VITAL & HEALTH STATISTICS

Diet and Dental Health, A Study of Relationships: United States, 1971-74

This report presents findings on the relationship between dietary intake and dental health from the first National Health and Nutrition Examination Survey, a national probability sample survey that was conducted in 1971-74. Data on decayed, missing, and filled permanent teeth and on the periodontal index are examined using regression techniques in relation to food intake, fluoride concentration, tooth-brushing frequency, smoking history, and alcohol consumption.

Data From the National Health Survey
Series 11, No. 225

DHHS Publication No. (PHS) 82-1675

U.S. Department of Health and Human Services
Public Health Service
Office of Health Research, Statistics, and Technology
National Center for Health Statistics
Hyattsville, Md.
January 1982

Library of Congress Cataloging in Publication Data

Diet and Dental Health, A Study of Relationships: United States, 1971-74.

(Vital and health statistics. Series 11, Data from the national health survey; no. 225) (DHHS publication; (PHS) 82-1675)

Bibliography: p. 27

1. Nutrition and dental health—United States. 2. Dental surveys—United States. 3. Nutrition surveys—United States. 4. Health and Nutrition Examination Survey. 5. Regression analysis. I. Burt, Brian Aubrey. II. Series. III. Series. DHHS publication; (PHS) 82-1675. [DNLM: 1. DMF index. 2. Periodontal index. 3. Nutrition surveys—United States diet surveys. 4. Diet—Adverse effects—Statistics. 5. Mouth diseases—Etiology—Statistics. 6. Tooth diseases—Etiology—Statistics. W2 A N148vk no. 225]

RA407.3.A347 no. 225 [RK281] 312'.0973s 81-14233
ISBN 0-8406-0235-9 [617.6'3071] AACR2

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

Cooperation of the U.S. Bureau of the Census

Under the legislation establishing the National Health Survey, the Public Health Service is authorized to use, insofar as possible, the services or facilities of other Federal, State, or private agencies. In accordance with specifications established by the National Center for Health Statistics, the U.S. Bureau of the Census participated in the design and selection of the sample and carried out the household interview stage of the data collection and certain parts of the statistical processing.

Foreword and Acknowledgments

The National Health and Nutrition Examination Survey (NHANES) is the only source of general U.S. population data that provides a direct link between indicators of health and nutritional status and reported dietary intake information. The Congress provided resources in the Departments of Labor and Health, Education, and Welfare, and Related Agencies Appropriation Bill, 1980 to the National Center for Health Statistics (NCHS) to fund an initiative to undertake more detailed analyses of nutrition-related health problems as measured in the first NHANES. As part of this initiative, the Division of Health Examination Statistics funded a contract (no. 223-79-2092) with the School of Public Health at the University of Michigan to examine relationships among dietary intake, food consumption patterns, and measures of dental health.

The approach and depth of analysis presented in this report differ from previous reports from the Division of Health Examination Statistics. This report is based on a statistical rather than a descriptive presentation of the data. The tables and text present the results of a regression analysis that incorporates the full design effect of the complex survey.

Cognizant that the underlying assumptions of traditional statistical analyses are violated to some extent, the degree of which is unknown, the authors and NCHS staff jointly determined that the assumptions made in the analyses presented in this report are reasonable in light of present knowledge. In addition, the authors have presented throughout the text and technical appendix material concerning appropriate qualifications that the reader should consider in interpreting the results and conclusions presented.

Mary Grace Kovar, the NCHS Project Officer, was instrumental in bringing the project to a successful completion. Her continuing interaction with the authors and their cooperation throughout the project aided the Center in dealing with difficult and highly technical analytic issues not faced previously by NCHS.

The authors gratefully acknowledge the technical assistance of Sharon A. Stehouwer, Ruth A. Serokman, James M. Lepkowski, and Edward DeVol in many aspects of data processing, implementation of the statistical analysis, text processing, and proofreading of the statistical appendix.

Robert S. Murphy
Director
Division of Health Examination Statistics

Contents

Appendixes

List of Text Tables

Symbols

- - -	Data not available
. . .	Category not applicable
-	Quantity zero
0.0	Quantity more than zero but less than 0.05
Z	Quantity more than zero but less than 500
*	Figure does not meet standards of reliability or precision
#	Figure suppressed to comply with confidentiality requirements

Diet and Dental Health, A Study of Relationships

by Brian A. Burt, B.D. Sc., M.P.H., Ph.D.; Stephen A. Eklund, D.D.S., M.H.S.A., Dr.P.H.; J. Richard Landis, Ph.D.; Frances A. Larkin, Ph.D.; Kenneth E. Guire, M.S.; and Frances E. Thompson, M.P.H., School of Public Health, The University of Michigan

Introduction

The National Health and Nutrition Examination Survey is one of a series of surveys conducted by the National Center for Health Statistics. It is unique in that specially designed and constructed mobile examination centers are moved to selected sample areas so that physical examinations can be given under standardized conditions in a controlled environment. The team of interviewers and examiners also moves with the examination centers. The standardized physical examinations of a probability sample of the population have several advantages over other means of collecting data about the health of the population. They are (1) the examination can be designed to focus on specified conditions and to furnish more reliable estimates of the prevalence of the specified conditions than can be obtained by interview; conditions unknown to the examinee can be identified and the criteria for diagnosis can be carefully specified, (2) the use of mobile examination centers and a constant team of trained personnel reduce the variability found in studies using local facilities and personnel, (3) the instruments are recalibrated and the interviewing and examining are monitored so the only source of variation is the person being examined. The geographically defined probability design reduces the bias that might be found in populations selected for specific purposes or in areas that are not characteristic of the country.

The importance of these data for formulating policy has already been recognized. They were a basis for recommendations made by the Institute of Medicine in 1980[1] on improving dental health. The central issue of that report is the need for implementing and financing primary prevention programs. This report, from the National Center for Health Statistics, complements the Institute of Medicine publication; knowledge of the relationship between diet and dental health is necessary to develop those prevention programs.

The first National Health and Nutrition Examination Survey included a dental examination, a dietary interview, and a medical history interview. Data from these three components are the basis of this report.

This report presents relationships between various dental examination findings and nutritional and medical history information collected during the first National Health and Nutrition Examination Survey. Whereas most of the previous reports on data from this survey have been descriptive or bivariate in nature, this report uses multiple regression analysis techniques to explore these relationships in greater depth.

The dental findings are based on examinations given by 10 dentists during 1971-74 to more than 20,000 people ages 1-74 years. Those who were examined were part of a probability sample of approximately 28,000 people selected from the civilian noninstitutionalized population of the coterminous United States, except those living on land reserved for the use of American Indians. A detailed description of the design, content, and operation of the survey has been published. A brief description of the sample design is also given in appendix I of this report. Definitions of the terms are in appendix II, and a copy of the dental examination form is in appendix III.

Since one area of emphasis in the survey was nutrition, the sample was selected so that certain population groups believed to be at high risk of malnutrition (those with low incomes, preschool children, women of childbearing age, and the elderly) were oversampled at specified rates. Because of this oversampling, and the complexity of the sampling design necessary in a national survey, statistical weighting adjustments were made for the sampling design, oversampling procedure, and nonresponse. These methods were used to adjust apparent relationships among variables as described in detail in appendix I. The sampling design for NHANES I is also described in that appendix.

At 65 survey locations, 20,749 sample persons were examined. Dental measurements and nutritional information were obtained from 20,218 of these 20,749 examinees. Dental data were imputed from those 531 persons whose records were lost or who did not receive the dental examination for some reason. In addition, a detailed medical examination was given to a subsample of 3,854 persons ages 25-74 years at the same 65 survey locations. This detailed examination included the information on smoking, dental visits, and tooth-brushing frequency. As a result, several of the relationships examined in this report that used this information could only be tested among this subsample. Separate sampling weights were developed for this detailed examination.

As part of NHANES I, there was also an "augmentation" survey of 3,059 adults ages 25-74 years continued until October 1975 at 35 additional survey locations. However, no information from this augmentation survey is included in this report since a dental examination was not part of the augmentation survey.

Information about each sample person examined during NHANES I was obtained by means of a household interview; a general medical history; a 24-hour dietary intake recall interview; a food frequency interview; a food program questionnaire; a general medical examination; dental, dermatological, and opthalmological examinations; anthropometric measurements; and 24 hematological, blood chemistry, and urological laboratory determinations. Hand-wrist X-rays were taken on those 1-17 years old.

Descriptive information on results of the dental examination has been given in two reports.[3,4] Several descriptive reports on nutritional information in NHANES I have also been issued,[5-7] as well as a further publication of nutritional interest from NHANES I.[8]

Sources and limitations of data

The dental examination

The dental examiners derived their findings as uniformly as possible by following a written set of objective standards in which they had been carefully trained. The standards were guidelines that, in effect, narrowed the range of examiner variability by eliminating many borderline or questionable conditions that are frequently a source of disagreement. To avoid other sources that might have resulted in systematic bias, the dentists did not dry or isolate teeth, remove oral debris and calculus, or probe tooth surfaces unless they showed overt signs of decay.

The examining dentist dictated the condition of each tooth present to a trained recorder (health technician). The teeth were classified as sound, filled, decayed, filled-defective, or nonfunctional. Missing permanent teeth were classified under one of the following four categories: unerupted, carious extraction, accidental loss, or orthodontic extraction. The decayed-missing-filled (DMF) index,[9] a cumulative index of lifetime dental caries experience, was derived from these recordings. When missing teeth were replaced on a fixed or partial denture, the condition of the tissue under the prosthesis as well as the adequacy of the prosthesis itself were rated. When there were no natural teeth remaining in a jaw, the condition of the jaw and the status of an artificial replacement, if one was present, were recorded.

The next step of the examination was to assess the periodontal structures and the status of oral hygiene. The periodontal index[10] (PI) was used to assess the presence or absence of periodontal disease. By this system of classification, scores are assigned to all teeth present in the mouth according to the extent of gingival inflammation, the presence or absence of periodontal pockets, and the firmness of teeth in their sockets. To assess oral hygiene by the simplified oral hygiene index[11] (OHI-S), scores are recorded for all or any of six predesignated teeth. The scores indicate the extent of both debris and calculus on selected tooth surfaces. Fluoride and nonfluoride opacities and other conditions such as bleeding gums, diffuse marginal inflammation, swollen red papillae, and gingival recession are also recorded.

The occlusion of persons ages 6-21 years was appraised by a series of counts and measurements. The anteroposterior position of the lower jaw in relation to the upper jaw was recorded. Counts were made of malaligned teeth and posterior teeth in a crossbite relationship. Measurements of mandibular protrusion and anterior overjet, overbite, and openbite were taken.

An enamel biopsy was done for persons who had an upper permanent incisor with a front surface free of cavities and fillings. The enamel sample was "polished off" from an area about one-eighth-inch in diameter and approximately 0.0002-inch deep. This is about as much enamel as that removed during a routine cleaning by a dentist or dental hygienist. The sample was analyzed to determine the fluoride content of the tooth it was removed from. Fluoride biopsy samples could only be obtained from 5,481 subjects, due to unforeseen problems with equipment and some unexpectedly high refusal rates, plus absence of the necessary teeth in very young, edentulous, and semi-edentulous persons.

Detailed information on the dental examination and a copy of the dental record form are given in appendix III. Some data on interexaminer variability are also given in appendix III (table XVI). Additional information about self-perceived needs for dental care and the receipt of dental care is available from the Health Care Needs Supplement.[2]

Nutritional data

The dietary interview was conducted with each sample person to obtain information about total food and drink consumption during the preceding 24 hours. This was followed by questions about the frequency of specific food group intake for the preceding 3 months. These interviews were conducted by dietary staff who graduated from accredited colleges and universities and who majored in home economics with emphasis in foods and nutrition. The parent or other adult responsible for a child's feeding provided information about preschool children. Usually both the parent and child were interviewed for subjects ages 6-12 years.

Information on food intake was obtained for the day, midnight to midnight, preceding the interview. Food recall included foods eaten on Monday through Friday but excluded foods eaten on the weekend as there was no examination on Sunday and Monday. It is recognized that weekend eating patterns may differ from those during the week.[12]

The dietary interview lasted approximately 20 minutes (maximum allowance was 30 minutes) and usually was administered in the mobile examination center. A small percent of the interviews took place in the subject's home. Home visits were made for several reasons. Some aged or ill examinees wished to spend less time at the examination center. Some mothers had several children who were examined, and it was more convenient for the mothers to have the children interviewed at home. Occasionally, home visits were made to collect dietary information because the mother or babysitter did not accompany a child to the examination center or because translators were needed when the examinee did not know enough English to understand or answer the interviewer.

Food portion models were used to assist the respondent in estimating amounts of foods consumed. The models developed for another survey[13] were used with slight modifications. A computer program, used to determine nutrient values of foods consumed was adapted from one developed and used in the Ten-State Nutrition Survey[14] and was based on a program developed originally at Tulane University. The original nutrient data base used in NHANES I was derived from the U.S. Department of Agriculture Handbook No. 8 (1963), table 1,[15] as well as information from other sources. Because of the constantly changing food supply, nutrient composition values for existing or new food products were added or updated continually according to information provided by the U.S. Department of Agriculture, food processors, and manufacturers.

The constituents of the food groups used in the 24-hour recall data are shown in appendix II. Major sources of calories and specific nutrients are also shown in appendix II, as are problems associated with deficiency and standards for evaluation of daily nutritional intakes used in NHANES I (tables XIV and XV).

The food frequency method served as a quality control technique for the 24-hour recall method of obtaining data while depicting diet profile patterns over a longer period of time. The frequency of consumption of food from the food groups ingested daily and/or weekly over the 3-month interval prior to the nutrition interview was obtained from the food frequency interview. All regular meals and between-meals foods or snacks eaten during the week (including special occasions and holidays) were reported in six frequency categories.

Limitations of data interpretation

The analyses presented in this report are cross-sectional in nature, and therefore are subject to the limitations of all cross-sectional studies. These limitations relate principally to the fact that data collected can be difficult to apply directly to the answering of questions generated after the survey is completed. Several such instances were encountered in these analyses, with the result that questions sometimes could not be answered completely. Others were approached through the generation of new variables from those provided.

Relationships found among these data can also demonstrate only associations, they can not show causal relationships. Some of the associations presented in this report are probably of a causal nature since they confirm the results of other studies, while others may be chance relationships. Although the temptation to impute cause-and-effect from the data in NHANES I is strong, to succumb would be to stretch the data beyond their limitations.

There are some inherent difficulties in associating the dental and dietary data gathered in the NHANES I survey. These problems stem from the fact that the DMF index is a cumulative measure of lifetime dental caries experience, while the 24-hour dietary history records a recent event. To make the associations valid, the dietary history recorded for the previous day would need to typify a lifetime diet, which in most cases is probably unlikely. A 40-year-old person, for example, probably accumulated the bulk of his or her recorded dental caries experience between the ages of 10 and 24. The dietary history recorded, in many cases, would not typify the dietary habits at that time. In view of these circumstances, when relationships are found it seems more likely that they are real rather than due to chance; their magnitude could also be underestimated. In addition, it is likely that numerous confounding variables are present that act to obscure relationships between dietary history and caries experience.

Variability in day-to-day eating patterns makes the 24-hour dietary record potentially misleading for correlation analysis on an individual basis.[16-20] Results of these studies on the validity of 24-hour dietary recalls suggest that recall is subject to overreporting of low intakes and underreporting of high intakes, thus increasing the danger of false negative information.

An additional problem related to the 24-hour recall as an estimate of long-term dietary patterns is the measurement error caused by day-to-day variation in individual dietary patterns. This kind of error in an independent variable in a regression equation will bias the estimates of the coefficients toward zero. However, because some empirical work has provided estimates of the ratio of interindividual (true between-subject variation in usual intake) to intraindividual (day-to-day variation in individual intake) variation, estimates of the magnitude of this bias are possible.[21] Given these inherent deficiencies in the nature of the 24-hour dietary recall data together with the potential for some statistical correction of these deficiencies, it is estimated that the trends in dental caries experience related to lifetime dietary patterns, as presented in this report, are likely to be underestimated.

A further limitation to be recognized with respect to the dental data is the likely influence of what is called "the treatment effect" in the information obtained. The treatment effect means that the DMF teeth count cannot necessarily be interpreted at face value solely as a measure of caries experience; it also reflects to some extent the type of treatment available and utilized by the individuals throughout their lives. It is likely, for example, that some filled teeth (therefore counted in the F part of DMF) would not have been diagnosed as carious by the examining dentists in the NHANES I survey had they been seen before they were filled. Another way of expressing this problem is that criteria used by dental practitioners to make a decision on whether or not to fill a tooth are not the same as the criteria used by epidemiologists in determining whether a tooth is to be called sound or carious.[22, 23] The possibility must, therefore, be entertained that a person with a given DMF tooth score, of which a high percentage is accounted for by filled teeth, may really have a lower caries experience than a person with the same DMF tooth score, of which a low percent is made up of filled teeth. This problem of the treatment effect, well recognized by oral epidemiologists, can be partly estimated by the use of a measure such as the ratio F/DMF.

There is virtual certainty that some degree of measurement error has been included in a survey of this size, a problem that can be recognized but probably not controlled. The corrective procedures required to adjust the observations for the complexities of the sampling design have been mentioned previously and are discussed in detail in appendix I.

Analytic approach

This report presents results from analysis of the following specific relationships:

1. The relationship between decayed, missing, and filled (DMF) teeth and dietary intake patterns.
2. The relationship between DMF teeth and fluoride content of the dental enamel.
3. The relationship between DMF teeth and the calcium/phosphorus dietary intake ratio.
4. The relationship between DMF teeth and periodontal disease.
5. The relationship between periodontal disease and alcohol consumption, tooth-brushing frequency, and smoking history and habits.
6. The relationship between dietary patterns of adults with natural teeth and dietary patterns of those adults without natural teeth or whose teeth are indicated for extraction.
7. The relationship between dietary intake patterns and the use of artificial dentures by edentulous adults.

Almost all of these relationships are subject to profound theoretical complications. The primary variables involved are all likely to be correlated with factors such as education, race, sex, and age. Because these interrelationships make bivariate analyses of the primary relationships a potentially misleading undertaking, a multiple regression approach was considered to be more appropriate. Multiple linear regression has been the method employed because of its ability to handle many possible specifications and interactions of the variables involved, and because most of the variables employed could be considered to be continuous.

While regression is an appropriate and powerful method for analyzing these relationships, numerous uncertainties remain as they always do with real data. Inevitably, theoretically important variables in the relationships are unavailable, and in many instances are unknown. The most appropriate specification for each variable is, at best, speculative. Distributions, while almost never perfectly normal even for single variables, become vastly more complex when joint normality is considered in a multiple regression model. Unquantifiable measurement error further complicates the picture. All of these factors combine to produce uncertainty about the true magnitude of the coefficients and probability estimates.

These reservations about the method of analysis for the NHANES I data should not, however, be construed as reflecting concern over the appropriateness of the method or the validity of the conclusions. The regression model approach actually permits more certainty about the stated conclusions than would be possible with bivariate analyses. This is because the inclusion of an important covariable in an analysis model in a theoretically plausible form, even if it is not specified perfectly, is likely to lead closer to the truth than would the implied specification of that variable when it is excluded from the model.

For each relationship to be investigated, a list of potentially related variables was assembled in addition to the dependent and independent variables specified. These lists included such covariables as age, race, sex, education, and income, amongst others. The selection of these variables was based on existing knowledge and on theory and was dictated by what was available in the data base. Sometimes a required variable was not available but had to be generated from several that were available, none of which individually was precisely what was needed. For example, there is no variable called "dietary intake pattern." A conceptual definition of what this term meant had to be developed, then made operational by selecting a list of dietary and nutritional variables from those available.

The basic model used is of the following form:

$$Y_i = B_1 + B_2 X_{2i} + B_3 X_{3i} + \ldots + B_k X_{ki} + E_i.$$

In general, the models can be described as being designed to assess the average effect of the independent variable on the dependent variable, given adjustments for various theoretically important covariables. The actual specifications of the equations can be determined from the tables of the regression results (shown in tables 1-28), with reference to appendix II for units and form of each variable. Most of these regressions were run separately for each of the five age groups examined (6-11, 12-17, 18-44, 45-64, and 65-74) to allow for the likelihood that the age effect is different in some of the age groups.

The sheer bulk of data dictated the initial steps in the analyses. Because there were limitations on the number of variables from such a large sample that could be analyzed simultaneously, subsets of the selected variables were analyzed. Any that failed to demonstrate patterns of potential importance were eliminated from further consideration, while those that showed any chance of being important were subjected to more rigorous analysis.

The variables selected for initial analysis in each relationship are shown in appendix II. Some of these variables were eliminated as analysis proceeded; those that were used in the analyses described in detail in this report can be found in tables 1-28. Many relationships that were tested and found to be nonexistent have not been described in this report. Results presented have been adjusted for sampling weights and sample design using the specific methods described in appendix I.

Several aspects of the presentation of data in this report should be mentioned here. One is that the number of subjects (in statistical terms, the "*n*") was not the same in all of the areas examined. Although the full sample numbered 20,749, several of the analyses used information only collected from the detailed subsample (see "Introduction"). In others, analysis was restricted to persons with specific conditions (such as absence of teeth), and in still others, the necessary data could not be collected from many intended subjects (such as fluoride content of dental enamel). As a result, in some of the analyses the number of subjects in certain age-sex-race groups becomes too small for useful presentation.

Finally, the conclusions in this report are based principally on the results of multiple linear regression analysis. All the multiple regression tables employed in this analysis are listed in tables 1-28. Many tables shown in the text are model-based estimates, simplified to show relationships between the two variables adjusted for the effect of the covariables in the regression model. They are, for the most part, not simple bivariate tables because such a method of demonstrating relationships, as described earlier, could be misleading.

These model-based estimates, shown in tabular form to provide a simplified presentation of the results, were obtained as predicted values from the corresponding multiple regression model. In effect, they quantify the relationship between two variables, adjusting for the effects of the covariables used in the regression model. Where regression coefficients are referred to and specified in the text, therefore, they describe an estimate of the average change in the dependent variable that is associated with a unit change in the independent variable. Given the same units, the higher the value of the coefficient, the larger the change.

Highlights

The word "diet" refers to the nature of the food ingested, whereas "nutrition" refers to the absorption of nutrients. The results of this study show that clear relationships exist between certain dietary practices and cumulative dental caries experience, though no relationship could be demonstrated between the level of intake of specific nutrients and dental caries experience.

Dental caries experience, as measured by the decayed-missing-filled (DMF) teeth index, was examined in relation to the intake level of a large number of specific nutrients. These nutrients included protein, fat, carbohydrate, riboflavin, calcium, phosphorus, iron, vitamin A, niacin, thiamin, vitamin C, sodium, and potassium. Dietary factors related to the DMF index were total calories ingested from sugar-rich foods, percent of calories ingested from sugar-rich foods, percent of calories ingested from sugar-rich foods as snacks between meals, frequency of ingestion of sugar-rich foods as snacks between meals, and the frequency of ingestion of other less sugary foods as snacks between meals. A factor that could have a powerful influence on these relationships but that could not be tested for the entire sample was the fluoride content of dental enamel.

Specific findings for nutrition and oral health can be summarized as follows:

- There is no statistically significant relationship of clinical importance between DMF experience and the levels of intake of specific nutrients in the United States.
- No statistically significant relationship of clinical importance could be demonstrated between dental caries experience and the ratio of calcium to phosphorus in the diet. Similarly, no statistically significant relation of clinical importance between dental caries experience and calcium to phosphorus ratio in blood serum could be demonstrated.
- A considerably higher proportion of persons with natural teeth ingested vitamin C at levels at or above the NHANES standard than did persons without natural teeth or whose natural teeth were indicated for extraction. In some age groups, slightly higher proportions of those with natural teeth also achieved the NHANES standards for ingestion of iron and protein. Most of these differences were statistically significant.
- Among edentulous persons, there were no statistically significant differences of clinical importance in nutrient intake by whether the subjects reported eating with their dentures in place or not.

Specific findings for dietary sugar and dental caries can be summarized as follows:

- There is a direct, strong, and statistically significant relationship between DMF experience and the frequency of intake of sugary snacks between meals. Persons who report greater frequency of ingestion of sugar-rich snacks between meals tend to have higher DMF scores.
- There are direct and statistically significant relationships between DMF scores and the frequency of ingestion of less sugary snack foods between meals. While evident, this relationship is not as strong as that found between DMF scores and frequency of ingestion of sugar-rich snacks between meals.
- There are direct and statistically significant relationships between DMF scores and total calories ingested from sugar-rich foods between meals. While evident, this relationship is not as strong as that found between DMF scores and frequency of ingestion of sugar-rich snacks between meals.
- There is little evidence of a statistically significant or clinically important independent relationship between DMF experience and total caloric intake of sugar-rich foods, meaning those sugar-rich foods ingested both with and between meals.

Specific findings for enamel fluoride can be summarized as follows:

- Younger persons tend to have higher levels of fluoride in their dental enamel than do older persons.
- The fluoride content of dental enamel tends to show a statistically significant inverse relation to dental caries experience.

Specific findings for correlates of periodontal disease can be summarized as follows:

- A strong, statistically significant, inverse relationship was found between reported frequency of tooth brushing and levels of periodontal disease.
- There was no statistically significant relationship between periodontal disease experience and reported levels of alcohol consumption when the effects of age, sex, education, income, toothbrushing habits, dental visits, and smoking were taken into account.
- A clear and statistically significant relationship was found between smoking and periodontal disease. The highest levels of periodontal disease were found among present smokers, and the lowest levels were found among those who reported that they had never smoked.
- No evidence of a negative correlation between dental caries experience and periodontal disease experience could be found. There was a statistically significant but clinically unimportant positive correlation found between the experience of the two diseases among these persons who did not receive an enamel biopsy.

These highlights are discussed in more detail in the subsequent section.

Detailed results

Dental decay and dietary intake patterns

Dental and nutritional data were recorded for 20,749 persons ages 1-74 years. Analysis was restricted to the 14,375 persons ages 6-64 years for whom usable data were available. Missing data kept the numbers below that total for most of the analyses.

"Dietary intake pattern" had to be defined conceptually and operationally for analytic purposes. As described earlier in this report, "diet" refers to the nature of the food ingested. In the dental disease context, dietary influences are those that have an immediate and local effect on dental plaque and subsequently on dental or periodontal tissues. "Nutrition," on the other hand, refers to the nutrients absorbed, unrelated to the physical form of the food ingested. "Dietary intake pattern," in this area of analysis, was defined as including both dietary and nutritional variables.

Dental information came from the dental examination; dietary and nutritional data came from the 24-hour recall interview. The 24-hour data were used to determine nutritional intake values and to summarize types of food ingested in 18 different food categories, both with and between meals. Data from the 3-month food intake information were not used directly in the analyses in this report because the frequency of ingestion reported there did not differentiate between ingestion with meals and between meals. The 24-hour recall data did make this differentiation, so they were used in these analyses.

Each of a series of nutritional variables was related to decayed-missing-filled (DMF) teeth values and examined within various age, sex, and race groups, both individually and in multiple regression models. These variables are protein, fat, and carbohydrate intake as a percentage of total calories and per kilogram of body weight, vitamin A, riboflavin, thiamin, niacin, vitamin C, calcium, and iron as percentages of NHANES standards (appendix III). No meaningful relationship of any kind could be demonstrated, and hence no tabular information in this area is presented. This finding is in accordance with previous research in this area, which has generally failed to demonstrate any correlation between dental caries experience and quality of nutrition in either well-nourished or malnourished populations.[24]

In the variables related to diet, analysis was chiefly concentrated on the relationship between sugar intake and dental caries. This area of analysis was chosen as the first priority because of the bulk of evidence, epidemiological and experimental,[25] that implicates sugar in the decay process more than any other aspect of diet.

The nature of the data precluded a comprehensive or direct estimate of total sugar consumed. Frequency of consumption with meals and between meals was recorded on the 24-hour recall data, which categorized food ingested into 18 food groups (appendix II), included categories on (a) sugar and primarily sugar products, including candy and sweetened beverages, (b) desserts and sweets, including cakes, pies, and pastries, and (c) cereals and grain products. Sucrose levels were not documented for each food type and could only be inferred from the general description of the food. For example, it was assumed that the carbohydrate in the foods in the "sugar and primarily sugar products" group was predominantly sucrose. This same assumption was required, though to a lesser degree, for the latter two categories.

It is likely that the bulk of sugar consumed would be included in these three food categories, but they would not include all sugar consumed. Sugar used extensively in food processing, the so-called "hidden sugar" that occurs in products such as processed meats, ketchup, salad dressing, soups and a variety of other foods, could not be readily estimated from the NHANES data. Whether this "hidden sugar" has any important relationship with dental caries experience is unknown, and unfortunately could not be addressed in this analysis. Of course, just as the 16 "low sugar" food groups are not free of sugar, it is also recognized that the 3 "sugar-rich" food categories are not entirely made up of sugar. A further issue of interest in dentistry is that the different types of sugar consumed (sucrose, glucose, fructose, maltose, lactose, among others) could not be differentiated in the NHANES I data in the form in which they are readily available. "Sugar" is used as a generic term in this report, though the bulk of sugar consumed at the time of this survey was sucrose.

What was addressed, therefore, was the relationship between DMF values and the three major sugar-containing food groups from the 24-hour dietary recall record. This approach was considered the most appropriate in view of the constraints presented by available data. These three sugar-rich categories were tested jointly as a combined category, referred to as "sweets," generated from summing the three food groups. Similarily, the "low sugar" categories were summed to provide a new category of "nonsugary" foods.

All of the patterns discussed here are taken from the results of multiple regression analysis, which takes into account the effects of age, sex, race, and the socioeconomic variables of income and education. Consideration of age in the analyses was critical, even within each age-specific group, because both dietary practices and DMF values are strongly correlated with age.

Percent of total calories from sweets.—This specific analysis was generated by the question: What relationship exists between the relative quantity of sugar consumed and dental caries experience? As stated previously, it was not possible to quantify accurately the total amounts of sugar ingested because of the "hidden sugar" in processed foods. Analysis proceeded on the assumption that cereals and grain products, sugar and primarily sugar products, and desserts and sweets accounted for much of the sugar consumed.

The variable for percent of total caloric intake from the three high-sugar categories was generated by summing the caloric values of each category from the 24-hour recall tape and dividing this sum by the total caloric intake from the 24-hour recall (X 100). This variable was then included in a multiple regression model, along with age, sex, race, income, and education variables for the four age categories of 6-11, 12-17, 18-44, and 45-64 years. The results, shown in tables A, 1, and 2, give little evidence of a pattern. In none of the age groups do the estimated effects of total sweet consumption approach significance, and the direction of the effect is inconsistent and of little practical importance.

It can be concluded that the NHANES I data fail to suggest that the effect of total caloric consumption of sweets on dental caries experience is important. Some inherent limitations in the nature of the data analyzed, to be discussed more fully later in this section, require that this conclusion be accepted with some caution.

Percent of total calories from sweets ingested between meals.—If the percent of total caloric consumption from sugar-rich foods, both with meals and between meals, seems to be of little importance in its association with caries, the next question was: Is dental caries experience associated with the percent of total calories from sweets consumed only between meals? Existing evidence indicates that sweets consumed between meals are more damaging than those consumed with meals.[26]

The percent of total calories from consumption of the three sugar-rich food groups between meals ("sweets") was determined as before, except that the numerator was restricted to those sweets identified as consumed between meals. This variable was again included in a multiple regression model with the variables of age, sex, race, income, and education. Results in all age-groups except for the youngest, indicate a statistically significant trend in DMF values related to between-meal sweets (tables B, 3, and 4). Regression coefficients in ascending order of age group are 0.013, 0.018, 0.046, and 0.053 (table 3). These values indicate that in, for example, the 12-17-year age group, each additional percent of calories from between-meal sweet consumption is associated with, on average, DMF values that are approximately 0.02

Table A. Model-based[1] estimates of mean number of decayed, missing, and filled (DMF) permanent teeth, by calories from sugar-rich foods[2] as a percent of total calories ingested, for persons ages 6-64 years: United States, 1971-74

Calories from sweets as percent of total calories	*Mean DMF, by age group*			
	6-11 years[3]	*12-17 years*[3]	*18-44 years*[3]	*45-64 years*[3]
10	1.6	6.6	15.4	23.2
20	1.6	6.5	15.5	23.2
30	1.6	6.3	15.5	23.1
40	1.6	6.2	15.6	23.1
50	1.7	6.1	15.7	23.0
60	1.7	6.0	15.8	22.9

[1]Model described in appendix I.
[2]Variable described in detail in appendix II.
[3]Trend not significant at $\underline{p} = 0.05$.

