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Factors associated with tooth loss and prosthodontic status among Sudanese adults

Nadia Khalifa[1)], Patrick F. Allen[2)], Neamat H. Abu-bakr[3)] and Manar E. Abdel-Rahman[4)]

[1)]Prosthodontic Department, Faculty of Dentistry, Khartoum University, Khartoum, Sudan
[2)]Department of Restorative Dentistry, Cork University Dental School & Hospital, Wilton, Cork, Ireland
[3)]Conservation Department, Faculty of Dentistry, Khartoum University, Khartoum, Sudan
[4)]School of Mathematics, Khartoum University, Khartoum, Sudan

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Abstract: A study was conducted to determine the degree of tooth loss, factors influencing tooth loss, and the extent of prosthodontic rehabilitation in Sudanese adults (≥ 16 years old) attending outpatient clinics in Khartoum State. Pearson and multivariate analyses were used to examine the relationships between tooth loss and specific characteristics determined through interviews and clinical examinations. The mean number of missing teeth was 3.6 (SD, 4.9) and the prevalence of edentulism was 0.1%. The prevalence of tooth loss (missing at least one tooth) was 78%; 66.9% of tooth loss was due to caries, and 11.2% was attributable to other reasons. Prosthetic replacement of missing teeth was evident in 3%, whereas a need for prosthetic replacement was evident in 57%. Having < 20 teeth was associated with age, gender, and socioeconomic status; tooth loss due to caries was associated with age, tribe, frequency of tooth-brushing, and a low rate of dental consultation. Tooth loss due to other reasons was associated with age, tribe, education, periodontal pocketing, tobacco use, tooth wear, and prosthetic status. The results of the present study indicated that the major cause of tooth loss was dental caries, thus emphasizing the importance of a public prevention-based healthcare program. Replacement of missing teeth was uncommon in the study subjects, which may reflect lack of access to this type of oral healthcare. (J Oral Sci 54, 303-312, 2012)

Keywords: tooth loss; prosthodontic rehabilitation; adult; Sudan; multivariate analysis.

Correspondence to Dr. Nadia Khalifa, Prosthodontic Department, Faculty of Dentistry, Khartoum University, P.O. Box 102, Khartoum, Sudan
Tel: +249-912201328
Fax: +249-187557654
E-mail: nadiakhalifa@uofk.edu

Introduction

Although many industrialized countries have experienced a dramatic reduction in the prevalence of edentulism and partial tooth loss (1), the proportion of edentulous individuals in aging societies worldwide continues to be significantly high. Epidemiological data on the incidence and prevalence of tooth loss vary considerably, making comparisons between countries difficult (2).

Retention of > 20 natural teeth has been linked to a reasonable level of oral health (3). In some African countries (4,5), people retain a functional dentition of > 20 teeth even in old age, a phenomenon that is in marked contrast to the much more extensive tooth loss in industrialized countries (6,7).

The main causes of tooth loss include the sequelae of caries and periodontal disease, but other factors have also been implicated (8-15). Tooth loss has been associated with several sociodemographic, behavioral, or medical factors (16-23). Once a sufficient number of teeth are missing, food choices and nutritional changes (24,25) could contribute to medical problems that might affect an individual's general well-being. Tooth loss can also have a negative impact on emotions (26) and oral health-

related quality of life (27).

Substitution of missing teeth with a prosthesis is infrequent in developing countries, even though a high proportion of individuals may require some sort of prosthetic replacement (28). Decision makers and health planners in Sudan need information about risk factors for tooth loss to help identify individuals at risk. When analyzing the factors associated with tooth loss, instead of merely analyzing single factors, the use of multivariate models helps distinguish which factors—socio-demographic, behavioral, or medical—are associated with clinical measures of tooth loss. There is a relative lack of data pertaining to adults in the developing world in general, and Sudan in particular.

This research was part of a greater survey investigating oral health in a Sudanese population (29). The aim of this study was to determine the level of tooth loss, factors influencing tooth loss, and level of prosthodontic rehabilitation among Sudanese adult patients.

