Community Dent Oral Epidemiol 2001; 29: 329–40
Printed in Denmark . All rights reserved

COMMUNITY DENTISTRY AND ORAL EPIDEMIOLOGY
ISSN 0301-5661

Risk indicators of edentulism, partial tooth loss and prosthetic status among black and white middle-aged and older adults

Teresa A. Dolan[1], Gregg H. Gilbert[2], R. Paul Duncan[3] and Ulrich Foerster[4]

[1]Division of Public Health Services and Research, University of Florida College of Dentistry, Gainesville, FL; [2]Department of Diagnostic Sciences, University of Alabama at Birmingham School of Dentistry, Birmingham, AL; [3]Department of Health Services Administration, University of Florida College of Health Professions, Gainesville, FL; [4]Department of Operative Dentistry, University of Florida College of Dentistry, Gainesville, FL, USA

Dolan TA, Gilbert GH, Duncan RP, Foerster U. Risk indicators of edentulism, partial tooth loss and prosthetic status among black and white middle-aged and older adults. Community Dent Oral Epidemiol 2001; 29: 329–40. © Munksgaard, 2001

Abstract – *Objectives:* To describe the prevalence and risk indicators of edentulism; to describe the frequencies of wearing removable dentures; to describe the prevalence and risk indicators of fixed prosthetic restorations; to test the hypothesis that fixed prosthetic restorations are most likely to have been placed in persons at lower risk for dental and periodontal diseases, and to test the hypothesis that, with dental disease, dental behaviors, dental attitudes and ability to afford crowns taken into account, blacks are less likely than whites to have received crowns. *Methods:* The Florida Dental Care Study is a cohort study of subjects 45 years old or older. A telephone screening interview was done as a first stage to identify 5254 subjects who met eligibility requirements and who self-reported whether they were edentulous. In a second stage, a subsample of dentate subjects was contacted after they completed their telephone screening interview. Of these, 873 subjects completed a baseline in-person interview and dental examination. *Results:* A total of 19% of first-stage subjects were edentulous. In a single multiple logistic regression, having a poorer self-rated level of general health was significantly associated with edentulism, as were being poor, older and white. Among the second-stage participants (all of whom were dentate), several prosthetic patterns were observed. For example, a total of 64% of maxillary full denture wearers reported wearing their denture all the time. Participants had also received numerous fixed prosthodontic services. The proportion of subjects with at least one crown varied widely by subject characteristics. *Conclusions:* A substantial percentage of non-ideal frequencies of wearing removable prostheses was reported, as were prosthesis-related soreness and broken prostheses. Although we expected and observed an association between having a fixed prosthetic crown and periodontal status, dental fillings, dental attitudes and financial resources, a residual association with race suggests that blacks are much less likely to receive prosthetic crowns. The several possible reasons for this circumstance warrant further investigation.

Key words: adults; epidemiology; dental care; oral health; prosthetic treatment; race

Gregg H. Gilbert, Department of Diagnostic Sciences, UAB School of Dentistry, SDB Room 109, 1530 3rd Avenue South, Birmingham, AL 35294–0007, USA
Tel: 1 205 934 5423
Fax: 1 205 975 0603
e-mail: ghg@uab.edu

Submitted 16 June 2000;
accepted 29 November 2000

Much like the fact that decline in activities of daily living (1) is a final common pathway for a broad range of decrements in general health, tooth loss constitutes a final common pathway for most dental diseases and conditions. This tooth loss can lead to substantial impacts on quality of life (2–4). Naturally, in an effort to prevent or ameliorate some of these decrements in oral health-related quality of life, dentists frequently recommend removable or fixed prosthetic treatment for tooth loss.

In our work to date from the Florida Dental Care Study (FDCS), we have been especially interested in the role that race and socioeconomic status play in dental care use and a broad range of oral health-related quality of life outcomes. Although a significant amount of research has investigated the role that race plays in risk for both partial and total tooth loss (5–7), and consequently the risk for being "eligible" for prosthetic treatment, we know much less about the role that race plays in whether and how tooth loss is treated prosthetically. To our knowledge, the only work that has addressed this issue is from the Piedmont 65+ Dental Study (8), which found that blacks were less likely to receive new fixed prosthetic crowns during a 5-year period. However, their analysis did not focus on this issue, and no multivariable assessment was done.

The overall purpose of this research project, called the FDCS, was to develop a risk assessment model of longitudinal oral health outcomes in middle-aged and older adults. This particular report used baseline data from the FDCS to address the following objectives using a diverse sample of adults:

- to describe the prevalence and risk indicators of edentulism;
- to describe the frequencies of wearing removable dentures;
- to describe the prevalence and risk indicators of fixed prosthetic restorations;
- to test the hypothesis that fixed prosthetic restorations are most likely to have been placed in persons at lower risk for dental and periodontal diseases; and
- to test the hypothesis that, with dental disease, dental behaviors, dental attitudes and ability to afford crowns taken into account, blacks are less likely than whites to have received crowns.

Materials and methods

Sampling methods and subject recruitment

The goal of the sampling design was to ensure that a large number of persons at a hypothesized increased risk for missing teeth and other dental health decrements were included in the sample. Hypothesized high-risk groups of special interest were blacks, residents of rural areas, persons who were 45 years old or older, and the poor, who were defined as having incomes below 100% and/or 150% of the US poverty level (9).

The FDCS sampling strategy has been described in detail in previous publications (10, 11). Briefly, four counties in north Florida were selected for study: three non-metropolitan counties and one metropolitan county. A telephone screening methodology was used in the first stage of subject recruitment to identify a random sample of 5254 persons in households with telephones who:

- resided in one of the four counties of interest;
- for the metropolitan county, resided in one of the urbanized ZIP codes;
- were English-speaking;
- were capable of engaging in coherent telephone conversation,
- resided in the household (and not in a congregate living facility, for example).

Data about edentulism were obtained from this first sampling stage.

In the second stage, a disproportionate stratified random sample of 1800 dentate subjects was contacted for further study after completion of the telephone screening interviews. Of these, 873 subjects completed a baseline interview and clinical examination. We have previously assessed the potential for bias in the sample; participation by the 873 subjects resulted in a sample of only modest bias with respect to the population of interest (10). This sample had a dental care recency at baseline that was very similar to 1989 National Health Interview Survey (NHIS) data, and conclusions drawn from the FDCS and the NHIS regarding sociodemographic determinants of dental care recency were the same (10). Data on partial tooth loss and prosthetic status were obtained from this second sampling stage.

