Measurement of Dental Health Status

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35th Year Rand HEALTH INSURANCE EXPERIMENT SERIES

The research reported herein was performed pursuant to Grant No. 016B-80 from the U.S. Department of Health and Human Services.

Library of Congress Cataloging in Publication Data

Main entry under title:

Measurement of dental health status.

"Prepared for the Department of Health and Human Services."
"November 1983."
Bibliography: p.
"R-2902-HHS."
1. Dental surveys--United States. 2. Dental caries--United States--Statistics. 3. Periodontal disease--United States--Statistics. 4. Dental care--United States--Utilization--Statistics. 5. Insurance, Health--United States. I. Spolsky, Vladimir, 1938- . II. United States. Dept. of Health and Human Services. [DNLM: 1. Dental care --United States. 2. Dental health surveys--United States. 3. Dental caries--Prevention and control. 4. Periodontal diseases--Prevention and control. WU 30 M484]
RK52.2.M36 1983 614.5'996'0287 83-22915
ISBN [illegible]

The Rand Publication Series: The Report is the principal publication documenting and transmitting Rand's major research findings and final research results. The Rand Note reports other outputs of sponsored research for general distribution. Publications of The Rand Corporation do not necessarily reflect the opinions or policies of the sponsors of Rand research.

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R-2902-HHS

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September 1983

Prepared under a grant from the
U.S. Department of Health and Human Services

35th Year

Rand
SANTA MONICA, CA. 90406

PREFACE

The Rand Health Insurance Experiment (HIE), funded by a grant from the U.S. Department of Health and Human Services, is a large-scale social experiment designed to assess how varying a patient's cost of health services affects his or her use of services, quality of care, patient satisfaction, and health status. It is also designed to study how the provision of services in either the fee-for-service system or a prepaid group practice affects those same variables.[1] This monograph describes the *enrollment* results of the dental portion of the experiment for persons of all ages.

A total of 7706 people in 2756 families were enrolled in the experiment in six sites across the United States: Dayton, Ohio; Seattle, Washington; Fitchburg, Massachusetts; Franklin County, Massachusetts; Charleston, South Carolina; and Georgetown County, South Carolina. The sites were chosen to represent the four census regions of the country and an urban-rural mix, and to reflect variation in the amount of stress on the ambulatory medical care system (in terms of long or short delay for new and return appointments).

Families were enrolled in the HIE for either 3 or 5 years (approximately 70 and 30 percent, respectively). Low-income families were oversampled. Eligibility for participation in the HIE was broad; ineligible persons were mainly heads of households 61 years of age and older at the time of enrollment, members of the military, people confined to various institutions, and people eligible for Medicare. When families were enrolled, they agreed to assign their own health insurance benefits (if they were previously covered) to the HIE for the duration of their enrollment. Their policies were kept in force so that the families could return to them at the end of their participation. For persons who had not been previously insured, a policy was purchased during the HIE; it was assumable by the family at the end of the experiment.

The families were assigned to one of several insurance plans that differ either in the amount of cost sharing required each year or in the system from which medical services were obtained. For this purpose, an unbiased allocation model (described in Morris, 1979) was used to ensure that the assortment of families in each plan closely resembled

[1]The experimental design for estimating the effects of insurance on the demand for medical or dental care was first described by Newhouse (1974a,b) and most recently by Newhouse et al. (1981). The structure of the experiment as it relates to covered services and rules of operation can be found in Clasquin and Brown (1977).

that in every other plan in terms of 24 different demographic and socioeconomic variables. The 16 experimental plans were as follows:

- One plan in which care was free to the family (i.e., 0-percent coinsurance).
- Three plans with 25-percent coinsurance (i.e., the family paid 25 percent of its dental bills).
- Three plans with 50-percent coinsurance for dental and outpatient mental health services and 25-percent coinsurance for all other services (the "25/50" plans).
- Three plans with 50-percent coinsurance.
- Three plans with 95-percent coinsurance (which approximates an income-related catastrophic insurance plan).
- One plan with 95-percent coinsurance on outpatient medical or dental expenditures up to a maximum out-of-pocket expenditure of $150 per individual ($450 per family) per year and no coinsurance above that; all inpatient care was free on this plan, which is referred to as the "individual deductible" plan.
- One plan that assigned some Seattle participants to a prepaid medical group practice (Group Health Cooperative of Puget Sound, or GHC). Free dental care was provided outside the group practice (i.e., 0-percent coinsurance for dental care). Families were reimbursed 5 percent (95-percent coinsurance) for services required outside GHC that were available (with no cost sharing) at GHC.
- An additional plan (a control group) that consisted of a random sample of people who were already members of the GHC at the time the HIE began in Seattle and who also met HIE eligibility requirements. They obtained their dental care from the community at large (i.e., through the fee-for-service system with their own financing or private dental insurance).