Materials and Methods

Study design

This cross-sectional oral health survey was conducted between August 2009 and March 2010 as part of a study designed to assess the functional and psychosocial impact of dental disease (29). The study participants were recruited from among those attending outpatient dental hospitals and dental health centers (DHCs) distributed among the 7 provinces (Umdurman, Khartoum Bahri, Khartoum, Jabal Aulia, Sharg En Nile, Karary, and Um badda) of Khartoum State. Sudan was the largest country in Africa before South Sudan became an independent country on July 9, 2011, at which time it was divided into 25 states, the capital, Khartoum State, being the most densely populated. The study population comprised 1,888 patients. The sample size was calculated using the formula for proportion estimates considering a tooth loss prevalence of 67% according to previous Sudanese studies (30,31), a precision of 3, and a design effect set at 2. Full details of the sampling procedures have been published elsewhere (29). Patients were selected consecutively until the required number from the different hospitals and DHCs was reached. Written consent was obtained from all patients. The study protocol was approved by the National Ethical Clearance Committee of the Federal Ministry of Health in Khartoum, Sudan.

Data collection

Interviews

Data on socio-demographic, behavioral, and medical characteristics were collected through application of a questionnaire administered during interviews by five certified dentists. The interviews were held in a confidential atmosphere before the clinical investigations, and took 15-20 min.

Clinical examination

Five certified dentists, including the main investigator, carried out the clinical examinations using clinical dental units, a dental mirror, and a World Health Organization (WHO) periodontal probe.

The clinical examination included a full-mouth recording of 32 teeth; tooth status was recorded using the decayed missing filled teeth (DMFT) index. Decay was recorded if a carious cavity was visually evident, and a community periodontal index (CPI) probe was used to confirm any visual evidence of caries. In addition to dental status, periodontal health was assessed by the CPI, and prosthetic status and need were established according to the WHO criteria (32). For prosthetic status, participants having no prosthesis, a bridge, more than one bridge, a partial denture, both bridge(s) and partial denture(s), and a full removable denture were recorded. Prosthetic need was judged subjectively by the five clinical investigators and was recorded as: no prosthesis needed, need for one unit prosthesis, need for a multiunit prosthesis or a full prosthesis (replacement of all teeth).

The 12 upper and lower anterior teeth were examined for wear (20,33). A tooth was recorded as missing due to caries if there was a history of a cavity prior to extraction. Tooth loss due to other reasons was considered to have occurred in the following cases: periodontal disease, trauma, orthodontic extraction, ritual extraction, congenital absence, and unknown reasons. The prevalence of tooth loss due to any reason was recorded as (0) no teeth lost and (1) 1+ tooth lost. The extent of tooth loss due to any reason was recorded as 0-20 teeth present (1) and 21+ teeth present (0).

Data analysis

Analyses were performed using the STATA Release 9 statistical software package (Stata Statistical Software 2005; StataCorp LP, College Station, TX, USA).

Data were subjected to calculation of frequency distributions. Bivariate analysis was conducted using Pearson's chi-squared test. Categorical-dependent or outcome variables were reduced to binary variables: 21+ teeth (0), 0-20 teeth (1); no missing teeth (0), ≥ 1 missing due to caries (1); and no missing teeth (0), ≥ 1 missing for other reasons (1).

Independent sociodemographic factors included sex, age group, ethnic group, occupation, monthly household

Table 1 Mean numbers of missing teeth in different age groups

Age group	*n*	Mean number of teeth (SD)	Mean number of missing teeth (SD)
16–24	413	30.8 (1.9)	1.2 (1.9)
25–34	616	30.1 (2.5)	1.9 (2.5)
35–44	368	27.8 (4.1)	4.2 (4.1)
45–54	253	26.5 (5.4)	5.5 (5.4)
55–64	133	24 (6.5)	8 (6.5)
65–74	77	20.7 (7.9)	11.3 (7.9)
75+	22	20.2 (10)	11.8 (10)
Total	1,882	28.4 (4.9)	3.6 (4.9)