Interview and clinical examination methods

Subjects were asked to participate in a baseline in-person interview, which was administered by trained interviewers and typically lasted 30 min. The actual wording of all items can be found at the FDCS Internet site listed in the Acknowledgments section. The interview was followed immediately by a clinical dental examination. Data were entered in the field directly into portable microcomputers. We have previously described the examination protocol, clinical diagnostic criteria, quantified inter-examiner reliability for the clinical examination, and quantified test-retest reliability of questions from the baseline interview, all of which were judged to be satisfactory (12–16). Subjects were examined for presence and location of remaining teeth, coronal and root caries, bulk restoration fractures, cusp/incisal edge fractures, root surface de-

fects, tooth mobility and periodontal attachment loss. All teeth were noted, including third molars. Tooth-specific evaluations consisted of whether the tooth was:

- present, but not crowned;
- crowned;
- a root fragment;
- missing but replaced by a fixed pontic, cantilever, or dental implant; or
- missing with no fixed replacement.

Clinically visible root fragments were defined as those having more than three-quarters of the anatomic (not clinical) crown missing, and were counted as present teeth, although they were identified separately as root fragments. ''Crowned'' teeth were defined as teeth with a full coverage cast restoration on a natural tooth/root, and did not include teeth with onlays or other partial coverage cast restorations, or restored dental implants. Fixed prosthetic pontics or cantilevers were also identified separately, although they were not included in the ''number of remaining teeth'' count for this report. Radiographs were not used as part of the clinical assessment; thus, the prevalence of some clinical conditions may have been under-estimated. One limitation of the study is that we did not record open dental spaces, which teeth were replaced by removable prostheses, or the condition of fixed or removable prosthetic replacements. Teeth were numbered for this report using the FDI two-digit system; during the clinical examination, the Universal system was used.

Six dental examiners participated in standardization and calibration training sessions before the baseline field phase began. Additionally, 82 subjects, who were dispersed temporally throughout the field phase, participated in two examinations to allow for interexaminer reliability estimates. Examiners were blinded to the previous examiner's findings, but because replicate examinations were conducted on the same day, examiners were not blinded to whether the examination was to be used for interexaminer reliability estimates. Examiner pairs agreed on the number of remaining teeth and the number of retained root fragments for 81 of the 82 subjects. The one examiner disagreement comprised only one tooth. Agreement between examiners for non-periodontal portions of the examination was quantified using the kappa statistic, κ (17). Because κ varies with the base prevalence (18), we also quantified agreement using the coefficient of colligation, Y (19, 20). For coronal caries, surface-specific κ was 0.89, Y was 0.91 and percent agreement was 96%. For root caries, surface-specific κ was 0.62, Y was 0.82 and percent agreement was 97%. For bulk-restoration fractures, tooth-specific κ was 0.62 and Y was 0.91. For cusp/incisal edge fractures, tooth-specific κ was 0.60 and Y was 0.89. Tooth-specific agreement for attachment loss ± 1 millimeter was 83%; for ± 2 millimeters, it was 97%.

Statistical methods

All results were weighted using the sampling proportions in order to reflect the population in the four counties studied. For example, although 35% of the sample of 873 subjects was poor, the weighted percentage was 16% to reflect the percentage of 45-year-old or older persons in these counties who were poor. The demographic targets were taken from county-specific and ZIP code-specific census data that detailed target populations by age, gender, race and poverty status (21). A proportional fitting algorithm minimized the variance inflation that resulted from sample design effects (10, 22).

Analyses were done using SAS (23) in the microcomputer environment (System for Windows®, version 3.1). Comments about statistical significance refer to probabilities of less than 0.05. The χ^2 and the Mantel-Haenszel χ^2 trend tests were used for bivariate comparisons when variables were nominal or ordinal, respectively, and Wilcoxon rank sum tests were used when variables were on an interval or ratio scale. Logistic regressions (LOGISTIC procedure, SAS) were used to quantify multivariable differences. Multicollinearity was measured using a procedure described by Belsley and colleagues (24), which is available in the REG procedure (23).

Model fit was assessed using the ''c'' statistic, which is a measure of the area under the curve of a plot of the sensitivity against 1–specificity (Receiver Operating Characteristic). The value of the ''c'' statistic for the typical test ranges from 0.50 (no better than chance) to 1.0 (perfect accuracy). Values of 0.5–0.7 have been classified as representing poor fit, 0.7–0.9 as useful for some purposes, and more than 0.9 as high accuracy (25).

The behavioral model of health services utilization proposed by Andersen and colleagues (26, 27) served as the framework for the multiple regression that explained whether or not a participant had a fixed prosthetic crown. The relevant population characteristics can be summarized by three groups: predisposing, enabling and need characteristics. *Predisposing* characteristics are those that ex-

ist prior to the disease, and can be either mutable or immutable. Mutable characteristics are those that can be altered; health attitudes are examples. Immutable variables cannot be altered with policy; examples are age, sex and race. *Enabling* characteristics are resources that affect one's ability to access health care systems and afford various treatment alternatives, such as household income or health insurance coverage. *Need* variables reflect illness levels that require the use of services, and examples include dental disease and tissue damage, pain, or a person's perceived need for care.

We used a stepwise analytic technique because we had multiple measures of each of the predisposing, enabling and need constructs, and we judged that a stepwise approach would be advisable for the sake of parsimony. For this stepwise modeling, we adopted a less stringent criterion for statistical significance, $P<0.10$. Our general approach was to test the non-sociodemographic measures of predisposing characteristics (reserving the sociodemographic measures for the last step), then the enabling variables, and then the need variables. The sociodemographic measures of predisposing characteristics were tested as the last step. This approach is further described in a previous publication (11).

We hypothesized that the mutable predisposing characteristics – attitudes about dental care – would be the most important in explaining whether or not a subject received fixed prosthetic treatment. Thus, the first step consisted of testing six attitudinal variables. The dental attitudes factors included in the analyses were measures of:

1. The quality of recent dental care (6-item scale);
2. The importance of dental visits to prevent dental problems (3-item scale);
3. The eventuality of dental decline (6-item scale);
4. The influence of dental care costs on past dental treatment (2-item scale);
5. Cynicism toward dentists and dental care (3-item scale);
6. The effectiveness of dental care (3-item scale).