All plans except the first one and the last three had a ceiling on annual out-of-pocket expenditures by the family amounting to 5, 10, or 15 percent of annual family income. This maximum dollar expenditure (MDE) per year per family was $1000 for the 50- and 95-percent coinsurance plans ($750 for the 25-percent plans in some sites and in some years). All plans had an identical, very comprehensive benefits package that covered all dental restorative, periodontal, and preventive services except orthodontia, ambulatory and inpatient medical care, prescription drugs, certain over-the-counter drugs, most supplies and durable medical equipment, psychiatric and psychological services, and almost all other personal medical services, including those delivered by

chiropractors and Christian Science healers. Newhouse et al. (1983) provide additional details on the dental benefit plan.

During the HIE, data were collected on demographic and socioeconomic variables, health status, use of health services, satisfaction with and attitudes toward health care, and types of providers seen. The sources of health data included baseline interviews before enrollment, self-administered (or parent-completed) Medical History Questionnaires, biweekly Health Reports, annual Health Questionnaires, medical screening examinations (including a dental examination),[2] and claims submitted (chiefly by providers) for reimbursement for services rendered.

Comprehensive assessment of each person's medical and dental health status occurred upon enrolling in and leaving the experiment. In addition, certain health measures were collected annually during the enrollment period. As noted, a major HIE objective is to assess the effects of varying the cost of health services on the health status of individuals sampled from a general population. To this end, reliable, valid, and understandable measures were specially developed or adapted to enable us to detect small but meaningful changes in the health status of enrollees.

HIE enrollment began in 1974, and the enrollment period ended for the last site in 1982. Enrollment data concerning dental health status in all six sites are available and reported herein, but complete longitudinal (experimental) data are not available as of this writing.

This report (R-2902-HHS) accompanies Rand report R-2262-HHS, which has the series title *Conceptualization and Measurement of Physiologic Health for Adults.* The volumes that constitute R-2262-HHS cover a wide variety of diseases and organ system defects, such as eyesight and hearing problems, cardiovascular and bronchopulmonary diseases (e.g., hypertension, chronic obstructive pulmonary disease), and surgery-related conditions (e.g., hernia, varicose veins). These are used to measure physiologic health, one of several conceptually distinct dimensions of health status defined for the HIE.

These disease-specific volumes detail the suitability of these conditions as health status measures for the HIE, discuss important measurement issues, describe HIE techniques for determining the prevalence and personal impact of the conditions, give HIE enrollment results, and outline the disease-specific criteria for quality-of-care analyses for the HIE. These volumes report on enrollees aged 14 years and older. A companion series on the measurement of physiologic

[2]Smith et al. (1978) give a detailed description of all aspects of tests and procedures carried out in the enrollment and exit screening examinations.

health among children under 14 years of age is also being published (as R-2898-HHS). This present monograph follows the general outline of the R-2262-HHS series. It covers dental health for all persons enrolled in the experiment (i.e., children, adolescents, and adults).

Three other dimensions of health status—physical, mental, and social health—have been defined for the HIE, as has an integrative measure—general health perceptions. These measures were initially described in the eight volumes of R-1987-HEW, which has the series title *Conceptualization and Measurement of Health for Adults in the Health Insurance Study.* More recent treatments of these health concepts can be found in R-2551-HHS, *Construction and Scoring of Aggregate Functional Status Indexes*; R-2737-HHS, *Refinements in the Measurement of Mental Health for Adults in the Health Insurance Study*; R-2937-HHS, *The Quantification of Social Contacts and Resources*; and R-2711-HHS, *Measuring Health Perceptions in the Health Insurance Experiment.* Measurement of these same health status dimensions for children and youths (i.e., enrollees under age 14) was discussed in R-2313-HEW, *Conceptualization and Measurement of Health for Children in the Health Insurance Study.*

Another Rand report series, *Conceptualization and Measurement of Health Habits for Adults in the Health Insurance Study*, contains information on two health habits being used by the HIE as proxy measures of future health status: smoking and overweight. These habits could conceivably be influenced by personal medical care, and the evidence strongly suggests that they have a serious effect on future morbidity and premature death. The series comprises two volumes: *Smoking*, R-2374/1-HEW, and *Overweight*, R-2374/2-HEW. Finaliy, several publications relate to the measurement of patient satisfaction with health care services. The most pertinent to this monograph is R-2712-HHS, *Development of a Dental Satisfaction Questionnaire for the Health Insurance Experiment.*