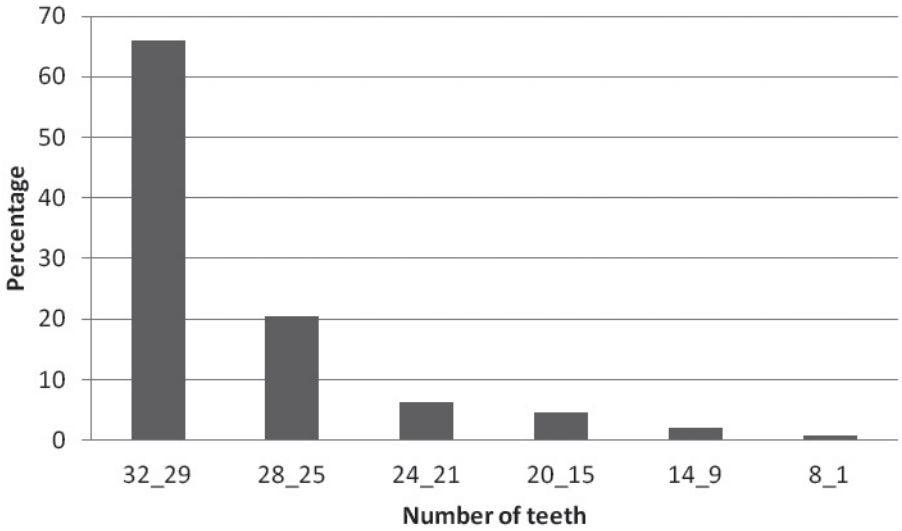

Fig. 1 Percentage of adults with teeth

income, and education level achieved. Behavioral factors included frequency of dental visits, tobacco use, and frequency and type of dental hygiene. Medical factors included how often the mouth felt dry, surgical history, and presence of disease. Clinical factors (only included in models for missing teeth due to caries/other reason) included: < 18 and ≥ 18 sound untreated natural teeth (SUNT); 0 decayed teeth (DT) and ≥ 1 DT; no tooth wear and tooth wear; healthy periodontal tissues and those with periodontal pockets of ≥ 4 mm; and presence or absence of prosthodontic replacement. Multivariate logistic modeling was used to take into account potential confounding variables.

Results

Reliability

Inter- and intra-examiner reliability was assessed using interclass correlation coefficients (ICC) at the beginning and during the survey with a 2-3-week interval. Details of the procedures have been published elsewhere (29). The ICC for CPI were fair to good, those for DMFT were excellent, and those for tooth wear were fair to good, according to Fleiss (34) .

Distribution

All of the participants were adults, and were divided into 7 age groups: 16-24, 25-34, 35-44, 45-54, 55-64, 65-74, and 75+ years. Women represented 59% of the sample. The characteristics of this group of adults have been described in more detail previously (29).

The mean number of missing teeth was 3.6 (SD, 4.9), whereas the mean number of teeth was 28.4 (SD 4.9). The highest mean number of teeth [30.8 (SD, 1.9)]was observed in the 16- to 24-year age group, and the lowest number of teeth [20.2 (SD, 10)] was observed in the 75+ -year age group (Table 1). The prevalence of edentulism was low (0.1%). The prevalence of tooth loss, i.e., missing at least 1 tooth, was 78%; 66.9% of tooth loss was due to caries, and 11.2% to other reasons. Even though most teeth were missing due to caries, the lower incisors were

Table 2 Prosthetic status and needs for the entire sample

Prosthetic Status	% Upper	% Lower
No prosthesis	95.7	98.3
Bridge	2.6	0.7
More than 1 bridge	0.5	0.5
Partial denture	0.7	0.3
Both bridge(s) and partial denture(s)	0.3	0.1
Full removable denture	0.2	0.1
Prosthetic Need		
No prosthesis needed	62.8	51.8
Need for one-unit prosthesis	11.4	15.6
Need for multi-unit prosthesis	22.7	28.9
Need for combination of one or multi-unit prosthesis	2.1	3.0
Need for full prosthesis (replacement of all teeth)	1.0	0.7

