Social Determinants of Tooth Loss

Gregg H. Gilbert, R. Paul Duncan, and Brent J. Shelton

Objectives. To quantify racial and socioeconomic status (SES) disparities in oral health, as measured by tooth loss, and to determine the role of dental care use and other factors in explaining disparities.

Data Sources/Study Setting. The *Florida Dental Care Study*, comprising African Americans (AAs) and non-Hispanic whites 45 years old or older who had at least one tooth.

Study Design. We used a prospective cohort design. Relevant population characteristics were grouped by predisposing, enabling, and need variables. The key outcome was tooth loss, a leading measure of a population's oral health, looked at before and after entering the dental care system. Tooth-specific data were used to increase inferential power by relating the loss of individual teeth to the disease level on those teeth.

Data Collection Methods. In-person interviews and clinical examinations were done at baseline, 24, and 48 months, with telephone interviews every 6 months.

Principal Findings. African Americans and persons of lower SES reported more new dental symptoms, but were less likely to obtain dental care. When they did receive care, they were more likely to experience tooth loss and less likely to report that dentists had discussed alternative treatments with them. At the first stage of analysis, differences in disease severity and new symptoms explained tooth loss disparities. Racial and SES differences in attitudes toward tooth loss and dental care were not contributory. Because almost all tooth loss occurs by means of dental extraction, the total effects of race and SES on tooth loss were artificially minimized unless disparities in dental care use were taken into account.

Conclusions. Race and SES are strong determinants of tooth loss. African Americans and lower SES persons had fewer teeth at baseline and still lost more teeth after baseline. Tooth-specific case-mix adjustment appears, statistically, to explain social disparity variation in tooth loss. However, when social disparities in dental care use are taken into account, social disparities in tooth loss that are not directly due to clinical circumstance become evident. This is because AAs and lower SES persons are more likely to receive a dental extraction once they enter the dental care system, given the same disease extent and severity. This phenomenon underscores the importance of understanding how disparities in health care use, dental insurance coverage, and service receipt contribute to disparities in health. Absent such understanding, the total effects of race and SES on health can be underestimated.

Key Words. Tooth loss, health disparities, race, socioeconomic status.

The growing literature on racial, ethnic, and socioeconomic status (SES) disparities in health has documented significantly poorer health among low-SES and non-Hispanic African Americans (AAs) when compared to high-SES

persons and non-Hispanic whites. Numerous possible reasons for these social (race/ethnicity and SES) disparities include differences in clinical condition, quality of health care, and insurance coverage, knowledge of disease or treatment options, overuse of health care by higher-SES persons and non-Hispanic whites or underuse by AAs and lower-SES persons, and subconscious treatment bias (King 1996; Kawachi and Kennedy 1999; Fiscella et al. 2000; Mayberry, Mili, and Ofili 2000; Modifi, Rozier, and King 2002). Although conclusions differ depending on the disease entity, a relatively consistent pattern of disadvantage for AAs and low-SES persons has emerged.

Because of the release of the first Surgeon General's report on oral health, social disparities in oral health are now widely recognized (U.S. Department of Health and Human Services 2000). Associations between oral health, race, and SES are particularly strong, and may help explain the links between SES and health in general. One leading indicator of oral health in adult populations is tooth loss. Much like the decline in activities of daily living (Katz et al. 1963) that is a final common pathway for a broad range of general health conditions, tooth loss is a final common pathway for most dental diseases and conditions. Tooth loss can substantially affect chewing ability, health-related quality of life, and nutrition (Gilbert, Duncan, Heft et al. 1998; Ritchie et al. 2002).

Although some studies have investigated social disparities in tooth loss, only a few have been longitudinal (Burt et al. 1990; Eklund and Burt 1994; Locker, Ford, and Leake 1996; Beck et al. 1997; Slade, Gansky, and Spencer 1997), and only two tested race or SES effects. To our knowledge, none have accounted for an extensive list of detailed, tooth-specific clinical conditions and related them to loss of specific teeth, as distinct from tooth loss per person. As shown here, such a distinction is important because it helps explain social disparities in tooth loss, and the tooth-specific data increase inferential power. This allows for a comprehensive case-mix adjustment when assessing social disparities in tooth loss. Furthermore, none have accounted for certain person-

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level circumstances that also may influence tooth loss, such as new dental symptoms, attitudes toward tooth loss and dental care, and differences in dental insurance coverage.