A more detailed description of these measures can be found in a previous publication (14). Because of problems with multicollinearity, we dropped two attitude items, and three of the four remaining items had a statistically significant parameter estimate (''quality of recent care'', ''eventuality of dental decline'' and ''influence of dental care costs'').

Retaining three variables from the previous step that met the $P<0.10$ criterion, the next step added the variable ''decide.'' Subjects were presented a hypothetical scenario that they had a toothache in a lower back tooth and treatment would take five visits and would cost $950. Subjects were asked to choose one of the following options: get a root canal and crown; not sure; extract the tooth after learning the cost of the procedure; or extract the tooth. In this regression step, all four variables (''quality of recent care'', ''eventuality of dental decline'', ''influence of dental care costs'' and ''decide'') met the $P<0.10$ criterion.

The next step added an enabling variable–an income measure that dichotomized the subject's annual household income as either below 150% of the poverty level, or at or above 150% of poverty. All five variables included in this step met the $P<0.10$ criterion. The fifth step of this modeling process introduced the clinically measured need variables, two measures of tobacco use and two oral hygiene variables. We hypothesized that disease and tissue damage would be associated with having a prosthetic crown, as would the subjects' brushing and flossing behaviors. The two clinically assessed disease measures used in this step were a measure of severe periodontal attachment loss (whether or not the subject had at least one site with 7+ mm of periodontal attachment loss) and a count of the number of tooth surfaces that were restored, excluding any surfaces that were restored as part of a prosthetic crown. Smoking and using smokeless tobacco can be associated with hard and soft tissue disease levels. Two measures of tobacco use were introduced in this step: whether or not the subject currently smoked cigarettes and whether or not the subject currently, formerly or never used smokeless tobacco. One of the attitude variables and the smoking variable did not meet the $P<0.10$ criterion and these variables were not included in the sixth step.

Four sociodemographic variables were added in the sixth step: age group, area of residence (urban vs. rural), sex and race. For the final step, age group and area of residence were dropped from the model because they did not meet the $P<0.10$ criterion. The final model contained 11 variables and appears in Table 4.

Results

Although they are relevant to this report, because we have previously described the sociodemographic characteristics of the FDCS sample and its prevalence of disease and tissue damage, pain and functional limitation (4, 12–15), we do not repeat them here.

Prevalence of edentulism

Overall, 19% of the respondents to the brief telephone interview said they were edentulous. In bivariate analyses (results not shown in tabular form), edentulism was significantly associated with having a household income less than 150% of the poverty level, being over age 65 years, living in a rural area, being black and being female. Being edentulous also varied by the subjects' rating of general health status: 37% of those who rated their general health as poor were edentulous, compared to 28% of subjects in fair health, 18% of those in good health, 16% of those in very good health, and 9% of subjects who rated their health as excellent. When the prevalence of edentulism for blacks and whites was compared while stratifying by 150% poverty status, poor whites had higher rates of edentulism than poor blacks (34% vs. 30%; χ^2 test; P value=0.03), and non-poor whites had a similar and not significantly different prevalence of edentulism as compared to non-poor blacks (12% vs. 9%; χ^2 test; P value=0.08).

In a single multiple logistic regression, having a household income less than 150% of the poverty level, being older, being white, and having a poorer self-rating of general health were significantly associated with being edentulous (Table 1). Residence and sex were not statistically significant in the model. A race * poverty interaction was tested, but was not statistically significant.

Table 1. Logistic regression of being edentulous

Explanatory covariate	Parameter estimate	Standard error	Odds Ratio (95% CI) *	*P* value
intercept	−2.95	0.23	–	0.01
age group:				
75 or older	1.76	0.14	5.8 (4.4–7.7)	0.01
65–74	1.20	0.13	3.3 (2.6–4.3)	0.01
55–64	0.95	0.14	2.6 (2.0–3.4)	0.01
general health:				
poor	1.08	0.17	2.9 (2.1–4.1)	0.01
fair	0.88	0.15	2.4 (1.8–3.3)	0.01
good	0.53	0.14	1.7 (1.3–2.2)	0.01
very good	0.49	0.15	1.6 (1.2–2.2)	0.01
poverty	0.83	0.10	2.3 (1.9–2.8)	0.01
race	0.37	0.10	1.4 (1.2–1.8)	0.01
residence	0.12	0.09	1.1 (0.9–1.3)	0.15
sex	0.05	0.08	1.1 (0.9–1.2)	0.56

* 95% confidence interval.
Weighted n=4461; model c=0.75; 11 df; P<0.0001; pairs concordant=74%.
The outcome of interest was coded 0=had at least one natural tooth; 1=edentulous.

Coding of explanatory covariates
age group: the reference group is persons 45–54 years old.
general health: self-reported general health: poor, fair, good, or very good. The reference group is persons who reported being in excellent general health.
poverty: 0=≥ 150% poverty level; 1=less than 150% of poverty level.
race: 0=black; 1=white.
residence: 0=rural; 1=urban.
sex: 0=male; 1=female.

Complete and partial dentures

Of the 143 subjects who reported ever having a maxillary partial denture and who had 1–15 teeth in the maxillary arch upon clinical examination, 28% reported never wearing it, 20% said the denture made their mouths sore, and 9% said the denture was broken (Table 2). Wearing the partial denture was associated with having adequate finances to pay for dental care, and brushing more than once daily, but was not associated with other sociodemographic or attitude variables (results not shown). Denture soreness was associated with frequency of wearing ($P < 0.05$)–43% of persons with soreness reported never wearing their mandibular partial denture, compared to 24% of those without soreness. Fourteen percent of persons with denture soreness wore their mandibular partial denture all the time, compared to 29% of those without soreness. No statistically significant association was observed with regard to broken denture and mandibular partial denture wearing pattern.

Of the 89 subjects with no maxillary teeth, 80 had a complete denture; 90% of these subjects reported that they wear the denture either all of the time or all the time during the day. Only 5% reported that they never wore the denture. About one in five subjects said that the denture caused mouth soreness, and/or the denture was broken.

