged by the number of present teeth alone. Recently, a hierarchical functional classification system was proposed that reflects oral functionality and seems to overcome some of the problems associated with the use of number of teeth as a single indicator. The system includes the number of natural teeth, their location in terms of dental region, and the number of posterior occluding pairs.[37] The sensitivity of this system in establishing the dental functional status and consequences of tooth replacements has been demonstrated.[38] Further investigation is needed to study the effects of treatments that aim to meet these proposed criteria on oral function and quality of life.

Conclusions

In this study population, the cutoff value of 20 natural teeth did not discriminate high-risk from low-risk subjects. Molar teeth were replaced less often than premolar and anterior teeth. Tooth replacement was associated with the number of present natural teeth, age, occupational status, and frequency of dental visits and toothbrushing. A better understanding of the determinants of oral health behavior may provide valuable information regarding the factors related to the need of and demand for prosthodontic care.

Acknowledgments

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