We have documented for this sample that, when compared to their high-SES and AA counterparts, low-SES persons and AAs had more negative attitudes toward dental care, worse dental health, and more tooth loss, and were less likely to know what a root canal is, a dentistry procedure that is sometimes needed to avoid tooth removal (Gilbert, Duncan, Heft, and Coward 1997). Also, low-SES persons and AAs were more likely to seek dental care only in response to a specific problem, instead of preventively (Gilbert, Shah et al. 2002; Gilbert, Shelton, and Duncan 2002).

In contrast to most medical care situations, persons who enter the dental care system are actually in *better* health than those who do not (Gilbert et al. 2003), depending upon how oral health is measured. This is especially relevant for tooth loss because, with the minor exception of dental self-extractions (Gilbert, Duncan, and Earls 1998), the only way to experience tooth loss is to enter the dental care system. Therefore, there may be social determinants of tooth loss that operate in *opposite* directions: lower-SES persons and AAs may be at *less* risk for tooth loss because they are less likely to enter the dental care system, but once they do enter, they may be at *higher* risk for tooth loss. Therefore, a fuller understanding of the total effect of race and SES would need to account for effects at both points, disaggregating the process into two steps.

With these findings as background (a complete publications list is available at the web site noted in the Acknowledgments section), this study at once takes into account detailed measures of preexisting and subsequent changes in clinical condition, related health behaviors, attitudes toward health and health care, and participant-specific measures of SES (instead of measures aggregated by small geographic area).

OBJECTIVES AND HYPOTHESES TESTED

Our objectives were to quantify racial and socioeconomic status (SES) disparities in oral health, as measured by tooth loss, and to determine the role of dental care use and other factors in explaining disparities. Therefore, we tested these hypotheses:

- H1.** African Americans and low-SES persons have a higher incidence of tooth loss.

- H2. Social disparities in preexisting tooth-specific conditions and new, postbaseline dental symptoms appear to account for the observed social disparities in tooth loss, rendering them nonstatistically significant.
- H3. Taking the extra step of formally accounting for social disparities in dental care use will again make evident the social disparities in tooth loss (because disaggregating the analytic process into two steps reveals effects that operate in opposite directions, which otherwise would cancel each other out).
- H4. African Americans and low-SES persons are less likely to report that dentists discussed treatment alternatives with them before they had a tooth removed.

METHODS

Sampling Methods and Attrition

We used a sample from the *Florida Dental Care Study*, comprising African Americans (AAs) and non-Hispanic whites 45 years old or older who had at least one tooth (the URL for the Florida study is noted in the Acknowledgments section). Sampling details have been provided previously (Gilbert, Duncan, Kulley et al. 1997). The 873 subjects who participated at baseline (weighted n of 244 AAs, 629 non-Hispanic whites) resulted in a sample that was representative of the population of interest, defined as persons aged 45 years or older, who had a household telephone, did not live in an institutional setting, resided in one of four counties in Florida, could engage in a coherent telephone conversation, and had at least one tooth. Race and ethnicity were queried separately; only AAs and non-Hispanic whites were included. The sample's typical interval since last dental visit at baseline was similar to national data (Bloom, Gift, and Jack 1992; Gilbert, Duncan, Kulley et al. 1997).

Although the study began with 873 participants, by 48 months 714 persons (unweighted n ; weighted $n = 743$) remained in the study, of whom 669 (unweighted n ; weighted $n = 687$) participated for a 48-month clinical examination of tooth status. An evaluation of the potential for bias as a result of subject attrition has been reported (Gilbert, Shelton et al. 2002). As examples of the typical magnitude of this bias, of the persons at baseline ($n = 873$), 47 percent reported that they had been to a dentist in the previous six months. If the baseline had only included persons who ultimately

participated for the 48-month clinical examination, that figure would have been 49 percent. The mean (S.D.) number of teeth present at baseline among the persons who participated at 48 months was 22.2 (7.0); for the non-participants it was 21.3 (7.5). This difference was not statistically significant.

Data Gathering

An in-person interview was conducted at baseline that was immediately followed by a clinical dental examination. The baseline interview and clinical examination were followed by telephone interviews at 6, 12, 18, 30, 36, and 42 months. At 24 and 48 months, interviews were done in person instead of by telephone, and were accompanied by additional clinical examinations.

Interview Content

Interviews queried dental care use since the last interview, including the types and number of services received. Self-reported dental signs and symptoms, certain health-related habits, and financial and demographic circumstance were also queried. When persons reported during the interview that they had received a dental extraction since the previous interview, they were asked why the tooth was removed and what treatment alternatives, if any, the dentist discussed. Questionnaire content and test-retest reliability of questions have been explained previously (Gilbert, Duncan, Heft, and Coward 1997; Gilbert, Duncan, and Vogel 1998; Gilbert et al. 1998), but for clarity, some items are reported in this article. (Full wording of all items can be found at the web site listed in the Acknowledgments section.)