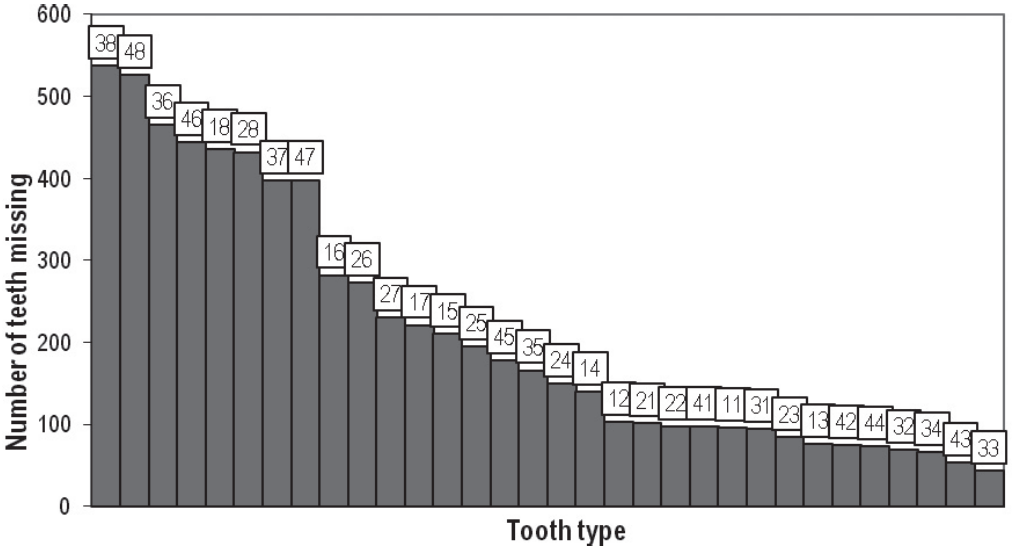

Fig. 2 Frequency of tooth loss according to tooth type

more commonly missing for other reasons. Periodontal disease (54%) was the most common cause of tooth loss due to other reasons, followed by congenitally missing teeth (15%), trauma (13%), symptomatic wisdom teeth (12%), ritual extractions (5%), and orthodontic extractions (1%). Nearly 93% of the study participants had > 21 teeth (Fig. 1). The teeth that were most frequently missing were the lower left and right third molars, followed by the lower left and right first and second molars. The lower canines were the least frequently missing (Fig. 2).

Very few subjects (4.3%) had either an upper bridge or a denture (Table 2). Prosthetic need was 37.2% in the upper jaw and 48.25% in the lower jaw. Periodontal pocketing of ≥ 4 mm was observed in 9.3% of the participants, and more than a third (35.5%) of the adults showed some degree of wear of their anterior teeth that involved at least some dentine. In this study, the DMFT was 7.4 (SD, 6.2) and the mean number of filled teeth was 0.2 (SD, 0.8). Untreated decayed teeth were present in 87% of the participants.

Bivariate analysis

For Pearson's chi-squared test, independent factors included socio-demographic, behavioral, medical and clinical factors, whereas dependent factors included having < 20 teeth missing teeth due to caries, and tooth loss due to other reasons. Variables were found to be significant at $P < 0.05$.

Mulivariate logistic regression analysis

Only the factors found to be significant by Pearson's chi-squared analysis were then entered into the multivariate logistic regression model. Table 3 shows the outcomes of three multivariate models, namely, predic-

Table 3 Association with, and likelihood of an adult having < 20 teeth, tooth loss due to caries, or tooth loss due to other reasons (based on Pearson's chi-squared test and odds ratios from logistic regression)