Table B. Model-based[1] estimates of mean number of decayed, missing, and filled (DMF) permanent teeth, by calories from sugar-rich foods[2] consumed between meals as a percent of total calories ingested, for persons ages 6-64 years: United States, 1971-74

Calories from between-meal sweets as percent of total calories	*Mean DMF, by age group*			
	6-11 years[3]	*12-17 years*	*18-44 years*	*45-64 years*
0	1.5	6.0	15.1	22.7
10	1.7	6.2	15.6	23.2
20	1.8	6.4	16.0	23.8
30	1.9	6.6	16.5	24.3
40	2.0	6.8	16.9	24.8

[1]Model described in appendix I.
[2]Variable described in detail in appendix II.
[3]Trend not significant at $p = 0.05$.

higher after the effect of the other variables listed has been accounted for.

It can be concluded from these NHANES I data that total consumption of sweets between meals as recorded by the 24-hour dietary recall is related to dental caries experience, but that this effect may be of only moderate clinical importance.

Frequency of ingestion of sweets between meals.— The next step was to test the relationship between the frequency of consumption of sweets between meals and dental caries experience. Frequency of consumption of food from all categories and time of ingestion is reported in the 24-hour recall data. The between-meal frequency of sweet consumption was generated by summing the frequencies of ingestion of the same three sugar-rich food groups used in the previous analyses, but restricted to those reported to occur outside of mealtimes. As before, this variable was included in a multiple regression model with age, sex, race, income, and education.

Results (tables C, 5, and 6) show that in each age group the regression effect of frequency of consumption of between-meal sweets (the independent variable) on dental caries experience (the dependent variable) is statistically significant at a probability level of at least $p = 0.05$. In addition, the coefficients are of a magnitude that can be considered clinically important. In ascending order of age groups the coefficients are 0.098, 0.145, 0.375, and 0.446. These values indicate that in the 18-44-year age group, for example, each additional reported instance of between-meal sweet snack consumption on the 24-hour recall record is associated with DMF values that are, on average, 0.375 higher after the effects of age, sex, race, income, and education have been accounted for.

It can be concluded that the NHANES I data show that the frequency of consumption of sugar-rich foods between meals has a statistically significant relationship with dental caries experience. The strength of the trend can be considered to be of some clinical importance.

Some further aspects of these relationships were explored. It could be expected that quantity and frequency of consumption of sugary foods are related, and that indeed proved to be so. The results, shown in tables 7-10, show that these two variables are highly correlated, with correlation coefficients ranging from 0.676 in the 18-44-year age group to 0.773 in the 6-11-year age group. To determine which of the two effects (quantity consumed or frequency of consumption) is most strongly associated with DMF values, analyses with both of these variables in the model at the same time were undertaken. The results, displayed in table 11, indicate that in the 18-44-year and 45-64-year age groups between-meal frequency is considerably more important than between-meal quantity, and that the previously observed relationship of between-meal quantity to DMF values could be attributable to the high correlation between frequency and quantity. For the two younger age groups, the picture is far less clear. Neither of the variables attains statistical significance, indicating that there is not enough uncorrelated explanatory power in either of them. In the younger age groups it can thus be said that while between-meal sugar intake clearly has a strong association with DMF values, the relative importance of quantity and frequency is not clear from these data.

In the two younger age groups, 6-11 and 12-17 years, the increased DMF values associated with increased snacking frequency were due predominantly to higher values in decayed and filled teeth. In the older age groups, 18-44 and 45-64 years, the higher DMF values were largely attributable to missing teeth (tables 12-14).

The apparent relationship between caries experience and frequency of between-meal sugary snacks prompted the question about other snacks of the nonsugary kind. Could it be just snacks per se, rather than sugary snacks specifically, that are principally associated with caries? This question was tested by examining the frequency of consumption of foods in the 16 "nonsugary" groups (described earlier in this section) between meals, relative to DMF values. The answer appears to be a qualified "No." While there was an apparent, although small, association between frequency of ingestion of nonsugary snacks and caries experience in all age groups (tables D, 15, and 16),

Table C. Model-based[1] estimates of mean number of decayed, missing, and filled (DMF) permanent teeth, by stated frequency of consumption of sugar-rich foods between meals,[2] for persons ages 6-64 years: United States, 1971-74

Frequency of consumption	*Mean DMF, by age group*			
	6-11 years	*12-17 years*	*18-44 years*	*45-64 years*
0	1.5	6.0	14.9	22.5
1	1.6	6.1	15.3	23.0
2	1.7	6.3	15.7	23.4
3	1.8	6.4	16.1	23.9
4	1.9	6.6	16.4	24.3
5	2.0	6.7	16.8	24.7
6	2.1	6.8	17.2	25.2

[1]Model described in appendix I.
[2]Variable described in detail in appendix II.

Table D. Model-based[1] estimates of mean number of decayed, missing, and filled (DMF) permanent teeth, by stated frequency of consumption of non-sugar-rich foods between meals,[2] for persons ages 6-64 years: United States, 1971-74

Frequency of consumption	*Mean DMF, by age group*			
	6-11 years[3]	*12-17 years*[3]	*18-44 years*	*45-64 years*
0	1.6	6.0	15.1	22.3
1	1.6	6.1	15.2	22.6
2	1.7	6.2	15.4	22.9
3	1.7	6.4	15.6	23.2
4	1.8	6.5	15.8	23.4
5	1.8	6.6	15.9	23.7
6	1.9	6.7	16.1	24.0

[1]Model described in appendix I.
[2]Variable described in detail in appendix II.
[3]Trend not significant at $p = 0.05$.

this association is possibly due to the relatively high correlation between sugary and nonsugary snacks in all age groups (tables 7-10). Again to investigate further these relationships, analyses were run with both of these variables in the model at the same time. The results, displayed in table 17, continue to show that, on average, the association of sweet snacks with DMF teeth is stronger than the association of nonsweet snacks with DMF teeth. Whether this smaller although persistent association between nonsweet snacks and DMF teeth is attributable to the sugar that is inevitably present in many of them, or to snacks per se, is not known. Nevertheless, what have been classified as sweet snacks seem to have the larger average effect.

The inherent difficulty in the philosophical basis of relating DMF to dietary data, (discussed earlier in "Limitations of data interpretation") requires that these findings be accepted with caution. To interpret properly the results so far presented, it is important to understand the consequences of this kind of measurement problem. In reality, what the tabular data present are the relationships between *yesterday's* dietary patterns and *lifelong* caries experience. In the representation of that relationship, the magnitude of the coefficients presented should be reasonable approximations. However, in terms of the more important question, that is of the relationship of *lifetime* dietary patterns to DMF teeth, these probably represent gross underestimates, as detailed in appendix I.

Despite this difficulty, the patterns that emerged are quite distinct. It could be suggested that older persons who now have a taste for sweet snacks developed this taste in their youth, so that while the snacks themselves are now different, their basic sugar-containing quality is not. The pattern of the relationship found, with an increasingly greater magnitude with age, tends to support this suggestion of a cumulative lifelong effect. Further, the relationship between frequency of sugary snacks and dental caries experience may be strong enough to emerge in spite of the inherent deficiencies of the data. It could be concluded that while the stated quantification of the snack frequency-caries relationship should perhaps not be taken literally, the relationship itself is likely to be real.

The findings in this analysis confirm the results of previous studies on the relationship between sugar consumption and dental caries. While sugar consumption per se is probably neither a necessary nor sufficient cause of dental caries, it is at least a strong contributing cause.[26,27] The nature of the data analyzed in this report does not allow conclusions regarding cause-and-effect, but it is highly likely that the associations found between aspects of sugar consumption and dental caries experience are in fact causal. The NHANES I data are supportive of previous research and the weight of previous research, both epidemiological and experimental,[25-30] leads overwhelmingly toward such a conclusion. Considerable value of the results from the NHANES I survey lies in the fact that these findings appear to be the first obtained from a large, nationally representative sample under nonexperimental conditions.

Accordingly, it can be concluded from the data in NHANES I that the frequency of between-meal consumption of sugary snacks is an important dietary determinant of dental caries activity in the United States. Total between-meal consumption of sugary foods is also a factor, though possibly of lesser importance, and total sugary food intake per se seems to be of relatively little importance. Nutritional factors seem to be unrelated to dental caries activity among the population of the United States.

Relationship between the number of decayed, missing, and filled teeth and the enamel fluoride content of the teeth

The cariostatic effect of the fluoride ion has been extensively documented, and the use of fluoride in various forms constitutes a major part of dentistry's efforts to prevent caries.[30] While the benefits of fluoride have been well-demonstrated in experimental situations and special demonstrations,[31] it is of interest to assess the relationship between dental caries experience and exposure to fluoride in the nonexperimental situation of the NHANES I survey.

Caries experience was assessed, as before, by use of the decayed-missing-filled (DMF) index.[9] Fluoride exposure was measured by use of the enamel biopsy technique,[32] a procedure by which a few microns of surface enamel are removed by use of a special rotary instrument. The removed enamel can then be analyzed chemically for fluoride and other constituents.

Fluoride biopsies could only be carried out on 5,481 examinees ages 6-74 years, although it was intended to carry one out on all dentate subjects. Analysis is therefore restricted to this group. Because the sample is small, the sampling errors are large, and estimates must be interpreted with caution. Reasons for this reduced response rate relate to unforeseen equipment failures, refusals, and absence of suitable teeth. Difficulties in obtaining high response rates for fluoride biopsies have been reported before.[33]

The enamel fluoride concentrations from the enamel biopsies were ranked, and the distribution divided into quintiles. Each quintile therefore contained the same number of subjects. The cutoff points, in parts per million (ppm) of fluoride in the sample of enamel, were as follows:

First quintile:	0 – <682 ppm
Second quintile:	682 – <970 ppm
Third quintile:	970 – <1300 ppm
Fourth quintile:	1,300 – <1803 ppm
Fifth quintile:	1,803 and over ppm.

Tables E-H show some of the patterns of distribution of enamel fluoride concentration in white males and white females. Data for races other than white are not tabulated because of very small numbers in many cells.

In addition to the apparent trend of lower DMF values in the younger age groups with increasing concentrations of enamel fluoride, there is an interesting pattern in the distribution of the numbers of subjects within each table (tables G and H). Most young people have relatively high concentrations of fluoride, while older people have lower concentrations.

Black persons initially appeared to have higher enamel fluoride levels than white persons. However, when distributed by age group (data not shown, as mentioned previously) this tendency disappeared, because it was due to the relatively large proportion of younger black persons in the sample. The disparity in enamel fluoride concentrations among age groups seemed as apparent among black persons as among white persons. There seemed to be no age-specific differences between black persons and white persons.

More detailed multiple regression analysis confirmed the pattern seen in tables E and F. Table 18 demonstrates that higher concentrations of enamel fluoride have a strong inverse association with DMF teeth in the 6-11-year, 12-17-year, and 18-44-year age groups. The 45-64-year age group has a less pronounced coefficient for the fluoride variable, and it has failed to attain statistical significance.

The findings on enamel fluoride concentration are among the most interesting in this NHANES project and emphasize what a pity it was that the data could be obtained only from such a small sample. The question arose as to whether this subsample represented any special self-selected group, and further investigation indicated that it did. Table J shows that those who received the enamel biopsy had distinctly lower levels of both DMF experience and periodontal disease than did those who did not. A possible reason for this difference could be that the enamel biopsy was perceived by many survey subjects as an operative dental procedure, and hence tended to be accepted by more regular dental patients (assuming their oral health levels were higher) than by more irregular patients. Unfortunately the relationship between enamel fluoride levels and frequency of dental visits could not be tested because dental visit frequency was only recorded for the subsample that

Table E. Mean number of decayed, missing, and filled (DMF) permanent teeth for white males, by age and fluoride concentration of enamel

Age	Fluoride concentration					
	All levels	*First quintile*[1]	*Second quintile*	*Third quintile*	*Fourth quintile*	*Fifth quintile*
All ages, 6-74 years	11.2	15.0	13.6	11.8	9.2	6.4
6-11 years	2.2	3.0	3.9	2.0	2.7	1.6
12-17 years	5.7	8.5	5.0	7.2	6.0	4.6
18-44 years	13.1	14.5	14.1	12.5	11.3	11.0
45-64 years	18.1	18.4	17.7	18.0	19.9	16.4
65-74 years	18.4	19.2	16.8	19.2	21.1	15.4

[1]These quintiles are based on a division of all subjects for whom fluoride data are available, regardless of race.

Table F. Mean number of decayed, missing, and filled (DMF) permanent teeth for white females, by age and fluoride concentration of enamel

Age	Fluoride concentration					
	All levels	*First quintile*[1]	*Second quintile*	*Third quintile*	*Fourth quintile*	*Fifth quintile*
All ages, 6-74 years	12.0	15.4	14.5	12.1	10.1	7.4
6-11 years	2.3	2.0	2.9	2.7	2.5	1.9
12-17 years	6.6	8.7	7.6	6.1	6.5	5.9
18-44 years	13.9	15.2	15.0	13.5	13.1	11.0
45-64 years	18.6	19.5	19.6	18.2	17.9	16.4
65-74 years	19.5	20.1	19.2	19.6	20.5	12.4

[1]These quintiles are based on a division of all subjects for whom fluoride data are available, regardless of race.

Table G. Number of white males examined, by age and fluoride concentration of enamel

Age	Fluoride concentration					
	All levels	*First quintile*[1]	*Second quintile*	*Third quintile*	*Fourth quintile*	*Fifth quintile*
All ages, 6-74 years	1,714	385	328	323	335	343
6-11 years	209	8	12	26	62	101
12-17 years	390	24	50	67	114	135
18-44 years	780	236	191	161	118	74
45-64 years	228	80	51	47	30	20
65-74 years	107	37	24	22	11	13

[1]These quintiles are based on a division of all subjects for whom fluoride data are available, regardless of race.

Table H. Number of white females examined, by age and fluoride concentration of enamel

Age	Fluoride concentration					
	All levels	*First quintile*[1]	*Second quintile*	*Third quintile*	*Fourth quintile*	*Fifth quintile*
All ages, 6-74 years	2,727	647	569	566	512	433
6-11 years	237	12	18	37	70	100
12-17 years	443	46	59	97	123	118
18-44 years	1,645	461	392	349	262	181
45-64 years	247	74	63	50	33	27
65-74 years	155	54	37	33	24	7

[1]These quintiles are based on a division of all subjects for whom fluoride data are available, regardless of race.

Table J. Number of examinees (*n*), mean number of decayed, missing, and filled (DMF) permanent teeth, and periodontal index (PI) score, by age group and biopsy status for persons ages 18-74 years: United States, 1971-74

Age group	*No biopsy*			*Biopsy*		
	n	*DMF*	*PI*	*n*	*DMF*	*PI*
18-44 years	4,071	16.28	1.06	2,894	13.27	0.40
45-64 years	1,584	21.57	1.87	575	17.61	0.90
65-74 years	1,510	23.20	2.67	310	18.61	1.23

received the detailed examination. The number of subjects who therefore had both dental visit frequency and enamel fluoride levels recorded was too small for adequate testing. Whether or not the biopsied group represented more regular dental patients, it did represent those with superior levels of oral health, relative to the total sample. Conclusions reached therefore must be accepted cautiously because of the special nature of the group examined.

An additional area that could not be tested satisfactorily was the potential interaction between enamel fluoride levels and frequency of ingestion of sweet snacks. Additional theoretical and statistical development is required before this interaction can be satisfactorily tested with NHANES-type data.

Within the limitations discussed, it is concluded that younger persons have higher levels of fluoride in their dental enamel than do older persons. It is also concluded that higher levels of enamel fluoride are associated with lower DMF values, though the data do not permit the conclusion that this relationship is one of cause-and-effect. The enamel biopsy technique is exacting; experience has shown that it should be used only with upper central incisor teeth (i.e., those most accessible) if reliable results are to be obtained.[34,35] Minor variations in pressure on the rotary instrument or in time of its application can make considerable difference in the depth of the enamel removed. Because the concentration of fluoride in enamel diminishes sharply with increasing depth from the surface,[32,36] the resultant fluoride concentration determined is related to the weight of the enamel sample removed. Statistical techniques have been developed to standardize results from enamel samples of varying weights in group studies.[37]

Fluoride levels of outer enamel layers appear to be higher among children with reduced incidence of dental caries, at least as reported from clinical trial data.[33,36,38,39] The findings from NHANES data in this report seem to confirm this relationship. The relationship between *whole* enamel and DMF values is less clear,[40,41] probably because of the diminished fluoride concentration with increasing depth of enamel.

Fluoride concentration of outer layers of enamel is a result of both systemic and topical influences.[33,34,38] It cannot be determined from the NHANES survey data whether the greater concentration of enamel fluoride in younger persons relative to older persons comes from higher quantities of fluoride in the food chain, or whether it comes from greater exposure of immature enamel to topical fluorides (e.g., dentifrices) than was available to older persons at the same stage of their dental development. Certainly this subject is worthy of additional study.

Relationship between dental caries experience and the calcium/phosphorus ratio

The presence of calcium (Ca) and phosphorus (P) ions in the dental plaque, and their ratio to each other, have been shown to influence the early stages of cariogenesis.[42,43] Expressed in necessarily simplified form, the initial stages of the carious process involves, among other things, a dissolution of Ca and P ions from the outer layers of the dental enamel. If Ca and P ions are available in the adherent dental plaque, this demineralization process can be arrested and the lesion does not proceed to clinical cavitation. This knowledge has led to efforts to prevent caries development by supplementing diets with phosphates, a procedure that has proved successful with animals but disappointing in human studies.[43]

The Ca and P in the dental plaque must originate from dietary sources. This analysis was carried out to see if the Ca : P ratio in the diet was related to caries experience; the rationale was that the Ca : P ratio in the constituents of the diet may be directly related to the Ca : P ratio in the dental plaque.

The analysis was carried out on 17,854 persons ages 6-74 years for whom both caries experience and dietary information were recorded. Caries experience was recorded by the DMF index, and the Ca : P ratio was determined from the record of dietary calcium and phosphorus from the 24-hour dietary recall. In addition, the levels of serum calcium and phosphorus from the blood studies were assessed to examine their relationship to DMF.

Because of the previously observed correlation of age with both decayed, missing, and filled teeth[3] and dietary intake pattern,[5] initial scatterplots and regressions (correlations) were developed using the following five age groups: 6-11 years, 12-17 years, 18-44 years, 45-64 years, and 65-74 years. Each of the six dependent variables (dietary calcium, dietary phosphorus, dietary Ca : P ratio, serum calcium, serum phosphorus, and serum Ca : P ratio) was plotted and regressed on the DMF values, within each of these age groups.

No pattern of obvious practical importance emerged from this first look at the data. A few relationships, however, did achieve statistical significance, but the nature of these relationships was almost always negative in the age groups under 45 years, and positive in the age groups 45 years and over, even for the same nutrient. This consistent pattern resembles the underlying correlation between diet and age, and thus prompted a look at the statistically significant relationships by 1-year intervals within each age group. The previously apparent correlations between DMF values and the nutrients in question disappeared with this closer inspection. These findings support the previous speculation that the correlations observed in broader age groups are caused by the correlation of both DMF values and dietary practices with age. However, there does not appear to be any direct relationship between DMF values and any of the Ca and P variables tested in this analysis.

In addition, the Ca : P ratio in both the diet and serum was related to DMF values using the multiple regression model described previously, and again no significant relationship could be demonstrated. The levels of Ca and P in dental plaque were not determined in the NHANES I survey, so no relationship between Ca and P in the plaque and in the diet and serum could be assessed.

Although the Ca and P constituents of the dental plaque clearly originate from dietary sources, their presence in the dental plaque is most directly related to saliva, and their concentration in plaque is presumably dictated by local factors in the oral environment. Their levels in serum are presumably a function of initial intake and systemic controlling factors. It must also be recognized that the dietary and biochemical measurements of Ca and P are probably imprecise indicators of the respondents' nutritional status. The 24-hour dietary recall, as mentioned, may not measure usual intake, and serum calcium levels are essentially constant over a wide range of intakes. Given an adequate supply of these nutrients in the diet, one conclusion from this analysis is that there is no relationship between dental caries experience and the Ca : P ratio in the diet or in serum. This conclusion based on NHANES data is for a population receiving adequate amounts of the nutrients in question; it may or may not be similar for a nutritionally deprived population.

Relationship between dental caries experience and periodontal disease

The belief that dental caries experience and periodontal disease are inversely related has been expressed within some quarters in dentistry for a long time.[44] The availability of data from NHANES I provided a good opportunity to test the relationship; analysis could be carried out for 10,944 persons, ages 18-74 years, for whom both DMF values and periodontal index (PI) data were recorded. Persons under 18 years of age were not included in this analysis because periodontal disease is considered insufficiently advanced at that age to provide useful comparisons.[45]

Initial regression of DMF values on PI data seemed to indicate a relatively large and statistically significant positive association between PI scores and DMF values. As DMF values increased, apparently so did PI scores, even after age, sex, race, income, education, and between-meal sweet-eating habits have been accounted for. Table K shows these results; the trends for increased DMF values among persons with higher PI scores is evident. The regression statistics from which these data are derived are shown in table 19.

However, when the enamel fluoride variable was included in the multiple regression model (resulting in a much smaller sample size because of the relatively small group who received an enamel biopsy, described previously), the apparent positive association of DMF values and PI scores is sharply diminished. Table L, based on the regression analysis in table 20, shows no significant relationship between PI and DMF scores in the 18-44-year and 45-64-year age groups among the 3,779 persons ages 18 and over who received an enamel biopsy. Table M, the analogous table for persons who did not receive an enamel biopsy, shows slightly stronger evidence of a positive relationship between PI and DMF scores.

The reason for these findings seems likely to be found in the data shown in table J: the systematic bias that seemed to be operating in the selection of subjects who received an enamel biopsy. As shown in table J, subjects with high PI scores and high DMF teeth scores were far less likely to have a fluoride biopsy taken, and therefore the two samples (those who received an enamel biopsy and those who did

Table K. Model-based[1] estimates of mean number of decayed, missing, and filled (DMF) permanent teeth, by various periodontal index (PI) scores,[2] for three age groups: United States, 1971-74

Periodontal index	Mean DMF, by age group		
	18-44 years	45-64 years	65-74 years
0	14.55	19.76	21.04
1	14.99	20.10	21.48
2	15.44	20.45	21.93
4	16.33	21.14	22.82
6	17.22	21.83	23.71
8	*	*	24.60

[1]Model described in appendix I.
[2]Variable described in detail in appendix II.

Table L. Model-based[1] estimates of mean number of decayed, missing, and filled (DMF) permanent teeth, by various periodontal index (PI) scores,[2] for three age groups from whom enamel biopsies were taken: United States, 1971-74

Periodontal index	Mean DMF, by age group		
	18-44 years[3]	*45-64 years*[3]	*65-74 years*
0	13.28	17.52	17.81
1	13.19	17.59	18.60
2	13.10	17.66	19.39

[1]Model described in appendix I.
[2]Variable described in detail in appendix II.
[3]Trend not significant at $\underline{p} = 0.05$.

Table M. Model-based[1] estimates of mean number of decayed, missing, and filled (DMF) permanent teeth, by various periodontal index (PI) scores,[2] for three age groups from whom no enamel biopsies were taken: United States, 1971-74

Periodontal index	Mean DMF, by age group		
	18-44 years	*45-64 years*[3]	*65-74 years*
0	15.92	21.13	22.44
1	16.26	21.33	22.66
2	16.61	21.52	22.88
4	17.29	21.92	23.32
6	17.97	22.32	23.77
8	*	*	24.21

[1]Model described in appendix I.
[2]Variable described in detail in appendix II.
[3]Trend not significant at $\underline{p} = 0.05$.

not) are comprised of quite different people in terms of dental health. The results from multiple regression analysis for those who had an enamel biopsy taken (table 20) shows that in this group with less severe disease, the relationship between PI scores and DMF values is unclear. For those who did not have the enamel biopsy taken, and who tended to have more severe oral disease (table 21), the positive association is a little more evident.

It can be concluded that there is no evidence in the data from this survey to support the existence of an inverse relationship between the severity of dental caries and periodontal disease. Among persons with lower levels of oral health there is a tendency toward a direct relationship, while among those with higher levels of oral health there is little relationship of any kind. These results confirm the findings of White and Russell.[44]

Relationship between periodontal disease and alcohol consumption, tooth brushing, and smoking

Periodontal disease is considered to be predominantly a bacterial disease of local origin, though systemic factors are thought to be of some influence in the etiology of the condition.[46]

Little evidence concerning the relationship between periodontal disease and alcohol consumption is available, though there is some evidence of a relationship between tobacco smoking and periodontal disease.[47-49] The link between periodontal disease and tooth brushing has been shown many times to be strong and direct.[50] The NHANES I survey provided the chance to examine the strength of these relationships in the U.S. population.

The analyses are limited by the availability of what are considered to be relevant covariables. Data on frequency of dental visits (a relevant covariable), smoking history, and tooth brushing are available only for those individuals included in the detailed survey (see "Introduction"), thus limiting the usable sample to no more than 3,847 persons. Missing data on other variables reduces the sample further in the multiple regression analyses.

Periodontal disease experience was assessed by the periodontal index (PI) score in each subject's dental record. However, several other variables employed in the analysis were generated from the provided variables. Most important among these are overall measures of smoking and drinking activity. The object was to develop variables that would be sufficiently discriminating while at the same time to leave reasonable numbers of individuals within categories. This latter concern was accentuated by the relatively small sample from which data on smoking were available.

A new "tobacco-use" variable was developed from seven other variables related to use of tobacco (see appendix II). Tobacco use was determined for the detailed sample, persons ages 25-74 years, who completed the medical history questionnaire. The new variable of tobacco use allocated subjects into one of three following categories:

1. Never have used tobacco in quantities up to or equal to the amounts stated in the medical history questionnaire, that is, at least 100 cigarettes, 50 cigars, or 3 packages of pipe tobacco during the subject's lifetime.
2. Have used tobacco at least up to the amounts stated in the questionnaire, but do not use tobacco now.
3. Used tobacco at the time of the interview, at least up to the amount stated in the questionnaire.

The creation of an alcohol-use variable was slightly more complex in that frequency and quantity were thought to be less correlated than with smoking, hence requiring that both of these factors be captured in the summary variable. This new summary variable was developed from three other variables. The following four categories were defined:

1. Those who claimed not to have had a drink in the past (called "none" in the tables).

2. Those who claimed to drink no more than once a week *and* when they did drink had three or fewer drinks (called "little" in the tables).
3. Those who stated they drank more often than once a week but have three or fewer drinks at a time, or those who said they drink no more than once a week but have four or more drinks when they do (called "moderate" in the tables).
4. Those who claimed to drink more than once a week *and* have four or more drinks at a time (called "heavy" in the tables).

Daily tooth-brushing frequency was recorded in the medical history questionnaire for the detailed sample of persons ages 25-74 years and could therefore be used directly as an independent variable in the analysis.

Because the dependent variable (PI scores) remains the same in these tests, and because the explicit independent variables in these relationships are probably related (drinking, smoking, and tooth brushing), these three relationships have been analyzed together in a multiple regression model. The distribution of the PI scores for the subsample available is close enough to normal to warrant tests based on parametric assumptions.

In a first look at the PI scores stratified by levels of alcohol consumption, an interesting pattern emerged (table N). It can be seen that nondrinkers and heavy drinkers appear to have higher levels of periodontal disease than moderate drinkers, a pattern described as a "U-shaped" relationship. The question naturally arose as to whether or not this pattern is real or spurious. The analysis proceeded through numerous steps, ending with a multiple regression model with PI as the dependent variable, alcohol consumption as the independent variable, and assorted additional variables designed to account for education, income, sex, race, age, tooth-brushing frequency, dental visits, and smoking. Table 22 shows the result of this multiple regression analysis.

The principal detail of interest in analyzing the relationship between periodontal disease and alcohol consumption is the lack of statistical significance ($t = 1.413$) of the regression coefficient for the drinking variable shown in table 22. This suggested that the apparent relationship between alcohol consumption and periodontal disease (table N) was spurious, but it was still possible that this finding could have resulted from a nonlinear (possibly U-shaped) relationship between these two variables. To test this possibility, a reduced multiple regression model (the full model with the drinking variable omitted) was computed, the residual values saved, and these residuals assessed in terms of the drinking variable. These residuals represent the unexplained variations in the PI scores after allowance has been made for the other variables in the model. The results of this analysis of residuals are shown in table O. These results indicate that the observed U-shaped distribution in the bivariate analysis (table N) is spurious, and that when the covariables are included in the analytic model the levels of

Table N. Average and median periodontal index (PI) scores per person among persons ages 25-74 years, by drinking category,[1] with standard errors and sample sizes: United States, 1971-74

Drinking category	*Number examined*	*Mean PI*	*Median PI*	*Standard error of mean*
All categories	2,943	1.28	0.42	0.05
None	713	1.60	0.59	0.10
Little	1,176	1.12	0.38	0.06
Moderate	827	1.21	0.38	0.09
Heavy	227	1.66	0.82	0.18

[1]These categories are described in the text.

Table O. Average and median residual of periodontal index (PI) scores per person among persons ages 25-74 years, by drinking category,[1] with standard errors and sample sizes: United States, 1971-74

Drinking category	*Number examined*	*Mean residual*	*Median residual*	*Standard error of mean*
All categories	2,715	0.00	−0.33	0.05
None	650	0.05	−0.35	0.08
Little	1,098	−0.01	−0.26	0.06
Moderate	755	−0.05	−0.44	0.09
Heavy	212	0.14	−0.33	0.15

[1]These categories are described in the text.

alcohol consumption can no longer be shown to be associated with PI scores.

It can be concluded that consumption of alcohol per se is not associated directly with periodontal disease. If there is no association, then obviously there cannot be any cause-and-effect relationship hypothesized.

Turning to the relationship between reported tooth-brushing frequency and PI scores, bivariate analysis of PI by tooth-brushing frequency shows a strong association between increased tooth-brushing frequency and low PI scores. This pattern is demonstrated in tables P and Q.

This strong bivariate association demonstrated between tooth brushing and peiodontal disease persists within the multiple regression model previously described (table 22). The magnitude of the coefficient for tooth-brushing frequency in table 22 suggests that, given the implicit assumptions of the model, on average the PI score decreases measurably for each additional occurrence of daily tooth brushing, even when factors of age, race, sex, socioeconomic status, alcohol consumption, smoking habits, and pattern of dental visits are taken into account. It is further evident that tooth brushing has its effect on the PI through its effect on oral cleanliness. This effect can be seen by adding the simplified oral hygiene index (OHI-S) score as an independent variable in the multiple regression model, as shown in table 23. Tooth brushing, which was statistically significant in table 22, is not significant in table 23; instead OHI-S is highly significant. In other words, the OHI-S variable becomes the strongest explanatory variable, and R^2 in table 23 is considerably larger than in table 22. In addition the variables for education, income, one of the race variables, and dental visits, in addition to the tooth-brushing variable, are no longer statistically significant.

The explanation for these changes is that tooth brushing, race, and the socioeconomic factors associated with education, income, and dental visits combine to determine the effectiveness of an oral hygiene regimen and thus play an important indirect role in the prevalence and severity of periodontal disease. The actual effect of these variables on OHI-S can be seen in table 24, where they are all shown to strongly influence the periodontal index.

It can be concluded that the NHANES I data show a strong association between tooth brushing and periodontal disease, an association that previous evidence[50] suggests is one of cause-and-effect. The effectiveness of tooth brushing in improving oral hygiene and thus limiting periodontal disease is influenced by factors associated with the socioeconomic variables of education, income, and dental visits, as well as by race.

The strong association between levels of oral hygiene and prevalence and intensity of periodontal disease has been demonstrated many times, and a cause-and-effect relationship has also been established.[51] The results of this analysis are therefore to be expected and add further weight to the importance of oral hygiene as a preventive and controlling factor in periodontal disease. Tooth-brushing frequency is clearly directly related to levels of oral hygiene (table 24). While one is tempted to say "naturally" after that last statement, dentists know that many persons who brush their teeth do not do so very well. However, the data show that brushing per se is important, apart from any consideration of its efficiency. Dental health education programs directed at improving oral hygiene might be advised to spend more effort on inducing people to brush regularly rather than directing their energies at brushing methods.