A Model of Longitudinal Dental Care Use

To conceptualize the study of tooth loss and dental care use, we used the Andersen behavioral model in which health care use is seen as the result of characteristics of the population at risk and the health care delivery system (Andersen and Newman 1973; Andersen 1995). Relevant population characteristics can be summarized by three groups of variables: predisposing, enabling, and need characteristics. *Predisposing* characteristics are those that exist prior to disease, and can be either mutable or immutable. *Enabling* characteristics are resources that affect one's ability to access the health care system, such as household income or health insurance coverage. *Need* variables reflect illness levels, such as dental disease, pain, or a person's perceived need for care. Table 1 lists all the variables that were tested as predictors of tooth loss.

Table 1: Factors Tested as Predictors of Tooth Loss

Predisposing Factors		Enabling Factors	Need Factors	
Race ^a		Ability to pay an unexpected \$500 dental bill ^c	Number of teeth at previous clinical exam ^d	Self-reported signs/symptoms ^f
Level of formal education ^b		Household income ^c	Tooth-specific clinical examination factors ^g	Toothache or abscessed tooth
Gender ^a		Poverty status ^a	Periodontal (gum) attachment level	Loose tooth
Area of residence (rural/urban) ^a		Dental insurance coverage ^b	Number surfaces with dental decay	Teeth sensitive to hot/cold
Age ^a			Number surfaces with fillings	Broken tooth or cap
Self-rated general health ^a			Whether tooth actually a root fragment	Broken filling
Propensity to use dental self-care ^g			Whether tooth severely loose	"Cavities"
Tooth brushing frequency ^b			Whether tooth has a cap/crown	Infected or sore gums
Flossing frequency ^b			Whether tooth has a fractured filling	Bleeding gums
Dental attitudes ^b			Whether tooth is fractured	Teeth stained or look bad
Frustration with past dental care			Whether tooth has severe root defect	Perceived need for dental care
Quality of recent dental care			Whether tooth in upper or lower jaw	- No, good shape now
Importance of dental visits to prevent dental problems			Tooth type (incisor, molar, etc.)	- Yes, for a routine check-up
Eventuality of dental decline				- Yes, for a dental problem
Influence of dental care costs on past dental treatment				- No, have problem, but can wait
Cynicism toward dentists and dental care				
Effectiveness of dental care				
Personal influence on dental decline				

^aMeasured during the telephone screening interview before baseline.

^bMeasured during baseline interview only.

^cMeasured during baseline, 24-month, and 48-month interviews.

^dMeasured by direct clinical examination at 24 and 48 months.

^eMeasured by clinical examination at baseline, 24, and 48 months.

^fMeasured during six-monthly interviews.

^gMeasured during the 30-month interview.

Predisposing Variables. In addition to race, gender, and age group (45–64 years old at baseline; 65 years old or older), area of residence was queried. Persons who resided in one of the three nonmetropolitan counties were classified as “rural.” Residents of the metropolitan county were classified as “urban.” Level of formal education was used as one of two measures of SES; it was coded into three categories (“8th grade or less,” “some high school,” and “high school graduate”). Eight dental attitude constructs were queried at baseline (Gilbert, Duncan, Heft, and Coward 1997). Participants were also asked to rate their general health as “excellent,” “very good,” “good,” “fair,” or “poor.”

Enabling Variables. Household income (relative to \$20,000 annually) was used as one of two measures of SES. Participants were asked about ability to pay an unexpected \$500 dental bill (not able to pay; able to pay, but with difficulty; or able to pay). Poverty status had been determined during the telephone screening interview. Subjects were asked at baseline if they had any dental insurance coverage, the source of that coverage, and which dental services were covered. Because of an expected and confirmed amount of overlap, ultimately only “household income” was used as an enabling variable in the final regression to explain tooth loss.

Need Variables. These were measured by querying participants about postbaseline dental symptoms, and by a clinical examination that recorded the presence and location of teeth, as well as other diseases and conditions that ultimately proved strongly predictive of tooth loss (Gilbert, Shelton, Chavers et al. 2002). Postbaseline dental symptoms were queried, many of which we have shown to be predictive of dental care seeking (Gilbert, Duncan, and Vogel 1998) using a multidimensional model of oral health (Gilbert, Duncan, Dolan, and Vogel 1998). Ultimately, the postbaseline symptoms most relevant to tooth loss were toothache pain and a loose tooth.