Characteristic	Having < 20 teeth		Missing teeth due to caries		Missing teeth due to other reason	
	Pearson's χ^2 *P* value	Multivariate logistic regression Odds Ratio(95% CI)	Pearson's χ^2 *P* value	Multivariate logistic regression Odds Ratio (95% CI)	Pearson's χ^2 *P* value	Multivariate logistic regression Odds Ratio (95% CI)
Socio-demographic						
Age group	0.000*		0.000*		0.000*	
16–24		1		1		1
25–34		2.29 (-2.76-7.34)		1.87** (1.3-2.44)		1.60** (1.35-1.85)
35–44		14.75** (-15.27-44.77)		4.24** (2.52-5.96)		1.62** (1.33-1.91)
45–54		26.39** (-25.33-78.11)		5.49** (2.69-8.29)		2.60** (0.31-4.89)
55–64		136.07** (-141.83-413.97)		5.01** (1.42-8.6)		4.03** (0.97-7.09)
65–74		282.44** (-305.36-870.24)				
75+		186.77 (-232.43-605.97)				
Gender	0.034*		0.022*		0.013*	
Male		1				1
Female		2.09* (0.84-3.34)				0.65** (0.45-0.85)
Ethnic group	0.009*		0.001*		0.000*	
Northern & Central tribe				1		1
Eastern tribe				0.50* (0.21-0.79)		
Western tribe				0.78+ (0.56-1.00)		
Southern tribe						2.68** (1.37-3.99)
Income	0.000*		0.776		0.538	
< 250 SDG		1				
250–500 SDG		0.28* (0.03-0.53)				
Education	0.000*		0.000*		0.002*	
No formal schooling/ Khalwa		1		1		1
Primary						0.61* (0.34-0.88)
Secondary				0.58** (0.36-0.80)		0.65+ (0.38-0.92)
College/university/post graduate degree		0.27** (0.02-0.52)		0.45** (0.28-0.62)		0.66+ (0.37-0.95)
Behavioural						
Dental visits	0.000*		0.000*		0.674	
Never		1		1		
Less frequent than every 2 years		3.31** (0.45-6.17)		15.26** (10.52-20.00)		
More frequent than every 2 years		4.82** (0.20-9.44)		19.91** (11.54-28.28)		
Tobacco use	0.054*		0.675		0.000*	
No						1
Yes						1.02* (-0.06-2.10)
Dental hygiene	0.020*		0.000*		0.096*	
Tooth brushing						
No		1		1		
Once		0.10** (-0.02-0.22)				
More than 2× / day		0.09** (-0.03-0.21)		0.25* (0.03-0.47)		

Table 3 Association with, and likelihood of an adult having < 20 teeth, tooth loss due to caries, or tooth loss due to other reasons (based on Pearson's chi-squared test and odds ratios from logistic regression)

Clinical				
Periodontal condition	0.009*		0.000*	
Healthy gums				1
Periodontal pockets of 4+ mm				1.56** (1.05-2.07)
Sound untreated natural teeth (SUNT)	0.000*		0.000*	
More than 18		1		1
Less than 18		2.98** (1.35-4.61)		1.89** (1.09-2.69)
Tooth wear	0.000*		0.002*	
No		1		1
Yes		1.83** (1.26-2.40)		0.53** (0.33-0.73)
Decay	0.000*		0.091	
No		1		
Decay (1 + tooth)		3.01* (0.76-5.26)		
Prosthetic status	0.002*		0.000*	
No bridge/denture				1
Has bridge/denture				2.41** (1.12-3.70)

*$P < 0.05$ significant by Pearson's chi-squared test
+ $P < 0.10$; * $P < 0.05$; ** $P < 0.01$ significant exponentiated coefficients (OR); 95% confidence intervals (CI) in parentheses
Some spaces are blank because only characteristics with increased odds of a positive/negative outcome are shown.

tors for having < 20 teeth, tooth loss due to caries, and tooth loss due to other reasons.

Predictors for having < 20 teeth

The odds for having < 20 teeth became significantly greater with increasing age. Female individuals were more than twice as likely to have fewer teeth than male individuals. Participants with a household income of 250-500 Sudanese guineas (SDG) per month had a smaller chance of having fewer teeth than those who were earning < 250 SDG. Similarly, those with a college/university/postgraduate degree were less likely to have fewer teeth than those with no formal schooling. People who visited a dentist more frequently were likely to have significantly fewer teeth than those who did not visit a dentist at all. The odds that individuals who regularly brushed their teeth would have fewer teeth were lower than for those who did not.

Predictors of tooth loss due to caries

Participants who were lacking teeth due to caries were less likely to belong to tribes other than northern and central tribes, less likely to have secondary schooling or higher education, significantly more likely to visit a dentist within a 2-year period (OR 15.26), less likely to brush their teeth more than twice a day, more likely to have < 18 sound teeth, and more likely to have tooth wear (OR 1.83) and decay (OR 3.01). The odds for teeth being missing due to caries increased with age.