The relationship between smoking and periodontal index scores was tested for the 2,948 subjects ages 25-74 years for whom both types of data were available. In this group, the mean PI score is 1.28. Bivariate analysis of PI by smoking category suggests an increased score with reported smoking as shown in tables R and S. The pattern evident in these bivariate tables is maintained remarkably well in the multiple regression model (table 22). This table shows that smokers, on average, have noticeably higher PI scores

Table P. Average and median periodontal index (PI) scores per person among persons ages 25-74 years, by tooth-brushing frequency, with standard errors and sample sizes: United States, 1971-74

Daily tooth-brushing frequency	*Number examined*	*Mean PI*	*Median PI*	*Standard error of mean*
All frequencies	2,903	1.27	0.41	0.05
Zero	152	3.54	4.05	0.32
One	1,180	1.40	0.57	0.06
Two	1,294	1.05	0.32	0.06
Three	237	0.99	0.31	0.10
Four	28	0.89	0.20	0.04
Five	10	0.19	0.08	0.13
Six	2	0.00	0.00	0.00

Table Q. Percent of persons ages 25-74 years with periodontal index (PI) scores of zero and greater than zero, by tooth-brushing frequency: United States, 1971-74

Daily tooth-brushing frequency	Number examined	PI score	
		Percent = zero	Percent > zero
All frequencies	2,903	48.0	52.0
Zero	152	17.4	82.6
One	1,180	42.8	57.2
Two	1,294	53.3	46.7
Three	237	52.3	47.7
Four	28	60.6	39.4
Five	10	85.7	14.3
Six	2	100.0	0.0

than do nonsmokers, even after age, race, sex, socioeconomic factors, dental visits, and tooth-brushing habits have been taken into account. This difference is highly statistically significant. While conclusions on causal relationships, as stated, cannot be made with NHANES data, previous evidence suggests that such a relationship exists.[47-49]

The finding that smoking has an adverse association with the development of periodontal disease is strengthened by examining the patterns of those who have smoked in the past but do not do so now. The multiple regression analysis in table 22 shows that those who have quit smoking have slightly higher PI scores than do those who have never smoked, though this difference is not statistically significant.

It could be suggested that interactions might exist between smoking, alcohol consumption, and tooth-brushing habits. Such interactions were explored, but none could be demonstrated with these data from NHANES I.

Smoking is a health hazard and is adversely related to a number of life-threatening diseases. The results of this analysis suggest that periodontal disease can be added to the list of diseases linked to smoking. Additional experimental research may identify the potential etiological role of smoking in periodontal disease.

Table S. Percent of persons ages 25-74 years with periodontal index (PI) scores of zero and greater than zero, by smoking history: United States, 1971-74

Smoking history	Number examined	PI score	
		Percent = zero	Percent > zero
All histories	2,948	48.0	52.0
Never	1,104	55.2	44.8
Past	516	53.0	47.0
Now	1,328	40.5	59.5

Relationship between dietary intake patterns of adults with natural teeth and those of adults without natural teeth or whose remaining teeth are indicated for extraction

There is little firm evidence to show that loss of teeth has deleterious effects on general health, though some potential effects have been identified.[52] One aspect that has received little study is the relationship between dietary and nutritional intake and loss (or imminent loss) of teeth. This was examined for the 13,479 persons ages 18-74 years for whom data were available.

"Dietary intake pattern" was defined earlier in this report to test the relationship between DMF values and the intake of sugar-rich foods. In this analysis, the term is interpreted as the intake of specific nutrients—protein, calcium, iron, vitamin A, and vitamin C—as well as total calories. NHANES standards for intake of these nutrients in males and females of different ages have been defined (appendix III), so that intake of these nutrients could be determined in the following two ways:

1. The mean and median percent of NHANES standard achieved for each nutrient, for each age and race group for males and females.
2. The percent of persons at or above the NHANES standard of intake for each nutrient, for each age and race group for males and females.

A new variable for presence of teeth had to be developed from information given. This variable was

Table R. Average and median periodontal index (PI) scores per person among persons ages 25-74 years, by smoking history, with standard errors and sample sizes: United States, 1971-74

Smoking history	Number examined	Mean PI	Median PI	Standard error of mean
All subjects	2,948	1.28	0.42	0.05
Never	1,104	1.01	0.31	0.07
Past	516	1.10	0.34	0.08
Now	1,328	1.55	0.68	0.08

created by subtracting the teeth diagnosed as requiring extraction, for any reason, from the number of teeth present. This new count was then converted to a two-level variable, with the first level indicating some sound natural teeth remaining and the second level indicating all teeth missing or indicated for extraction.

Tables T and U show the mean and median intake of the five nutrients and total calories, expressed as percents of NHANES standards for white males and white females. Tables W and Y present the same data for black males and black females. These data hint at favoring those with some natural teeth in the attainment of NHANES standards, though the pattern is not clear-cut. Another way of looking at the trends is shown in tables Z-CC, which present the proportion of black and white males and females who attain or exceed the NHANES standards for the nutrients under study. These tables are similar to others presented in a previous report[5] and contain data of a similar magnitude. Patterns in tables Z-CC are essentially the same as in tables T-Y. The trends shown in tables T-CC are, however, difficult to quantify and interpret. Therefore multiple regression models were again employed, using the measures of NHANES standards for nutrient intake in turn as dependent variables. The independent variable of primary concern was the previously described dichotomous variable of presence or absence of teeth. To ensure that the effects of age were allowed for, age was included as a covariable in these analyses for the 18-44 year, 45-64 year, and 65-74 year age groups separately.

The instances when dental status was related to specific nutrients to a statistically significant degree are shown in tables 25-27. The coefficient in all five models is negative, indicating that a lower proportion of edentulous persons tended to attain NHANES nutritional standards than did dentate persons. The clearest and most consistent pattern is seen with differences in the intake of vitamin C. In all three age groups (table 25) the coefficient is of remarkably similar magnitude, and in all age groups the difference in attainment of vitamin C standards between edentulous and dentate groups attains a high level of statistical significance. The regression coefficients in table 26, relating to protein, and table 27, relating to iron, are smaller. No statistically significant differences were detected between dentate and edentulous persons with respect to total calories, calcium, and vitamin A.

The difference in intake of vitamin C between the dentate and the edentulous is intriguing. Some would suggest that the difference may be a causal relationship, that is that reduced vitamin C intake leads to tooth loss. While such a relationship is theoretically possible through the effect of insufficient vitamin C

Table T. Mean and median percent of NHANES standards for selected dietary components, by dental status for white males ages 18-74 years, with standard errors: United States, 1971-74

Nutrient	Some natural teeth			Edentulous or indicated for extraction		
	Mean	*Median*	*Standard error*	*Mean*	*Median*	*Standard error*
18-44 years	Number examined = 1,765			Number examined = 97		
Calories	93.2	88	1.3	96.2	96	5.0
Protein	142.0	130	2.0	140.3	129	8.0
Calcium	259.9	216	6.7	280.5	175	28.3
Iron	158.8	147	2.4	172.3	167	10.2
Vitamin A	153.9	109	5.9	170.8	93	40.4
Vitamin C	163.1	113	5.8	119.6	80	13.8
45-64 years	Number examined = 804			Number examined = 325		
Calories	83.7	79	1.4	83.0	80	2.8
Protein	124.4	114	3.1	112.8	107	4.0
Calcium	212.5	179	6.4	197.7	170	12.7
Iron	146.9	137	2.8	136.1	125	4.4
Vitamin A	153.6	109	6.8	159.6	91	22.6
Vitamin C	159.3	128	6.5	124.7	72	8.5
65-74 years	Number examined = 626			Number examined = 717		
Calories	77.1	72	1.5	72.7	69	1.8
Protein	104.5	97	2.1	97.0	91	2.6
Calcium	188.6	164	6.0	178.6	148	6.3
Iron	128.6	116	2.9	116.8	111	3.0
Vitamin A	177.7	109	12.4	136.8	88	9.0
Vitamin C	169.3	144	6.5	130.5	86	8.0

Table U. Mean and median percent of NHANES standards for selected dietary components, by dental status for white females ages 18-74 years, with standard errors: United States, 1971-74

Nutrient	Some natural teeth			Edentulous or indicated for extraction		
	Mean	*Median*	*Standard error*	*Mean*	*Median*	*Standard error*
18-44 years	Number examined = 3,763			Number examined = 247		
Calories	80.3	76	1.0	75.0	72	2.0
Protein	106.3	97	1.6	93.7	88	3.6
Calcium	113.6	95	2.3	101.6	82	5.3
Iron	58.5	53	0.7	51.9	49	1.6
Vitamin A	118.9	76	3.2	94.0	65	7.4
Vitamin C	150.0	100	3.6	119.5	74	11.3
45-64 years	Number examined = 889			Number examined = 361		
Calories	83.0	80	1.4	83.0	77	2.0
Protein	107.6	97	1.6	102.5	93	3.1
Calcium	101.4	86	0.9	100.6	83	4.8
Iron	77.3	68	1.5	82.9	76	3.3
Vitamin A	160.6	88	1.7	169.5	73	38.6
Vitamin C	171.6	139	1.6	146.9	114	9.8
65-74 years	Number examined = 724			Number examined = 766		
Calories	79.6	77	1.3	75.8	72	1.5
Protein	95.6	90	2.1	87.0	79	2.1
Calcium	100.2	87	2.4	93.2	80	2.7
Iron	97.8	90	2.3	90.4	79	1.9
Vitamin A	145.8	87	14.2	154.3	83	16.6
Vitamin C	180.7	159	6.1	147.3	121	6.1

Table W. Mean and median percent of NHANES standards for selected dietary components, by dental status for black males ages 18-74 years, with standard errors: United States, 1971-74

Nutrient	Some natural teeth			Edentulous or indicated for extraction		
	Mean	*Median*	*Standard error*	*Mean*	*Median*	*Standard error*
18-44 years	Number examined = 322			Number examined = 15		
Calories	87.8	80	2.5	63.5	69	7.9
Protein	131.1	121	4.8	191.2	98	14.3
Calcium	181.6	156	10.7	161.8	136	48.2
Iron	143.6	136	5.3	101.5	105	14.1
Vitamin A	156.3	84	13.6	102.4	102	27.4
Vitamin C	150.6	80	15.9	58.6	19	13.2
45-64 years	Number examined = 176			Number examined = 39		
Calories	71.2	68	2.7	78.3	62	13.2
Protein	113.3	101	7.6	111.9	88	16.3
Calcium	144.3	120	11.6	181.6	117	48.4
Iron	125.1	115	6.4	148.0	103	31.0
Vitamin A	186.0	92	21.9	169.4	82	37.1
Vitamin C	157.5	101	20.7	149.4	90	42.7
65-74 years	Number examined = 153			Number examined = 140		
Calories	61.0	57	2.3	70.0	64	4.8
Protein	84.7	78	5.1	88.1	83	5.1
Calcium	134.7	116	10.5	138.6	123	8.7
Iron	104.6	89	8.9	110.7	93	13.7
Vitamin A	179.4	98	48.5	155.0	80	38.8
Vitamin C	127.2	110	14.8	149.0	96	24.7

Table Y. Mean and median percent of NHANES standards for selected dietary components, by dental status for black females ages 18-74 years, with standard errors: United States, 1971-74

Nutrient	*Some natural teeth*			*Edentulous or indicated for extraction*		
	Mean	*Median*	*Standard error*	*Mean*	*Median*	*Standard error*
18-44 years	Number examined = 923			Number examined = 70		
Calories	75.2	71	1.6	75.1	64	7.9
Protein	95.4	83	2.0	99.4	91	12.3
Calcium	77.9	67	2.5	67.8	49	7.7
Iron	53.6	47	1.4	51.3	46	6.5
Vitamin A	119.1	67	9.9	97.8	49	25.0
Vitamin C	146.6	93	6.6	67.0	28	12.6
45-64 years	Number examined = 169			Number examined = 75		
Calories	68.6	62	2.7	72.4	69	3.8
Protein	89.0	75	7.3	83.5	75	5.3
Calcium	66.7	54	4.8	79.6	63	7.6
Iron	61.6	52	3.3	63.8	63	4.7
Vitamin A	144.0	62	23.4	157.0	92	24.1
Vitamin C	122.8	85	13.8	176.4	162	23.2
65-74 years	Number examined = 119			Number examined = 194		
Calories	73.4	68	5.6	69.7	66	3.8
Protein	95.8	84	9.8	80.5	72	6.1
Calcium	76.9	78	5.8	76.4	62	3.5
Iron	89.3	76	6.9	76.4	70	3.6
Vitamin A	149.0	67	19.9	153.9	78	14.0
Vitamin C	186.6	116	43.4	127.2	92	14.9

Table Z. Percent of white males ages 18-74 years at or above the recommended levels for various nutrients, by dental status: United States, 1971-74

Nutrient	*Some natural teeth*		*Edentulous or indicated for extraction*	
	Percent	*Standard error*	*Percent*	*Standard error*
18-44 years	Number examined = 1,765		Number examined = 97	
Calories	35.9	1.8	46.0	7.4
Protein	73.6	1.1	68.7	5.2
Calcium	83.7	1.1	80.5	5.3
Iron	81.2	1.0	83.2	4.8
Vitamin A	55.6	1.6	47.1	6.8
Vitamin C	53.9	2.1	40.0	6.9
45-64 years	Number examined = 804		Number examined = 325	
Calories	24.5	1.8	26.2	3.7
Protein	66.5	2.8	57.3	3.0
Calcium	80.7	1.6	72.4	3.4
Iron	79.9	2.0	67.5	3.4
Vitamin A	54.6	2.3	46.5	2.4
Vitamin C	58.0	2.1	41.2	3.4
65-74 years	Number examined = 626		Number examined = 717	
Calories	14.8	1.4	13.5	1.6
Protein	46.9	2.7	40.8	3.0
Calcium	75.5	2.1	74.4	2.6
Iron	67.1	2.1	59.1	2.2
Vitamin A	53.3	2.2	44.6	2.8
Vitamin C	63.9	2.4	47.0	2.4

Table AA. Percent of white females ages 18-74 years at or above the recommended levels for various nutrients, by dental status: United States, 1971-74

Nutrient	Some natural teeth		Edentulous or indicated for extraction	
	Percent	Standard error	Percent	Standard error
18-44 years	Number examined = 3,763		Number examined = 247	
Calories	23.2	1.0	18.9	2.9
Protein	48.0	1.3	37.0	3.8
Calcium	47.5	1.3	40.1	3.6
Iron	7.7	0.6	3.1	1.1
Vitamin A	37.2	1.3	33.2	3.8
Vitamin C	50.2	1.0	38.4	4.1
45-64 years	Number examined = 889		Number examined = 361	
Calories	26.4	1.9	26.5	3.0
Protein	47.9	2.1	43.5	3.1
Calcium	41.5	1.9	37.2	3.4
Iron	22.7	1.9	30.5	3.3
Vitamin A	43.9	2.1	39.2	3.1
Vitamin C	59.6	2.2	53.3	3.8
65-74 years	Number examined = 724		Number examined = 766	
Calories	19.9	1.9	15.8	1.8
Protein	41.4	2.9	27.8	2.2
Calcium	42.3	2.5	37.0	2.4
Iron	39.8	2.6	31.7	1.8
Vitamin A	43.7	2.8	42.6	2.3
Vitamin C	67.1	2.5	55.1	2.3

Table BB. Percent of black males ages 18-74 years at or above the recommended levels for various nutrients, by dental status: United States, 1971-74

Nutrient	Some natural teeth		Edentulous or indicated for extraction	
	Percent	Standard error	Percent	Standard error
18-44 years	Number examined = 322		Number examined = 15	
Calories	29.1	2.6	4.7	4.8
Protein	64.6	3.8	48.6	19.4
Calcium	69.8	3.8	64.2	15.6
Iron	67.1	2.9	52.2	19.0
Vitamin A	43.6	3.5	52.7	18.8
Vitamin C	42.7	3.2	24.8	9.2
45-64 years	Number examined = 176		Number examined = 39	
Calories	9.8	2.6	28.4	13.8
Protein	50.2	5.4	46.9	12.2
Calcium	57.0	5.6	58.1	10.9
Iron	61.0	6.3	59.8	9.8
Vitamin A	49.2	6.2	38.0	9.1
Vitamin C	51.6	5.5	47.2	7.8
65-74 years	Number examined = 153		Number examined = 140	
Calories	5.6	2.5	9.1	4.8
Protein	26.6	5.7	30.8	6.2
Calcium	53.6	6.0	64.2	6.4
Iron	38.0	4.9	44.0	6.3
Vitamin A	47.7	5.0	33.9	5.0
Vitamin C	50.2	7.0	50.0	6.6

Table CC. Percent of black females ages 18-74 years at or above the recommended levels for various nutrients, by dental status: United States, 1971-74

Nutrient	Some natural teeth		Edentulous or indicated for extraction	
	Percent	Standard error	Percent	Standard error
18-44 years	Number examined = 923		Number examined = 70	
Calories	19.7	1.7	25.2	9.6
Protein	39.4	2.0	50.0	8.5
Calcium	26.8	2.3	23.5	6.9
Iron	5.9	1.2	3.2	2.2
Vitamin A	32.5	2.6	19.8	5.7
Vitamin C	47.6	1.9	22.3	4.8
45-64 years	Number examined = 169		Number examined = 75	
Calories	14.2	3.4	14.4	5.5
Protein	26.3	5.6	28.9	6.6
Calcium	20.0	3.8	26.5	6.3
Iron	14.1	3.7	13.0	5.6
Vitamin A	36.8	4.9	46.3	8.8
Vitamin C	47.0	7.2	69.6	7.4
65-74 years	Number examined = 119		Number examined = 194	
Calories	16.0	6.6	17.5	3.8
Protein	33.1	6.1	26.6	6.5
Calcium	29.1	6.8	29.7	3.3
Iron	29.7	6.2	23.1	4.3
Vitamin A	44.6	6.8	41.6	4.5
Vitamin C	54.4	6.8	44.4	5.5

on periodontal tissue, it seems unlikely to be occurring in this instance. Tables T-CC show that there is hardly an insufficiency of vitamin C (at least in relation to NHANES standards). Although there are differences between the groups, even those with the lowest levels of intake are still relatively well-off.

A more plausible explanation is that loss of teeth is likely to influence dietary choices. It is reasonable to assume that persons with dentures or nonfunctional natural teeth find mastication of fibrous foods such as fruits and vegetables more difficult than do persons with healthy natural teeth, and that therefore they tend to avoid such foods. This explanation is strengthened by the results of analysis of reported ingestion of fruit by dentate and edentulous persons. The record of fruit ingestion was taken from the food frequency interview. Results show that edentulous persons consume less fruit than do dentate persons (table 28).

This analysis suggests that total tooth loss might result in a diminution of vitamin C intake because of the resulting change in dietary habits. Ingestion of protein and iron may be similarly affected to a lesser extent.

Relationship between dietary intake patterns and use of artificial dentures for eating by edentulous adults

This analysis investigated whether, among the edentulous, there were nutritional differences according to whether dentures were worn for eating or not. There were 3,046 edentulous persons examined in three age groups, 18-44 years, 45-64 years, and 65-74 years. They were categorized as (a) those who do not wear a denture while eating, (b) those who wear one denture, and (c) those who wear both upper and lower dentures. Nutrients examined were the same as before, that is, total calories, protein, calcium, iron, and vitamins A and C.

Bivariate analysis and multiple regression analysis, the latter including age, sex, race, education, and income as covariables, were carried out. No consistent trends were apparent in the bivariate analysis, and no differences among the three groups were found in the multiple regression analysis. Thus tabular results are not presented.

It was concluded that nutritional intake among edentulous persons is not associated with wearing dentures for eating.

References

[1] Institute of Medicine: *Public Policy Options for Better Dental Health*. Washington. National Academy Press, Dec. 1980.

[2] National Center for Health Statistics: Plan and operation of the Health and Nutrition Examination Survey, United States, 1971-1973, by H. Miller. *Vital and Health Statistics.* Series 1-Nos. 10a and 10b. DHEW Pub. No. (HSM) 73-1310. Health Services and Mental Health Administration. Washington. U.S. Government Printing Office, Feb. 1973.

[3] National Center for Health Statistics: Basic data on dental examination findings of persons 1-74 years, United States, 1971-1974, by J. E. Kelly and C. R. Harvey. *Vital and Health Statistics.* Series 11-No. 214. DHEW Pub. No. (PHS) 79-1662. Public Health Service. Washington. U.S. Government Printing Office, May 1979.

[4] National Center for Health Statistics: Decayed, missing, and filled teeth among persons 1-74 years, United States, by C. R. Harvey and J. E. Kelly. *Vital and Health Statistics.* Series 11-No. 223. DHHS Pub. No. (PHS) 81-1673. Public Health Service. Washington. U.S. Government Printing Office, Aug. 1981.

[5] National Center for Health Statistics: Dietary intake findings, United States, 1971-1974, by S. Abraham et al. *Vital and Health Statistics.* Series 11-No. 202. DHEW Pub. No. (HRA) 77-1647. Health Resources Administration. Washington. U.S. Government Printing Office, July 1977.

[6] National Center for Health Statistics: Caloric and selected nutrient values for persons 1-74 years of age, United States, 1971-1974, by S. Abraham et al. *Vital and Health Statistics.* Series 11-No. 209. DHEW Pub. No. (PHS) 79-1657. Public Health Service. Washington. U.S. Government Printing Office, June 1979.

[7] National Center for Health Statistics: Food consumption profiles of white and black persons ages 1-74 years, United States, 1971-1974, by C. M. Dresser et al. *Vital and Health Statistics.* Series 11-No. 210. DHEW Pub. No. (PHS) 79-1658. Public Health Service. Washington. U.S. Government Printing Office, May 1979.

[8] National Center for Health Statistics: *Dietary Intake Source Data, United States 1971-1974.* DHEW Pub. No. (PHS) 79-1221. Public Health Service. Washington. U.S. Government Printing Office, Sept. 1979.

[9] Klein, H. et al.: Studies on dental caries: I. Dental status and dental needs of elementary school children. *Pub. Health Rep.* 53(9): May 13, 1938.

[10] Russell, A. L.: A system of scoring for prevalence surveys of periodontal disease. *J. Dent. Res.* 35(6): June 1956.

[11] Greene, J. C., and Vermillion, J. C.: The simplified oral hygiene index. *J. Am. Dent. Assoc.* 68(1): Jan. 1964.

[12] Youland, D. M., and Engle, A.: Dietary data methodology in HANES. *J. Am. Diet. Assoc.* 68(1): Jan. 1976.

[13] Center for Disease Control: *Ten-State Nutrition Survey in the United States, 1968-1970.* Vol. V, Dietary. DHEW Pub. No. (HSM) 72-8133. Health Services and Mental Health Administration. Atlanta. U.S. Government Printing Office, 1972.

[14] Tulane Dietant: Listing of Dietant Identification Data and Food Values per 100 Gram Edible Portion. Unpublished computer printout. New Orleans. Nutrition Section, BioMedical Computing System, Tulane University, 1969.

[15] Watt, B. K., and Merrill, A. L.: *Composition of Foods–Raw, Processed, Prepared.* Agriculture Handbook No. 8 (rev.). Washington. U.S. Department of Agriculture, 1963.

[16] U.S. Department of Agriculture: Methodology of large-scale surveys of household and individual diets, by M. C. Burk and E. M. Pao. Washington. Agricultural Research Service, Home Economics Research Report No. 40, 1976.

[17] Garn, S. M. et al.: The problem with one-day dietary intakes. *Ecol. Food Nutr.* 5: 1976.

[18] Gersovitz, M. et al.: Validity of the 24-hour dietary recall and seven-day record for group comparisons. *J. Am. Diet. Assoc.* 73(1): July 1978.

[19] Greger, J. L., and Entyre, G. M.: Validity of 24-hour dietary recalls by adolescent females. *Am. J. Public Health.* 68(1): Jan. 1978.

[20] Hankin, J. H. et al.: Assessment of a short dietary method for a prospective study on cancer. *Am. J. Clin. Nutr.* 31(2): Feb. 1978.

[21] Beaton, G. H. et al.: Sources of variance in 24-hour dietary recall data: Implications for nutrition study design and interpretation. *Am. J. Clin. Nutr.* 32(6): Dec. 1979.

[22] Moller, I. J.: Impact of oral diseases across cultures. *Int. Dent. J.* 28(3): Sept. 1978.

[23] Pickles, T. H.: The relationship of caries prevalence data and diagnosed treatment needs in a child population. *Med. Care.* 8(6): Nov.-Dec. 1970.

[24] Russell, A. L.: The epidemiology of dental caries and periodontal diseases, in W. O. Young and D. F. Striffler, eds., *The Dentist, His Practice, and His Community.* 2d ed. Philadelphia. Saunders, 1969. pp. 73-86.

[25] Finn, S. B., and Glass, R. B.: Sugar and dental decay. *World Rev. Nutr. Diet.* 22(2): 1975.

[26]Gustafsson, B. E. et al.: The Vipeholm dental caries study. The effect of different levels of carbohydrate intake on caries activity in 436 individuals observed for five years. *Acta. Odontal. Scand.* 11(3-4): 1954.

[27]Russell, A. L.: Carbohydrates as a causative factor in dental caries: Epidemiological evidence, in H. L. Sipple and K. W. McNutt, eds., *Sugars in Nutrition*. New York. Academic Press, 1974. pp. 635-644.

[28]Makinen, K. K.: Sugars and the formation of dental plaque, in H. L. Sipple and K. W. McNutt, eds., *Sugars in Nutrition*. New York. Academic Press, 1974. pp. 645-687.

[29]Bibby, B. G.: Dental caries. *Caries Res.* 12 (Suppl. 1): 1978.

[30]Mandel, I. D.: Dental caries. *Am. Sci.* 67(6): Nov.-Dec. 1979.

[31]Heifetz, S. B., and Horowitz, H. S.: Fluorides and sealants for the prevention of dental caries. *Fam. Community Health.* 3(3): Nov. 1980.

[32]Brudevold, F. et al.: An enamel biopsy method for determination of fluoride in human teeth. *Arch. Oral Biol.* 13(8): Aug. 1968.

[33]DePaola, P. F. et al.: Effect of high-concentration ammonium and sodium fluoride rinses in dental caries in schoolchildren. *Community Dent. Oral Epidemiol.* 5(1): Jan. 1977.

[34]Aasenden, R. et al.: An *in vivo* study on enamel fluoride in children living in a fluoridated area. *Arch. Oral Biol.* 16(12): Dec. 1971.

[35]Aasenden, R., and Moreno, E. C.: Evaluation of biopsy data in human enamel fluoride studies. *Arch. Oral Biol.* 16(12): Dec. 1971.

[36]Aasenden, R. et al.: Effect of daily rinsing and ingestion of fluoride solutions upon dental caries and enamel fluoride. *Arch. Oral Biol.* 17(12): Dec. 1971.

[37]Bookstein, F. et al.: Regression-based techniques for estimating fluoride in surface enamel in large study groups. *J. Dent. Res.* 55(1): Jan.-Feb. 1976.

[38]DePaola, P. F., and Mellberg, J. R.: Caries experience and fluoride uptake in children receiving semiannual prophylaxes with an acidulated phosphate fluoride paste. *Am. Dent. A. J.* 87(1): July 1973.

[39]Mellberg, J. R. et al.: Fluoride uptake and caries inhibition from self-application of an acidulated phosphate fluoride prophylaxis paste. *Caries Res.* 8(1): 1974.

[40]Curzon, M. E. J., and Losee, F. L.: Dental caries and trace element composition of whole human enamel: Eastern United States. *Am. Dent. A. J.* 94(6): June 1977.

[41]Curzon, M. E. J., and Losee, F. L.: Dental caries and trace element composition of whole human enamel: Western United States. *Am. Dent. A. J.* 96(5): May 1978.

[42]Newbrun, E.: *Cariology*. Baltimore. Williams and Wilkins, 1978. p. 91.

[43]Nizel, A. E., and Harris, R. S.: The effects of phosphates on experimental dental caries: A literature review. *J. Dent. Res.* 43(6): Nov.-Dec. 1964.

[44]White, C. L., and Russell, A. L.: Some relations between dental caries experience and active periodontal disease in two thousand adults. *NY. J. Dent.* 32(6): June-July 1962.

[45]National Center for Health Statistics: Periodontal disease among youths 12-17 years, United States, by M. J. Sanchez. *Vital and Health Statistics.* Series 11-No. 141. DHEW Pub. No. (HRA) 74-1623. Health Resources Administration. Washington. U.S. Government Printing Office, June 1974.

[46]Ranney, R. R.: Pathogenesis of periodontal disease, in *International Conference on Research in the Biology of Periodontal Disease*. Chicago. University of Illinois, College of Dentistry, 1977. p. 223.

[47]Alexander, A. G.: The relationship between tobacco smoking, calculus, and plaque accumulation and gingivitis. *Dent. Health.* 9(1): Jan.-Mar. 1970.

[48]Sheiham, A.: Periodontal disease and oral cleanliness in tobacco smokers. *J. Periodontol.* 42(5): May 1971.

[49]Summers, C. J., and Oberman, A.: Association of oral disease with 12 selected variables. I. Periodontal disease. *J. Dent. Res.* 47(3): May-June 1968.

[50]Sheiham, A.: Prevention and control of periodontal disease, in *International Conference on Research in the Biology of Periodontal Disease.* Chicago. University of Illinois, College of Dentistry, 1977. p. 309.

[51]Loe, H. et al.: Experimental gingivitis in man. *J. Periodontol.* 36(3): May-June 1965.

[52]Young, W. O.: Dentistry looks toward the twenty-first century, in W. E. Brown, ed., *Oral Health, Dentistry, and the American Public.* Norman. University of Oklahoma Press, 1974. pp. 3-49.

[53]National Center for Health Statistics: A study of the effect of renumeration upon response in the Health and Nutrition Examination Survey, United States, by E. E. Bryant, M. G. Kovar, and H. Miller. *Vital and Health Statistics.* Series 2-No. 67. DHEW Pub. No. (HRA) 76-1341. Health Resources Administration. Washington. U.S. Government Printing Office, Oct. 1975.

[54]Lepkowski, J. M.: Design Effects for Multivariate Categorical Interactions. Doctoral thesis, University of Michigan, 1980.

[55]Survey Research Center Computer Support Group: OSIRIS IV User's Manual. University of Michigan, Institute for Social Research, 1979.

[56]Vinter, S. T.: Survey sampling errors with OSIRIS IV. Paper presented at the COMPSTAT conference, Aug. 1980.

[57]Kmenta, J.: *Elements of Econometrics*. New York. Macmillan Publishing Co., Inc., 1971.

[58]Holt, D. et al.: Regression analysis of data from complex surveys. *J. R. Stat. Soc. A.* 143(4): 1980. pp. 474-487.

[59]Snedecor, G. W., and Cochran, W. G.: *Statistical Methods*. 6th ed. Ames. The Iowa State University Press, 1967.

[60]Beaton, G. H. et al.: Sources of variance in 24-hour dietary recall data: Implications for nutrition study design and interpretation. *Am. J. Clin. Nutr.* 32(6): Dec. 1979.