Tooth Loss. Loss was defined as having occurred if, upon clinical examination at 24 months, a tooth present at baseline was no longer present, or if upon examination at 48 months, a tooth present during the 24-month examination was no longer present. Thus, we had two consecutive observation intervals, each of 24 months’ duration.

Statistical Methods

Data were weighted using the sampling proportions to reflect the population in the counties studied (Gilbert, Duncan, Kulley et al. 1997). Predisposing and enabling variables in Table 2 were tested using Pearson χ^2 , Mantel-Haenszel

χ^2 trend, or Duncan's multiple-range tests. Regressions in Table 3 used the GENMOD procedure (SAS Institute 2000). The unit of analysis in Table 3 was the tooth-interval. One tooth-interval comprised one tooth in a given person observed for a 24-month interval. Because there were 48 months of follow-up, most persons contributed two tooth-intervals for each tooth present at baseline. Although the tooth was the unit of analysis, clustering of teeth within persons was accounted for, allowing for testing of both tooth-specific and person-level characteristics. Because each person and tooth could contribute up to two consecutive observation periods, this repeated-measures design was taken into account. In Table 3, results are presented as three regressions. In model 1, race and SES are the only explanatory covariates. In model 2, race and SES are kept in the regression, but tooth-specific clinical examination and person-level dental symptoms are also included. Model 3 comprises model 2, except that the analysis is limited to persons who had at least one dental visit in the interval. For ease of interpretation, parameter estimates were converted to odds ratios with 95 percent confidence intervals. Multicollinearity was assessed using a procedure described by Belsley and colleagues (1980); none was observed.

Our analysis accounts for tooth-specific conditions (e.g., whether or not the tooth had dental decay, severe gum disease, a fracture, and so on) and person-level characteristics (e.g., new dental symptoms, race, SES). This is important because tooth-specific data increase inferential power; loss of individual teeth can be related to the disease level on those teeth. In turn, this allows for a comprehensive case-mix adjustment when assessing social disparities in tooth loss, such that we can say that any remaining social disparities in tooth loss are most probably not due to social differences in disease level.

RESULTS

Table 2 shows tooth loss during the full 48-month observation period, where the unit of analysis is the person, not the tooth. Race and each of the enabling characteristics were significantly associated with tooth loss incidence. When analysis was limited to persons who lost at least one tooth during follow-up, we found that African Americans, persons with fewer years of formal education, less ability to pay, and poor persons, lost a larger number of teeth.

When the bivariate unit of analysis was the tooth-interval (GENMOD procedure; not shown in table), with clustering of teeth within persons taken

Table 2: Percent of Persons Who Lost One or More Teeth, and Mean (S.D.) Number of Teeth Lost between Baseline and 48 Months after Baseline, by Selected Characteristics

<i>Characteristic (n)</i>	<i>Percent of Persons Who Lost One or More Teeth During 48 Months of Follow-up</i>	<i>Percent of Persons Who Lost One or More Teeth, Limited to Persons with at Least One Visit during 48 Months of Follow-up</i>	<i>Mean (S.D.) Number Teeth Lost, Once Limited to Persons with at Least One Visit during 48 Months of Follow-up and Who Lost at Least One Tooth during 48 Months of Follow-up</i>
<i>Race</i>			
AA (179)	48%*	56%*	4.5 (3.8)*
non-Hispanic whites (506)	32%	33%	2.7 (3.8)
missing (1)			
<i>Highest level of formal education</i>			
8th grade or less (70)	65%*	77%*	4.7 (3.8)*
Some high school (247)	38%	43%	3.5 (3.9)
Some college (368)	29%	33%	2.9 (3.3)
Missing (1)			
<i>Household income</i>			
Below \$20,000 (291)	47%*	52%*	3.6 (3.5) ^{ns}
At or above \$20,000 (366)	28%	29%	2.8 (3.6)
Missing (29)			
<i>Poverty status</i>			
Below 100% poverty level (99)	54%*	63%*	5.2 (3.6)*
At or above the 100% level (552)	32%	33%	2.6 (3.4)
Missing (36)			
<i>Ability to pay</i>			
Not able to pay (78)	48%*	61%*	4.3 (3.7)*
Able to pay, but with diff. (269)	41%	45%	3.5 (3.8)
Able to pay comfortably (337)	29%	29%	2.6 (2.9)
Missing (2)			
<i>Has dental insurance</i>			
Yes (235)	31% ^{ns}	32%*	3.2 (3.8) ^{ns}
No (430)	38%	41%	3.3 (3.4)

*Statistically significant, $p < .05$

The unit of analysis in this table is the person, not the tooth. This table is limited to persons who participated for the 48-month clinical examination ($n = 687$). Statistical differences in percentages were tested using Pearson χ^2 or Mantel-Haenszel χ^2 trend tests. Means were tested using Duncan's multiple range tests.