Of the 186 subjects who reported ever having a mandibular partial denture and who had 1–15 teeth in the mandibular arch upon clinical examination, 35% said they never wore the denture; 20% said the denture made their mouths sore, and 16% reported that the denture was broken. Wearing the denture was associated with reporting regular and recent dental check-ups and brushing more than once daily, but was not associated with other sociodemographic or attitude variables (results not shown). Frequency of wearing was also not associated with denture soreness or having a broken denture.

Table 2. The number and proportion of subjects who have ever had removable partial or complete dentures, the proportion who currently wear the dentures, and problems related to the dentures

		Maxilla		Mandible
Ever had a full or partial denture		partial* $n=143$ %	full** $n=89$ %	partial*** $n=186$ %
Frequency of wearing full or partial denture	all the time	26.0	64.0	32.3
	all the time during the day	39.3	26.4	29.8
	only when eating	0.4	0.8	0.3
	all day except when eating	3.9	0.9	1.3
	all the time except when eating	2.5	2.5	1.5
	never	27.9	5.3	34.8
Problem with full or partial denture	makes mouth sore	20.4	23.2	20.5
	is broken	8.9	21.6	15.8

* Only includes persons who reported ever having a maxillary partial denture and who upon clinical examination had 1–15 teeth in the maxillary arch.
** Only includes persons who upon clinical examination were edentulous in the maxilla.
*** Only includes persons who reported ever having a mandibular partial denture and who upon clinical examination had 1–15 teeth in the mandibular arch.

Tooth status

The bar graph (Fig. 1) indicates the proportion of teeth that were either clinically present (''present''), present with a prosthetic crown (''crowned''), a ''root fragment'', missing and replaced with a fixed prosthetic replacement (''replaced'') or missing and not replaced with a fixed prosthetic replacement (''missing''). Tooth status varied by tooth type and dental arch. For example, teeth 28, 36, and 33 were missing in 86%, 44% and 3% of subjects, respectively. Only a small proportion (typically less than 1%) of teeth were root fragments.

Subjects had received numerous fixed prosthodontic services. In the maxillary arch, the tooth types most commonly crowned were the second premolars (27%), followed by the first molars (24%), the first premolars (24%), the central incisors (24%), the canines (21%), the second molars (20%), the lateral incisors (19%) and the third molars (0.5%). In the mandibular arch, the first molars were the most commonly crowned (33%), followed by the second molars (27%), the second premolars (26%), the first premolars (15%), the canines (8%), the third molars (4%), the lateral incisors (2%) and the central incisors (2%).

Prosthetic crowns, pontics, and cantilevers

Overall, 58% of the sample had one or more crowns (mean 2.8, SD 3.7) and 23% had one or more pontics (mean 0.5, SD 1.2). In bivariate analyses, the proportion of the sample with one or more crowns did not vary by age group or sex, but was associated with other sociodemographic, behavioral and clinical variables (Table 3). Some striking differences were noted. For example, 81% of non-poor whites had one or more crowns, as compared to 20% of poor blacks. Similarly, 77% of subjects who reported that they could comfortably pay an unexpected $500 dental bill had one or more crowns, as compared to 26% of the subjects who said that they would not be able to pay the bill. Subjects without clinical evidence of disease were more likely to have crowns. For example, 70% of subjects without severe periodontal attachment loss had one or more crowns, as compared to 38% of subjects with severe attachment loss. The pattern was similar for subjects with dental caries: 75% of subjects without caries had one or more crowns, as compared to 42% of subjects with caries. Subjects who reported good oral hygiene behaviors were more likely to have one or more crowns than subjects with less optimal behaviors. Each measure of dental attitudes was more positive among subjects with one or more crowns (results not shown). The differences were statistically significant in each measure, except for ''cynicism.'' Although statistically significant, the magnitude of the differences was small.

The mean number of crowns per subject for the subset of subjects that had one or more crowns is also found in Table 3. Patterns were similar to those previously described for the dichotomous measure of crowns. For example, not only were non-poor whites more likely to have one or more crowns