List of detailed tables

Table 1. Effect of percent of calories from sweets on the number of decayed, missing, and filled (DMF) permanent teeth controlling for specified variables, by age for persons ages 6-64 years: United States, 1971-74

Age and variable	Regression analysis statistics					
	Regression coefficient (B)	Sigma (B)	t-statistic	Standardized coefficient (Beta)	Sigma (Beta)	Partial r
6-11 years[1] $R^2 = 0.239$						
Independent variable:						
Percent of calories from sweets	0.004	0.004	0.960	0.024	0.026	0.028
Covariables:						
Education:						
High school indicator	–0.198	0.127	1.556	–0.050	0.031	–0.041
College indicator	–0.439	0.167	2.630	–0.096	0.035	–0.074
Total family income	0.001	0.010	0.090	0.003	0.030	0.003
Age at interview	0.556	0.033	16.877	0.480	0.025	0.480
Sex indicator	0.114	0.095	1.208	0.029	0.024	0.033
Race:						
Black indicator	0.016	0.142	0.114	0.003	0.025	0.003
Other indicator	0.406	0.520	0.782	0.016	0.018	0.018
12-17 years[2] $R^2 = 0.142$						
Independent variable:						
Percent of calories from sweets	–0.012	0.007	1.650	–0.039	0.023	–0.042
Covariables:						
Education:						
High school indicator	0.168	0.277	0.605	0.018	0.029	0.015
College indicator	–0.489	0.388	1.262	–0.044	0.035	–0.033
Total family income	–0.000	0.020	0.015	–0.000	0.028	–0.000
Age at interview	0.968	0.061	15.778	0.348	0.022	0.351
Sex indicator	1.100	0.288	3.818	0.117	0.030	0.125
Race:						
Black indicator	–0.548	0.533	1.027	–0.040	0.039	–0.041
Other indicator	–0.116	2.266	0.051	–0.002	0.035	–0.002
18-44 years[3] $R^2 = 0.281$						
Independent variable:						
Percent of calories from sweets	0.008	0.007	1.040	0.015	0.014	0.018
Covariables:						
Education:						
High school indicator	1.604	0.571	2.809	0.101	0.036	0.075
College indicator	0.577	0.533	1.007	0.034	0.033	0.024
Total family income	–0.018	0.017	1.092	–0.015	0.014	–0.016
Age at interview	0.510	0.014	37.432	0.504	0.013	0.502
Sex indicator	1.172	0.224	5.228	0.074	0.014	0.086
Race:						
Black indicator	–3.078	0.548	5.618	–0.120	0.023	–0.136
Other indicator	–4.151	0.912	4.550	–0.060	0.014	–0.070
45-64 years[4] $R^2 = 0.136$						
Independent variable:						
Percent of calories from sweets	–0.006	0.011	0.524	–0.011	0.022	–0.012
Covariables:						
Education:						
High school indicator	0.806	0.564	1.428	0.052	0.036	0.046
College indicator	–0.133	0.662	0.201	–0.007	0.036	–0.006
Total family income	–0.050	0.029	1.719	–0.047	0.027	–0.043
Age at interview	0.273	0.022	12.598	0.197	0.016	0.203
Sex indicator	1.058	0.398	2.654	0.068	0.026	0.073
Race:						
Black indicator	–7.387	0.639	11.561	–0.272	0.027	–0.273
Other indicator	–9.799	2.980	3.289	–0.098	0.037	–0.104

[1]Estimated total population of 23,356,053 based on 1,920 persons examined.
[2]Estimated total population of 24,653,755 based on 1,998 persons examined.
[3]Estimated total population of 73,881,716 based on 6,904 persons examined.
[4]Estimated total population of 42,362,317 based on 2,655 persons examined.

Table 2. Estimated population by age group and percent of calories from sweets[1]: United States, 1971-74

Age group	Percent of calories from sweets[1]						
	0-9	*10-19*	*20-29*	*30-39*	*40-49*	*50-59*	*60 or more*
6-11 years	249,380	2,148,791	5,175,435	6,591,271	5,638,750	2,648,306	904,119
12-17 years	648,987	2,443,578	5,671,517	6,331,384	4,848,167	2,887,853	1,822,268
18-44 years	4,227,888	10,950,339	17,272,043	17,570,196	12,698,400	7,259,074	3,903,775
45-64 years	2,812,279	6,865,816	9,698,690	10,567,758	7,086,086	3,494,481	1,837,207

[1]Sum of the three food groups; cereals and grain products, sugar and primarily sugar products, and desserts and sweets, from the 24-hour recall record.

Table 3. Effect of percent of calories from sweets consumed between meals on the number of decayed, missing, and filled (DMF) permanent teeth controlling for specified variables, by age for persons ages 6-64 years: United States, 1971-74

Age and variable	*Regression analysis statistics*					
	Regression coefficient (B)	*Sigma (B)*	*t-statistic*	*Standardized coefficient (Beta)*	*Sigma (Beta)*	*Partial r*
6-11 years[1] $R^2 = 0.243$						
Independent variable:						
Percent of calories from between-meal sweets	0.013	0.006	2.233*	0.071	0.032	0.081
Covariables:						
Education:						
High school indicator	−0.181	0.123	1.473	−0.046	0.030	−0.038
College indicator	−0.409	0.162	2.519	−0.090	0.034	−0.068
Total family income	−0.000	0.010	0.040	−0.001	0.031	−0.001
Age at interview	0.556	0.032	17.151	0.479	0.025	0.481
Sex indicator	0.117	0.094	1.237	0.030	0.024	0.034
Race:						
Black indicator	0.031	0.140	0.219	0.005	0.025	0.006
Other indicator	0.425	0.496	0.856	0.017	0.018	0.019
12-17 years[2] $R^2 = 0.143$						
Independent variable:						
Percent of calories from between-meal sweets	0.018	0.010	1.878	0.048	0.025	0.051
Covariables:						
Education:						
High school indicator	0.194	0.270	0.717	0.020	0.029	0.017
College indicator	−0.445	0.385	1.154	−0.040	0.035	−0.030
Total family income	−0.000	0.020	0.026	−0.001	0.029	−0.001
Age at interview	0.954	0.059	16.177	0.343	0.022	0.346
Sex indicator	1.121	0.296	3.786	0.119	0.030	0.128
Race:						
Black indicator	−0.645	0.540	1.195	−0.047	0.039	−0.049
Other indicator	0.047	2.298	0.020	0.001	0.035	0.001
18-44 years[3] $R^2 = 0.284$						
Independent variable:						
Percent of calories from between-meal sweets	0.046	0.009	4.845*	0.062	0.013	0.073
Covariables:						
Education:						
High school indicator	1.573	0.560	2.810	0.099	0.035	0.074
College indicator	0.575	0.550	1.045	0.035	0.033	0.025
Total family income	−0.019	0.016	1.159	−0.015	0.013	−0.017
Age at interview	0.515	0.014	36.602	0.509	0.013	0.506
Sex indicator	1.132	0.226	4.998	0.071	0.014	0.084
Race:						
Black indicator	−3.091	0.542	5.701	−0.121	0.022	−0.138
Other indicator	−4.101	0.923	4.442	−0.059	0.014	−0.070
45-64 years[4] $R^2 = 0.140$						
Independent variable:						
Percent of calories from between-meal sweets	0.053	0.021	2.544*	0.067	0.026	0.072
Covariables:						
Education:						
High school indicator	0.808	0.564	1.433	0.052	0.036	0.046
College indicator	−0.063	0.694	0.090	−0.003	0.038	−0.003
Total family income	−0.048	0.029	1.621	−0.045	0.027	−0.041
Age at interview	0.280	0.022	12.602	0.202	0.017	0.208
Sex indicator	1.048	0.394	2.656	0.068	0.026	0.072
Race:						
Black indicator	−7.317	0.636	11.508	−0.269	0.027	−0.271
Other indicator	−10.031	3.269	3.069	−0.100	0.038	−0.107

[1]Estimated total population of 23,356,053 based on 1,920 persons examined.
[2]Estimated total population of 24,653,755 based on 1,998 persons examined.
[3]Estimated total population of 73,881,716 based on 6,904 persons examined.
[4]Estimated total population of 42,362,317 based on 2,655 persons examined.
*Denotes statistical significance at the 5-percent level.

Table 4. Estimated population by age group and percent of calories from sweets consumed between meals[1]: United States, 1971-74

Age group	Percent of calories from between-meal sweets[1]					
	0-9	10-19	20-29	30-39	40-49	50-59
6-11 years	13,456,967	6,402,223	2,235,448	894,698	242,085	124,632
12-17 years	12,127,278	6,970,766	3,267,421	1,398,071	508,917	381,302
18-44 years	44,268,369	17,402,964	8,040,185	2,874,440	881,499	414,259
45-64 years	29,434,346	8,114,513	3,139,478	1,178,303	314,161	181,517

[1]Sum of the three food groups; cereals and grain products, sugar and primarily sugar products, and desserts and sweets, from the 24-hour recall record, and recorded as eaten at other than mealtimes.

Table 5. Effect of frequency of between-meal sweet snacks on the number of decayed, missing, and filled (DMF) permanent teeth controlling for specified variables, by age for persons ages 6-64 years: United States, 1971-74

Age and variable	Regression analysis statistics					
	Regression coefficient (B)	Sigma (B)	t-statistic	Standardized coefficient (Beta)	Sigma (Beta)	Partial r
6-11 years[1] $R^2 = 0.244$						
Independent variable:						
Number of between-meal sweet snacks	0.098	0.036	2.744*	0.078	0.030	0.089
Covariables:						
Education:						
High school indicator	−0.190	0.124	1.532	−0.048	0.031	−0.040
College indicator	−0.422	0.163	2.588	−0.092	0.034	−0.071
Total family income	−0.001	0.010	0.129	−0.004	0.031	−0.004
Age at interview	0.555	0.032	17.332	0.479	0.024	0.481
Sex indicator	0.115	0.094	1.228	0.030	0.024	0.034
Race:						
Black indicator	0.029	0.140	0.206	0.005	0.025	0.006
Other indicator	0.390	0.500	0.778	0.016	0.018	0.018
12-17 years[2] $R^2 = 0.144$						
Independent variable:						
Number of between-meal sweet snacks	0.145	0.074	1.963*	0.050	0.026	0.054
Covariables:						
Education:						
High school indicator	0.204	0.269	0.757	0.022	0.029	0.018
College indicator	−0.428	0.389	1.102	−0.039	0.035	−0.029
Total family income	−0.001	0.020	0.068	−0.002	0.028	−0.002
Age at interview	0.962	0.061	15.808	0.346	0.022	0.350
Sex indicator	1.129	0.291	3.885	0.120	0.030	0.128
Race:						
Black indicator	−0.607	0.534	1.138	−0.044	0.039	−0.046
Other indicator	−0.012	2.313	0.005	−0.000	0.035	−0.000
18-44 years[3] $R^2 = 0.286$						
Independent variable:						
Number of between-meal sweet snacks	0.375	0.051	7.349*	0.080	0.011	0.093
Covariables:						
Education:						
High school indicator	1.530	0.562	2.719	0.096	0.035	0.072
College indicator	0.552	0.555	0.994	0.033	0.034	0.024
Total family income	−0.021	0.016	1.310	−0.017	0.013	−0.019
Age at interview	0.514	0.014	37.612	0.507	0.013	0.506
Sex indicator	1.308	0.224	5.835	0.082	0.014	0.096
Race:						
Black indicator	−3.009	0.548	5.489	−0.117	0.022	−0.134
Other indicator	−4.021	0.940	4.275	−0.058	0.014	−0.068
45-64 years[4] $R^2 = 0.143$						
Independent variable:						
Number of between-meal sweet snacks	0.446	0.122	3.651*	0.088	0.025	0.094
Covariables:						
Education:						
High school indicator	0.711	0.561	1.267	0.046	0.036	0.040
College indicator	−0.138	0.694	0.199	−0.008	0.038	−0.006
Total family income	−0.049	0.030	1.632	−0.046	0.028	−0.042
Age at interview	0.282	0.022	12.969	0.204	0.016	0.210
Sex indicator	1.131	0.386	2.928	0.073	0.025	0.078
Race:						
Black indicator	−7.226	0.641	11.264	−0.266	0.027	−0.268
Other indicator	−9.982	2.928	3.409	−0.100	0.036	−0.107

[1]Estimated total population of 23,356,053 based on 1,923 persons examined.
[2]Estimated total population of 24,653,755 based on 2,012 persons examined.
[3]Estimated total population of 73,881,716 based on 6,947 persons examined.
[4]Estimated total population of 42,362,317 based on 2,665 persons examined.
*Denotes statistical significance at the 5-percent level.

Table 6. Estimated population by age group and frequency of between-meal sweet snacks[1]: United States, 1971-74

Age group	*Frequency of between-meal sweet snacks*[1]							
	0	*1*	*2*	*3*	*4*	*5*	*6*	*More than 6*
6-11 years	5,885,758	6,754,462	4,863,890	2,879,092	1,698,036	717,993	389,878	166,946
12-17 years	4,891,414	6,412,763	6,039,416	3,400,326	1,852,988	1,294,884	437,697	324,268
18-44 years	19,829,235	19,564,823	14,570,994	9,374,317	5,222,512	2,739,523	1,375,145	1,205,169
45-64 years	16,627,709	10,933,814	6,845,777	4,010,128	2,070,494	1,142,906	359,492	371,997

[1]Sum of the between-meal frequency of three food groups; cereals and grain products, sugar and primarily sugar products, and desserts and sweets, from the 24-hour recall record.

Table 7. Correlation matrix of variables used in the analysis of diet versus decayed, missing, and filled (DMF) permanent teeth for 1,923 persons ages 6-11 years

Variable	*Variable*										
	DMF teeth	*Percent of calories from sweets*	*Percent of calories from between-meal sweets*	*Frequency of between-meal sweets*	*Frequency of between-meal nonsweets*	*High school indicator*	*College indicator*	*Family income*	*Age at interview*	*Sex*	*Race (black)*
Percent of calories from sweets	0.043[1]										
Percent of calories from between-meal sweets	0.086[1]	0.478[2]									
Frequency of between-meal sweet snacks	0.092	0.339[2]	0.773[1]								
Frequency of between-meal nonsweet snacks	0.044	–0.136[2]	0.207[2]	0.371							
High school indicator	0.010	0.012[1]	0.000[1]	–0.002	0.030						
College indicator	–0.064	–0.067[1]	–0.050[1]	–0.019	–0.032	–0.668					
Family income	–0.004	–0.100[1]	0.002[1]	0.047	0.044	–0.125	0.406				
Age at interview	0.481	0.029[1]	0.024[1]	0.026	–0.006	–0.006	–0.001	0.059			
Sex	0.021	–0.057[1]	–0.026[1]	–0.029	–0.047	0.011	–0.011	0.033	–0.012		
Race (black)	0.010	0.048[1]	–0.024[1]	–0.026	–0.050	0.000	–0.133	–0.301	–0.013	0.013	
Race (other)	0.036	0.052[1]	0.010[1]	0.030	–0.005	–0.075	0.065	0.036	0.045	–0.026	–0.032

[1]Number examined equals 1,920.
[2]Number examined equals 2,015.

Table 8. Correlation matrix of variables used in the analysis of diet versus decayed, missing, and filled (DMF) permanent teeth for 2,012 persons ages 12-17 years

Variable	*DMF teeth*	*Percent of calories from sweets*	*Percent of calories from between-meal sweets*	*Frequency of between-meal sweets*	*Frequency of between-meal nonsweets*	*High school indicator*	*College indicator*	*Family income*	*Age at interview*	*Sex*	*Race (black)*
Percent of calories from sweets	−0.031[1]										
Percent of calories from between-meal sweets	0.068[1]	0.536[2]									
Frequency of between-meal sweet snacks	0.049	0.353[2]	0.708[1]								
Frequency of between-meal nonsweet snacks	0.054	−0.104[2]	0.186[2]	0.407							
High school indicator	0.048	−0.003[1]	−0.003[1]	−0.028	0.021						
College indicator	−0.055	−0.048[1]	−0.030[1]	0.021	0.004	−0.603					
Family income	−0.014	−0.060[1]	−0.016[1]	0.042	0.012	−0.091	0.438				
Age at interview	0.351	0.041[1]	0.069[1]	0.026	0.030	0.013	−0.018	−0.005			
Sex	0.121	−0.044[1]	−0.006[1]	−0.064	−0.035	0.002	−0.034	−0.050	0.009		
Race (black)	−0.045	0.088[1]	0.086[1]	0.020	0.029	0.009	−0.145	−0.286	−0.027	0.013	
Race (other)	0.005	−0.038[1]	−0.032[1]	−0.013	−0.000	−0.005	0.015	−0.026	0.019	−0.011	−0.033

[1]Number examined equals 1,998.
[2]Number examined equals 2,117.

Table 9. Correlation matrix of variables used in the analysis of diet versus decayed, missing, and filled (DMF) permanent teeth for 6,947 persons ages 18-44 years

Variable	*Variable*										
	DMF teeth	*Percent of calories from sweets*	*Percent of calories from between-meal sweets*	*Frequency of between-meal sweets*	*Frequency of between-meal nonsweets*	*High school indicator*	*College indicator*	*Family income*	*Age at interview*	*Sex*	*Race (black)*
Percent of calories from sweets	–0.006[1]										
Percent of calories from between-meal sweets	0.025[1]	0.508[2]									
Frequency of between-meal sweet snacks	0.056	0.308[2]	0.676[1]								
Frequency of between-meal nonsweet snacks	0.117	–0.147[2]	0.184[2]	0.471							
High school indicator	0.074	0.025[1]	0.052[1]	0.051	0.014						
College indicator	–0.045	–0.087[1]	–0.062[1]	–0.030	0.024	–0.764					
Family income	0.100	–0.107[1]	–0.042[1]	0.027	0.097	–0.087	0.215				
Age at interview	0.502	–0.041[1]	–0.085[1]	–0.047	0.119	–0.002	–0.019	0.192			
Sex	0.070	0.090[1]	0.063[1]	–0.110	–0.143	0.011	–0.023	–0.050	–0.003		
Race (black)	–0.121	0.065[1]	0.029[1]	–0.036	–0.076	0.039	–0.137	–0.193	–0.017	0.034	
Race (other)	–0.063	0.010[1]	–0.013[1]	–0.023	–0.012	–0.053	0.065	–0.014	–0.007	–0.021	–0.040

[1]Number examined equals 6,904.
[2]Number examined equals 7,274.

Table 10. Correlation matrix of variables used in the analysis of diet versus decayed, missing, and filled (DMF) permanent teeth for 2,665 persons ages 45-64 years

Variable	*Variable*										
	DMF teeth	*Percent of calories from sweets*	*Percent of calories from between-meal sweets*	*Frequency of between-meal sweets*	*Frequency of between-meal nonsweets*	*High school indicator*	*College indicator*	*Family income*	*Age at interview*	*Sex*	*Race (black)*
Percent of calories from sweets	−0.015[1]										
Percent of calories from between-meal sweets	0.063[1]	0.469[2]									
Frequency of between-meal sweet snacks	0.083	0.315[2]	0.714[1]								
Frequency of between-meal nonsweet snacks	0.092	−0.125[2]	0.245[2]	0.474							
High school indicator	0.069	−0.029[1]	0.039[1]	0.057	0.048						
College indicator	−0.041	−0.111[1]	−0.041[1]	0.002	0.064	−0.518					
Family income	−0.040	−0.136[1]	−0.013[1]	0.041	0.116	−0.008	0.402				
Age at interview	0.214	0.030[1]	−0.067[1]	−0.081	−0.114	−0.071	−0.056	−0.195			
Sex	0.075	0.021[1]	0.010[1]	−0.075	−0.102	0.033	−0.046	−0.117	0.023		
Race (black)	−0.269	0.054[1]	−0.032[1]	−0.065	−0.140	−0.075	−0.106	−0.200	−0.034	0.017	
Race (other)	−0.095	0.024[1]	0.028[1]	0.016	0.047	−0.059	0.051	−0.009	0.001	−0.012	−0.024

[1]Number examined equals 2,655.
[2]Number examined equals 2,850.

Table 11. Effect of percent of calories from sweets consumed between meals and number of between-meal sweet snacks on the number of decayed, missing, and filled (DMF) permanent teeth controlling for specified variables, by age for persons ages 6-64 years: United States, 1971-74

Age and variable	Regression analysis statistics					
	Regression coefficient (B)	*Sigma (B)*	*t-statistic*	*Standardized coefficient (Beta)*	*Sigma (Beta)*	*Partial r*
6-11 years[1] $R^2 = 0.245$						
Independent variables:						
Percent of calories from between-meal sweet snacks	0.005	0.009	0.581	0.027	0.047	0.020
Number of between-meal sweet snacks	0.070	0.054	1.300	0.056	0.044	0.041
Covariables:						
Education:						
High school indicator	−0.183	0.122	1.502	−0.046	0.030	−0.038
College indicator	−0.411	0.161	2.546	−0.090	0.034	−0.069
Total family income	−0.001	0.010	0.120	−0.004	0.031	−0.004
Age at interview	0.555	0.032	17.182	0.479	0.025	0.481
Sex indicator	0.119	0.094	1.263	0.030	0.024	0.035
Race:						
Black indicator	0.028	0.140	0.202	0.005	0.025	0.006
Other indicator	0.396	0.500	0.793	0.016	0.018	0.018
12-17 years[2] $R^2 = 0.143$						
Independent variables:						
Percent of calories from between-meal sweet snacks	0.014	0.012	1.221	0.037	0.030	0.028
Number of between-meal sweet snacks	0.043	0.084	0.508	0.015	0.029	0.011
Covariables:						
Education:						
High school indicator	0.197	0.270	0.728	0.021	0.029	0.017
College indicator	−0.445	0.385	1.156	−0.040	0.035	−0.030
Total family income	−0.001	0.020	0.045	−0.001	0.028	−0.001
Age at interview	0.955	0.059	16.147	0.343	0.022	0.347
Sex indicator	1.128	0.293	3.850	0.120	0.030	0.128
Race:						
Black indicator	−0.640	0.539	1.186	−0.047	0.039	−0.048
Other indicator	0.038	2.292	0.017	0.001	0.035	0.001
18-44 years[3] $R^2 = 0.287$						
Independent variables:						
Percent of calories from between-meal sweet snacks	0.011	0.014	0.807	0.016	0.019	0.013
Number of between-meal sweet snacks	0.318	0.081	3.909*	0.068	0.018	0.058
Covariables:						
Education:						
High school indicator	1.523	0.561	2.714	0.096	0.035	0.072
College indicator	0.540	0.558	0.969	0.033	0.034	0.024
Total family income	−0.022	0.016	1.361	−0.018	0.013	−0.020
Age at interview	0.515	0.014	35.991	0.509	0.013	0.506
Sex indicator	1.294	0.220	5.868	0.081	0.014	0.094
Race:						
Black indicator	−3.018	0.543	5.562	−0.118	0.022	−0.134
Other indicator	−4.016	0.945	4.251	−0.058	0.014	−0.068
45-64 years[4] $R^2 = 0.144$						
Independent variables:						
Percent of calories from between-meal sweet snacks	0.007	0.025	0.269	0.008	0.031	0.006
Number of between-meal sweet snacks	0.419	0.151	2.770*	0.083	0.030	0.062
Covariables:						
Education:						
High school indicator	0.746	0.569	1.310	0.048	0.036	0.042
College indicator	−0.128	0.700	0.183	−0.007	0.038	−0.006
Total family income	−0.049	0.030	1.645	−0.046	0.027	−0.042
Age at interview	0.283	0.022	12.801	0.204	0.017	0.210
Sex indicator	1.150	0.391	2.941	0.074	0.026	0.079
Race:						
Black indicator	−7.245	0.645	11.234	−0.267	0.027	−0.269
Other indicator	−9.985	3.001	3.327	−0.100	0.037	−0.107

[1]Estimated total population of 23,356,053 based on 1,920 persons examined.
[2]Estimated total population of 24,653,755 based on 1,998 persons examined.
[3]Estimated total population of 73,881,716 based on 6,904 persons examined.
[4]Estimated total population of 42,362,317 based on 2,655 persons examined.
*Denotes statistical significance at the 5-percent level.

Table 12. Effect of frequency of between-meal sweet snacks on the number of filled permanent teeth controlling for specified variables, by age for persons ages 6-64 years: United States, 1971-74

Age and variable	Regression analysis statistics					
	Regression coefficient (B)	Sigma (B)	t-statistic	Standardized coefficient (Beta)	Sigma (Beta)	Partial r
6-11 years[1] $R^2 = 0.176$						
Independent variable:						
Number of between-meal sweet snacks	0.050	0.034	1.474	0.053	0.037	0.058
Covariables:						
Education:						
High school indicator	0.062	0.119	0.520	0.020	0.040	0.016
College indicator	0.108	0.149	0.724	0.031	0.044	0.023
Total family income	0.028	0.009	3.079	0.118	0.038	0.111
Age at interview	0.325	0.026	12.441	0.370	0.020	0.376
Sex indicator	0.220	0.082	2.678	0.074	0.028	0.081
Race:						
Black indicator	–0.233	0.126	1.854	–0.055	0.028	–0.057
Other indicator	–0.561	0.335	1.675	–0.029	0.018	–0.032
12-17 years[2] $R^2 = 0.169$						
Independent variable:						
Number of between-meal sweet snacks	0.131	0.069	1.889	0.053	0.028	0.058
Covariables:						
Education:						
High school indicator	0.664	0.220	3.016	0.083	0.028	0.070
College indicator	0.964	0.360	2.675	0.103	0.038	0.078
Total family income	0.069	0.018	3.799	0.115	0.032	0.106
Age at interview	0.642	0.046	13.928	0.272	0.018	0.286
Sex indicator	0.543	0.231	2.355	0.068	0.029	0.074
Race:						
Black indicator	–2.271	0.240	9.471	–0.196	0.023	–0.202
Other indicator	0.005	2.691	0.002	0.000	0.049	0.000
18-44 years[3] $R^2 = 0.209$						
Independent variable:						
Number of between-meal sweet snacks	0.006	0.045	0.127	0.001	0.012	0.002
Covariables:						
Education:						
High school indicator	2.807	0.374	7.497	0.218	0.029	0.154
College indicator	5.393	0.409	13.172	0.404	0.030	0.271
Total family income	0.158	0.015	10.240	0.160	0.016	0.166
Age at interview	0.044	0.013	3.356	0.053	0.016	0.058
Sex indicator	0.531	0.178	2.987	0.041	0.014	0.046
Race:						
Black indicator	–4.473	0.324	13.804	–0.216	0.019	–0.230
Other indicator	–2.522	1.144	2.204	–0.045	0.020	–0.050
45-64 years[4] $R^2 = 0.233$						
Independent variable:						
Number of between-meal sweet snacks	–0.070	0.112	0.628	–0.016	0.026	–0.018
Covariables:						
Education:						
High school indicator	1.695	0.375	4.518	0.126	0.028	0.116
College indicator	5.012	0.543	9.228	0.314	0.036	0.261
Total family income	0.185	0.027	6.902	0.199	0.029	0.191
Age at interview	–0.141	0.033	4.312	–0.117	0.028	–0.129
Sex indicator	0.626	0.326	1.923	0.046	0.024	0.052
Race:						
Black indicator	–3.389	0.342	9.914	–0.143	0.014	–0.156
Other indicator	–2.853	1.462	1.951	–0.033	0.018	–0.037

[1]Estimated total population of 23,356,053 based on 1,923 persons examined.
[2]Estimated total population of 24,653,755 based on 2,012 persons examined.
[3]Estimated total population of 73,881,716 based on 6,947 persons examined.
[4]Estimated total population of 42,362,317 based on 2,665 persons examined.

Table 13. Effect of frequency of between-meal sweet snacks on the number of decayed permanent teeth controlling for specified variables, by age for persons ages 6-64 years: United States, 1971-74

Age and variable	Regression coefficient (B)	Sigma (B)	t-statistic	Standardized coefficient (Beta)	Sigma (Beta)	Partial r
6-11 years[1] $R^2 = 0.121$						
Independent variable:						
Number of between-meal sweet snacks	0.039	0.019	2.033*	0.052	0.024	0.055
Covariables:						
Education:						
High school indicator	–0.229	0.104	2.189	–0.095	0.043	–0.073
College indicator	–0.466	0.102	4.550	–0.168	0.036	–0.119
Total family income	–0.025	0.004	6.438	–0.132	0.019	–0.120
Age at interview	0.179	0.015	11.738	0.254	0.019	0.261
Sex indicator	–0.028	0.051	0.552	–0.012	0.021	–0.012
Race:						
Black indicator	0.112	0.092	1.222	0.033	0.027	0.034
Other indicator	0.768	0.600	1.279	0.050	0.038	0.053
12-17 years[2] $R^2 = 0.090$						
Independent variable:						
Number of between-meal sweet snacks	0.026	0.037	0.700	0.016	0.023	0.017
Covariables:						
Education:						
High school indicator	–0.387	0.180	2.151	–0.073	0.034	–0.059
College indicator	–1.016	0.191	5.322	–0.163	0.029	–0.118
Total family income	–0.042	0.011	3.916	–0.106	0.026	–0.094
Age at interview	0.171	0.037	4.634	0.110	0.023	0.114
Sex indicator	0.184	0.103	1.789	0.035	0.019	0.036
Race:						
Black indicator	1.028	0.244	4.212	0.134	0.034	0.133
Other indicator	–0.784	0.590	1.329	–0.024	0.018	–0.025
18-44 years[3] $R^2 = 0.099$						
Independent variable:						
Number of between-meal sweet snacks	0.010	0.023	0.453	0.007	0.016	0.008
Covariables:						
Education:						
High school indicator	–0.488	0.144	3.386	–0.098	0.028	–0.066
College indicator	–1.102	0.159	6.928	–0.213	0.029	–0.138
Total family income	–0.025	0.008	3.060	–0.066	0.022	–0.065
Age at interview	–0.047	0.006	7.195	–0.148	0.018	–0.151
Sex indicator	–0.251	0.075	3.327	–0.050	0.015	–0.053
Race:						
Black indicator	1.317	0.222	5.945	0.164	0.028	0.166
Other indicator	–0.121	0.309	0.393	–0.006	0.014	–0.006
45-64 years[4] $R^2 = 0.032$						
Independent variable:						
Number of between-meal sweet snacks	0.027	0.024	1.155	0.027	0.024	0.028
Covariables:						
Education:						
High school indicator	0.054	0.082	0.667	0.018	0.026	0.015
College indicator	0.041	0.093	0.439	0.011	0.026	0.009
Total family income	–0.022	0.005	4.267	–0.103	0.022	–0.089
Age at interview	–0.030	0.006	5.106	–0.110	0.021	–0.109
Sex indicator	–0.124	0.092	1.356	–0.041	0.029	–0.041
Race:						
Black indicator	0.477	0.148	3.218	0.089	0.028	0.087
Other indicator	0.381	0.813	0.468	0.019	0.030	0.020

[1]Estimated total population of 23,356,053 based on 1,923 persons examined.
[2]Estimated total population of 24,653,755 based on 2,012 persons examined.
[3]Estimated total population of 73,881,716 based on 6,947 persons examined.
[4]Estimated total population of 42,362,317 based on 2,665 persons examined.
*Denotes statistical significance at the 5-percent level.

Table 14. Effect of frequency of between-meal sweet snacks on the number of missing permanent teeth controlling for specified variables, by age for persons ages 6-64 years: United States, 1971-74

Age and variable	Regression analysis statistics					
	Regression coefficient (B)	Sigma (B)	t-statistic	Standardized coefficient (Beta)	Sigma (Beta)	Partial r
6-11 years[1] $R^2 = 0.030$						
Independent variable:						
Number of between-meal sweet snacks	0.008	0.011	0.738	0.018	0.025	0.018
Covariables:						
Education:						
High school indicator	–0.023	0.050	0.466	–0.016	0.038	–0.012
College indicator	–0.063	0.050	1.272	–0.039	0.032	–0.026
Total family income	–0.004	0.003	1.390	–0.037	0.031	–0.032
Age at interview	0.051	0.009	5.534	0.124	0.028	0.124
Sex indicator	–0.077	0.032	2.394	–0.055	0.020	–0.056
Race:						
Black indicator	0.150	0.072	2.071	0.075	0.032	0.072
Other indicator	0.183	0.221	0.829	0.020	0.024	0.021
12-17 years[2] $R^2 = 0.067$						
Independent variable:						
Number of between-meal sweet snacks	–0.011	0.030	0.381	–0.009	0.024	–0.009
Covariables:						
Education:						
High school indicator	–0.073	0.140	0.525	–0.018	0.040	–0.014
College indicator	–0.376	0.125	3.009	–0.079	0.038	–0.057
Total family income	–0.028	0.008	3.378	–0.092	0.024	–0.081
Age at interview	0.149	0.026	5.714	0.125	0.028	0.128
Sex indicator	0.401	0.118	3.413	0.099	0.019	0.102
Race:						
Black indicator	0.636	0.343	1.853	0.108	0.052	0.106
Other indicator	0.766	0.570	1.345	0.031	0.024	0.032
18-44 years[3] $R^2 = 0.286$						
Independent variable:						
Number of between-meal sweet snacks	0.359	0.056	6.431*	0.073	0.012	0.086
Covariables:						
Education:						
High school indicator	–0.790	0.500	1.578	–0.048	0.030	–0.036
College indicator	–3.739	0.508	7.365	–0.216	0.028	–0.157
Total family income	–0.154	0.013	11.870	–0.121	0.011	–0.132
Age at interview	0.518	0.012	41.608	0.489	0.012	0.492
Sex indicator	1.028	0.221	4.650	0.062	0.013	0.072
Race:						
Black indicator	0.147	0.409	0.358	0.005	0.015	0.006
Other indicator	–1.378	0.545	2.530	–0.019	0.007	–0.022
45-64 years[4] $R^2 = 0.152$						
Independent variable:						
Number of between-meal sweet snacks	0.489	0.200	2.449*	0.067	0.028	0.072
Covariables:						
Education:						
High school indicator	–1.038	0.775	1.339	–0.046	0.035	–0.041
College indicator	–5.190	0.992	5.234	–0.197	0.038	–0.159
Total family income	–0.212	0.046	4.611	–0.138	0.030	–0.127
Age at interview	0.454	0.042	10.857	0.228	0.021	0.234
Sex indicator	0.629	0.531	1.186	0.028	0.024	0.030
Race:						
Black indicator	–4.314	0.698	6.177	–0.110	0.019	–0.115
Other indicator	–7.510	2.098	3.580	–0.052	0.016	–0.056

[1]Estimated total population of 23,356,053 based on 1,923 persons examined.
[2]Estimated total population of 24,653,755 based on 2,012 persons examined.
[3]Estimated total population of 73,881,716 based on 6,947 persons examined.
[4]Estimated total population of 42,362,317 based on 2,655 persons examined.
*Denotes statistical significance at the 5-percent level.