In contrast to results in Table 3, results in this table used a single observation interval 48 months in length; two consecutive 24-month intervals were not used. This was done so that sample sizes for each stratum would sum to the total number of persons in the stratum observed, not person-intervals.

into account, race and SES were strongly associated with tooth loss. African Americans lost a tooth in 8.1 percent of tooth-intervals, compared to 2.2 percent for non-Hispanic whites—with an odds ratio (95 percent confidence interval) of 4.30 (2.83, 6.52). Persons with an eighth-grade education or less lost a tooth in 12.9 percent of tooth-intervals, compared to 2.6 percent of persons with more than an eighth-grade education—with an odds ratio of 5.58 (3.40, 9.15). Persons with an annual household income of less than \$20,000 lost a tooth in 5.8 percent of tooth-intervals, compared to 1.9 percent of persons with an income of \$20,000 or more—with an odds ratio of 2.64 (1.84, 3.79).

Models 1–3 of Table 3 show results using the tooth-interval, not the person, as the unit of analysis. These three models are meant to demonstrate for this sample that social disparities are statistically significant (model 1), that differences in tooth-specific dental conditions and postbaseline dental symptoms account for these social disparities in tooth loss (model 2, in which the social disparities are no longer statistically significant), and that if we limit the analysis in model 2 to persons who had at least one dental visit (and who were therefore potential candidates for tooth loss), the social disparities once again are statistically significant and have large effect magnitudes (model 3). The transition from model 2 to model 3 disaggregates the tooth loss process into two stages (one must first enter the dental care system, and then once at a dental office, one may have a tooth removed). With three variables in the model (race, education, income), AAs and persons with fewer years of formal education had significantly higher probabilities of tooth loss, consistent with hypothesis (1), and household income was not statistically significant.

From model 2 in Table 3, we see that taking into account tooth-specific measures of dental disease and new person-level symptoms, there were no statistically significant racial and SES disparities in tooth loss. This suggests that racial and SES differences in dental disease and dental symptoms account for racial and SES disparities in tooth loss. That is, as suggested by hypothesis (2), with a comprehensive tooth-specific case-mix adjustment for disease level and new symptoms, social disparities are not evident.

Because tooth loss can occur only if participants enter the dental care system (with the minor exception of dental self-extraction), we next limited the analysis in model 2 to persons who had at least one dental visit during the observation interval, as shown in model 3. With these differences in entry into the dental care system taken into account, we found that AAs, persons with

Table 3: Logistic Regressions of Tooth Loss, Showing Effects as Odds Ratios with 95% Confidence Intervals and in Which the Tooth is the Unit of Analysis

<i>Characteristic</i>	<i>Model 1 (Race, SES Only)</i>	<i>Model 2 (Model 1, Plus Need Variables)</i>	<i>Model 3 (Model 2, but Only Includes Persons with a Dental Visit during Interval)</i>
<i>Race</i>			
African American	2.18 (1.33, 3.57)	1.39 (0.87, 2.23)	1.75 (1.10, 2.79)
non-Hispanic white	1.00	1.00	1.00
<i>Education</i>			
8th grade or less	1.96 (1.13, 3.39)	1.31 (0.73, 2.33)	2.04 (1.10, 3.78)
Some high school	1.00	1.00	1.00
<i>Household Income</i>			
Below \$20,000	1.60 (0.98, 2.61)	1.38 (0.86, 2.22)	1.71 (1.05, 2.77)
At or above	1.00	1.00	1.00
Need variables	—	(included) ^a	(included) ^a
<i>Model Statistics</i>			
Number persons	745	745	613
Number tooth-intervals	26,538	24,695	18,489
Deviance	7,018.9	4,961.8	4,323.2

Parameter estimates were converted to odds ratios with 95% confidence intervals. Statistically significant odds ratios ($p < .05$) appear in bold and italic font.