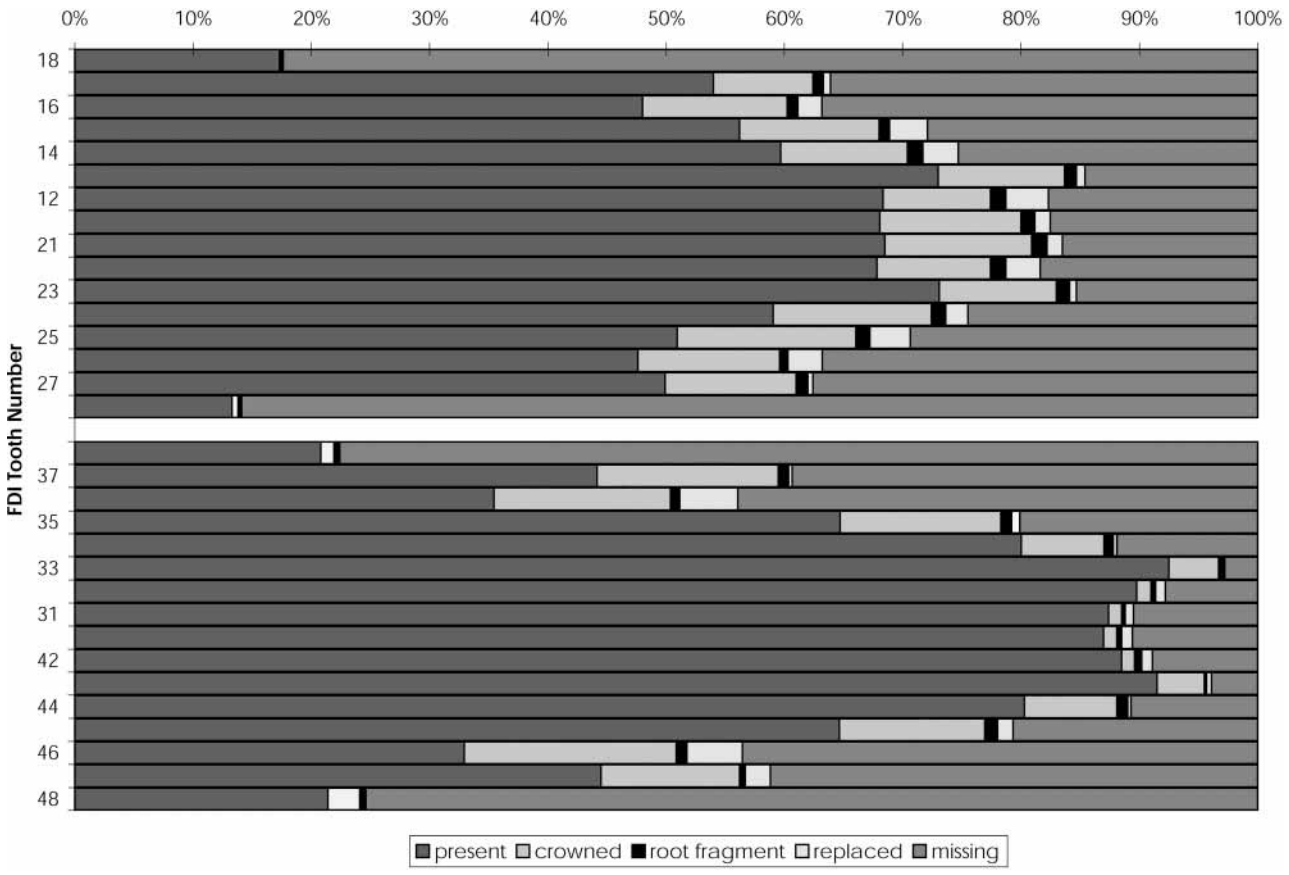

Fig. 1. Tooth status by tooth number. Based on a clinical examination, teeth were categorized as either: (1) present, but not a root fragment and did not have a full coverage cast restoration; (2) present and had a full coverage cast restoration; (3) a root fragment, which was defined as a retained tooth with at least 3/4 of the anatomic crown missing; (4) missing and had a fixed prosthetic replacement, including a restored dental implant; (5) missing and did not have a fixed prosthetic replacement.

than their counterparts, but in the subgroups that had one or more crowns, non-poor whites also had a higher mean number of crowns.

Multiple regression findings

The results of the multiple regression of the presence of one or more prosthetic crowns are shown in Table 4. We observed that predisposing, enabling and need characteristics were explanatory of having one or more prosthetic crowns. Only one of the attitude variables was statistically significant in the final model. This variable was a summary of two items that asked subjects to rate the influence of dental care costs on past dental treatment. Specifically, subjects were asked to rate, on a 4-point scale, the extent to which they agreed with the following statements "The cost of dental care has affected the type of dental treatment I have received in the past," "In the past, I have had to delay dental treatment because of other expenses such as medical care and household expenses". Poor respondents were less likely to have crowns. Making the hypothetical decision to have a painful tooth removed rather than to undergo time-consuming and expensive dental treatment was also associated with not having crowns.

Subjects who used dental floss infrequently were less likely to have a crown, as were subjects with one or more sites of severe periodontal attachment loss. Subjects with more filled tooth surfaces (excluding surfaces scored as filled due to a crown) were more likely to have a crown. Both race and sex were significantly associated with having at least one prosthetic crown, with odds ratios of 3.8 and 2.0, respectively. Area of residence (urban vs. rural) did not enter into the final model.

Discussion

Edentulism

The epidemiology of tooth loss in FDCS subjects is consistent with the pattern of declining prevalence

Table 3. Mean number of fixed prosthetic crowns, percentage of participants who had one or more crowns, by participant characteristics; for participants with one or more crowns, mean number of crowns, by participant characteristics

Participant characteristic	Category (weighted *n*)	Mean no. of crowns[1] mean (S.D.)	has 1+ crowns (%)	Mean no. of crowns[2] mean (S.D.)
age group	45–64 years (512)	2.6 (4.0)*	57[ns]	4.5 (4.6)*
	65+ years (361)	3.1 (3.5)	58	5.2 (3.8)
sex	male (382)	2.5 (4.2)[ns]	56[ns]	4.5 (5.0)[ns]
	female (491)	3.0 (3.5)	59	5.0 (3.9)
race and poverty status[3]	poor blacks (112)	0.5 (0.9)*	20*	2.4 (1.4)*
	non-poor blacks (93)	1.1 (2.6)	34	3.1 (3.4)
	poor whites (158)	1.9 (3.3)	46	4.1 (3.9)
	non-poor whites (426)	4.2 (5.1)	81	5.2 (5.0)
	missing (84)			
residence	rural (436)	2.3 (3.6)[ns]	51*	4.6 (4.0)[ns]
	urban (437)	3.2 (3.9)	65	4.9 (4.4)
	missing (5)			
ability to pay an unexpected $500 dental bill	not able to pay (122)	0.6 (1.2)*	26*	2.5 (1.7)*
	able to pay (342)	1.9 (3.0)	47	4.1 (3.5)
	pay comfortably (406)	4.1 (4.7)	77	5.3 (4.7)
	missing (3)			
ever use dental floss	no (316)	1.2 (2.3)*	33*	3.6 (3.5)*
	yes (557)	3.6 (4.3)	72	5.1 (4.3)
smoking status	current smoker (163)	1.6 (2.5)*	44*	3.6 (3.0)*
	former smoker (313)	3.2 (4.3)	64	4.9 (4.7)
	never smoker (393)	2.9 (3.6)	58	5.0 (4.0)
	missing (4)			
smokeless tobacco use	current user (35)	0.5 (0.9)*	21*	2.2 (1.1)[ns]
	former user (87)	1.5 (2.2)	44	3.5 (2.5)
	never user (740)	3.0 (3.9)	61	4.9 (4.3)
	missing (11)			
decide[4]	extract (187)	0.5 (1.3)*	22*	2.3 (2.3)*
	extract after cost (207)	2.0 (3.2)	41	5.0 (3.9)
	don't know (56)	3.3 (4.1)	79	4.1 (4.7)
	get root canal (422)	4.0 (4.4)	80	5.1 (4.4)
	missing (1)			
has one or more surfaces of decay (crown or root)	yes (432)	1.6 (2.6)	42*	3.8 (3.4)*
	no (433)	4.0 (4.5)*	75	5.3 (4.6)
has filled tooth surfaces that are not due to crowns	no (174)	0.7 (2.0)*	15*	4.3 (4.4)[ns]
	yes (691)	3.3 (4.1)	69	4.8 (4.2)
has one or more sites of 7+mm periodontal attachment loss	yes (271)	1.4 (2.4)*	38*	3.8 (3.3)*
	no (500)	3.5 (4.3)	70	5.0 (4.5)
	not probed/missing (102)			

* $P<0.05$.