Table 15. Effect of frequency of between-meal nonsweet snacks on the number of decayed, missing, and filled (DMF) permanent teeth controlling for specified variables, by age for persons ages 6-64 years: United States, 1971-74

Age and variable	Regression analysis statistics					
	Regression coefficient (B)	Sigma (B)	t-statistic	Standardized coefficient (Beta)	Sigma (Beta)	Partial r
6-11 years[1] $R^2 = 0.240$						
Independent variable:						
Number of between-meal nonsweet snacks	0.055	0.032	1.719	0.047	0.027	0.054
Covariables:						
Education:						
High school indicator	–0.203	0.127	1.604	–0.051	0.031	–0.042
College indicator	–0.436	0.164	2.662	–0.096	0.035	–0.073
Total family income	–0.000	0.010	0.050	–0.002	0.031	–0.002
Age at interview	0.557	0.032	17.261	0.481	0.024	0.482
Sex indicator	0.115	0.095	1.213	0.029	0.025	0.034
Race:						
Black indicator	0.033	0.140	0.237	0.006	0.025	0.006
Other indicator	0.449	0.519	0.866	0.018	0.018	0.020
12-17 years[2] $R^2 = 0.144$						
Independent variable:						
Number of between-meal nonsweet snacks	0.114	0.071	1.613	0.050	0.031	0.053
Covariables:						
Education:						
High school indicator	0.170	0.273	0.624	0.018	0.029	0.015
College indicator	–0.453	0.391	1.158	–0.041	0.035	–0.031
Total family income	0.000	0.020	0.006	0.000	0.028	0.000
Age at interview	0.962	0.060	15.992	0.346	0.022	0.350
Sex indicator	1.116	0.290	3.843	0.119	0.030	0.127
Race:						
Black indicator	–0.609	0.533	1.142	–0.045	0.039	–0.046
Other indicator	–0.046	2.323	0.020	–0.001	0.036	–0.001
18-44 years[3] $R^2 = 0.284$						
Independent variable:						
Number of between-meal nonsweet snacks	0.168	0.039	4.274*	0.060	0.013	0.069
Covariables:						
Education:						
High school indicator	1.539	0.558	2.759	0.097	0.035	0.073
College indicator	0.497	0.547	0.908	0.030	0.033	0.022
Total family income	–0.022	0.016	1.336	–0.018	0.013	–0.020
Age at interview	0.503	0.013	37.530	0.496	0.013	0.495
Sex indicator	1.301	0.230	5.664	0.082	0.015	0.095
Race:						
Black indicator	–2.987	0.551	5.422	–0.116	0.023	–0.132
Other indicator	–4.086	0.893	4.574	–0.059	0.013	–0.069
45-64 years[4] $R^2 = 0.144$						
Independent variable:						
Number of between-meal nonsweet snacks	0.281	0.061	4.628*	0.096	0.020	0.101
Covariables:						
Education:						
High school indicator	0.692	0.554	1.250	0.045	0.036	0.039
College indicator	–0.212	0.683	0.310	–0.012	0.037	–0.009
Total family income	–0.053	0.029	1.819	–0.050	0.027	–0.046
Age at interview	0.286	0.022	13.128	0.207	0.016	0.212
Sex indicator	1.169	0.402	2.904	0.076	0.026	0.080
Race:						
Black indicator	–7.052	0.640	11.025	–0.260	0.027	–0.261
Other indicator	–10.268	2.882	3.562	–0.103	0.037	–0.110

[1]Estimated total population of 23,356,053 based on 1,923 persons examined.
[2]Estimated total population of 24,653,755 based on 2,012 persons examined.
[3]Estimated total population of 73,881,716 based on 6,947 persons examined.
[4]Estimated total population of 42,362,317 based on 2,665 persons examined.
*Denotes statistical significance at the 5-percent level.

Table 16. Estimated population by age group and frequency of between-meal nonsweet snacks[1]: United States, 1971-74

Age group	Frequency of between-meal nonsweet snacks[1]							
	0	1	2	3	4	5	6	More than 6
6-11 years	5,965,905	6,530,888	4,567,750	3,279,786	1,597,937	664,938	345,458	403,391
12-17 years	5,650,529	6,604,733	4,678,223	3,269,598	1,873,459	1,068,598	557,955	950,659
18-44 years	12,833,931	13,705,255	12,546,012	10,178,866	7,639,630	5,014,794	3,891,419	8,071,808
45-64 years	8,187,947	7,877,170	7,468,068	5,510,755	4,483,180	2,858,478	2,207,340	3,769,378

[1]Sum of the between-meal frequency of the 16 nonsweet food groups from the 24-hour recall record.

Table 17. Effect of frequency of between-meal sweet and nonsweet snacks on the number of decayed, missing, and filled (DMF) permanent teeth controlling for specified variables, by age for persons ages 6-64 years: United States, 1971-74

Age and variable	Regression analysis statistics					
	Regression coefficient (B)	Sigma (B)	t-statistic	Standardized coefficient (Beta)	Sigma (Beta)	Partial r
6-11 years[1] $R^2 = 0.245$						
Independent variables:						
Number of between-meal sweet snacks	0.088	0.036	2.458*	0.070	0.030	0.074
Number of between-meal nonsweet snacks	0.025	0.032	0.800	0.022	0.027	0.023
Covariables:						
Education:						
High school indicator	−0.191	0.124	1.542	−0.048	0.031	−0.040
College indicator	−0.418	0.162	2.582	−0.092	0.034	−0.070
Total family income	−0.001	0.010	0.152	−0.005	0.031	−0.005
Age at interview	0.556	0.032	17.233	0.479	0.024	0.482
Sex indicator	0.119	0.095	1.250	0.030	0.025	0.035
Race:						
Black indicator	0.033	0.140	0.237	0.006	0.025	0.006
Other indicator	0.398	0.497	0.801	0.016	0.017	0.018
12-17 years[2] $R^2 = 0.145$						
Independent variables:						
Number of between-meal sweet snacks	0.104	0.072	1.461	0.036	0.025	0.036
Number of between-meal nonsweet snacks	0.080	0.071	1.128	0.035	0.031	0.034
Covariables:						
Education:						
High school indicator	0.187	0.270	0.693	0.020	0.029	0.017
College indicator	−0.441	0.390	1.129	−0.040	0.035	−0.030
Total family income	−0.001	0.020	0.057	−0.002	0.028	−0.002
Age at interview	0.960	9.060	15.987	0.346	0.022	0.350
Sex indicator	1.132	0.291	3.891	0.120	0.030	0.129
Race:						
Black indicator	−0.619	0.532	1.163	−0.045	0.039	−0.047
Other indicator	−0.022	2.321	0.009	−0.000	0.035	−0.000
18-44 years[3] $R^2 = 0.287$						
Independent variables:						
Number of between-meal sweet snacks	0.315	0.061	5.129*	0.067	0.014	0.069
Number of between-meal nonsweet snacks	0.078	0.046	1.689	0.028	0.016	0.028
Covariables:						
Education:						
High school indicator	1.513	0.558	2.712	0.095	0.035	0.072
College indicator	0.527	0:552	0.955	0.032	0.033	0.023
Total family income	−0.022	0.016	1.389	−0.018	0.013	−0.020
Age at interview	0.510	0.014	37.108	0.504	0.013	0.499
Sex indicator	1.347	0.229	5.876	0.085	0.015	0.099
Race:						
Black indicator	−2.980	0.547	5.446	−0.116	0.022	−0.132
Other indicator	−4.012	0.929	4.319	−0.058	0.014	−0.068
45-64 years[4] $R^2 = 0.147$						
Independent variables:						
Number of between-meal sweet snacks	0.285	0.136	2.099*	0.056	0.027	0.054
Number of between-meal nonsweet snacks	0.204	0.067	3.029*	0.070	0.022	0.066
Covariables:						
Education:						
High school indicator	0.667	0.554	1.205	0.043	0.036	0.038
College indicator	−0.203	0.690	0.294	−0.011	0.038	−0.009
Total family income	−0.052	0.030	1.749	−0.048	0.027	−0.045
Age at interview	0.289	0.022	13.136	0.209	0.016	0.214
Sex indicator	1.195	0.396	3.016	0.077	0.026	0.082
Race:						
Black indicator	−7.047	0.647	10.897	−0.260	0.027	−0.261
Other indicator	−10.241	2.873	3.565	−0.102	0.037	−0.110

[1]Estimated total population of 23,356,053 based on 1,923 persons examined.
[2]Estimated total population of 24,653,755 based on 2,012 persons examined.
[3]Estimated total population of 73,881,716 based on 6,947 persons examined.
[4]Estimated total population of 42,362,317 based on 2,665 persons examined.
*Denotes statistical significance at the 5-percent level.

Table 18. Effect of enamel fluoride levels and frequency of between-meal sweet snacks on the number of decayed, missing, and filled (DMF) permanent teeth controlling for specified variables, by age for persons ages 6-64 years: United States, 1971-74

Age and variable	*Regression analysis statistics*					
	Regression coefficient (B)	*Sigma (B)*	*t-statistic*	*Standardized coefficient (Beta)*	*Sigma (Beta)*	*Partial r*
6-11 years[1] $R^2 = 0.188$						
Independent variables:						
Number of between-meal sweet snacks	0.158	0.077	2.043*	0.123	0.066	0.135
Enamel fluoride level	−0.651	0.220	2.966*	−0.160	0.048	−0.173
Covariables:						
Education:						
High school indicator	−0.353	0.292	1.210	−0.085	0.070	−0.064
College indicator	−0.569	0.362	1.574	−0.122	0.077	−0.085
Total family income	0.009	0.020	0.458	0.028	0.061	0.027
Age at interview	0.547	0.065	8.450	0.356	0.039	0.365
Sex indicator	−0.011	0.211	0.052	−0.003	0.052	−0.003
Race:						
Black indicator	−0.322	0.287	1.121	−0.051	0.044	−0.054
12-17 years[2] $R^2 = 0.157$						
Independent variables:						
Number of between-meal sweet snacks	0.121	0.096	1.256	0.044	0.035	0.047
Enamel fluoride level	−1.157	0.306	3.786*	−0.133	0.035	−0.141
Covariables:						
Education:						
High school indicator	0.347	0.403	0.861	0.038	0.044	0.031
College indicator	−0.099	0.515	0.193	−0.009	0.049	−0.007
Total family income	0.021	0.029	0.710	0.029	0.042	0.028
Age at interview	0.874	0.095	9.150	0.324	0.034	0.329
Sex indicator	0.778	0.302	2.575	0.086	0.032	0.092
Race:						
Black indicator	−0.922	0.734	1.256	−0.068	0.054	−0.070
Other indicator	1.281	2.513	0.510	0.027	0.048	0.030
18-44 years[3] $R^2 = 0.312$						
Independent variables:						
Number of between-meal sweet snacks	0.369	0.065	5.717*	0.093	0.017	0.110
Enamel fluoride level	−1.473	0.294	5.015*	−0.131	0.027	−0.155
Covariables:						
Education:						
High school indicator	2.532	0.520	4.874	0.193	0.038	0.129
College indicator	2.432	0.502	4.842	0.184	0.038	0.121
Total family income	0.008	0.024	0.321	0.008	0.025	0.009
Age at interview	0.420	0.016	26.789	0.494	0.018	0.497
Sex indicator	1.094	0.268	4.078	0.083	0.020	0.099
Race:						
Black indicator	−2.444	0.586	4.168	−0.100	0.024	−0.116
Other indicator	−3.367	1.183	2.847	−0.054	0.018	−0.065
45-64 years[4] $R^2 = 0.215$						
Independent variables:						
Number of between-meal sweet snacks	0.402	0.232	1.732	0.092	0.052	0.102
Enamel fluoride level	−0.332	0.585	0.568	−0.034	0.056	−0.037
Covariables:						
Education:						
High school indicator	2.486	0.741	3.352	0.200	0.058	0.164
College indicator	3.461	1.034	3.349	0.260	0.078	0.190
Total family income	0.022	0.052	0.423	0.028	0.065	0.026
Age at interview	0.023	0.063	0.364	0.019	0.053	0.021
Sex indicator	1.099	0.555	1.982	0.088	0.044	0.096
Race:						
Black indicator	−7.457	1.166	6.396	−0.330	0.056	−0.340
Other indicator	−8.106	6.184	1.311	−0.137	0.078	−0.151

[1]Estimated total population of 23,356,053 based on 569 persons in sample.
[2]Estimated total population of 24,653,755 based on 1,036 persons in sample.
[3]Estimated total population of 73,881,716 based on 2,753 persons in sample.
[4]Estimated total population of 42,362,317 based on 539 persons in sample.
*Denotes statistical significance at the 5-percent level.

Table 19. Relationship of periodontal index (PI) score to the number of decayed, missing, and filled (DMF) permanent teeth controlling for specified variables, by age for persons ages 18-74 years: United States, 1971-74

Age and variable	Regression analysis statistics: Regression coefficient (B)	Sigma (B)	t-statistic	Standardized coefficient (Beta)	Sigma (Beta)	Partial r
18-44 years[1] $R^2 = 0.274$						
Independent variables:						
Periodontal index	0.444	0.107	4.136*	0.081	0.019	0.089
Number of between-meal sweet snacks	0.364	0.052	7.066*	0.084	0.012	0.097
Covariables:						
Education:						
High school indicator	1.824	0.519	3.515	0.124	0.035	0.091
College indicator	1.468	0.524	2.801	0.097	0.034	0.068
Total family income	0.021	0.018	1.170	0.018	0.016	0.020
Age at interview	0.441	0.015	29.698	0.467	0.014	0.462
Sex indicator	1.333	0.220	6.046	0.091	0.015	0.104
Race:						
Black indicator	−2.808	0.538	5.218	−0.120	0.024	−0.134
Other indicator	−0.802	0.984	3.862	−0.060	0.016	−0.070
45-64 years[2] $R^2 = 0.159$						
Independent variables:						
Periodontal index	0.345	0.112	3.072*	0.107	0.037	0.108
Number of between-meal sweet snacks	0.447	0.108	4.157*	0.099	0.024	0.106
Covariables:						
Education:						
High school indicator	2.070	0.577	3.588	0.153	0.041	0.128
College indicator	2.729	0.726	3.758	0.180	0.046	0.139
Total family income	0.032	0.025	1.269	0.034	0.027	0.032
Age at interview	0.129	0.033	3.935	0.105	0.027	0.111
Sex indicator	1.464	0.381	3.846	0.108	0.028	0.115
Race:						
Black indicator	−6.102	0.745	8.195	−0.274	0.035	−0.272
Other indicator	−9.100	3.205	2.839	−0.115	0.047	−0.124
65-74 years[3] $R^2 = 0.082$						
Independent variables:						
Periodontal index	0.445	0.086	5.182*	0.178	0.034	0.176
Number of between-meal sweet snacks	0.471	0.180	2.623*	0.087	0.034	0.090
Covariables:						
Education:						
High school indicator	0.948	0.558	1.699	0.070	0.042	0.064
College indicator	2.116	0.706	2.999	0.142	0.047	0.116
Total family income	0.050	0.037	1.355	0.050	0.038	0.046
Age at interview	0.210	0.068	3.096	0.091	0.029	0.094
Sex indicator	0.610	0.475	1.285	0.047	0.037	0.048
Race:						
Black indicator	−2.706	0.775	3.491	−0.123	0.036	−0.120
Other indicator	−6.297	4.034	1.561	−0.081	0.052	−0.084

[1]Estimated total population of 73,881,716 based on 6,611 persons examined.
[2]Estimated total population of 42,362,317 based on 2,011 persons examined.
[3]Estimated total population of 12,773,574 based on 1,616 persons examined.
*Denotes statistical significance at the 5-percent level.

Table 20. Relationship of periodontal index (PI) score to the number of decayed, missing, and filled (DMF) permanent teeth controlling for specified variables, by age for persons ages 18-74 years from whom enamel biopsies were obtained: United States, 1971-74

Age and variable	Regression analysis statistics					
	Regression coefficient (B)	*Sigma (B)*	*t-statistic*	*Standardized coefficient (Beta)*	*Sigma (Beta)*	*Partial r*
18-44 years[1] $R^2 = 0.312$						
Independent variables:						
Periodontal index	-0.087	0.176	0.494	-0.011	0.022	-0.013
Enamel fluoride content	-1.466	0.292	5.026*	-0.131	0.026	-0.154
Number of between-meal sweet snacks	0.371	0.065	5.709*	0.093	0.017	0.110
Covariables:						
Education:						
High school indicator	2.511	0.518	4.847	0.191	0.038	0.128
College indicator	2.394	0.508	4.714	0.181	0.038	0.118
Total family income	0.006	0.024	0.268	0.007	0.025	0.008
Age at interview	0.421	0.016	27.157	0.496	0.017	0.494
Sex indicator	1.074	0.272	3.952	0.082	0.021	0.097
Race:						
Black indicator	-2.422	0.584	4.150	-0.099	0.024	-0.115
Other indicator	-3.341	1.190	2.807	-0.054	0.018	-0.065
45-64 years[2] $R^2 = 0.215$						
Independent variables:						
Periodontal index	0.070	0.242	0.291	0.015	0.053	0.016
Enamel fluoride content	-0.341	0.584	0.584	-0.035	0.056	-0.038
Number of between-meal sweet snacks	0.401	0.232	1.724	0.092	0.052	0.102
Covariables:						
Education:						
High school indicator	2.497	0.744	3.357	0.200	0.058	0.164
College indicator	3.496	1.050	3.329	0.262	0.080	0.191
Total family income	0.025	0.051	0.488	0.031	0.064	0.029
Age at interview	0.022	0.062	0.349	0.018	0.053	0.020
Sex indicator	1.124	0.557	2.017	0.090	0.045	0.098
Race:						
Black indicator	-7.479	1.181	6.330	-0.331	0.056	-0.340
Other indicator	-8.191	6.221	1.317	-0.139	0.080	-0.151
65-74 years[3] $R^2 = 0.205$						
Independent variables:						
Periodontal index	0.791	0.280	2.826*	0.212	0.075	0.215
Enamel fluoride content	-1.136	0.990	1.147	-0.106	0.091	-0.114
Number of between-meal sweet snacks	0.149	0.405	0.368	0.025	0.068	0.027
Covariables:						
Education:						
High school indicator	0.826	1.395	0.592	0.064	0.107	0.058
College indicator	2.698	1.722	1.567	0.202	0.123	0.166
Total family income	0.066	0.100	0.611	0.068	0.100	0.069
Age at interview	0.112	0.169	0.659	0.049	0.075	0.053
Sex indicator	1.787	0.974	1.835	0.141	0.079	0.152
Race:						
Black indicator	-8.026	1.313	6.112	-0.305	0.070	-0.313
Other indicator	-4.550	4.629	0.983	-0.030	0.023	-0.033

[1]Estimated total population of 73,881,716 based on 2,753 persons examined.
[2]Estimated total population of 42,362,317 based on 539 persons examined.
[3]Estimated total population of 12,773,574 based on 281 persons examined.
*Denotes statistical significance at the 5-percent level.

Table 21. Relationship of periodontal index (PI) score to the number of decayed, missing, and filled (DMF) permanent teeth controlling for specified variables, by age for persons ages 18-74 years from whom no enamel biopsies were obtained: United States, 1971-74

Age and variable	Regression analysis statistics					
	Regression coefficient (B)	Sigma (B)	t-statistic	Standardized coefficient (Beta)	Sigma (Beta)	Partial r
18-44 years[1] $R^2 = 0.260$						
Independent variables:						
Periodontal index	0.341	0.123	2.767*	0.071	0.025	0.077
Number of between-meal sweet snacks	0.333	0.079	4.191*	0.075	0.018	0.086
Covariables:						
Education:						
High school indicator	1.440	0.555	2.597	0.094	0.036	0.074
College indicator	0.943	0.623	1.515	0.057	0.038	0.044
Total family income	0.056	0.022	2.484	0.046	0.018	0.049
Age at interview	0.427	0.019	22.137	0.432	0.019	0.430
Sex indicator	1.482	0.324	4.573	0.096	0.021	0.110
Race:						
Black indicator	−3.248	0.659	4.930	−0.145	0.030	−0.161
Other indicator	−4.350	1.403	3.100	−0.070	0.023	−0.081
45-64 years[2] $R^2 = 0.153$						
Independent variables:						
Periodontal index	0.198	0.121	1.638	0.068	0.043	0.069
Number of between-meal sweet snacks	0.342	0.133	2.566*	0.078	0.031	0.084
Covariables:						
Education:						
High school indicator	1.868	0.589	3.173	0.140	0.043	0.120
College indicator	2.313	0.709	3.263	0.152	0.046	0.120
Total family income	0.058	0.031	1.871	0.061	0.033	0.056
Age at interview	0.121	0.039	3.068	0.100	0.032	0.106
Sex indicator	1.445	0.408	3.537	0.109	0.031	0.115
Race:						
Black indicator	−5.614	0.877	6.402	−0.266	0.043	−0.262
Other indicator	−8.563	4.725	1.812	−0.097	0.055	−0.104
65-74 years[3] $R^2 = 0.071$						
Independent variables:						
Periodontal index	0.222	0.089	2.482*	0.097	0.039	0.096
Number of between-meal sweet snacks	0.498	0.170	2.925*	0.099	0.035	0.102
Covariables:						
Education:						
High school indicator	1.406	0.467	3.009	0.109	0.037	0.100
College indicator	2.379	0.660	3.605	0.162	0.046	0.133
Total family income	0.039	0.036	1.092	0.041	0.038	0.036
Age at interview	0.193	0.088	2.201	0.087	0.039	0.089
Sex indicator	0.269	0.471	0.571	0.022	0.038	0.022
Race:						
Black indicator	−1.745	0.622	2.805	−0.086	0.030	−0.084
Other indicator	−6.942	4.431	1.566	−0.102	0.065	−0.105

[1]Estimated total population of 73,881,716 based on 3,858 persons examined.
[2]Estimated total population of 42,362,317 based on 1,472 persons examined.
[3]Estimated total population of 12,773,574 based on 1,335 persons examined.
*Denotes statistical significance at the 5-percent level.

Table 22. Relationship of periodontal index (PI) score to alcohol consumption controlling for specified variables, by age for persons ages 25-74 years: United States, 1971-74

Age and variable	Regression analysis statistics					
	Regression coefficient (B)	Sigma (B)	t-statistic	Standardized coefficient (Beta)	Sigma (Beta)	Partial r
25-74 years[1] $R^2 = 0.205$						
Independent variables:						
Alcohol consumption	0.068	0.048	1.413	0.031	0.022	0.031
Daily tooth-brushing frequency	–0.240	0.045	5.347*	–0.097	0.018	–0.101
Dental visit pattern	0.153	0.026	5.847*	0.138	0.023	0.142
Use tobacco now	0.091	0.130	0.699	0.018	0.026	0.018
Used tobacco in past	0.420	0.110	3.809*	0.112	0.028	0.102
Covariables:						
Education:						
High school indicator	–0.493	0.115	4.298	–0.131	0.030	–0.101
College indicator	–0.650	0.114	5.703	–0.163	0.030	–0.117
Total family income	–0.036	0.006	5.721	–0.132	0.022	–0.128
Age at interview	0.032	0.004	8.203	0.216	0.027	0.225
Sex indicator	–0.028	0.084	0.334	–0.008	0.022	–0.007
Race:						
Black indicator	0.468	0.135	3.464	0.076	0.023	0.082
Other indicator	1.360	0.719	1.890	0.067	0.033	0.074

[1]Estimated total population of 104,340,369 based on 2,715 persons examined.
*Denotes statistical significance at the 5-percent level.

Table 23. Relationship of periodontal index (PI) score to tooth-brushing frequency controlling for specified variables, by age for persons ages 25-74 years: United States, 1971-74

Age and variable	Regression analysis statistics					
	Regression coefficient (B)	Sigma (B)	t-statistic	Standardized coefficient (Beta)	Sigma (Beta)	Partial r
25-74 years[1] $R^2 = 0.493$						
Independent variables:						
Daily tooth-brushing frequency	–0.026	0.047	0.545	–0.011	0.020	–0.014
Dental visit pattern	0.035	0.020	1.758	0.033	0.019	0.042
Use tobacco now	0.115	0.100	1.146	0.025	0.022	0.030
Used tobacco in past	0.208	0.096	2.167*	0.059	0.027	0.069
Oral hygiene index (OHI-S)	0.918	0.055	16.570*	0.624	0.034	0.597
Covariables:						
Education:						
High school indicator	–0.072	0.132	0.547	–0.020	0.038	–0.019
College indicator	–0.063	0.148	0.426	–0.017	0.040	–0.015
Total family income	–0.009	0.005	1.808	–0.035	0.019	–0.043
Age at interview	0.022	0.003	6.438	0.153	0.024	0.203
Sex indicator	0.063	0.065	0.964	0.018	0.018	0.022
Race:						
Black indicator	0.047	0.126	0.376	0.008	0.022	0.011
Other indicator	1.443	0.677	2.131	0.078	0.035	0.108

[1]Estimated total population of 104,340,369 based on 2,436 persons examined.
*Denotes statistical significance at the 5-percent level.

Table 24. Relationship of oral hygiene index (OHI-S) score to tooth-brushing frequency controlling for specified variables, by age for persons ages 25-74 years: United States, 1971-74

Age and variable	Regression analysis statistics					
	Regression coefficient (B)	*Sigma (B)*	*t-statistic*	*Standardized coefficient (Beta)*	*Sigma (Beta)*	*Partial r*
25-74 years[1] $R^2 = 0.278$						
Independent variables:						
Daily tooth-brushing frequency	−0.208	0.040	5.224*	−0.130	0.025	−0.142
Dental visit pattern	0.140	0.020	6.857*	0.198	0.027	0.210
Use tobacco now	0.027	0.070	0.390	0.009	0.023	0.009
Used tobacco in past	0.237	0.056	4.259*	0.099	0.024	0.097
Covariables:						
Education:						
High school indicator	−0.532	0.082	6.485	−0.222	0.033	−0.176
College indicator	−0.744	0.093	8.009	−0.296	0.036	−0.216
Total family income	−0.024	0.003	7.312	−0.139	0.018	−0.142
Age at interview	0.005	0.002	2.612	0.051	0.020	0.058
Sex indicator	−0.160	0.058	2.754	−0.067	0.024	−0.071
Race:						
Black indicator	0.451	0.115	3.931	0.116	0.032	0.129
Other indicator	−0.070	0.220	0.319	−0.006	0.016	−0.006

[1]Estimated total population of 104,340,369 based on 2,437 persons examined.
*Denotes statistical significance at the 5-percent level.

Table 25. Relationship of an absence of teeth to percent of the NHANES standard attained for vitamin C controlling for specified variables, by age for persons ages 18-74 years: United States, 1971-74

Age and variable	Regression analysis statistics: Regression coefficient (B)	Sigma (B)	t-statistic	Standardized coefficient (Beta)	Sigma (Beta)	Partial r
18-44 years[1] $R^2 = 0.021$						
Independent variable:						
Absence of teeth	−20.454	8.378	2.438*	−0.027	0.011	−0.026
Covariables:						
Education:						
High school indicator	14.946	6.963	2.146	0.044	0.021	0.028
College indicator	28.453	7.012	4.058	0.081	0.019	0.050
Total family income	2.124	0.417	5.089	0.082	0.017	0.077
Age at interview	−1.969	0.351	5.611	−0.091	0.016	−0.088
Sex indicator	−11.210	5.039	2.225	−0.033	0.014	−0.033
Race:						
Black indicator	2.089	9.144	0.228	0.004	0.017	0.004
Other indicator	14.256	26.383	0.540	0.010	0.018	0.010
45-64 years[2] $R^2 = 0.048$						
Independent variable:						
Absence of teeth	−22.097	8.270	2.672*	−0.067	0.025	−0.064
Covariables:						
Education:						
High school indicator	20.085	8.929	2.249	0.069	0.031	0.058
College indicator	37.614	14.470	2.599	0.109	0.042	0.083
Total family income	2.394	0.662	3.617	0.199	0.033	0.104
Age at interview	3.452	0.671	5.143	0.133	0.026	0.129
Sex indicator	12.458	7.848	1.588	0.043	0.027	0.044
Race:						
Black indicator	10.119	10.949	0.924	0.020	0.021	0.020
Other indicator	22.471	33.206	0.677	0.012	0.014	0.012
65-74 years[3] $R^2 = 0.069$						
Independent variable:						
Absence of teeth	−18.331	7.204	2.545*	−0.065	0.025	−0.064
Covariables:						
Education:						
High school indicator	27.210	6.986	3.895	0.092	0.025	0.087
College indicator	67.317	9.750	6.904	0.182	0.030	0.154
Total family income	2.527	0.812	3.113	0.104	0.033	0.095
Age at interview	1.491	0.976	1.528	0.030	0.019	0.031
Sex indicator	18.008	7.143	2.521	0.063	0.025	0.065
Race:						
Black indicator	13.695	15.155	0.904	0.027	0.030	0.028
Other indicator	33.388	72.046	0.463	0.017	0.035	0.018

[1]Estimated total population of 73,881,716 based on 6,947 persons examined.
[2]Estimated total population of 42,362,317 based on 2,665 persons examined.
[3]Estimated total population of 12,773,574 based on 3,080 persons examined.
*Denotes statistical significance at the 5-percent level.

Table 26. Relationship of an absence of teeth to percent of the NHANES standard attained for protein controlling for specified variables, by age for persons ages 65-74 years: United States, 1971-74

Age and variable	Regression analysis statistics					
	Regression coefficient (B)	Sigma (B)	t-statistic	Standardized coefficient (Beta)	Sigma (Beta)	Partial r
65-74 years[1] $R^2 = 0.032$						
Independent variable:						
Absence of teeth	-5.454	1.846	2.955*	-0.066	0.023	-0.065
Covariables:						
Education:						
High school indicator	4.397	2.042	2.154	0.051	0.024	0.048
College indicator	4.699	2.594	1.812	0.044	0.024	0.037
Total family income	0.316	0.135	2.340	0.045	0.020	0.040
Age at interview	-1.074	0.348	3.080	-0.074	0.025	-0.075
Sex indicator	-7.402	1.763	4.198	-0.090	0.021	-0.090
Race:						
Black indicator	-5.087	3.294	1.544	-0.035	0.023	-0.035
Other indicator	0.145	16.954	0.008	0.000	0.026	0.000

[1]Estimated total population of 12,773,574 based on 3,080 persons examined.
*Denotes statistical significance at the 5-percent level.