The outcome of interest (loss of a specific tooth) was coded 1 if the tooth was lost, and 0 if not. Therefore, this is a tooth-level analysis, not a person-level analysis (as appears in Table 2). Although the tooth is the unit of analysis, clustering of teeth within persons is accounted for in the correlation structure, allowing for both tooth-specific and person-level characteristics to be tested. The observation period was divided into two 24-month intervals, such that the need variables (clinical examination measures) from the baseline examination were used to predict tooth loss by the 24-month time point, and clinical variables from the 24-month exam were used to predict tooth loss between the 24-month and 48-month exams.

^aThese need variables were included: tooth-specific variables determined by direct clinical examination (periodontal [gum] attachment level, upper/lower jaw location, tooth type, tooth severely loose, tooth had a fractured filling, root fragment, tooth surfaces with fillings), and two person-level signs/symptoms reported during the interval by interview (toothache and loose tooth). Consistent with the notion that clinical variables are important to understanding social disparities in tooth loss, each of these need variables were statistically significant with large effect magnitudes. The rationale for including these variables is found in Gilbert, Shelton et al. 2002. Because accounting for clinical detail is not the focus of this report, and for ease of presentation, results from the full model are not presented. However, they are available at <http://nersp.nerdc.ufl.edu/~gilbert/supplemental.html>.

fewer years of formal education, and persons with household income of less than \$20,000, had significantly higher probabilities of tooth loss, supporting hypothesis (3).

African Americans, persons with fewer years of formal education, and persons with fewer financial resources were less likely to report a dental visit during six-month observation intervals (Gilbert, Shah et al. 2002). Most relevant to the current analysis is entry into the dental care system during each 24-month tooth-interval observation period. African Americans had one or more dental visits in 58 percent of tooth-intervals, compared to 84 percent for non-Hispanic whites—with an odds ratio of 0.29 (0.21, 0.39). Persons with an eighth-grade education or less had one or more dental visits in 51 percent of tooth-intervals, compared to 81 percent of persons with more than an eighth-grade education—with an odds ratio of 0.34 (0.23, 0.49). Persons with an annual household income of less than \$20,000 had one or more dental visits in 67 percent of tooth-intervals, compared to 85 percent of persons with an income of \$20,000 or more—with an odds ratio of 0.70 (0.42, 1.18).

In keeping with hypothesis (4), for 54 percent of teeth removed during follow-up, participants said that the dentist did not discuss any other treatment alternative (not shown in tables). This percentage did not differ by race, level of formal education, or household income (GENMOD procedure). For 13 percent of the teeth lost by non-Hispanic whites, non-Hispanic whites reported that a root canal was discussed as a treatment alternative, compared to 3 percent among AAs ($p < .001$; GENMOD procedure). For 12 percent of the teeth lost by non-Hispanic whites, non-Hispanic whites reported that a cap or crown was discussed as a treatment alternative, compared to 8 percent among AAs ($p < .001$; GENMOD procedure).

In a multivariable logistic regression of whether or not a root canal was discussed, AAs were less likely to have had the alternative discussed—odds ratio of 0.26 (0.09, 0.72). This regression was adjusted for level of formal education, household income, baseline clinical status (loose teeth upon clinical examination, presence of severe gum attachment loss, presence of a root fragment), and reason for the dental extraction (toothache, loose tooth, broken tooth, cavities). Although race was significant, education and income were not.

We also did a multivariable logistic regression of whether or not a cap or crown was discussed as an alternative. African Americans were less likely to have had the alternative discussed—odds ratio of 0.11 (0.03, 0.51)—but education and income were not significant. In addition to race, income, and education level, this regression was adjusted for baseline clinical status (loose teeth upon clinical examination, presence of severe gum attachment loss, presence of a root fragment) and reason for the dental extraction (toothache, loose tooth, broken tooth, cavities) because these might limit the relevance of various treatment alternatives.

DISCUSSION

African Americans and low-SES persons began the study with fewer teeth and were in worse oral health using other measures, such as active dental disease, dental pain, chewing ability, and oral health-related quality of life (Gilbert et al. 1998; Schoenberg and Gilbert 1998). Nonetheless, these racial and SES disparities not only persisted during follow-up, they actually were exacerbated. Not only did AAs and lower-SES persons experience more tooth loss during follow-up, as shown in the current analyses, they also experienced more dental disease, painful symptoms, and reductions in oral health-related quality of life (Gilbert, Shah et al. 2002).

Recent reviews of ethnicity and socioeconomic position posited that race effects remaining after adjusting for SES may be due to causes other than biologic, cultural, or behavioral (Adler and Ostrove 1999; Davey Smith 2000; Adler and Newman 2002). For example, one limitation of our study is that SES did not include a measure of occupational status, nor could we account for possible different meanings of SES indicators between racial and SES groups. These possible differences are worthy of further investigation.