[ns] not statistically significant.

This table is limited to full-coverage fixed prosthetic crowns on retained natural roots; does not include fixed prosthetic pontics, cantilevers, onlays, partial coverage crowns, or dental implants.

[1] Includes all subjects, whether they have any crowns or not.

[2] Includes only those subjects with one or more crowns.

[3] Poverty was defined as having a household income less than 150% of the poverty level.

[4] Subjects were presented a hypothetical scenario in which the subject had a toothache in a mandibular back tooth. Told that treatment would take 5 visits and would cost $950 to do a root canal and crown. Subjects were asked to choose one of the following decisions: get a root canal and crown, not sure, extract the tooth after learning the cost of the procedure, or extract the tooth for $40 in one visit.

Table 4. Logistic regression of the presence of one or more prosthetic crowns

Explanatory covariate	Parameter estimate	Standard error	Odds Ratio (95% CI) *	*P* value
intercept	−2.59	1.37	–	0.06
attitude: quality	0.24	0.14	1.3 (1.0–1.7)	0.10
attitude: cost	0.28	0.10	1.3 (1.1–1.6)	0.01
attitude: external	0.21	0.22	1.2 (0.8–1.9)	0.34
decide	0.90	0.15	2.5 (1.8–3.4)	0.01
poverty	0.68	0.24	2.0 (1.2–3.2)	0.01
uses floss	0.45	0.23	1.6 (1.0–2.5)	0.05
uses smokeless tobacco	0.29	0.29	1.3 (0.8–2.4)	0.30
has severe periodontal AL	0.45	0.23	1.6 (1.0–2.4)	0.05
filled surfaces not due to crowns	0.03	0.01	1.03 (1.01–1.05)	0.01
race	1.34	0.26	3.8 (2.3–6.4)	0.01
sex	0.68	0.24	2.0 (1.2–3.2)	0.01

* 95% confidence interval.
Weighted $n=676$; model c=0.87; 11 df; $P<0.0001$; pairs concordant=87%.
The outcome of interest was coded 1=if the subject had one or more crowns; 0=if not.

Coding of explanatory covariates
attitude – quality: rating of overall quality of recent dental care (summary of 6 items). A higher rating means a more positive attitude.
attitude – cost: rating of the influence of dental care costs on past dental treatment (summary of 2 items). A higher rating means a more positive attitude.
attitude – external: rating of eventuality of dental decline (summary of 6 items). A higher rating means a more positive attitude.
decide: hypothetical scenario in which the subject had a toothache in a mandibular back tooth. After being told that treatment would take 5 visits and would cost $950 to do a root canal and crown, the subject would 0=extract the tooth in one visit for $40; 1=extract the tooth after learning the cost of the procedure; 2=get a root canal and crown, or not sure.
poverty: 0=household income less than 150% of poverty level; 1=at or greater than 150% of poverty level.
uses floss: 0=does not ever use dental floss to clean teeth; 1=does.
uses smokeless tobacco: 0=current; 1=former; 2=never uses smokeless tobacco.
has severe periodontal attachment loss: 0=has at least one tooth with 7+ mm of periodontal attachment loss, 1=does not.
number of filled tooth surfaces not due to crowns: a count of tooth surfaces that were scored as filled, but the filled surfaces were not due to crown restorations.
race: 0=black; 1=white.
sex: 0=male; 1=female.

of tooth loss and edentulism in the United States (7, 28). Edentulism is more common in disadvantaged populations, and is associated with older age, having a low income, less education, being unmarried, having a less prestigious occupation, and belonging to a minority group (5, 29). In this regard, this report from the FDCS corroborates existing literature, but does not add any new findings. However, our finding specifically regarding edentulism and race actually contradicts some of the existing literature, and, at least according to our review, our finding regarding edentulism and self-reported general health adds to the literature. In the FDCS, the difference in edentulism prevalence between blacks and whites remained statistically significant even after accounting for poverty status, age group, self-reported general health, area of residence, and sex, and was actually in an unexpected direction. Poor whites had higher rates of edentulism than poor blacks, and non-poor whites also had a higher rate of edentulism as compared to non-poor blacks. This finding is in contrast to the National Survey of Oral Health in US Employed Adults and Seniors (6), which observed that racial differences in edentulism were largely eliminated when education or income were controlled. In the Third National Health and Nutrition Examination Survey (NHANES III), race-ethnicity was consistently related to tooth loss, after adjustment for age and sex; black non-Hispanics had the highest rates of tooth loss (5). These racial and ethnic variations in tooth loss may reflect differences in educational attainment and family income. However, the persistence of a race effect in the multiple regression,

with poverty status accounted for, argues against that explanation. These racial and ethnic variations in tooth loss may reflect differences in patterns of dental utilization. Marcus and colleagues (5) proposed that going to a dentist may increase the probability that a given tooth will be extracted. Not going to a dentist may be associated with the retention of diseased teeth, which should be extracted. Longitudinal data from the FDCS support this notion (30, 31). The presence of root fragments, in which the tooth is present, but debilitated, is also relevant. A previous report from the FDCS documented that root fragments were more prevalent in blacks (15).

Eklund & Burt (32) analyzed data from the NHANES I, and were able to determine which individuals became edentulous during the subsequent 10-year follow-up. Although self-perception of poor general health was associated with a higher risk of becoming edentulous, during multiple regression analysis, the association was no longer statistically significant. This contrasts with our finding, in which we found that self-rated general health was independently associated with edentulism. Due to the cross-sectional nature of our analysis, we cannot state that the relationship is causative. An equally likely explanation would be that conditions that contribute to decline in self-rated general health also contribute to tooth loss.