Table 27. Relationship of an absence of teeth to percent of the NHANES standard attained for iron controlling for specified variables, by age for persons ages 65-74 years: United States, 1971-74

Age and variable	Regression analysis statistics					
	Regression coefficient (B)	Sigma (B)	t-statistic	Standardized coefficient (Beta)	Sigma (Beta)	Partial r
65-74 years[1] $R^2 = 0.092$						
Independent variable:						
Absence of teeth	-6.640	2.295	2.893*	-0.064	0.022	-0.064
Covariables:						
Education:						
High school indicator	2.645	2.597	1.018	0.024	0.024	0.023
College indicator	5.050	3.595	1.405	0.037	0.026	0.032
Total family income	0.515	0.209	2.461	0.058	0.023	0.053
Age at interview	-1.049	0.416	2.518	-0.057	0.023	-0.059
Sex indicator	-27.010	2.246	12.025	-0.258	0.020	-0.258
Race:						
Black indicator	-10.412	4.810	2.165	-0.056	0.027	-0.058
Other indicator	-2.773	21.782	0.127	-0.004	0.027	-0.004

[1]Estimated total population of 12,773,574 based on 3,080 persons examined.
*Denotes statistical significance at the 5-percent level.

Table 28. Relationship of an absence of teeth and weekly frequency of fruit ingestion to percent of the NHANES standard attained for vitamin C controlling for specified variables, by age for persons ages 18-74 years: United States, 1971-74

Age and variable	Regression analysis statistics					
	Regression coefficient (B)	Sigma (B)	t-statistic	Standardized coefficient (Beta)	Sigma (Beta)	Partial r
18-44 years[1] $R^2 = 0.097$						
Independent variables:						
Absence of teeth	-13.771	8.241	1.671	-0.018	0.011	-0.018
Weekly frequency of fruit ingestion	7.208	0.601	11.985*	0.282	0.027	0.277
Covariables:						
Education:						
High school indicator	3.574	7.207	0.496	0.010	0.021	0.007
College indicator	7.332	5.903	1.242	0.021	0.016	0.013
Total family income	1.396	0.386	3.620	0.054	0.016	0.052
Age at interview	-2.062	0.374	5.513	-0.095	0.016	-0.095
Sex indicator	-19.067	4.994	3.818	-0.056	0.014	-0.059
Race:						
Black indicator	9.576	9.605	0.997	0.017	0.018	0.018
Other indicator	0.930	18.972	0.049	0.001	0.012	0.001
45-64 years[2] $R^2 = 0.160$						
Independent variables:						
Absence of teeth	-14.768	7.491	1.971*	-0.044	0.023	-0.046
Weekly frequency of fruit ingestion	7.456	0.568	13.128*	0.354	0.023	0.344
Covariables:						
Education:						
High school indicator	4.126	8.055	0.512	0.014	0.028	0.012
College indicator	20.317	14.096	1.441	0.059	0.041	0.048
Total family income	1.194	0.619	1.927	0.059	0.031	0.055
Age at interview	2.677	0.673	3.980	0.103	0.026	0.106
Sex indicator	-1.775	7.447	0.238	-0.006	0.026	-0.007
Race:						
Black indicator	24.311	10.922	2.226	0.047	0.021	0.049
Other indicator	46.140	32.438	1.422	0.024	0.017	0.026
65-74 years[3] $R^2 = 0.181$						
Independent variables:						
Absence of teeth	-10.070	6.363	1.582	-0.035	0.022	-0.037
Weekly frequency of fruit ingestion	7.381	0.615	12.000*	0.350	0.026	0.346
Covariables:						
Education:						
High school indicator	20.221	6.256	3.232	0.068	0.022	0.068
College indicator	48.959	8.714	5.619	0.132	0.027	0.119
Total family income	1.545	0.815	1.895	0.063	0.033	0.062
Age at interview	1.598	0.814	1.962	0.032	0.016	0.035
Sex indicator	7.333	6.283	1.167	0.026	0.022	0.028
Race:						
Black indicator	33.710	14.096	2.391	0.066	0.027	0.071
Other indicator	34.354	59.766	0.575	0.018	0.029	0.019

[1]Estimated total population of 73,881,716 based on 6,850 persons examined.
[2]Estimated total population of 42,362,317 based on 2,620 persons examined.
[3]Estimated total population of 12,773,574 based on 2,974 persons examined.
*Denotes statistical significance at the 5-percent level.

Appendixes

Contents

Appendix Figure

List of Appendix Tables

Appendix I

Statistical Notes

Survey design

The sample design for the first National Health and Nutrition Examination Survey (NHANES I) is basically a three-stage, stratified probability sample of loose clusters of persons in land-based segments. The sample was designed to be representative of the civilian noninstitutionalized population within designated age ranges in the coterminous United States, excluding persons residing on lands set aside for the use of American Indians. Successive elements dealt with in the process of sampling were the primary sampling unit (PSU), census enumeration district (ED), segment (a cluster of households), household, eligible person, and finally sample person.

For the period April, 1971 to June, 1974, the design provided for selection of a representative sample of the target population 1-74 years of age to be given the health interview and a medical examination. A subsample of adults 25-74 years of age who would also receive a more detailed examination focused on other aspects of health and health care needs. To increase the size for this subsampling and consequently the usefulness of the data obtained, the design further provided for the selection of an additional nationally representative sample of adults 25-74 years between July 1974 and September 1975, who were to be given the more detailed examination. This extension of NHANES I is referred to as the "augmentation survey."

The estimated civilian noninstitutionalized U.S. population aged 1-74 years is shown in table I by sex, race, and age at examination. The estimates closely approximate the U.S. population estimated by the U.S. Bureau of the Census as of the midpoint of the survey sample design. The figures in table I may differ slightly from the census estimates because the latter are based on the ages of sample persons at the time they were examined, whereas the poststratification was based on the ages at interview. Because certain analyses must be done on the basis of age at examination, the population estimates have also been based on age at examination for the sake of consistency.

The starting points in the first stage of this design were the 1960 decennial census lists of addresses and the nearly 1,900 primary sampling units (PSU's) into which the entire United States was divided. Each PSU is either a standard metropolitan statistical area (SMSA), a county, or two or three contiguous counties. The PSU's were grouped into 357 strata, as they were for use in the National Health Interview Survey, and subsequently collapsed into 40 superstrata for use in NHANES I. This same procedure had been used in Cycles II and III of the National Health Examination Surveys of 1963-65 and 1966-70, respectively.

During the April 1971 - June 1974 period, 15 of the 40 superstrata that contained a single large metropolitan area of more than 2 million population were chosen in the sample with certainty. The remaining 25 noncertainty strata were classified into 4 broad geographic regions of approximately equal population (when the large metropolitan areas selected with certainty were included) and cross-classified into 4 broad population density groups in each region. Then a modified Goodman-Kish controlled-selection technique was used to select 2 PSU's from each of the 25 noncertainty superstrata, with the probability of selection of a PSU proportionate to its 1960 population, and so that proportionate representation of specified State groups and rate of population change classes were maintained in the sample. In this manner a total first-stage sample of 65 PSU's was selected. These 65 sample PSU's are the areas within which a cluster sample of persons was selected for examination at the particular examination location designated within each area. The mobile examining units were moved from one location to the next during this 39-month period (1971-74) to permit administering those single-time examinations to the cross-sectional sample of the target population.

Although the 1970 census data were used as the frame for selecting the sample within the PSU when they became available, the calendar of operations required that the 1960 census data be used for the first

Table I. NHANES I population estimates for examination locations 1-65, by sex, race, and age at examination

Age at examination	Estimated population						
	Total	Male			Female		
		All races	White	Black	All races	White	Black
Total	193,976,381	94,239,866	82,740,899	10,413,986	99,736,515	86,867,546	11,999,935
1 year	3,313,458	1,693,074	1,401,508	280,212	1,620,384	1,327,657	257,289
2-3 years	6,963,162	3,553,765	2,997,107	479,362	3,409,397	2,872,581	505,442
4-5 years	6,672,346	3,378,503	2,866,374	485,872	3,293,843	2,755,016	511,134
6-7 years	7,193,663	3,652,322	3,060,888	573,867	3,541,341	2,951,927	576,578
8-9 years	7,696,597	3,880,396	3,279,649	586,419	3,816,201	3,257,936	539,855
10-11 years	8,465,793	4,381,730	3,732,593	563,823	4,084,063	3,424,070	617,793
12-14 years	12,335,321	6,312,591	5,397,061	879,377	6,022,802	5,122,189	836,252
15-17 years	12,318,434	6,312,519	5,311,596	812,321	6,111,265	5,233,091	853,294
18-19 years	7,352,200	3,673,321	3,206,467	404,045	3,678,879	3,158,930	504,417
20-24 years	17,325,038	8,109,775	7,094,036	866,201	9,215,263	7,972,486	1,073,358
25-34 years	26,936,001	13,002,514	11,594,115	1,231,793	13,933,487	12,160,578	1,646,337
35-44 years	22,268,477	10,675,731	9,515,530	1,004,953	11,592,746	10,111,458	1,318,050
45-54 years	23,313,316	11,150,110	10,039,124	1,056,837	12,163,206	10,879,167	1,237,459
55-64 years	19,049,001	9,072,586	8,274,948	702,647	9,976,415	9,037,157	871,098
65-74 years	12,773,574	5,496,351	4,969,903	486,257	7,277,223	6,603,303	651,579

44 locations in the sample. The 1970 census data were then used for the final 21 stands of the sample.

Beginning with the use of the 1970 census data, the segment size was changed from an expected 6 households selected from compact clusters of 18 households to an expected compact cluster of 8 households. This change was implemented because of operational advantages and results of research by the U.S. Bureau of the Census indicating that precision of estimates would not be appreciably affected by such a modification. In urban enumeration districts the segments were clusters of addresses from the 1960 Census Listing Books (later the corresponding books for 1970). For ED's not having usable addresses, area sampling was employed and consequently some variation in the segment size occurred. To make the sample representative of the then current population of the United States, the address or list segments were supplemented by a sample of housing units that had been constructed since 1960.

Within each PSU a systematic sample of segments was selected. The enumeration districts selected for the sample were coded into one of two economic classes. The first class, identified as the "poverty stratum," was composed of "current poverty areas" that had been identified by the Bureau of the Census in 1970 (pre-1970 Census), plus other ED's in the PSU with a mean income of less than $3,000 in 1959 (based on 1960 Census). The second economic class, the "nonpoverty stratum," included all ED's not designated as belonging to the "poverty stratum." All sample segments classified as being in the poverty stratum were retained in the sample. For those sample segments in nonpoverty stratum ED's, the selected segments were divided into eight random subgroups and one of the subgroups was chosen to remain in the NHANES I sample. Continuing research indicated that efficiency of estimates could be increased by changing the ratio of poverty to nonpoverty segments from 8 : 1 to 2 : 1. Therefore, in the later stands the selected segments in the nonpoverty-stratum ED's were divided into two random subgroups, and one of the subgroups was chosen to remain in the sample. This procedure permits separate analyses, with adequate reliability, of those classified as being below the poverty level and those classified as being above the poverty level.

After identifying the sample segments, a list of all current addresses within the segment boundaries was made, and the households were interviewed to determine the age and sex of each household member, as well as other demographic and socioeconomic information required for the survey. If no one was at home after repeated calls or if the household members refused to be interviewed, the interviewer tried to determine the household composition from questioning neighbors.

To select the persons in the sample segments to be examined in NHANES I, all household members ages 1-74 years in each segment were listed on a sample selection worksheet, with each household in the segment listed serially. The number of household members in each of the six age-sex groups shown in table II were listed on the worksheet under the appropriate age-sex group column. The sample selection worksheets were then put in segment number order, and a systematic random sample of persons in each age-sex group was selected to be examined using the sampling rates displayed in table II. This sampling strategy in the 65 stands of the general sample of NHANES I resulted in the selection of 28,043 sample persons 1-74 years of age, a sample that can be regarded as representative of the target population displayed in table I.

A subsample of those adults 25-74 years of age in the total or "nutrition" sample was then selected to also receive the detailed health examination at the first 65 stands of NHANES I. This detailed sample was chosen systematically after a random start, using the sampling rates shown in table III. Consequently, adults 45-74 years of age in the first 65 PSU's were subsampled for the detailed examination at a somewhat higher rate than those 25-44 years of age.

Table II. Sampling rates by age-sex groups for general sample of the NHANES I

Age and sex	Sampling rate
1-5 years	1/2
6-19 years	1/4
20-44 years (men)	1/4
20-44 years (women)	1/2
45-64 years	1/4
65-74 years	1

Table III. Subsampling rates by age-sex groups for detailed sample of the NHANES I

Age and sex	Subsampling rate
25-44 years (men)	2/5
25-44 years (women)	1/5
45-64 years	3/5
65-74 years	1/4

Nonresponse

In any health examination survey, after the sample is identified and the sample persons are requested to participate in the examination, the survey meets one of its more severe problems. Usually a sizable number of sample persons who are willing to complete the household questionnaire and possibly some of the medical history will not participate in the examination. Individual participation is determined by many factors, some of them are uncontrollable, and many are unrelated to health. Therefore, participation may be treated as a random event with a particular probability of occurrence. If this probability were known and were greater than zero for all persons, then the examined persons would constitute a probability sample from which unbiased estimates of the target population could be derived. In this situation, the effect of nonparticipation would only reduce the sample size, thereby increasing the sampling variability of examination findings; this effect can be, and was, planned for in the sample specifications.

In practice, however, a potential for bias due to nonresponse exists because exact probabilities of nonparticipation are never known. A further potential for bias exists if either a sizable proportion of sample persons have a zero probability of participation (that is, they would never agree to participate in an examination survey employing the same procedures and inducements) or these persons differ from other sample persons with respect to characteristics under examination. It is for these reasons that intensive efforts were made in NHANES I to develop and implement procedures and inducements that would reduce the number of nonrespondents and thereby reduce the potential of bias due to nonresponse. These procedures are discussed elsewhere.[2]

Also during the early stages of NHANES I, when it became apparent that the response rate for the examinations was lower than in the preceding health examination surveys, a study of the effect of remuneration on response in NHANES I was undertaken. The findings[53] were considered sufficient to include remuneration as a routine procedure in NHANES I starting with the 21st and 22d examination locations.

Despite response rates at the household interview stage of over 98 percent and these intensive efforts of persuasion, only 20,749 (74 percent) of the sample persons from the first 65 stands were examined. When adjustments are made for differential sampling for high-risk groups, the response rate becomes 75.2 percent. Consequently, the potential for a sizable bias does exist in the estimates in this publication. However, from what is known about the nonrespondents and the nature of nonresponse, the likelihood of sizable bias appears to be small. For instance, only a small proportion of sample persons from the first 65 examination locations gave reasons for nonparticipation that would lead to the belief that they would never agree to participate in examination surveys and that they may differ from examined persons with respect to the characteristics under examination. Only 15 percent of nonrespondents gave the following reasons for nonparticipating: personal illness, physical inability, pregnancy, antidoctor feelings, or a fear of finding something wrong. Typical among the reasons given by the other nonrespondents were the following: inability to take time off from work, school, or household duties; suspicion or skepticism about the program; uninterested in participating; and considered their private medical care sufficient, or they had just visited a doctor.

An analysis of the medical history data obtained for most nonexaminees as well as examinees also supports the belief that the likelihood of sizable bias due to nonresponse is small. No large differences were

NOTE: A list of references follows the text.

found between the examined group and the nonexamined group for the statistics compared. For example, the percent of persons examined who reported ever being told by a doctor that they had arthritis was 20 percent; the percent for high blood pressure was 18 percent; and for diabetes, 4 percent. The corresponding percents for nonexamined persons were arthritis, 17 percent; high blood pressure, 21 percent; and diabetes, 4 percent.

A procedure (similar to that used in previous National Health Examination Surveys) was used in which the reciprocal of the probability of selection of the sample persons is multiplied by a factor that brings estimates based on examined persons up to a level that would have been attained if all sample persons had been examined. This factor is the ratio of the sum of sample weights for all sample persons with a relatively homogeneous class defined by age, sex, and five income groups (under $3,000; $3,000-$6,999; $7,000-$7,999; $10,000-$14,999 and $15,000 or over) within each stand, to the sum of sample weights for all responding sample persons within the same homogeneous class for the same stand.

In addition, there is a poststratified ratio adjustment that makes the final sample estimates of the population agree approximately with independent controls prepared by the U.S. Bureau of the Census for the noninstitutionalized population of the United States as of November 1, 1972 (approximately mid-survey point), by race, sex, and age as shown in table I.

To the degree that homogeneous groups can be defined that are also homogeneous with respect to the characteristics under study, this poststratification procedure can be effective in reducing the variance and bias. Overall, the extent of adjustment for nonresponse and poststratification among the detailed examinees was 1.45 during the 1971-74 period.

For the 65-stand sample of NHANES I, the percent distribution of the adjustment factors used for the 325 cells (determined by the crossclassification of the 5 income groups by the 65 stands) is shown in table IV.

Table IV. Percent distribution of adjustment factors

Size of adjustment factor	*Number of cells*	*Percent distribution*
Total (1.00-3.03)	325	100.0
1.00-1.24	106	32.6
1.25-1.49	125	38.4
1.50-1.74	59	18.2
1.75-1.99	24	7.4
2.00-2.49	9	2.8
2.50-2.99	1	0.3
3.00-3.03	1	0.3

Missing data

Examination surveys are subject to the loss of information not only through failure to examine all sample persons but also from the failure to obtain and record all items of information for examined persons. Dental findings were obtained and records were available for 20,218 of the 20,749 examinees in the NHANES I survey. Those 531 persons whose dental records were lost or not obtained through examinations were assigned imputed values as described in the next section. These imputed values are included in the detailed tables and findings of this report. The age-sex distribution of the examinees is shown in table V.

Imputation

Imputation of dental findings for an examinee was done by randomly selecting a match from among the group of examinees of the same age, race, sex, and income group with information recorded. The

Table V. Total number of examinees and those without dental examination records, by age and sex: National Health and Nutrition Examination Survey, United States, 1971-74

Age	*Both sexes*	*Male*	*Female*	*Both sexes*	*Male*	*Female*
	Total number examined			Number without dental examination records		
All ages, 1-74 years	20,749	8,819	11,930	531	207	324
1-5 years	2,953	1,502	1,451	78	36	42
6-11 years	2,019	1,001	1,018	63	30	33
12-17 years	2,132	1,063	1,064	48	18	30
18-24 years	2,297	770	1,527	60	14	46
25-34 years	2,694	799	1,895	80	26	54
35-44 years	2,327	666	1,661	55	14	41
45-54 years	1,599	767	832	43	22	21
55-64 years	1,252	591	671	33	10	23
65-74 years	3,466	1,655	1,811	71	37	34

findings of this "matched" examinee were then used as the imputation for the examinee with missing data. When data for the income variable was not available, the match was limited to age, race, and sex.

Design considerations for examined persons

Although the sample design for this survey is described in extensive detail in the previous sections and in another report,[2] the aspects of the design pertaining to data analysis considerations are discussed further in this section. All 20,749 examined persons received a specifically designed nutrition examination. In addition, approximately a 20 percent subsample (3,854 persons) of those aged 25-74 years received a more detailed health examination based on the prior National Health Examination Survey. The data collection forms for the entire sample, together with the additional forms for the detailed sample, are contained elsewhere.[2]

Although the sample design for this survey was fairly complex, the essential feature is the selection of primary sampling units (PSU's), such as counties or groups of counties from each of several strata. In particular, the NHANES I design involved the selection of 15 large metropolitan areas referred to as "certainty strata," each with a large number of enumeration districts selected as PSU's, and the selection of exactly 2 PSU's from each of the remaining 25 strata. However, for purposes of computing sampling variances, these 15 certainty strata were combined to form only 10 strata. The data tapes from NCHS reflect this revised indexing of the certainty strata. The number of PSU's and the corresponding number of examined persons in each of these strata are summarized in table VI. Thus, for analytic purposes, this design can be described as having the following characteristics:

1. 10 strata with multiple selection of PSU's.
2. 25 strata with paired selection of PSU's.

Throughout the remainder of this appendix these paired or multiple clusters will be referred to as sampling error computational units (SECU's), to indicate their role in variance calculations.

Another important aspect of the NHANES I design is the multiplication by the reciprocal of the probabilities for selection to adjust for the oversampling of the following subgroups thought to be at high risk of malnutrition (table II):

1. Persons with low income.
2. Preschool children.
3. Women of childbearing age.
4. Elderly persons.

Adjusted sampling weights that reflect these selection probabilities and the poststratification adjustments mentioned earlier were computed and are available on the data tapes for analytic purposes.

An additional design complication arises because at the first 65 sites of the nutrition survey a subset of the sample persons aged 25-74 years received a more detailed health examination. No particular oversampling of subgroups of the population was done in this subsample; for example, women of childbearing age were not oversampled as they were for the major nutrition component of NHANES I. The total number of examined persons involved in this detailed examination is 3,854 persons aged 25-74 years, for which separate adjusted sampling weights have been computed and are available on the data tapes.

Consequently, when computing estimates of analytic statistics and their estimated variance-covariance

NOTE: A list of references follows the text.

Table VI. Number of primary sampling units (PSU's) and number of examined persons for the general and detailed survey, by stratum number for the NHANES I design

Stratum number	*Number of PSU's general and detailed*	*Number of examined persons*	
		General	*Detailed*
Total	1,263	16,895	3,854
1-10	1,213	3,661	853
1	169	509	112
2	106	287	80
3	125	395	87
4	156	608	129
5	197	598	143
6	83	202	48
7	108	324	71
8	61	146	42
9	89	247	57
10	119	345	84
11-35	50	13,234	3,001

structure, the appropriate sampling weights need to be utilized in the weighted analyses. Thus, hypotheses involving variables from the initial detailed sample of persons aged 25-74 years in stands 1-65 were investigated using the adjusted sampling weights associated with the detailed persons. Otherwise, hypotheses involving variables from the entire initial sample (stands 1-65) utilized the adjusted sampling weights for the entire initial sample (tape location 176-181).

Analytical strategies

Because of the complexities in the sample design, each analysis could be performed one of three different ways depending on whether the sampling weights were included and/or whether the design structure was incorporated in the calculations. For simplicity, these three options are labeled in subsequent discussion and tabular results as follows:

Option	Inclusion of sampling	
	Weights	Design
1	No	No
2	Yes	No
3	Yes	Yes

As might be expected, the implementation of each option in successive order from 1 to 3 involved considerably more set-up time and computing costs. Consequently, most hypotheses initially were investigated under option 1. Relationships found to be statistically significant at this stage were then subjected to more definitive analyses under option 3 utilizing the sample weights and the survey design effects. Consequently, the estimated covariance structure for the sample estimators based on the complexities of the survey design was utilized in all final models and inferential conclusions.

In survey research, the design effect is commonly defined to be the ratio of the actual variance for a statistic from a complex sample to the corresponding variance from a simple random sample. These effects are used by survey designers and analysts for a variety of purposes. Quite frequently, the design effect has been used to summarize conveniently the effects of a complex sample design on the precision of estimates from the survey data and to formulate new survey designs. Increasingly, design effects are being used to adjust estimates and statistics computed under simple random sampling assumptions for the effects of the complexities in the sample design on measures of precision. Given the importance of these effects to persons who design and analyze surveys, simple but useful models have been sought for design effects. Such models are useful not only for deriving estimates of design effects for statistics for which they are not available but also for suggesting methods to adjust estimates computed under independence assumptions for complexities in the sample design. An extensive literature review of these design effect considerations and analytical strategies for survey data from complex sample designs is presented by Lepkowski.[54] Throughout the subsequent discussion, the estimated design effects are computed under option 3 to illustrate the importance of utilizing these effects in definitive hypothesis tests or model-fitting calculations.

All analyses under option 1 were performed quite simply and inexpensively using standard statistical software. In this option sampling weights and design effects were totally ignored. Thus, the data were regarded as coming from a simple random sample with equal representation and probability of selection. On the other hand, analyses under option 2 incorporated the adjusted sampling weights in estimating the analytic statistics, but simple random sampling computations were still utilized for the variance estimates. These calculations were performed within the OSIRIS IV software package.[55] Finally, analyses under option 3 utilized both the adjusted sampling weights and the sampling design in calculating the estimated variance-covariance structure of analytic statistics. In particular, the computer program &PSALMS was used for estimating ratio means and the program &REPERR was utilized to fit regression models. Both of these routines are available within the OSIRIS IV library and are described in more detail by Vinter.[57] Briefly, for relatively simple statistics, such as ratio means, differences of such ratios, and totals, the &PSALMS routine approximates the complex sample variance of these estimators using a linearized Taylor Series expansion. For more complex statistics, such as regression coefficients, several replicated variance estimation procedures are available. In particular, the balanced repeated replication (BRR) option within the &REPERR routine was utilized to fit multiple regression models.

The estimation procedure to implement option 3 can be extremely time consuming and expensive, particularly in fitting regression models by the balanced half-sample approach, because of the multiple sampling error computing units within the certainty strata 1-10. To alleviate some of these difficulties, the multiple sampling error computing unit identification codes were randomly allocated into 2 "pseudoreplicates" for each of these 10 strata. Consequently, the paired selection computations then could be utilized for all 35 strata. The effects of randomly assigning the multiple sampling error computing units to two paired pseudoreplicates was investigated by the comparative analysis of standard errors and design effects for decayed, missing, and filled teeth and calories within the selected age groups shown in table VII.

NOTE: A list of references follows the text.

Table VII. Cooperative analyses of standard errors and design effects for multiple and paired sampling error computational units (SECU's) within certainty strata for decayed, missing, and filled (DMF) teeth and calories, by age for NHANES I data

Age	Number of examined persons	Mean	Multiple SECU's: Standard error of mean	Multiple SECU's: Square root of design effect	Paired SECU's: Standard error of mean	Paired SECU's: Square root of design effect
			DMF teeth			
1-74 years	20,749	14.723	0.166	2.094	0.161	2.034
1-17 years	7,104	3.965	0.071	1.545	0.070	1.538
18-24 years	2,297	11.924	0.237	1.766	0.237	1.768
25-34 years	2,694	16.918	0.261	1.823	0.262	1.826
35-44 years	2,327	21.436	0.249	1.560	0.248	1.555
45-54 years	1,599	22.826	0.216	1.085	0.232	1.164
55-64 years	1,262	25.744	0.291	1.278	0.279	1.224
65-74 years	3,466	27.727	0.154	1.283	0.154	1.278
			Calories			
1-74 years	20,749	2,000.0	17.80	2.923	17.88	2.937
1-17 years	7,104	2,011.0	20.75	2.106	20.03	2.033
18-24 years	2,297	2,294.8	37.02	1.660	35.32	1.584
25-34 years	2,694	2,177.5	27.66	1.479	29.44	1.573
35-44 years	2,327	2,042.9	28.33	1.545	28.94	1.578
45-54 years	1,599	1,897.3	31.76	1.515	30.41	1.451
55-64 years	1,262	1,723.2	33.06	1.418	33.45	1.435
65-74 years	3,466	1,518.9	20.68	1.870	19.99	1.808

The means and standard errors were computed under the multiple sampling error computing unit classification as well as under the paired sampling error computing unit groupings. At least for these variables, it is apparent that the random allocation of sampling error computing units in the certainty strata to form a complete paired design has not substantially altered the estimates of variances or the corresponding design effects.

As a result of this pairing for the 10 certainty strata, all variance-covariance computations could be obtained directly as appropriate sums of squares and cross-products of differences across the 35 strata, and thus, 70 sampling error computing units. Consequently, all the analyses under option 3 were performed assuming this paired selection design.

Continuous variables: Means

The basic calculations for means and standard deviations were performed for several representative variables to investigate the relative effects of the sampling weights and the sampling design. These results are displayed in table VIII for three variables of

Table VIII. Number of examined persons, estimated means, standard deviations, standard errors of the mean, and design effects for decayed, missing, and filled (DMF) teeth, calories, and age, under analysis options 1-3 for NHANES I data

Option number	Inclusion of sampling: Weights	Inclusion of sampling: Design	Number examined	Mean	Standard deviation	Standard error of mean	Square root of design effect
				DMF teeth			
1	No	No	20,749	14.93	11.418	0.079	---
2	Yes	No	20,749	14.72	10.776	0.075	---
3	Yes	Yes	20,749	14.72	23.227	0.161	2.034
				Calories			
1	No	No	20,749	1,827.5	877.00	6.088	---
2	Yes	No	20,749	2,000.0	944.91	6.560	---
3	Yes	Yes	20,749	2,000.0	2,575.9	17.883	2.937
				Age			
1	No	No	20,749	32.23	22.972	0.159	---
2	Yes	No	20,749	30.61	20.120	0.140	---
3	Yes	Yes	20,749	30.61	34.417	0.239	1.498

primary interest in these analyses, namely, decayed, missing, and filled (DMF) teeth, calories, and age.

Note that for the total sample, the unweighted and weighted analyses (options 1 and 2) for these variables are quite similar, both for the means and variances. However, under option 3, the complex sample design introduces a considerable increase in the estimated variance of the mean. In particular, the ratio of the standard error of the mean under option 3 to that obtained under option 1 in the last column in table VIII ranges from 1.498 to 2.937. Consequently, the design effects for these three variables range from 2.24 to 8.63.

In view of the fact that age was a crucial variable in the oversampling aspects of the design, one might expect the design effects to be less important when stratifying by age. To investigate this possibility, means and standard deviations of these same variables were computed within age groups as shown in table IX. Even though the design effects are somewhat reduced, they are certainly not negligible, ranging from 1.35 to 4.13.

Continuous variables: Multiple regression models

The basic model used for the majority of the analyses in this report is the multiple regression model. This model is as follows:

$$Y_i = B_1 + B_2 X_{2i} + B_3 X_{3i} + \ldots + B_k X_{ki} + E_i$$

where Y_i denotes the ith observation of the dependent variable; X_i denotes the ith observation of each independent or explanatory variable; and E_i is the random variation of the ith observation of Y. The subscripts 1, 2, . . . , k identify the specific explanatory variables. B_1 is the mean of Y_i when each of the explanatory variables is equal to zero; B_k is the change in the expected value of Y_i corresponding to a unit change in the kth explanatory variable, holding all other explanatory variables constant. $B_2, B_3, \ldots, B_k$ are often referred to as the regression slopes or (partial) regression coefficients.

Also presented in the regression results tables are beta coefficients, which are the result of linear regression in which each variable is "normalized" by subtracting its mean and dividing by its estimated standard deviation. In other words, the beta coefficient adjusts the estimated slope parameter by the ratio of the standard deviation of the independent variable to the standard deviation of the dependent variable. A beta coefficient of 0.3 may be interpreted to mean that a standard deviation change of 1.0 in the independent variable will lead to a 0.3 standard deviation change in the dependent variable. Beta coefficients are also used to make statements about the relative importance of the X variables in the model.

Assumptions of the multiple regression model

The classical assumptions associated with the regression model are as follows:

1. The model specification is correct.
2. The X's are nonstochastic. In addition, no exact linear relationship exists among two or more of the independent variables.
3. The random variation has zero expected value and constant variance for all observations.
4. Random variations corresponding to different observations are uncorrelated.
5. The random variation term is normally distributed.

Any set of real data is unlikely to meet all these assumptions, particularly one utilizing a complex sample survey design such as the NHANES I survey. However, certain violations of these assumptions may not seriously affect statistical inferences. For example, under simple random sampling arguments, it is straightforward to show that the least squares estimators of the regression coefficients retain their desirable asymptotic properties (unbiased, consistent, and efficient), when the X's are stochastic (violation of the second assumption), provided that the explanatory variables are each distributed independently of the true errors in the model. See, for example, Kmenta.[57] More detailed discussions of the properties of regression model estimates from complex sample surveys can be found in Holt et al.[58]

Specification error

If any variables are omitted from the regression equation that are correlated with both the dependent variable and the independent variable(s) whose regression coefficients are to be estimated, the estimates will be biased. In fact, this phenomenon is the reason a multivariable estimation procedure was chosen for this analysis. For example, in the investigation of the relationship between dietary intake patterns and dental caries experience, if a variable such as age is omitted, biased estimates of that relationship emerge. In spite of the effort made to include all the theoretically important variables in the model, if some have been omitted either because they were not part of the data collected or theory has not yet advanced sufficiently to suggest that they should be included, the estimators given by the model could be biased.

Another concern relating to specification error is the form of variables in the model. They are included in forms that seem to be reasonable according to theory, and, therefore, no serious misspecifications should be present that are attributable to the form of the variables.

NOTE: A list of references follows the text.