To our knowledge, this is the first longitudinal study focused on social disparities in tooth loss that has detailed, tooth-specific information on clinical status, a level of detail necessary for comprehensive case-mix adjustment. This proved elucidative, because racial and SES differences in dental clinical status, along with information on postbaseline dental symptoms, did indeed account for a major portion of social disparities in tooth loss, rendering the observed disparities nonstatistically significant in model 2. We acknowledge that one limitation of the study is the fact we did not have information on clinical status at the time of dental extraction, instead of that gathered up to two years beforehand. Due to the slow, chronic nature of most dental conditions that affect tooth loss (e.g., gum disease, dental decay), and because each dental condition was strongly predictive of tooth loss in the multivariable model, we judge that this did not have a substantive effect on conclusions, especially because clinical status did indeed reduce social disparities to statistical nonsignificance.

Although we have demonstrated that this sample had much in common with what would have been derived from a comparable national sample (Bloom, Gift, and Jack 1992; Gilbert, Duncan, Kulley et al. 1997), we remind the reader that generalization is regarding the defined population of interest, and studies from other AA and non-Hispanic white populations are advisable. Persons in this study are now 55 years old or older, an age group that comprises a substantial portion of the U.S. population. Although recent

research has documented that treatment patterns are changing (e.g., Eklund 1999), we speculate that AAs and lower-SES persons will continue for the foreseeable future to have different dental attitudes, different dental care use patterns, and different experiences in the dental care system than their non-Hispanic white and higher-SES counterparts.

We also raise the methodologic issue of length-of-observation interval in this study. It is possible that if the observation interval were extended to say, a decade, the observed social disparities would be diminished. Short observation intervals may overestimate social disparities if AAs and low-SES persons with accumulated, untreated need (due to infrequent dental care) arbitrarily choose to seek care within the single 24-month observation interval. However, we have demonstrated previously that non-Hispanic whites actually were at *increased* risk of having no teeth at all before baseline (assessed in a telephone screening survey before the baseline phase). The odds ratio was 1.4 (95 percent confidence interval of 1.2–1.8), with age group, self-reported general health, poverty status, rural/urban area of residence, and gender accounted for (Dolan et al. 2001). Ultimately, of course, the observation interval could be extended further, but the goal of our analyses is to shed light on the mechanism of the social disparities. Had we not been persistent about understanding the mechanism, we would not have concluded that there even was a disparity in tooth loss incidence. This is because without disaggregating the use-to-health outcome process by presenting both models 2 and 3 in Table 3, we would not have observed any racial or SES differences. Our overall intent is to shed light on the different impacts that race and SES have before persons enter the dental care system compared to after. Before entering the dental care system, race and SES make a difference due to social differences in disease levels and new dental symptoms (which we accounted for in model 2 of Table 3), and due to social differences in propensity to seek dental care. After entering the dental care system (as in model 3 of Table 3), race and SES make a difference due to social differences in which treatment is received. Given that we accounted for social differences in disease level and new dental symptoms in model 3 (a form of case-mix adjustment), the social differences in tooth loss that are apparent in model 3 would be due to different reasons. That is, given that we can level the playing field statistically with regard to dental need at the beginning of the interval, African Americans and lower-SES persons still receive different services, and these affect their oral health. The reasons for these differences in service receipt might include social differences in treatment preferences, differences in treatment options discussed with the patient, and subconscious treatment bias.

The Implications of Dental Attitudes in Tooth Loss

Dental attitudes in this sample were associated with problem-oriented rather than regular dental attendance (Gilbert, Duncan, Heft, and Coward 1997), and with receipt of fixed prosthodontic services (such as caps, crowns, and bridges) (Dolan et al. 2001), services that are often needed to avoid tooth loss. Nonetheless, attitudes toward tooth loss and dental care were not predictive of tooth loss incidence in multivariable regressions in Table 3 (results not shown). Instead, race and SES effects remained prominent. In univariable analyses, the dental attitudes "quality of recent care," "eventuality of dental decline," and "influence of dental care costs on past dental care," were each predictive of tooth loss, such that persons with more positive dental attitudes had lower probabilities of tooth loss. The attitudes remained significantly associated with tooth loss, even after accounting for presence or absence of a dental visit during the tooth-interval. This parallels studies in other health care contexts, in which it has been hypothesized that racial differences in quality of care or racial bias in health care at least partly account for racial disparities in health (Fiscella et al. 2000). However, attitudes were not significant once tooth-specific disease severity and postbaseline symptoms were taken into account, suggesting that attitudes may exert an indirect effect on tooth loss through dental disease. Modifying dental attitudes may help reduce tooth loss long-term. We have shown previously in this sample that race and SES are indeed related to dental attitudes (Gilbert et al. 1997) and to oral hygiene and dental care use (Gilbert, Duncan, Heft, and Coward 1997; Gilbert, Duncan, and Vogel 1998; Gilbert, Shah, et al. 2002). Our results are consistent with the conclusion that race and SES shape dental attitudes, which then shape oral health-related behaviors (e.g., oral hygiene, dental care use), which in turn shape treatment preferences and receipt of specific dental services. Future investigations that test these temporal relationships may prove elucidative.