Frequency of wearing removable prostheses

Many of the FDCS subjects who ever had removable partial dentures reported that they never wore the denture. Many of the removable partial denture prostheses caused mouth soreness or were broken at the time of the interview. In what the authors reported as the first population-based study of removable partial denture satisfaction, Frank and colleagues (33) observed that approximately 34% of their sample reported wearing their mandibular partial denture all the time; this compares to a 32% figure in the FDCS (Table 2). Approximately 74% of their subjects reported being ''completely satisfied'' or ''moderately satisfied'', but questions about denture soreness or having a broken denture were not asked. With the FDCS results, we were impressed by the significant percentages of persons who apparently were tolerating removable partial dentures that caused soreness or were broken in some way. In a study of 290 persons who had received removable partial dentures in a dental school setting, 258 (89%) persons were wearing their dentures from 24 to 33 months later, although only 238 (82%) were doing so without complaint (34).

Note from Table 2 that the modal pattern for maxillary full dentures was to wear the denture all the time. A study of New England residents found that approximately one-third of completely edentulous persons wore both their maxillary and mandibular dentures while sleeping, and an additional 12% slept with only the maxillary denture in place (35). Because the dental profession advises against ''all the time'' wearing, presumably each of these subjects' dentists advised against this frequency of wearing, but the majority of subjects chose to do so anyway. Even among subjects who reported denture soreness and broken prostheses, ''all the time'' wearing predominated.

We observed that 5% of persons with no maxillary teeth never wear their maxillary denture. Other studies have found a similar prevalence. For example, a study of older Finns found that 4% of fully edentulous persons never wear their dentures (36). In the aforementioned New England study, 10% of completely edentulous persons did not wear any dentures (35).

Prevalence of fixed prostheses

The FDCS participants received many fixed prosthodontic services, and the prevalence varied greatly by subject characteristics. Our findings suggest that there is a substantial variation in the proportion of teeth crowned. This variability was related to the accessibility of treatment, attitudes toward it, and ability to afford this type of treatment. Our results are consistent with those of the Piedmont 65+ dental study, which showed that the prevalence and incidence of crowned surfaces are higher in more educated people, in those who attend the dentist regularly, and in those with higher incomes (8). Our findings were fairly consistent with a study that observed that patients visiting private dental practices in rural towns were likely to receive a different pattern of prosthetic treatment services – more extractions, less tooth replacement and fewer fixed prosthodontic services – than patients visiting practices in more urban areas (37). In the FDCS, the urban participants had an average of 3.2 crowns as compared to 2.3 crowns in the rural subgroup. However, area of residence was not a significant predictor of having one or more crowns when other factors were taken into account in the multiple regression model. We should note that different methodologies were used in the studies; the study by Bader and col-

leagues (37) was a survey of general dentists designed to quantify the provision of prosthetic services, whereas the FDCS data were obtained from clinical examinations done on a sample representative of certain community-based, not clinic, populations. Our findings suggest that rural–urban area of residence is not a salient consideration once differences in income, clinical factors, behavioral, and attitudinal factors are taken into account.

Because teeth can be crowned for a variety of reasons, understanding the relationships between subject characteristics and the prevalence of crowned teeth can be challenging. For example, teeth are often crowned for reasons other than dental caries, such as for esthetic reasons or to prevent tooth fracture. New to the literature is our finding that even once differences in income, clinical factors, behavioral and attitudinal factors are taken into account, whites are still much more likely than blacks to have received fixed prostheses. As a result of other findings in the FDCS (14), we are intrigued by the fact that blacks were much less likely to have received crowns. For example, within poverty status groupings, FDCS whites were more than twice as likely as blacks to report that a dentist had recommended a root canal to them at some point in the past. This is despite the fact that blacks had more dental decay than whites (15), which should increase the likelihood that blacks would find themselves in need of root canal therapy. Blacks also gave poorer ratings to the quality of their dental care (14). From our FDCS data, we cannot state whether blacks opt out of fixed prosthetic treatment as a result of an appraisal of the costs and benefits of prosthetic treatment, or whether dentists are for some reason less likely to discuss with blacks fixed prostheses as a treatment option. An additional possibility is that blacks select dental practices that seldom offer fixed prostheses as an option to any patient. The role that the dentist plays in influencing exactly what treatment is received has been hypothesized as a strong one (38). However, this complex scenario of patient, practitioner and health care system interactions requires further investigation.

Implications

In this community-based sample of adults, a substantial percentage of non-ideal wearing patterns for removable prostheses was reported, as were a substantial amount of prosthesis-related soreness and broken prostheses. These results add to the growing body of literature that tooth loss ultimately leads to substantive reductions in oral health-related quality of life.

The presence of a statistically significant association between presence of crowns and the presence of dental caries, and presence of crowns and presence of severe attachment loss, could be because patients with higher disease levels are not offered prosthetic treatment or because they opt not to receive it. This association could also be because dentists are appropriately recommending crowns on persons at lower disease risk, opting not to recommend an expensive treatment that may ultimately fail because of recurrent caries or because the tooth itself would have to be extracted because of attachment loss.

Although we expected and observed an association between having fixed prosthetic crowns and periodontal status, dental fillings, dental attitudes and financial resources, the residual association with race suggests that blacks are much less likely to receive prosthetic crowns. The several possible reasons for this circumstance deserve further investigation.

Acknowledgments

This research was supported by NIH grants DE-12587, DE-11020 and DE-00392. Additional support was provided by funds from the University of Florida. We acknowledge the contributions of D. E. Antonson, D. W. Legler, and M. L. Ringelberg, who in addition to T. A. Dolan, U. Foerster, and G. H. Gilbert served as clinical examiners for the study. We are also grateful to J. L. Earls and B. A. Ringelberg, who served as regional coordinators for the baseline phase of the study. The opinions and assertions contained herein are those of the authors and are not to be construed as necessarily representing the views of the University of Florida, the University of Alabama at Birmingham or the National Institutes of Health. The informed consent of all human subjects who participated in the investigation was obtained after the nature of the procedures had been explained fully. More details about the FDCS can be found at http://nersp.nerdc.ufl.edu/~gilbert/ (formerly at http://www.nerdc.ufl.edu/~gilbert).