Table IX. Number of examined persons, estimated means, standard deviations, standard errors of the mean, and design effects for decayed, missing, and filled (DMF) teeth and calories within age groups, under analysis options 1-3 for NHANES I data

Age	Number of examined persons	Option 1			Option 2			Option 3			
		Mean	Standard deviation	Standard error of mean	Mean	Standard deviation	Standard error of mean	Mean	Standard deviation	Standard error of mean	Square root of design effect
					DMF teeth						
1-74 years	20,749	14.935	11.418	0.793	14.723	10.776	0.0748	14.723	23.227	0.1613	2.034
1-17 years	7,104	3.338	3.8493	0.0457	3.965	4.0810	0.0484	3.965	5.9219	0.0703	1.538
18-24 years	2,297	12.050	6.4173	0.1339	11.924	6.2566	0.1305	11.924	11.345	0.2367	1.768
25-34 years	2,694	16.872	7.4408	0.1434	16.918	7.2497	0.1397	16.918	13.589	0.2618	1.826
35-44 years	2,327	21.271	7.6962	0.1595	21.436	7.3482	0.1523	21.436	11.966	0.2481	1.555
45-54 years	1,599	22.515	7.9700	0.1993	22.826	7.5709	0.1893	22.826	9.2767	0.2320	1.164
55-64 years	1,262	25.234	8.0990	0.2280	25.744	7.6022	0.2140	25.744	9.9110	0.2790	1.224
65-74 years	3,466	27.608	7.0741	0.1202	27.727	6.7742	0.1151	27.727	9.0423	0.1536	1.278
					Calories						
1-74 years	20,749	1,827.5	877.00	6.088	2,000.0	944.91	6.560	2,000.0	2,575.9	17.883	2.937
1-17 years	7,104	1,880.4	830.42	9.8525	2,011.0	874.24	10.372	2,011.0	1,688.5	20.033	2.033
18-24 years	2,297	2,084.6	1,068.7	22.298	2,294.8	1,136.6	23.715	2,294.8	1,692.6	35.317	1.584
25-34 years	2,694	1,954.5	971.00	18.708	2,177.5	1,050.1	20.232	2,177.5	1,527.8	29.435	1.573
35-44 years	2,327	1,829.0	884.65	18.339	2,042.9	966.51	20.036	2,042.9	1,395.8	28.935	1.578
45-54 years	1,599	1,840.4	838.33	20.965	1,897.3	816.17	20.411	1,897.3	1,216.0	30.410	1.451
55-64 years	1,262	1,679.2	828.08	23.310	1,723.2	814.02	22.914	1,723.2	1,188.5	33.454	1.435
65-74 years	3,466	1,497.2	651.06	11.059	1,518.9	649.50	11.032	1,518.9	1,176.9	19.991	1.808

The possibility also exists that some of the relationships studied might be better represented by a series of simultaneous interdependent equations. It is not difficult to imagine, for example, that the symptoms of periodontal disease influence the frequency of dental visits, that dental visits influence toothbrushing behavior, and that tooth brushing in turn affects periodontal disease. In such a circumstance, ordinary least squares estimation of individual equations can lead to biased and inconsistent parameter estimates. While it is not believed that these forms of possible misspecification pose a serious threat to the conclusions reached, they do warrant future exploration to more precisely assess the underlying form of these relationships.

Measurement error

When variables are measured with error, they can, of course, affect the results of statistical procedures applied to them. In general, considerable effort was expended to ensure a minimum of observer error in the gathering of the data used in this analysis. Some of the procedures employed are described in the section titled "Sources and limitations of the data." However, for the group of nutritional and dietary variables from the 24-hour recall record, special note is necessary. There are both short-term and long-term variations in what people eat. Therefore the 24-hour recall record is an imperfect measure of long-term dietary patterns. This kind of random error in an independent variable in a regression equation will bias the estimate of the regression coefficient of that variable toward zero.

For example, under simple random sampling arguments, it is possible to demonstrate that the form of the bias is as follows:

$$\hat{B}' = \hat{B}/(1 + \lambda)$$

where

$\hat{B}'$ = the biased estimate of the regression parameter as computed by ordinary least squares,

$\hat{B}$ = the unbiased estimator, and

λ = the ratio of the true variance to the additional variance attributable to the measurement error.

See, for example, Snedecor and Cochran.[59] The extent to which the bias in estimates of regression coefficients can be expressed in this formulation under the complexities of option 3, utilizing both the sampling weights and the survey design effects, would require further investigation.

Because some empirical work has been done to provide estimates of the ratio of interindividual (true between-subject variation in individual intake) to intraindividual (day-to-day variation in individual intake) variation, rough estimates of this bias are possible.[59] These data suggest that values of $\wedge$ of at least one or two are not unreasonable. Based on this information, the trends in dental caries experience related to 24-hour recall variables are, as estimates of the relationship between dental caries experience and *lifetime* dietary patterns, underestimates by a factor of 1/2 to 1/3. Stated another way, lifetime trend estimates are likely to be two or three times larger than those provided by the 24-hour data.

When a variable with this type of error is used as a dependent variable, as in the investigation of the effect of dentulous status on dietary patterns, the problem encountered is less severe. Standard errors will be overestimated, but estimators will be unbiased. Therefore, the only real hazard is the failure to reject the null hypothesis when it should be rejected.

Heteroscedasticity

When the third assumption is violated, standard errors estimated by ordinary least squares tend to be inefficient. Because the variance of both the DMF and PI measures tends to increase with age, the possibility of this phenomenon influencing the results presented was investigated. Weighted least squares procedures were employed using the same variables that had been studied by means of ordinary least squares. The computed t-statistics for the statistically significant regression coefficients were virtually identical between the two methods, and there was no consistent pattern of one being larger than the other. This finding indicates that, at least for the models considered in this report, heteroscedasticity is not a problem. The results presented are thus based on ordinary least squares.

Nonnormality of random variation term

The dependent variables of decayed, missing, and filled teeth and the periodontal index have distributions that are skewed toward zero in the younger age groups. The random variation term is therefore not normally distributed, as demonstrated by the median values in table O. The t-tests are nevertheless employed as though the disturbances are normally distributed because the procedure is considered to be relatively robust when sample sizes as large as these are used.

Empirical results for regression models

In order to investigate predictive relationships among continuous variables, multiple regression models also can be fitted under either option 1, 2, or 3. Specifically, the effects of the sampling weights and complex design on the precision of regression

NOTE: A list of references follows the text.

coefficients was investigated under options 1-3 for decayed, missing, and filled (DMF) teeth and calories on age as summarized in table X. First, it can be observed in the corresponding entries under options 1 and 2 that the results are quite similar, particularly for DMF teeth on age, which has a strong linear relationship in all the race-sex subclasses. However, for calories on age, which has extremely small R^2 criteria for all subgroups, the estimate of the slope is quite different for some subclasses; in fact, for the "other males" category there is a 12-fold increase in the slope under option 2 compared with option 1, and for the "other females" category it differs by a factor of nearly 3. Of course, in both of these subclasses the sample size is relatively small.

Otherwise, note in table X that the results under option 3 are only reported for the white subgroups, even though the number of black persons examined appears to be reasonably large. This omission is due to the failure of the balanced half-sample routine in the weighted regression program in OSIRIS IV resulting from entire strata with no data for these subclasses as shown in table XI. Modification of this routine or another sampling error program could still be used to obtain these estimates for the other subclasses. This problem of missing sampling error computing units is even more pronounced within the more restrictive detailed examination as displayed in table XII. Consequently, due to the sparse design across strata, only the white and black race data were used in many of the analyses.

In addition to simple linear regression models, multiple regression models can also be fitted within this same framework. Table XIII summarizes the results of DMF regressed jointly on age, race, sex, and sweets for 6,349 cases ages 11-30 years. Here again, the design effects for the regression coefficients range from 1.19 to 6.40.

These empirical results, as expressed in terms of estimated design effects, demonstrate the critical importance of incorporating the sampling weights and the survey design adjustments into all definitive multiple regression models.

Table X. Summary of simple regression models of decayed, missing, and filled (DMF) teeth and calories on age under analysis options 1-3, by race and sex for NHANES I data

Race and sex	Number of examined persons	Unweighted design (option 1)				Weighted design						
		R^2	Slope	Standard error	t-statistic	R^2	Slope	(Option 2)		(Option 3)		Square root of design effect
								Standard error	t-statistic	Standard error	t-statistic	
						DMF on age						
Total	20,749	0.67	0.408	0.0020	206.89	0.65	0.432	0.0022	196.52	0.0032	135.09	1.62
White males	7,004	0.73	0.416	0.0030	138.91	0.67	0.440	0.0037	118.93	0.0042	105.49	1.39
Black males	1,707	0.63	0.335	0.0062	54.44	0.47	0.308	0.0080	38.52	---	---	---
All other males	109	0.53	0.317	0.0287	11.04	0.45	0.294	0.0316	9.28	---	---	---
White females	9,347	0.67	0.414	0.0030	136.49	0.68	0.439	0.0031	139.50	0.0053	82.76	1.75
Black females	2,456	0.59	0.391	0.0065	59.91	0.54	0.385	0.0072	53.29	---	---	---
All other females	126	0.40	0.337	0.0372	9.07	0.25	0.244	0.0376	6.50	---	---	---
						Calories on age						
Total	20,749	0.02	−4.90	0.2629	−18.64	0.01	−5.50	0.3238	−16.99	0.3171	17.35	0.98
White males	7,004	0.01	−3.39	0.4873	−6.95	0.00	−3.52	0.6102	−5.78	0.6314	−5.58	1.03
Black males	1,707	0.01	−3.74	0.9217	−4.05	0.00	−1.08	1.212	−0.89	---	---	---
All other males	109	0.00	1.00	3.598	0.28	0.05	12.50	5.101	2.45	---	---	---
White females	9,347	0.04	−5.89	0.3034	−19.41	0.04	−6.44	0.3315	−19.43	0.4339	−14.85	1.31
Black females	2,456	0.06	−8.39	0.6578	−12.75	0.06	−9.45	0.7420	−12.74	---	---	---
All other females	126	0.00	−1.23	3.474	−0.35	0.01	−3.35	3.899	−0.86	---	---	---

Table XI. Number of examined persons by race, sex, and stratum number in the NHANES I design

Stratum number	Total	Number of examined persons by race and sex					
		White males	Black males	All other males	White females	Black females	All other females
Total	20,749	7,004	1,707	109	9,347	2,456	126
1	621	169	88	2	220	138	4
2	367	146	24	0	157	38	2
3	482	123	85	1	171	102	0
4	737	198	102	11	255	162	9
5	741	232	65	13	328	88	15
6	250	67	35	2	85	57	4
7	395	85	90	0	93	127	0
8	188	67	16	0	79	26	0
9	304	109	13	1	149	32	0
10	429	138	32	13	190	37	19
11	481	205	4	0	267	3	2
12	517	198	14	0	286	17	2
13	531	232	2	2	290	4	1
14	701	273	15	2	396	14	1
15	486	185	20	4	226	43	8
16	563	178	68	5	211	98	3
17	594	235	6	0	346	6	1
18	505	176	39	2	224	62	2
19	585	237	12	4	317	14	1
20	446	171	13	1	246	14	1
21	790	344	0	0	446	0	0
22	551	114	107	3	141	185	1
23	619	167	85	0	249	116	2
24	499	131	73	0	170	122	3
25	728	225	73	0	311	119	0
26	887	232	156	0	305	194	0
27	684	262	23	1	379	17	2
28	1,001	259	174	0	327	241	0
29	634	222	51	1	292	68	0
30	868	284	84	1	371	124	4
31	651	221	34	5	334	52	5
32	691	250	22	8	367	32	12
33	619	222	3	21	345	10	18
34	545	236	5	5	295	1	3
35	1,059	411	74	1	479	93	1

Table XII. Number of examined persons by race, sex, and stratum number in the NHANES I design for the detailed sample

Stratum number	Total	Number of examined persons by race and sex					
		White males	Black males	All other males	White females	Black females	All other females
Total	3,854	1,541	277	21	1,667	335	13
1	112	37	13	1	34	27	0
2	80	38	4	0	27	11	0
3	87	23	18	0	29	17	0
4	129	46	15	1	43	23	1
5	143	60	11	4	55	12	1
6	48	17	7	1	12	11	0
7	71	16	18	0	17	20	0
8	42	19	0	0	18	5	0
9	57	25	1	0	27	4	0
10	84	34	8	4	30	5	3
11	100	45	0	0	53	1	1
12	93	40	3	0	49	0	1
13	92	45	1	0	46	0	0
14	129	54	1	0	70	4	0
15	78	43	2	1	27	5	0
16	101	29	13	0	41	18	0
17	107	52	1	0	54	0	0
18	81	41	4	1	28	7	0
19	109	45	2	1	59	2	0
20	81	34	2	0	44	1	0
21	162	72	0	0	90	0	0
22	89	28	17	1	23	20	0
23	112	33	16	0	48	15	0
24	81	28	8	0	30	15	0
25	156	67	8	0	67	14	0
26	150	45	22	0	65	18	0
27	141	65	6	0	68	1	1
28	182	57	26	0	64	35	0
29	126	50	10	0	58	8	0
30	152	63	14	0	64	11	0
31	113	49	3	1	51	8	1
32	123	51	2	2	61	6	1
33	119	45	0	2	69	0	3
34	100	46	2	0	52	0	0
35	224	99	19	1	94	11	0

Table XIII. Summary of multiple regression models for decayed, missing, and filled (DMF) teeth on age, race, sex, and sweets for 6,349 examined persons ages 11-30 years, under analysis options 1-3

Variable	Regression coefficient	Standard error of coefficient	t-statistic	Square root of design effect
		Unweighted SRS design (option 1)		
Age	0.685	0.0130	52.42	---
Race	0.875	0.0899	9.73	---
Sex	-0.491	0.0752	-6.52	---
Sweets	0.057	0.0070	8.21	---
		Weighted SRS design (option 2)		
Age	0.705	0.0125	56.29	---
Race	0.795	0.1072	7.42	---
Sex	-0.465	0.0698	-6.65	---
Sweets	0.049	0.0068	7.17	---
		Weighted complex sampling design (option 3)		
Age	0.705	0.0209	33.67	1.60
Race	0.796	0.2277	3.50	2.53
Sex	-0.465	0.0928	-5.01	1.23
Sweets	0.049	0.0077	6.43	1.09

Appendix II

Definitions of Terms and Variables

Statistical terms

Regression coefficient (B).—The estimated additive effect on the dependent variable for each unit of change in the independent variable within the multiple regression model for which all the other independent variables are held constant.

Sigma (B).—The model-based estimated standard error of the regression coefficient (*B*).

Standardized coefficient (Beta).—The estimated additive effect on the dependent variable for each unit of change in the independent variable which has been standardized to have mean zero and variance unity, within the multiple regression model in which all the other independent variables have been standardized and held constant.

Sigma (Beta).—The model-based estimated standard error of the standardized coefficient (Beta).

Partial r.—The estimated correlation coefficient between the dependent variable and the independent variable within the multiple regression model for which all the other independent variables are held constant.

t-statistic.—The test criterion obtained as the ratio of the regression coefficient (*B*) to its estimated standard error, Sigma (*B*), to test the hypothesis that *B* is zero.

Demographic variables

High school indicator.—An indicator variable based on the reported highest grade attained by head of household. Coded 1 if head of household reported highest grade as 9th grade, 10th grade, 11th grade, or 12th grade. Coded 0 for all other valid responses.

College indicator.—An indicator variable based on the reported highest grade attained by head of household. Coded 1 if head of household reported highest grade as first year of college, second year of college, third year of college, fourth year of college, or graduate. Coded 0 for all other valid responses.

Total family income.—An analytic variable for total family income. The original data available were in the form of 12 income categories. In order to approximate a continuous variable, these codes were transformed as follows:

Code	Income represented	Transformed variable
11.	Under $1,000	0
12.	$1,000-$1,999	1
13.	$2,000-$2,999	2
14.	$3,000-$3,999	3
15.	$4,000-$4,999	4
16.	$5,000-$5,999	5
17.	$6,000-$6,999	6
18.	$7,000-$9,999	8
19.	$10,000-$14,999	12
20.	$15,000-$19,999	17
21.	$20,000-$24,999	22
22.	$25,000 and over	29

Sex indicator.—An indicator variable for sex, coded 0 for males, 1 for females.

Black indicator.—An indicator variable for race, coded 1 for black, 0 for white and other.

Other indicator.—An indicator variable for race, coded 1 for other, 0 for white and black.

Age categories.—Categorical variable based on age of respondent at time of interview. Five categories, ages 6-11, 12-17, 18-44, 45-64, and 65-74 years.

Age at interview.—Age of respondent at interview, in years, taken directly from the supplied tapes.

Dietary variables

Calories as a percent of standard.—Individual caloric intake as the percent of NHANES I dietary standards, computed for food items listed in 24-hour recall.

Protein as a percent of standard.—Individual protein intake as the percent of NHANES I dietary standards, computed for food items listed in 24-hour recall.

Calcium as a percent of standard.—Individual calcium intake as a percent of NHANES I dietary standards, computed for food items listed in 24-hour recall.

Iron as a percent of standard.—Individual iron intake as a percent of NHANES I dietary standards, computed for food items listed in 24-hour recall.

Vitamin A as a percent of standard.—Individual vitamin A intake as a percent of NHANES I dietary standards, computed for food items listed in 24-hour recall.

Vitamin C as a percent of standard.—Individual vitamin C intake as a percent of NHANES I dietary standards, computed for food items listed in 24-hour recall.

Percent of calories from sweets.—Individual caloric intake from the food groups sugar and primarily sugar products, desserts and sweets, and cereals and grain products as a percent of total caloric intake. Computed for items listed in the 24-hour recall.

Percent of calories from between-meal sweets.—Individual caloric intake from the food groups sugar and primarily sugar products, desserts and sweets, and cereals and grain products eaten between meals as a percent of total caloric intake. Computed for items listed in the 24-hour recall.

Number of between-meal sweet snacks.—Number of between-meal snacks from the food groups sugar and primarily sugar products, desserts and sweets, and cereals and grain products eaten between meals. Computed for items listed in the 24-hour recall.

Number of between-meal nonsweet snacks.—Number of between-meal snacks from the food groups other than primarily sugar products, desserts and sweets, and cereals and grain products eaten between meals. Computed for items listed in the 24-hour recall.

Weekly frequency of fruit ingestion.—How often fruit is eaten during the week.

Dental variables

Oral hygiene index (OHI-S).—Oral hygiene index (simplified) score for entire mouth as given in the data provided.

Periodontal index (PI).—Periodontal index score for entire mouth as given in the data provided.

Nonfunctional carious teeth.—Total nonfunctional carious permanent teeth present. A subset of total missing (because of caries) permanent teeth.

Decayed teeth (D).—Total carious permanent teeth.

Missing teeth (M).—Total missing (because of caries) permanent teeth.

Filled teeth (F).—Total filled permanent teeth without decay.

Filled defective teeth.—Total filled defective permanent teeth. A subset of total decayed permanent teeth.

DMFT.—Sum of decayed (D), missing (M), and filled (F) permanent teeth.

Absence of teeth.—Categorical variable for the absence of functional natural teeth. Coded 0 if at least one functional natural tooth, coded 1 if edentulous or all remaining teeth indicated for extraction.

One denture.—Categorical variable for the wearing of dentures by the edentulous for eating. Coded 1 if one denture worn, coded 0 if neither or both worn.

Both dentures.—Categorical variable for the wearing of dentures by the edentulous for eating. Coded 1 if both worn, coded 0 if one or none worn.

Enamel fluoride content.—The natural logarithm of the fluoride content of enamel in parts per million that has been adjusted for biopsy depth. The formula for depth adjustment is:

$$F_{\text{adjusted}} = \frac{F_{\mu(1,287,817)}}{488,502 + \dfrac{1,598,630}{\text{depth in microns}}}$$

Daily tooth-brushing frequency.—Usual daily tooth-brushing frequency.

Behavioral variables

Dental visit pattern.—An ordinal variable created from answers to a series of questions concerning the most recent dental office visit. The variable has the following seven levels:

1. Less than 6 months ago.
2. At least 6 months, but less than 1 year.
3. At least 1 year, but less than 2 years.
4. At least 1 year, but less than 4 years.
5. Four or more years.
6. A visit to a dentist at a site other than a dental office (e.g., hospital emergency room).
7. Never visited a dentist.

Tobacco use.—The tobacco-use variable allocated subjects into the following three categories:

1. Never have used tobacco in quantities up to or equal to the amounts stated in the medical history questionnaire, that is, at least 100 cigarettes, 50 cigars, or 3 packages of pipe tobacco during the subject's lifetime.
2. Have used tobacco at least up to the amounts stated in the questionnaire but do not use tobacco now.
3. Used tobacco at the time of the interview, at least up to the amount stated in the questionnaire.

Used tobacco in the past.—An indicator variable coded 1 = used tobacco in any form in the past but do not use it now, 0 = other.

Use tobacco now.—An indicator variable coded 1 = use tobacco in any form now, 0 = other.

Alcohol consumption.—Categorical variable derived from three other variables. The four categories are as follows:

1. None: Those who claimed not to have had a drink in the past.
2. Little: Those who claimed to drink no more than once a week *and* when they did drink had three or fewer drinks.
3. Moderate: Those who stated they drank more than once a week but have three or fewer drinks at a time, or those who drink no more than once a week but have four or more drinks when they do.
4. Heavy: Those who claimed to drink more often than once a week *and* have four or more drinks at a time.

Other variables used

Other variables that were used but that do not appear in the detailed tables are the following:

Dietary calcium
Dietary phosphorus
Weekly frequency of desserts
Weekly frequency of candy
Weekly frequency of sugar drinks
Calories per kilogram of body weight
Protein per kilogram of body weight
Fat per kilogram of body weight
Carbohydrates per kilogram of body weight
Calcium per kilogram of body weight
Phosphorus per kilogram of body weight
Iron per kilogram of body weight
Sodium per kilogram of body weight
Potassium per kilogram of body weight
Vitamin A per kilogram of body weight
Thiamin per kilogram of body weight
Riboflavin per kilogram of body weight
Niacin per kilogram of body weight
Vitamin C per kilogram of body weight
Protein as a percent of calories
Fat as a percent of calories
Carbohydrates as a percent of calories
Calcium to phosphorus ratio (dietary)
Serum calcium
Serum phosphorus
Calcium to phosphorus ratio (serum)

Definitions of food groups in 24-hour recall data

Milk and milk products.—Includes milk drunk as a beverage or used on cereals; flavored milk drinks; cocoa made from milk; skim milk, yogurt, or buttermilk; ice milk; ice cream or puddings made with milk; cheese and cheese dishes. Exception: cream cheese.

Meat.—Includes beef, pork, lamb, veal, luncheon meats, canned meats, and frankfurters.

Poultry.—Includes chicken, turkey, duck, game birds, and cornish hen.

Organ meats.—Includes liver, kidney, heart, and spleen.

Fish or shellfish.—All varieties of fish and shellfish regardless of whether canned, fresh, frozen, dried, or salted.

Eggs.—Includes eggs eaten, e.g., fried, boiled, poached, deviled, or egg salad. Exceptions: eggs in cooked or baked dishes (as in custards or puddings).

Soups, sauces, and gravies.—Includes milk- and water-based stocks and meat- and vegetable-based gravies and sauces.

Fats and oils.—Includes butter, margarine, salad oil, salad dressing, bacon, cream cheese, cream, peanut butter, nondairy cream, and olives.

Legumes and nuts.—Includes cooked dry beans and peas and previously dried legumes and nuts such as pinto; red beans, black-eyed peas, lentils, peanuts, soy beans, and soy products.

Cereals and grain products.—Includes breakfast cereals, either dry such as cornflakes or cooked such as oatmeal; grain products such as bread, rolls, biscuits, muffins, cornbread, crackers, unsalted pretzels, rice, and pasta.

Fruits and vegetables.—Includes raw, canned, frozen, or cooked produce; fruits and vegetables rich in vitamin A; and fruits and vegetables rich in vitamin C.

Sugar and primarily sugar products.—Includes all candy, fruitades, soft drinks, jam, jelly, honey, sugar, and icings.

Desserts and sweets.—Includes cake, pie, cookies, fruit puddings, nonprotein gelatins, doughnuts (cake-type and yeast-type), sherbet, and sweet snacks. Exceptions: ice cream and ice milk.

Miscellaneous.—Includes mustard, gelatin, malt, beverage powders, chili powder, seeds, and low-fat salad dressings.

Mixed protein dishes with carbohydrates (starches) or vegetables.—Includes casseroles, pot pies, pizza, and pasta dishes with meat. Exceptions: plain cheese dishes.

Alcoholic beverages.—Includes beer, wine, and distilled liquors.

Sugar-free and low-calorie beverages.—Includes coffee (regular and decaffeinated), tea, bouillon, consomme, and low-calorie carbonated drinks.

Salty snacks.—Includes potato chips, corn chips, puffed snacks, cheese snacks, salted popcorn, and salted pretzels.

Table XIV. Major functions, problems associated with deficiency, and major food sources of calories and selected nutrients

Calorie and nutrient	*Major function*	*Problems associated with deficiency*	*Major food sources*
Calorie	Supplies energy for growth and development, basal metabolism, and physical activity	Inadequate caloric intake in children is evidenced by lack of growth and energy, loss of weight in all age groups	All foods; starchy, sweet, and fat foods are concentrated sources
Protein	Essential for normal growth and development; for maintenance and repair of all body tissue	A severe or prolonged deficiency results in retarded growth; symptoms may include edema, lassitude, and decreased resistance to infections	Eggs, milk and milk products, meats, fish, poultry, soybeans, dried beans, peas, and nuts
Vitamin A	Essential for the maintenance of healthy skin and mucous membranes, for normal night vision; aids in maintaining resistance to infections	Deficiency signs: night blindness and skin changes characterized by dry, rough skin. Prolonged deficiency can lead to permanent blindness	Liver, whole milk and whole milk products, and dark green leafy and deep yellow vegetables
Vitamin C	Production of intercellular cementing substance; wound healing; plays a role in normal resistance to infections	Deficiency results in soft, spongy gums, prolonged wound healing, and in the advanced deficiency state, the classical disease scurvy	Citrus fruits, tomatoes, strawberries, cantaloupe, raw cabbage, and green peppers
Calcium	Necessary for formation of bones and teeth; plays a role in blood coagulation and normal reactions of nerve and muscle tissue	Deficiency in children may be associated with rickets; in adults, calcium may be lost from the bones (osteoporosis)	Milk and milk products, certain green leafy vegetables, oysters, clams, and shrimp
Iron	Necessary for formation of hemoglobin, the oxygen-carrying pigment of red blood cells	Weakness and fatigability; advanced deficiency leads to anemia	Liver and other organ meats, dark green leafy vegetables, dried fruits, whole grain and enriched cereals and cereal products, and molasses
Thiamin	Essential for growth, normal function of the nervous system, and normal metabolism	Deficiency results in retarded growth, edema, and changes in the nervous system; advanced deficiency can result in beriberi	Liver, eggs, whole grain or enriched cereals and cereal products, and lean meat
Riboflavin	Essential for utilization of protein and is also involved in other metabolic processes	Deficiency can result in skin changes such as angular lesions, tongue changes, and poor growth	Dairy products are the major source, but meats and green leafy vegetables are other sources
Niacin	Essential for normal digestion and utilization of food	The classical deficiency state is pellagra, characterized by diarrhea, dermatitis, dementia, and death	Liver, meats, whole grain, and enriched cereals and cereal products

Table XV. Standards for evaluation of daily dietary intakes used in the National Health and Nutrition Examination Survey, by age, sex, and physiological state: United States, 1971-74

Age, sex, and physiological state	*Calories (per kg)*	*Protein (gm per kg)*	*Calcium (mg)*	*Iron (mg)*	*Vitamin A[1] (IU)*	*Vitamin C (mg)*	*B vitamins (all ages)*
Age and sex							
1-5 years:							
12-23 months, male and female	90	1.9	450	15	2,000	40	Thiamin,
24-47 months, male and female	86	1.7	450	15	2,000	40	0.4 mg/
48-71 months, male and female	82	1.5	450	10	2,000	40	1,000
6-7 years, male and female	82	1.3	450	10	2,500	40	calories
8-9 years, male and female	82	1.3	450	10	2,500	40	
10-12 years:							Riboflavin,
Male	68	1.2	650	10	2,500	40	0.55 mg/
Female	64	1.2	650	18	2,500	40	1,000
13-16 years:							calories
Male	60	1.2	650	18	3,500	50	
Female	48	1.2	650	18	3,500	50	Niacin,
17-19 years:							6.6 mg/
Male	44	1.1	550	18	3,500	55	1,000
Female	35	1.1	550	18	3,500	50	calories
20-29 years:							
Male	40	1.0	400	10	3,500	60	
Female	35	1.0	600	18	3,500	55	
30-39 years:							
Male	38	1.0	400	10	3,500	60	
Female	33	1.0	600	18	3,500	55	
40-49 years:							
Male	37	1.0	400	10	3,500	60	
Female	31	1.0	600	18	3,500	55	
50-54 years:							
Male	36	1.0	400	10	3,500	60	
Female	30	1.0	600	18	3,500	55	
55-59 years:							
Male	36	1.0	400	10	3,500	60	
Female	30	1.0	600	10	3,500	55	
60-69 years:							
Male	34	1.0	400	10	3,500	60	
Female	29	1.0	600	10	3,500	55	
70 years and over:							
Male	34	1.0	400	10	3,500	60	
Female	29	1.0	600	10	3,500	55	
Physiological state							
Pregnancy (5th month and beyond), add to basic standard	200	20	200		1,000	5[2]	
Lactating, add to basic standard	1,000	25	500		1,000	5	

[1]Assumed 70 percent carotene, 30 percent retinol.
[2]For all pregnancies.

Appendix III

The Dental Examination

The examination

The dental examination findings were recorded on a form that eliminated the time-consuming task of coding and keypunching. The form (figure I), four pages bound at the lefthand margin, was fed into an Optical Mark Page Reader that read the findings and entered the data directly on IBM cards.

Instructions for determining the conditions of individual teeth and recording the information were as follows:

1. Primary tooth present—A primary tooth was coded as "D," and its status was also coded.
2. Permanent tooth present—Only the status of a permanent tooth was coded.
3. Normal—Unfilled teeth without carious lesions were coded as "3."
4. Carious—Unfilled teeth with carious lesions were coded according to the surfaces involved.
5. Filled (including crown)—Teeth with satisfactory fillings and no carious lesions were coded according to the surfaces involved.
6. Filled defective (or tooth both filled and carious)—Filled or crowned teeth with new or recurrent carious lesions were coded according to the surfaces involved. Noncarious filled teeth were coded in the same way when the restoration was loose, or fractured, and the base or pulpal wall of the cavity preparation was exposed. Teeth with temporary fillings or crowns were coded as filled defective.
7. Nonfunctional-carious—When decay had penetrated the pulp chamber of a tooth, the tooth was coded under "XD." Carious teeth are nonfunctional when there was the following evidence:
   a. Visible evidence of a periapical abscess or pulpal exposure.
   b. Visible evidence of extensive undermining of all enamel walls or if roots only were remaining.
8. Retained deciduous teeth—When any portion of the succedaneous tooth could be seen, it was given an appropriate status code under teeth present and also coded "XD" and "D."
9. Missing teeth (unerupted, extracted, and replaced)—When neither a primary nor a permanent tooth was present (the tooth space may have been vacant or the missing tooth may have been replaced by a fixed or removable partial denture), a code was recorded indicating the status of the tooth space. For persons 35 years old or under, the reason that the tooth was missing should have been determined. When there was doubt, it was scored as missing because of decay. The codes were as follows:

   2 = Unerupted, primary.

   0 = Unerupted, permanent.

   IR = Extracted, caries.

   1 = Extracted, accident, orthodontics, impaction.

   F = Missing, replaced on a fixed bridge. The reason for extraction was also coded if the sample person was age 35 years or under.

   FD = Missing, replaced on a defective fixed bridge. The reason for extraction was also coded if the sample person was age 35 years or under.

   Fixed bridges were defective:

   A. When one of the abutment teeth was nonfunctional because of either caries or loss of supporting structure, or when there was visible evidence of periapical pathology.