Predictors of tooth loss due to other reasons

Individuals who were lacking teeth for reasons other than caries were more likely to belong to older age groups, less likely to be female, more likely to belong to southern tribes (OR 2.68) than to northern and central tribes, less likely to have received a formal education, more likely to use tobacco (OR 1.02), more likely to have periodontal pockets of ≥ 4 mm, more likely to have < 18 sound teeth, less likely to have tooth wear, and more likely to have a bridge or a denture.

Discussion

The findings of the present study show that even up to old age, most subjects retained > 21+ teeth according to the WHO Dentition Status criteria. This finding has to be viewed cautiously because unrestorable teeth as well as the mere presence of roots were considered teeth being present. The results confirm observations from other African countries (4,35,36) but are in marked contrast to findings of much more extensive tooth loss in industrialized countries (6,7). The difference may be due to the lack of access to dental care in developing

countries compared to industrialized countries. Accordingly, tooth number is not a marker of dental "health" in this population; rather, it is more a reflection of the lack of access to dental services and possibly a lack of dental awareness among the population.

Although this study showed that it is possible to obtain information on oral health issues from patients attending outpatient facilities of hospitals and dental health centers in Khartoum State, the findings may not be representative of Sudan as a whole. This study sample was biased in that visits by the individuals attending these clinics were problem-based. Given the limited infrastructure of oral health services in Khartoum, the prevalence rates of the conditions reported here are unlikely to be overestimated.

The principal cause of tooth loss in this series was caries, a finding that is in accordance with that of another study (37). It is difficult to establish the validity of reasons for tooth extraction, because this relies on the accuracy of subjective information provided by each individual. Moreover, in accordance with other studies (4,5), molars accounted for the majority of missing teeth, and overall tooth loss was due mainly to caries, except for mandibular incisors, which were missing mainly for reasons other than caries.

Multivariate logistic regression analysis

The aim of multivariate analysis in our study was to help predict factors that may be responsible for variations in tooth loss.

Predictors of having < 20 teeth

Tooth loss increased with age, and female individuals were more likely to have < 20 teeth, a finding that has been reported elsewhere (18). It could be speculated that the reason for this is the more frequent attendance pattern of female individuals (38), or that female individuals are more likely to request extraction of a tooth that appears unattractive.

Socioeconomic status in this study seemed to play a relevant role in that people with a greater monthly income and higher education were more likely to retain ≥ 20 teeth. This finding is similar to the multivariate results of the 1998 UK Adult Dental Health Survey (39), in which the odds of being edentate were almost 9× higher for adults with no qualifications and 4× higher for those with qualifications below degree level.

In the present study, people who visited a dentist more frequently had a significantly higher likelihood of having fewer teeth. This finding could be related to problem-based attendance and requests for extraction by patients, or possibly the influence of dentists themselves. It is known that dentists' perceptions of the need for dental treatment and its extent can be significant predictors of tooth extraction (21). If more emphasis were to be placed on the use of relatively cheap atraumatic restorative treatment (ATR) when cavities are still small, this might help avoid unnecessary tooth extractions in the future.

The idea that the frequency of dental hygiene procedures, for example tooth-brushing frequency, could affect the number of teeth seems logical. An association between the number of teeth and oral hygiene has been identified (40), people with better oral hygiene scores losing fewer teeth (18). This finding implies that oral health policies should target identified risk factors while emphasizing preventive programs that include oral hygiene instructions.

Predictors of tooth loss due to caries

Tooth loss due to caries was associated with increasing age in our series, a finding that is consistent with the results of other studies. Tribal differences were observed in terms of teeth that were missing due to caries, being less prevalent in eastern tribes than in northern and central tribes; this difference could be due to differences in social or cultural factors and might warrant further investigation. People with formal schooling were less likely to have tooth loss due to caries, a finding that is in accordance with previous studies (41), suggesting that subjects with a higher education level have a lower risk of tooth loss. In our study, participants who reported more frequent problem-based dental attendance had significantly higher numbers of teeth that were missing due to caries, a finding that may be explained by the fact that people with caries are more likely to undergo tooth extraction than restorative treatment. In Sudan, there is a shortage of essential equipment in the government's health facilities, and charges at private facilities are high, making dental treatment unaffordable to many Sudanese. It is therefore not surprising that our study subjects showed a high frequency of tooth loss and low prosthetic status. One study has stated: "Oral diseases are the fourth most expensive to treat in most industrialized countries. Were it available in many low-income countries, treatment of dental caries in children alone would exceed the total child health care budget" (42). Improving oral health in dentally deprived communities such as those in Sudan by promoting prevention and community programs for oral health would have a greater impact and would be far more effective than the curative and technological aspects that tend to be emphasized by the dental profession and governments (www.ibiblio.org/taft/cedros/english/newsletter/n5/Berlin.html).