Disaggregating the Tooth Loss Process into Two Steps

With the minor exception of dental self-extractions (Gilbert, Duncan, and Vogel 1998), the tooth loss process can be disaggregated into two steps: (1) deciding to enter the dental care system for treatment of any type, and (2) receiving treatment for the condition being addressed. Our results show the importance of understanding disparities in dental care use if we hope to understand oral health disparities, and the value of disaggregating the process. Had the process not been disaggregated (i.e., if modeling had ended with model 2 in Table 3), we would have concluded that social disparities can be

adequately explained by social differences in the prevalence of tooth-specific conditions and postbaseline dental symptoms. To our knowledge, this is the first study to have formally accounted for the role that dental care incidence plays in tooth loss incidence. As we hypothesized, the role of dental care incidence in tooth loss results from race and SES effects that operate in opposite directions: a *decreased* risk for tooth loss among AAs and low-SES persons due to low dental care use rates, but an *increased* risk for tooth loss if the dental care system is entered. Because of the slow, chronic nature of most dental diseases (and consistent with the higher prevalence and incidence of dental problems among AAs and low-SES persons), these groups seem to have endured disease and its burden until treatment could not be delayed any longer. One explanation is that demand for medical care or demand for higher-priority needs (e.g., housing and daily living expenses) may “crowd out” demand for dental care (Kuthy, Strayer, and Caswell 1996). Although need for care predicts use of it (for both medical care and dental care), the effects can move in opposite directions; more need leads to more medical care, but more dental need can be associated with *less* dental care, depending upon how need is measured (Gilbert et al. 2003). For some AAs and lower-SES persons, underuse of dental care may come from a reasonable decision-making process because of perceived lack of long-term benefit based upon subgroup or family norms, or upon previous experience with dental care.

The Role of Treatment Alternatives and Treatment Preferences

The salience of race, education, and household income, even after accounting for clinical status, may have to do with differences in treatment preferences. In the first 24 months of the study, AAs and lower-SES persons were less likely to receive treatments that can serve as alternatives to tooth removal (Gilbert, Shah et al. 2002). Dental practice characteristics, or racial/SES differences in the degree to which treatment alternatives are discussed with patients, may also play a role in social disparities in tooth loss, and this line of research may prove fruitful (van Ryn 2002). We know from baseline results that AAs reported less knowledge of certain treatments that can prevent tooth loss (Gilbert, Duncan, Heft, and Coward 1997). They also reported a lower likelihood that a dentist had discussed these alternatives. During the 48-month follow-up period, the same phenomenon was observed: AAs who lost at least one tooth were much less likely to have reported that the dentist had discussed other treatment alternatives. This mirrors findings for other health care treatments, where AAs had fewer alternatives discussed with them compared to non-Hispanic whites (Institute of Medicine 2002).

CONCLUSION

The larger contribution of this paper lies in its demonstration that we cannot understand health disparities without understanding disparities in health care use and treatment receipt. Our paper simply uses as an example a particular measure of health: tooth loss. Our example underscores the importance of disaggregating health care use (e.g., dental care use) from health outcome (e.g., tooth loss). Because social disparities in health care use and health outcome can operate in opposite directions, disaggregation allows us to observe a substantial disparity. If the disaggregation is not done, then no disparity is apparent. This disaggregation not only identifies a disparity, it helps us to understand its mechanism. Taken as a whole, this study suggests that: (1) race and SES are strong determinants of tooth loss incidence, (2) a detailed accounting of racial and SES differences in dental disease extent and severity and new dental symptoms explains a major portion of social disparities in tooth loss, a leading measure of a population's oral health, (3) African Americans and lower-SES persons are less likely to enter the dental care system, but are at increased risk for tooth loss once they do, and (4) accounting for disparities in dental care use plays a major role in understanding race and SES effects on tooth loss; absent such understanding, the total effects of race and SES on health can be underestimated.

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