   B. When the connection of the pontic with its abutment was broken.

   C. When an abutment crown or inlay was defective because of one of the following reasons:

      1. The tooth structures exposed by abrasion of the crown or inlay were carious.

DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
PUBLIC HEALTH SERVICE
HEALTH SERVICES AND MENTAL HEALTH ADMINISTRATION
NATIONAL CENTER FOR HEALTH STATISTICS
ROCKVILLE, MARYLAND 20852

Confidentiality has been assured the individual as set forth in 22 FR 1687

HEALTH AND NUTRITION EXAMINATION SURVEY IV
DENTAL EXAMINATION

NAME

STAND AND CONTROL									
0	1	2	3	4	5	6	7	8	9
0	1	2	3	4	5	6	7	8	9
0	1	2	3	4	5	6	7	8	9
0	1	2	3	4	5	6	7	8	9
0	1	2	3	4	5	6	7	8	9

AGE										
0	1	2	3	4	TENS	5	6	7	8	9
0	1	2	3	4	UNITS	5	6	7	8	9

SEX—RACE: MW FW MN FN MO FO

EXAMINEE									
0	1	2	3	4	5	6	7	8	9
0	1	2	3	4	5	6	7	8	9
0	1	2	3	4	5	6	7	8	9

UPPER LEFT						UPPER RIGHT						LOWER LEFT						LOWER RIGHT				
XD	D	2	0	IR		XD	D	2	0	IR	CENTRAL	XD	D	2	0	IR		XD	D	2	0	IR
6X	3	0	4X	5X	OCC	6X	3	0	4X	5X		6X	3	0	4X	5X	OCC	6X	3	0	4X	5X
60			40	50	LIN	60			40	50		60			40	50	LIN	60			40	50
61			41	51	BUC	61			41	51		61			41	51	BUC	61			41	51
62	F	R	42	52	MES	62	F	R	42	52		62	F	R	42	52	MES	62	F	R	42	52
63	FD	RD	43	53	DIS	63	FD	RD	43	53		63	FD	RD	43	53	DIS	63	FD	RD	43	53
XD	D	2	0	IR		XD	D	2	0	IR	LATERAL	XD	D	2	0	IR		XD	D	2	0	IR
6X	3	0	4X	5X	OCC	6X	3	0	4X	5X		6X	3	0	4X	5X	OCC	6X	3	0	4X	5X
60			40	50	LIN	60			40	50		60			40	50	LIN	60			40	50
61			41	51	BUC	61			41	51		61			41	51	BUC	61			41	51
62	F	R	42	52	MES	62	F	R	42	52		62	F	R	42	52	MES	62	F	R	42	52
63	FD	RD	43	53	DIS	63	FD	RD	43	53		63	FD	RD	43	53	DIS	63	FD	RD	43	53
XD	D	2	0	IR		XD	D	2	0	IR	CUSPID	XD	D	2	0	IR		XD	D	2	0	IR
6X	3	0	4X	5X	OCC	6X	3	0	4X	5X		6X	3	0	4X	5X	OCC	6X	3	0	4X	5X
60			40	50	LIN	60			40	50		60			40	50	LIN	60			40	50
61			41	51	BUC	61			41	51		61			41	51	BUC	61			41	51
62	F	R	42	52	MES	62	F	R	42	52		62	F	R	42	52	MES	62	F	R	42	52
63	FD	RD	43	53	DIS	63	FD	RD	43	53		63	FD	RD	43	53	DIS	63	FD	RD	43	53
XD	D	2	0	IR		XD	D	2	0	IR	1ST BICUSPID	XD	D	2	0	IR		XD	D	2	0	IR
6X	3	0	4X	5X	OCC	6X	3	0	4X	5X		6X	3	0	4X	5X	OCC	6X	3	0	4X	5X
60			40	50	LIN	60			40	50		60			40	50	LIN	60			40	50
61			41	51	BUC	61			41	51		61			41	51	BUC	61			41	51
62	F	R	42	52	MES	62	F	R	42	52		62	F	R	42	52	MES	62	F	R	42	52
63	FD	RD	43	53	DIS	63	FD	RD	43	53		63	FD	RD	43	53	DIS	63	FD	RD	43	53
XD	D	2	0	IR		XD	D	2	0	IR	2ND BICUSPID	XD	D	2	0	IR		XD	D	2	0	IR
6X	3	0	4X	5X	OCC	6X	3	0	4X	5X		6X	3	0	4X	5X	OCC	6X	3	0	4X	5X
60			40	50	LIN	60			40	50		60			40	50	LIN	60			40	50
61			41	51	BUC	61			41	51		61			41	51	BUC	61			41	51
62	F	R	42	52	MES	62	F	R	42	52		62	F	R	42	52	MES	62	F	R	42	52
63	FD	RD	43	53	DIS	63	FD	RD	43	53		63	FD	RD	43	53	DIS	63	FD	RD	43	53
XD		2	0	IR		XD		2	0	IR	1ST MOLAR	XD		2	0	IR		XD		2	0	IR
6X	3	0	4X	5X	OCC	6X	3	0	4X	5X		6X	3	0	4X	5X	OCC	6X	3	0	4X	5X
60			40	50	LIN	60			40	50		60			40	50	LIN	60			40	50
61			41	51	BUC	61			41	51		61			41	51	BUC	61			41	51
62	F	R	42	52	MES	62	F	R	42	52		62	F	R	42	52	MES	62	F	R	42	52
63	FD	RD	43	53	DIS	63	FD	RD	43	53		63	FD	RD	43	53	DIS	63	FD	RD	43	53

Figure I. Dental examination form.

DENTAL EXAMINATION

:0:	:1:	:2:	:3:	:4:		:5:	:6:	:7:	:8:	:9:
:0:	:1:	:2:	:3:	:4:	STAND	:5:	:6:	:7:	:8:	:9:
:0:	:1:	:2:	:3:	:4:	AND	:5:	:6:	:7:	:8:	:9:
:0:	:1:	:2:	:3:	:4:	CONTROL	:5:	:6:	:7:	:8:	:9:
:0:	:1:	:2:	:3:	:4:		:5:	:6:	:7:	:8:	:9:

UPPER LEFT						UPPER RIGHT						LOWER LEFT						LOWER RIGHT				
:XD:	:::::	:2:	:0:	:R:		:XD:	:::::	:2:	:0:	:R:	2ND MOLAR	:XD:	:::::	:2:	:0:	:R:		:XD:	:::::	:2:	:0:	:R:
:6X:	:3:	:0:	:4X:	:5X:	OCC	:6X:	:3:	:0:	:4X:	:5X:		:6X:	:3:	:0:	:4X:	:5X:	OCC	:6X:	:3:	:0:	:4X:	:5X:
:60:	:::::	:::::	:40:	:50:	LIN	:60:	:::::	:::::	:40:	:50:		:60:	:::::	:::::	:40:	:50:	LIN	:60:	:::::	:::::	:40:	:50:
:61:	:::::	:::::	:41:	:51:	BUC	:61:	:::::	:::::	:41:	:51:		:61:	:::::	:::::	:41:	:51:	BUC	:61:	:::::	:::::	:41:	:51:
:62:	:F:	:R:	:42:	:52:	MES	:62:	:F:	:R:	:42:	:52:		:62:	:F:	:R:	:42:	:52:	MES	:62:	:F:	:R:	:42:	:52:
:63:	:FD:	:RD:	:43:	:53:	DIS	:63:	:FD:	:RD:	:43:	:53:		:63:	:FD:	:RD:	:43:	:53:	DIS	:63:	:FD:	:RD:	:43:	:53:
:XD:	:::::	:2:	:0:	:R:		:XD:	:::::	:2:	:0:	:R:	3RD MOLAR	:XD:	:::::	:2:	:0:	:R:		:XD:	:::::	:2:	:0:	:R:
:6X:	:3:	:0:	:4X:	:5X:	OCC	:6X:	:3:	:0:	:4X:	:5X:		:6X:	:3:	:0:	:4X:	:5X:	OCC	:6X:	:3:	:0:	:4X:	:5X:
:60:	:::::	:::::	:40:	:50:	LIN	:60:	:::::	:::::	:40:	:50:		:60:	:::::	:::::	:40:	:50:	LIN	:60:	:::::	:::::	:40:	:50:
:61:	:::::	:::::	:41:	:51:	BUC	:61:	:::::	:::::	:41:	:51:		:61:	:::::	:::::	:41:	:51:	BUC	:61:	:::::	:::::	:41:	:51:
:62:	:F:	:R:	:42:	:52:	MES	:62:	:F:	:R:	:42:	:52:		:62:	:F:	:R:	:42:	:52:	MES	:62:	:F:	:R:	:42:	:52:
:63:	:FD:	:RD:	:43:	:53:	DIS	:63:	:FD:	:RD:	:43:	:53:		:63:	:FD:	:RD:	:43:	:53:	DIS	:63:	:FD:	:RD:	:43:	:53:

PERIODONTAL INDEX (NO P. I. :::::)				QUADRANT	MISSING OR ROOTS ONLY	TOOTH SPACE	MISSING OR ROOTS ONLY	QUADRANT	PERIODONTAL INDEX			
					:NA:		:NA:					
1	2	6	8		X		X		1	2	6	8
:1:	:1:	:1:	:1:	UPPER ARCH RIGHT	:1:	3RD MOLAR	:17:	LOWER ARCH LEFT	:17:	:17:	:17:	:17:
:2:	:2:	:2:	:2:		:2:	2ND MOLAR	:18:		:18:	:18:	:18:	:18:
:3:	:3:	:3:	:3:		:3:	1ST MOLAR	:19:		:19:	:19:	:19:	:19:
:4:	:4:	:4:	:4:		:4:	2ND BI	:20:		:20:	:20:	:20:	:20:
:5:	:5:	:5:	:5:		:5:	1ST BI	:21:		:21:	:21:	:21:	:21:
:6:	:6:	:6:	:6:		:6:	CUSPID	:22:		:22:	:22:	:22:	:22:
:7:	:7:	:7:	:7:		:7:	LATERAL	:23:		:23:	:23:	:23:	:23:
:8:	:8:	:8:	:8:		:8:	CENTRAL	:24:		:24:	:24:	:24:	:24:
1	2	6	8		X		X		1	2	6	8
:9:	:9:	:9:	:9:	UPPER ARCH LEFT	:9:	CENTRAL	:25:	LOWER ARCH RIGHT	:25:	:25:	:25:	:25:
:10:	:10:	:10:	:10:		:10:	LATERAL	:26:		:26:	:26:	:26:	:26:
:11:	:11:	:11:	:11:		:11:	CUSPID	:27:		:27:	:27:	:27:	:27:
:12:	:12:	:12:	:12:		:12:	1ST BI	:28:		:28:	:28:	:28:	:28:
:13:	:13:	:13:	:13:		:13:	2ND BI	:29:		:29:	:29:	:29:	:29:
:14:	:14:	:14:	:14:		:14:	1ST MOLAR	:30:		:30:	:30:	:30:	:30:
:15:	:15:	:15:	:15:		:15:	2ND MOLAR	:31:		:31:	:31:	:31:	:31:
:16:	:16:	:16:	:16:		:16:	3RD MOLAR	:32:		:32:	:32:	:32:	:32:

OPACITIES	NON-FLUORIDE	FLUORIDE
NONE	:::::	:::::
MILD	:::::	:::::
MODERATE-SEVERE	:::::	:::::
NA	:::::	:::::

OTHER CONDITIONS	YES	NO
BLEEDING GUMS	:::::	:::::
DIFFUSE MARGINAL INFLAMMATION	:::::	:::::
SWOLLEN RED PAPILLAE	:::::	:::::
RECESSION	:::::	:::::

FOUR OR MORE PAIRS OF OPPOSING SERVICEABLE POSTERIOR TEETH ::::: PRESENT ::::: ABSENT

ORTHODONTIC APPLIANCE ::::: PRESENT ::::: ABSENT

ORAL HYGIENE INDEX

UPPER ARCH									LOWER ARCH								
RIGHT			ANTERIOR			LEFT			RIGHT			ANTERIOR			LEFT		
DEBRIS		CALCULUS	DEBRIS		CALCULUS	DEBRIS		CALCULUS	DEBRIS		CALCULUS	DEBRIS		CALCULUS	DEBRIS		CALCULUS
:0:	NONE	:0:	:0:	NONE	:0:	:0:	NONE	:0:	:0:	NONE	:0:	:0:	NONE	:0:	:0:	NONE	:0:
:1:	1/3	:1:	:1:	1/3	:1:	:1:	1/3	:1:	:1:	1/3	:1:	:1:	1/3	:1:	:1:	1/3	:1:
:2:	2/3	:2:	:2:	2/3	:2:	:2:	2/3	:2:	:2:	2/3	:2:	:2:	2/3	:2:	:2:	2/3	:2:
:3:	2/3+	:3:	:3:	2/3+	:3:	:3:	2/3+	:3:	:3:	2/3+	:3:	:3:	2/3+	:3:	:3:	2/3+	:3:
:NA:		:NA:	:NA:		:NA:	:NA:		:NA:	:NA:		:NA:	:NA:		:NA:	:NA:		:NA:

Figure 1. Dental examination form—Con.

DENTAL EXAMINATION

::0::	::1::	::2::	::3::	::4::	::5::	::6::	::7::	::8::	::9::
::0::	::1::	::2::	::3::	::4::	::5::	::6::	::7::	::8::	::9::
::0::	::1::	::2::	::3::	::4::	::5::	::6::	::7::	::8::	::9::
::0::	::1::	::2::	::3::	::4::	::5::	::6::	::7::	::8::	::9::
::0::	::1::	::2::	::3::	::4::	::5::	::6::	::7::	::8::	::9::

STAND AND CONTROL

BUCCAL SEGMENT RELATION

RIGHT	LEFT	
::1::	::1::	MESIAL-SEVERE
::2::	::2::	-MODERATE
::3::	::3::	NORMAL
::4::	::4::	DISTAL-MODERATE
::5::	::5::	-SEVERE
::NA:	::NA:	NOT APPLICABLE
:::::	:::::	PRIMARY ARCH

POSTERIOR CROSSBITE

RIGHT BUCCAL	RIGHT LINGUAL	LEFT BUCCAL	LEFT LINGUAL
::0::	::0::	::0::	::0::
::1::	::1::	::1::	::1::
::2::	::2::	::2::	::2::
::3::	::3::	::3::	::3::
::4::	::4::	::4::	::4::
::5::	::5::	::5::	::5::
::NA:	::NA:	::NA:	::NA:

ENAMEL BIOPSY

::NO: TEETH ABSENT

::NO: EQUIPMENT FAILURE

::NO: OTHER REASON ______

::YES:

TOOTH

::7:: ::8::

::10: ::9::

HLD INDEX (HANDICAPPING LABIO-LINGUAL DEVIATIONS)

OVERJET		MANDIBULAR PROTRUSION	
::0::	::0::	::0::	::0::
::1::	::1::	::1::	::1::
::2::	::2::	::2::	::2::
::3::	::3::	::3::	::3::
	::4::		::4::
	::5::		::5::
	::6::		::6::
	::7::		::7::
	::8::		::8::
	::9::		::9::
	::NA:		::NA:

INCISOR RELATIONSHIP		OVERBITE	
	OPENBITE (MM)	::0::	::0::
::1::	4+	::1::	::1::
::2::	2+-4	::2::	::2::
::3::	0-2	::3::	::3::
	OVERBITE		::4::
::4::	INC 3RD		::5::
::5::	MID 3RD		::6::
::6::	GIN 3RD		::7::
::7::	TISSUE		::8::
::8::	IMPINGING OVERBITE		::9::
::NA:	NOT APPLICABLE		::NA:

OPENBITE		LABIO-LINGUAL SPREAD		DEFORMITY
::0::	::0::	::0::	::0::	::::: ABSENT
::1::	::1::	::1::	::1::	
::2::	::2::	::2::	::2::	::::: PRESENT
::3::	::3::	::3::	::3::	
	::4::		::4::	
	::5::		::5::	
	::6::		::6::	
	::7::		::7::	
	::8::		::8::	
	::9::		::9::	
	::NA:		::NA:	

MALALIGNED TEETH

UPPER ::NA:

ANTERIOR

::0:: ::1:: ::2:: ::3:: ::4:: MINOR ::5:: ::6::

::0:: ::1:: ::2:: ::3:: ::4:: MAJOR ::5:: ::6::

POSTERIOR

::0:: ::1:: ::2:: ::3:: ::4:: MINOR ::5:: ::6:: ::7:: ::8:: ::9::

::0:: ::1:: ::2:: ::3:: ::4:: MAJOR ::5:: ::6:: ::7:: ::8:: ::9::

LOWER

ANTERIOR

::0:: ::1:: ::2:: ::3:: ::4:: MINOR ::5:: ::6::

::0:: ::1:: ::2:: ::3:: ::4:: MAJOR ::5:: ::6::

POSTERIOR

::0:: ::1:: ::2:: ::3:: ::4:: MINOR ::5:: ::6:: ::7:: ::8:: ::9::

::0:: ::1:: ::2:: ::3:: ::4:: MAJOR ::5:: ::6:: ::7:: ::8:: ::9::

EXAMINER ::1:: ::2:: ::3:: ::4:: ::5:: ::6:: ::7:: ::8::

RECORDER ::1:: ::2:: ::3:: ::4:: ::5:: ::6:: ::7:: ::8::

EDENTULOUS ARCHES-DENTURE STATUS

	ABSENT	PRESENT	DEFECTIVE
UPPER	:::::	:::::	:::::
LOWER	:::::	:::::	:::::

WHEN YOU EAT,	YES	NO
DO YOU USE AN UPPER PLATE?	:::::	:::::
DO YOU USE A LOWER PLATE?	:::::	:::::

REMARKS: PRESENT ::::: ABSENT :::::

______

______

______

______

______

Figure I. Dental examination form—Con.

DENTAL EXAMINATION

STAND AND CONTROL

0	1	2	3	4	5	6	7	8	9
0	1	2	3	4	5	6	7	8	9
0	1	2	3	4	5	6	7	8	9
0	1	2	3	4	5	6	7	8	9
0	1	2	3	4	5	6	7	8	9

INTERVIEW

DO YOU HAVE ANY TROUBLE; YES NO

CHEWING STEAKS, CHOPS OR FIRM MEATS? :::: ::::

BITING APPLES OR CORN-ON-THE-COB? :::: ::::

BITING OR CHEWING ANY OTHER FOODS? :::: ::::

TREATMENT NEEDS

:::: NO APPARENT NEED FOR DENTAL CARE

YES NO

:::: :::: REMOVAL OF DEBRIS AND CALCULUS

:::: :::: GINGIVITIS TREATMENT

:::: :::: PERIODONTAL DISEASE TREATMENT

:::: :::: SEVERE MALOCCLUSION TREATMENT

:::: :::: DECAYED PRIMARY TEETH

		0	1	2	3	4		5	6	7	8	9
ONE-SURFACE FILLINGS	TENS	::::	::::	::::	::::							
	UNITS	::::	::::	::::	::::	::::		::::	::::	::::	::::	::::
TWO-SURFACE FILLINGS	TENS	::::	::::	::::	::::							
	UNITS	::::	::::	::::	::::	::::		::::	::::	::::	::::	::::
THREE (OR MORE)-SURFACE FILLINGS	TENS	::::	::::	::::	::::							
	UNITS	::::	::::	::::	::::	::::		::::	::::	::::	::::	::::
EXTRACTIONS	TENS	::::	::::	::::	::::							
	UNITS	::::	::::	::::	::::	::::		::::	::::	::::	::::	::::

:::: :::: DECAYED PERMANENT TEETH

		0	1	2	3	4		5	6	7	8	9
ONE-SURFACE FILLINGS	TENS	::::	::::	::::	::::							
	UNITS	::::	::::	::::	::::	::::		::::	::::	::::	::::	::::
TWO-SURFACE FILLINGS	TENS	::::	::::	::::	::::							
	UNITS	::::	::::	::::	::::	::::		::::	::::	::::	::::	::::
THREE (OR MORE)-SURFACE FILLINGS	TENS	::::	::::	::::	::::							
	UNITS	::::	::::	::::	::::	::::		::::	::::	::::	::::	::::
EXTRACTIONS	TENS	::::	::::	::::	::::							
	UNITS	::::	::::	::::	::::	::::		::::	::::	::::	::::	::::

		0	1	2	3	4		5	6	7	8	9
:::: :::: EXTRACTIONS, PERIODONTAL DISEASE	TENS	::::	::::	::::	::::							
	UNITS	::::	::::	::::	::::	::::		::::	::::	::::	::::	::::
:::: :::: EXTRACTIONS, OTHER	TENS	::::	::::	::::	::::							
	UNITS	::::	::::	::::	::::	::::		::::	::::	::::	::::	::::

:::: :::: FIXED BRIDGES AND/OR PARTIAL DENTURES INDICATED REPLACING TEETH NO.'S

UPPER ARCH	1	2	3	4	5	6	7	8
	9	10	11	12	13	14	15	16
LOWER ARCH	17	18	19	20	21	22	23	24
	25	26	27	28	29	30	31	32
NO. OF BRIDGES		1	2	3	4	5	6	
NO. OF PARTIALS		1	2	3	4	5	6	

:::: :::: REPAIR OR RELINE OF DENTURE OR BRIDGE

REPAIR	F.U. ::::	F.L. ::::	P.U. ::::	P.L. ::::
RELINE	F.U. ::::	F.L. ::::	P.U. ::::	P.L. ::::

:::: :::: CONSTRUCT DENTURE(S) F.U. :::: F.L. ::::

Figure 1. Dental examination form—Con.

2. A carious lesion at one of the margins of the restoration had resulted in extensive undermining of an enamel wall.

The periodontal index (PI)

Scores were assigned according to the following criteria:

0 – Negative. There is neither overt inflammation in the investing tissues nor loss of function due to destruction of supporting tissues.

1 – Mild gingivitis. There is an overt area of inflammation in the free gingivae but the area does not circumscribe the tooth.

2 – Gingivitis. Inflammation completely circumscribes the tooth but there is no apparent break in the epithelial attachment.

6 – Gingivitis with pocket formation. The epithelial attachment has been broken, and there is a pocket (not merely a deepened gingival crevice due to swelling in the free gingivae). There is no interference with normal masticatory function; the tooth is firm in its socket and has not drifted.

8 – Advanced destruction with loss of masticatory function. The tooth may be loose; may have drifted; may sound dull on percussion with a metallic instrument.

RULE: When in doubt, assign the lesser score.

Each tooth present in the mouth, unless it was a root, was scored, and the arithmetic average of all scores was the individual's PI.

The simplified oral hygiene index (OHI-S)

Selected surfaces of six teeth were used in making this estimation of oral hygiene status. For the purposes of this examination each surface that was used, buccal or lingual, was considered to encompass half of the circumference of the tooth. The buccal surface of a molar, for example, was considered to include half of the mesial surface and half of the distal.

On both sides of the arch the posterior tooth assessed was the most anterior, fully erupted permanent molar or, in its absence, the most distal fully erupted primary molar. In most cases, this was a first permanent molar; in other cases it was a first or second primary molar or a second permanent molar. The buccal surfaces of upper molars and the lingual of lower molars were examined. In the anterior portion of the mouth, the labial surfaces of the upper right central incisor and the lower left central incisor were examined. When these teeth were missing, only the adjacent central incisor was examined.

Examining for oral debris.—The surface area covered by debris was estimated by running a No. 5 explorer along the surface being examined and noting the occlusal or incisal extent of the debris as it was removed from the tooth surface and adhered to the explorer.

Scores were assigned according to the following criteria:

0 – No debris or stain present.

1 – (a) Soft debris covering not more than the gingival third of the tooth surface, or
(b) the presence of extrinsic stains without debris regardless of surface area covered.

2 – Soft debris covering more than one-third but not more than two-thirds of the exposed tooth surface.

3 – Soft debris covering more than two-thirds of the exposed tooth surface.

Examining for oral calculus.—A No. 5 explorer was also used to estimate the surface area covered by supragingival calculus and to probe for subgingival calculus.

Scores were assigned according to the following criteria:

0 – No calculus present.

1 – Supragingival calculus covering not more than one-third of the exposed tooth surface.

2 – Supragingival calculus covering more than one-third but not more than two-thirds of the exposed tooth surface and/or the presence of individual flecks of subgingival calculus around the cervical portion of the tooth.

3 – Supragingival calculus covering more than two-thirds of the exposed tooth surface and/or a continuous heavy band of subgingival calculus around the cervical portion of the tooth.

Edentulous arches—denture status

No entry was made in this section unless at least one arch was edentulous. An arch with erupted or partly erupted teeth was considered edentulous if a full denture was being used.

Absent.—No teeth (or roots) were present in the arch and the examinee did not have a denture either in the mouth or on his or her person at the time of examination.

Present.—A denture was present in the mouth and not defective at the time of examination.

Defective.—There was visible evidence that the denture was causing extensive destruction of the primary stress-bearing areas of the ridge or palate. Tissue in these areas may have been acutely inflamed; bone resorption may have occurred, hyperthrophied tissue may have been present. The denture was also defective if it was in the possession of the examinee at the time of the examination but not in the mouth. If a denture status code for either or both arches was marked, the following should also be true:

A. The spaces for the appropriate arch (or arches) under Status of Tooth Spaces, Periodontal Index, and Malaligned Teeth should be left blank.

B. The "NA" spaces for the appropriate arch (or arches) under OHI should be marked.

C. The "NA" spaces under Opacities, Buccal Segment Relation, Posterior Crossbite, Incisor Relationship, and Handicapping Labio-Lingual Deviations (HLD) index should be marked.

Treatment needs

This estimate was based on the examiner's clinical judgment. Certain factors, however, should have been kept in mind when it was decided whether missing teeth ought to be replaced and when all remaining teeth in an arch ought to be extracted and a full denture constructed. In addition to the status of oral hygiene and periodontal disease, the examinee's age, responses to the questions about chewing and eating, and the probable benefit of recommended service to the individual's health and nutrition were all taken into account.

A "yes" or "no" was reported for each area of need. Counts of the numbers of fillings and extractions needed were recorded when appropriate, and teeth to be replaced by fixed bridges or partial dentures were indicated. The type of denture was marked in the area provided for repair, reline, and construction of dentures.

The examiners

Each of the 20,218 sample persons who received dental examinations during 1971-74 (and for whom the dental records were available) was examined by one of the 10 dentists. The dentists included two senior examiners, 1 and 2, who trained and supervised the other dentists, 3-10.

Sample persons were not assigned randomly or equally among the various examiners. At most survey locations they were examined by only one dentist—3, 4, 5, 6, 7, 8, 9, or 10. At 18 of 65 locations, however, a small subsample was examined by either 1 or 2 or, as occurred at 4 locations, by both 1 and 2. Thus, the senior dentists examined relatively few sample persons. All dental records that were done at survey location number 54 were lost, and data for them had to be imputed. Examiner number is unknown for these records. The number and percent of persons examined by each dentist (with records available) are as follows:

Dental examiner number	*Number of sample persons examined*	*Percent distribution of sample persons examined*
1-10	20,218	100.00
1	285	1.4
2	1,220	6.0
3	255	1.3
4	2,137	10.6
5	2,193	10.8
6	2,368	11.7
7	1,646	8.1
8	2,986	14.8
9	5,011	24.8
10	2,117	10.5

Most examinations completed by the senior dentists resulted from a planned series of replicate examinations. As a rule, the findings of the senior dentist were made part of the sample person's examination record, and the findings of the dentist with whom the examinee was paired were kept separate. The primary aim of the replicate examinations was to correct any examiner divergence from the accepted examination procedures.

Throughout the replicate examinations, the senior dentist completed the examination first and dictated the findings to a trained recorder. After completing the examination, the senior dentist recorded the findings of the other dentist, who had previously been absent from the examining room. Appreciable inter-examiner differences as well as any procedure that diverged from the accepted one were discussed and, if indicated, either resolved or corrected while the sample person was still present. However, the findings originally recorded were not altered. To indicate the level of agreement among examiners, the results of the replicate examinations are shown in table XVI. The direction of the disagreements that occurred is shown by a plus or minus sign. A plus sign indicates that a finding of the senior dentist was lower than that of another dentist, and a minus sign indicates the opposite.

Table XVI. Percent distribution of differences in dental findings between senior dentists and other dentists on 360 replicate examinations: National Health and Nutrition Examination Survey, 1971-74

Dental findings	*All replicate examinations*	*Differences observed in affected teeth*								
		–4 or more	*–3*	*–2*	*–1*	*0*	*+1*	*+2*	*+3*	*+4 or more*
		Percent distribution								
Decayed, missing, and filled teeth	100.0	6.1	2.8	7.2	9.7	44.1	10.6	9.2	2.8	7.5
Decayed teeth	100.0	3.1	2.5	7.5	13.6	56.4	10.8	3.3	1.4	1.4
Missing teeth	100.0	5.0	0.8	2.8	5.3	63.3	10.0	4.2	2.8	5.8
Filled teeth	100.0	0.6	0.3	2.2	7.2	69.2	13.6	3.9	1.9	1.1

Vital and Health Statistics series descriptions

SERIES 1. **Programs and Collection Procedures.**—Reports describing the general programs of the National Center for Health Statistics and its offices and divisions and the data collection methods used. They also include definitions and other material necessary for understanding the data.

SERIES 2. **Data Evaluation and Methods Research.**—Studies of new statistical methodology including experimental tests of new survey methods, studies of vital statistics collection methods, new analytical techniques, objective evaluations of reliability of collected data, and contributions to statistical theory.

SERIES 3. **Analytical and Epidemiological Studies.**—Reports presenting analytical or interpretive studies based on vital and health statistics, carrying the analysis further than the expository types of reports in the other series.

SERIES 4. **Documents and Committee Reports.**—Final reports of major committees concerned with vital and health statistics and documents such as recommended model vital registration laws and revised birth and death certificates.

SERIES 10. **Data From the National Health Interview Survey.**—Statistics on illness, accidental injuries, disability, use of hospital, medical, dental, and other services, and other health-related topics, all based on data collected in the continuing national household interview survey.

SERIES 11. **Data From the National Health Examination Survey and the National Health and Nutrition Examination Survey.**—Data from direct examination, testing, and measurement of national samples of the civilian noninstitutionalized population provide the basis for (1) estimates of the medically defined prevalence of specific diseases in the United States and the distributions of the population with respect to physical, physiological, and psychological characteristics and (2) analysis of relationships among the various measurements without reference to an explicit finite universe of persons.

SERIES 12. **Data From the Institutionalized Population Surveys.**—Discontinued in 1975. Reports from these surveys are included in Series 13.

SERIES 13. **Data on Health Resources Utilization.**—Statistics on the utilization of health manpower and facilities providing long-term care, ambulatory care, hospital care, and family planning services.

SERIES 14. **Data on Health Resources: Manpower and Facilities.**—Statistics on the numbers, geographic distribution, and characteristics of health resources including physicians, dentists, nurses, other health occupations, hospitals, nursing homes, and outpatient facilities.

SERIES 15. **Data From Special Surveys.**—Statistics on health and health-related topics collected in special surveys that are not a part of the continuing data systems of the National Center for Health Statistics.

SERIES 20. **Data on Mortality.**—Various statistics on mortality other than as included in regular annual or monthly reports. Special analyses by cause of death, age, and other demographic variables; geographic and time series analyses; and statistics on characteristics of deaths not available from the vital records based on sample surveys of those records.

SERIES 21. **Data on Natality, Marriage, and Divorce.**—Various statistics on natality, marriage, and divorce other than as included in regular annual or monthly reports. Special analyses by demographic variables; geographic and time series analyses; studies of fertility; and statistics on characteristics of births not available from the vital records based on sample surveys of those records.

SERIES 22. **Data From the National Mortality and Natality Surveys.**—Discontinued in 1975. Reports from these sample surveys based on vital records are included in Series 20 and 21, respectively.

SERIES 23. **Data From the National Survey of Family Growth.**—Statistics on fertility, family formation and dissolution, family planning, and related maternal and infant health topics derived from a periodic survey of a nationwide probability sample of ever-married women 15-44 years of age.

For a list of titles of reports published in these series, write to:

Scientific and Technical Information Branch
National Center for Health Statistics
Public Health Service
Hyattsville, Md. 20782

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Office of Health Research, Statistics, and Technology
National Center for Health Statistics
3700 East-West Highway
Hyattsville, Maryland 20782

HRST
from the Office of Health Research, Statistics, and Technology
DHHS Publication No. (PHS) 82-1675, Series 11, No. 225