References

1. Katz S, Ford AB, Moskowitz RW, Jackson BA, Jaffe MW. Studies of illness in the aged. The Index of ADL: a standardized measure of biological and psychosocial function. JAMA1963;185:914–9.
2. Locker D, Miller Y. Evaluation of subjective oral health status indicators. J Public Health Dent 1994;54:167–76.
3. Slade GD, Spencer AJ. Development and evaluation of the Oral Health Impact Profile. Community Dent Health 1994;11:3–11.
4. Gilbert GH, Duncan RP, Heft MW, Dolan TA, Vogel WB. Multi-dimensionality of oral health in dentate adults. Med Care 1998;36:988–1001.

5. Marcus SE, Drury TF, Brown LJ, Zion GR. Tooth retention and tooth loss in the permanent dentition of adults: United States, 1988–1991. J Dent Res 1996;75:684–95.
6. Brown LJ, Meskin LH. Sociodemographic differences in tooth loss patterns in US employed adults and seniors, 1985–86. Gerodontics 1988;4:345- 62.
7. Brown LJ. Trends in tooth loss among U.S. employed adults from 1971 to 1985. J Am Dent Assoc 1994;125:533–40.
8. Beck JD, Lawrence HP, Koch GG. Analytic approaches to longitudinal caries in data in adults. Community Dent Oral Epidemiol 1997;25:42–51.
9. US Bureau of the Census. Census of Population and Housing, 1990. Public Use Microdata Samples. US Technical Documentation, Washington (DC) US Bureau of the Census, 1992.
10. Gilbert GH, Duncan RP, Kulley AM, Coward RT, Heft MW. Evaluation of bias and logistics in a survey of adults at increased risk for oral health decrements. J Public Health Dent 1997;57:48–58.
11. Gilbert GH, Duncan RP, Vogel WB. Determinants of dental care use in dentate adults: six-monthly use during a 24-month period in the Florida Dental Care Study. Soc Sci Med 1998;47:727–37.
12. Dolan TA, Gilbert GH, Ringelberg ML, Legler DW, Antonson DE, Foerster U, et al. Behavioral risk indicators of attachment loss in adult Floridians. J Clin Periodontol 1997;24: 223–32.
13. Gilbert GH, Duncan RP, Heft MW, Dolan TA, Vogel WB. Oral disadvantage among dentate adults. Community Dent Oral Epidemiol 1997;25:301–13.
14. Gilbert GH, Duncan RP, Heft MW, Coward RT. Dental health attitudes among dentate Black and White adults. Med Care 1997;35:255–71.
15. Gilbert GH, Antonson DE, Mjör IA, Ringelberg ML, Dolan TA, Foerster U, et al. Coronal caries, root fragments, and restoration and cusp fractures in US adults. Caries Res 1996;30:101–11.
16. Ringelberg ML, Gilbert GH, Antonson DE, Dolan TA, Legler DW, Foerster U, et al. Root caries and root defects in urban and rural adults. J Am Dent Assoc 1996;127:885–91.
17. Cohen J. A coefficient of agreement for nominal scales. Educ Psychol Measure 1960;20:37–46.
18. Maclure M, Willett WC. Misinterpretation and misuse of the kappa statistic. Am J Epidemiol 1987;126:161–9.
19. Yule GU. On the methods of measuring association between two attributes. J Roy Stat Soc 1912;75:579–42.
20. Spitznagel EL, Helzer JE. A proposed solution to the base rate problem in the kappa statistic. Arch Gen Psychiat 1985;42:725–8.
21. U.S. Bureau of the Census. Unpublished special tabulations for the University of Florida from the 1990 Census of Population and Housing for the U.S. and four counties in north Florida;1994.
22. Korn EL, Graubard BI. Epidemiologic studies utilizing surveys: accounting for the sampling design. Am J Public Health 1991;81:1166–73.
23. SAS Institute, Inc. SAS/STAT User's Guide Version 6. 4th edn. Cary, NC: SAS Institute, Inc.;1989.
24. Belsley DA, Kuh E, Welsch RE. Regression diagnostics: identifying influential data and sources of collinearity. New York: Wiley;1980.
25. Swets JA. Measuring the accuracy of diagnostic systems. Science 1988;240:1285–93.
26. Andersen R, Newman JF. Societal and individual determinants of medial care utilization in the United States. Milbank Mem Fund Quart 1973;51:95–124.
27. Andersen RM. Revisiting the behavioral model and access to medial care: Does it matter? J Health Soc Behav 1995;36:1–10.
28. Weintraub JA, Burt BA. Oral health status in the United States: tooth loss and edentulism. J Dent Educ 1985;49: 368–78.
29. Hunt RJ, Beck JD, Lemke JH, Kohout FJ, Wallace RB. Edentulism and oral health problems among elderly rural Iowans: the Iowa 65+ rural health study. Am J Public Health 1985;75:1177–81.
30. Gilbert GH, Miller MK, Duncan RP, Ringelberg ML, Dolan TA, Foerster U. Tooth-specific and person-level predictors of 24-month tooth loss among older adults. Community Dent Oral Epidemiol 1999;27:372–85.
31. Gilbert GH, Duncan RP, Earls JL. Taking dental self-care to the extreme: dental self-extractions in the Florida Dental Care Study. J Public Health Dentistry 1998;58:131–4.
32. Eklund SA, Burt BA. Risk factors for total tooth loss in the United States; longitudinal analysis of national data. J Public Health Dent 1994;54:5–14.
33. Frank RP, Milgrom P, Leroux BG, Hawkins NR. Treatment outcomes with mandibular removable partial dentures: a population-based study of patients' satisfaction. J Pros Dent 1998;80:36–45.
34. Cowan RD, Gilbert JA, Elledge DA, McGlynn FD. Patient use of removable partial dentures: two- and four-year telephone interviews. J Pros Dent 1991;65:668–70.
35. Marcus PA, Joshi A, Jones JA, Morgano SM. Complete edentulism and denture use for elders in New England. J Prosthet Dent 1996;76:260–6.
36. Nevalainen MJ, Närhi TO, Siukosaari P, Schmidt-Kaunisaho K, Ainamo A. Prosthetic rehabilitation in the elderly inhabitants of Helsinki, Finland. J Oral Rehab 1996;23: 722–8.
37. Bader JD, Scurria MS, Shugars DA. Urban/rural differences in prosthetic dental service rates. J Rural Health 1994;10:26–30.
38. Bader JD, Shugars DA. Variation, treatment outcomes, and practice guidelines in dental practice. J Dent Educ 1995;59:61–95.