In a Tanzanian study (5), women suffered more tooth decay and visited dentists more frequently. The authors of that study subsequently concluded that the greater number of teeth lost due to caries in women appeared to be related to dental caries experience and the use of dental care services. The use of extraction as the main treatment for dental caries suggests that the education and training of dentists in this region may be problematic. It also suggests that patients may not be aware of the need to seek treatment before caries advances to such an extent that dental extraction becomes the only remedy. There may also be economic barriers to conservative dental care; as such, it is important to develop health promotion initiatives aimed at preventing dental disease.

Participants who stated that they brushed their teeth more than twice a day had a decreased likelihood of tooth loss due to caries, which again indicates that individuals with better oral hygiene have less tooth decay. Individuals lacking teeth due to caries are also less likely to have ≥ 18 SUNT, due probably to the higher rate of extractions in comparison with restorations. Use of ≥ 18 SUNT as an arbitrary cut-off point has been adopted previously in adult national oral health surveys in the United Kingdom (20) and Ireland (18).

Individuals lacking teeth due to caries are also more likely to develop tooth wear due to an increase of occlusal load on the remaining teeth.

Predictors of tooth loss due to other reasons

Loss of teeth due to other reasons has also been associated with increasing age, which is to be expected in view of the accumulated burden of disease with age. Tooth loss in people from southern tribes might be linked to ritual extractions. Here again, as in the case of tooth loss due to caries, more educated individuals had a lower risk of tooth loss. The fact that individuals lacking teeth due to other reasons presented with more periodontal pocketing suggests that tooth loss was mostly due to periodontal disease. Tobacco use also has an effect on tooth loss for reasons other than caries, which is supported by the finding that tobacco use affects the condition of the periodontium (43). It is not surprising that such individuals are less likely to have ≥ 18 SUNT. They are also more likely to have a bridge or denture, suggesting that individuals who lack teeth for reasons other than caries have a higher demand for prosthodontic treatment. This may be connected to factors such as the location of the missing teeth, which in the case of ritual extractions, for example, tends to be in the anterior area (10,44).

There was a very low prevalence of participants wearing either a fixed bridge or removable denture prosthesis. This finding may reflect the lack of availability of expertise to provide this service or financial barriers limiting access to prosthodontic treatment. According to the Global Oral Data Bank, Sudan has a very low dentist-to-patient ratio of 3:100,000, which may also explain the lack of prosthetic replacement of missing teeth. Attitudes of patients to tooth loss were not clear in this population, and thus further investigation is warranted.

In conclusion, despite the lack of preventive programs initiated in adult populations, the extent of tooth loss was low, most of the present adults having a functional dentition of > 21 teeth.

The major cause of tooth loss was dental caries and factors associated with tooth loss were as follows: Having less than 20 teeth was associated with age, gender, income, education, and frequency of dental visits; tooth loss due to caries was associated with age, tribe, education, frequency of dental visits and tooth brushing, having < 18 and ≥ 18 SUNT, tooth wear and decay; tooth loss due to other reasons was associated with age, gender, tribe, education, tobacco use, periodontal condition, < 18 and ≥ 18 SUNT, tooth wear and prosthetic status.

The level of prosthodontic rehabilitation in adults was low, and access to prosthodontic treatment appeared restricted; this issue needs to be explored further. Providing more dental manpower, education, and continuing education could help ensure that oral healthcare providers have sufficient skills and a more profound understanding of all aspects of oral healthcare.

Prevention is more cost-effective than treatment of oral disease, and this should be implemented using technologies that are affordable and meet the oral health needs of the Sudanese population.

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