DISEASES AND CONDITIONS FOR HEALTH STATUS AND QUALITY-OF-CARE MEASUREMENT

Diseases and Conditions	Applicable Age Group		
	0-4 Years	5-13 Years	14+ Years
Acne			X
Anemia	X	X	X
Angina pectoris and selected electrocardiographic abnormalities			X
Asthma		X	
Cancer	X	X	X
Chronic airway obstruction and shortness of breath			X
Colds	X		
Congestive heart failure			X
Convulsions	X	X	
Dental conditions	X	X	X
Diabetes mellitus			X
Eczema	X	X	
Enuresis (bedwetting)		X	
Growth and development disorders	X		
Hay fever		X	X
Hearing disorders		X	X
Hemorrhoids			X
Hernia			X
Hypercholesterolemia (high cholesterol)			X
Hypertension			X
Hyperthyroidism and hypothyroidism			X
Joint disorders			X
Lead poisoning	X	X	
Otitis media (middle ear infection)	X	X	
Stomach pain and peptic ulcer disease			X
Urinary tract infection		X	X
Varicose veins			X
Vision disorders		X	X

SUMMARY

DEFINITION AND MEASUREMENT OF DENTAL DISEASE

The Rand Health Insurance Experiment (HIE) will use data on the prevalence and adverse consequences of dental caries (tooth decay) and periodontal disease to study the effects of different levels of health insurance on the use and quality of dental care in a general population. These conditions were selected for intensive study for several reasons: They are widely prevalent; they are relatively easy to detect; they can cause considerable pain and discomfort or various complications that adversely affect the general physical well-being of an individual; and they can prompt significant levels of worry and concern and interfere with interpersonal communication or usual daily activities. If left untreated, both can ultimately lead to tooth loss. They are, however, notably responsive to both preventive and therapeutic dental care.

Dental caries is the end result of a slow, chronic process of acid decalcification of the tooth structure. It occurs when certain microorganisms, which may be indigenous to the mouth, aggregate in a film (dental plaque) on a susceptible tooth surface for a sufficient length of time, ultimately metabolizing sucrose (from ingested sucrose-containing food) to lactic acid. This process lowers the acidity of the tooth surface to levels commensurate with decalcification. Dental caries is said to be present when at least one of the following phenomena is present: tooth enamel that yields to underlying soft material; a pit, fissure, or hole in the tooth's enamel or root cementum; a defective restoration; or an erosion-type lesion on the gingival one-third of the tooth (the one-third nearest the gum).

Dental caries experience refers to any sign of past or present tooth decay; it is most often measured by age-specific indicators of decayed, missing, or filled teeth or surfaces. The DMFT index and the DMFS index, based on either 28 or 32 teeth, are used to categorize permanent teeth. An equivalent deft or defs index (where e stands for extracted or indicated for extraction) is used to score primary (baby) teeth.

Decay can begin shortly after teeth erupt and may be detected as early as 1 year of age; it is chiefly responsible for the caries experience (decayed, missing, or filled teeth) of children and adolescents. As an individual ages, teeth may be missing for reasons other than decay, particularly periodontal disease, but also noneruption of the tooth,

accidents, or extractions for orthodontia. The DMFT or DMFS indexes are reasonably accurate estimators of dental caries up to about age 35.

Periodontal disease includes all diseases that affect the periodontium of the oral cavity, i.e., the supporting tissues of the tooth such as gingiva (gums), alveolar bone (jawbone), and ligaments. Bacterial plaque, a highly adhesive substance composed of microorganisms and debris that adheres to the tooth surface, is the main etiologic agent, although only the plaque that accumulates on the gingiva (rather than on the tooth surface) is of any consequence in periodontal disease. In the absence of care, plaque may eventually calcify and form dental calculus, which can exacerbate periodontal disease by favoring yet more plaque accumulation. The longer that plaque is present, the greater its potential to separate the teeth from their supporting alveolar bone and, ultimately, to promote tooth loss.

Numerous indexes are available for measuring periodontal disease. The most common is the Periodontal Index (PI), which assesses the presence and severity of gingival inflammation, formation of pockets of periodontal disease, and tooth mobility. In addition, the Simplified Oral Hygiene Index (OHI-S) assesses the degree to which the surfaces of six selected teeth are covered by plaque and calculus. It assumes that the longer oral hygiene practices are neglected, the greater the surface area of the tooth covered by such material. Given the relationship between the accumulation of plaque and calculus and possible periodontal disease, some view the result of the OHI-S as an intermediate "outcome" that can signal the onset of disease.

PREVALENCE OF DENTAL DISEASE

Virtually no one escapes dental caries. The National Center for Health Statistics (NCHS) estimated, for example, that less than 1.3 percent of the adult population had 0 DMFT32 teeth (NCHS, 1981a). By 10 years of age, approximately 14 percent of teeth have experienced dental decay; by 20 years, 33 percent; and by 50 years, 60 percent. The incidence of new decayed, missing, or filled teeth rises with age until about age 24 and then begins to decline, reflecting the fact that dental caries is primarily a disease of the young (NCHS, 1981a). Generally, *total* dental caries experience is higher among women than men, among white adults than black adults,[1] among individuals of higher education

[1]Racial differences are small or nonexistent between white and black children, however.

and income (who have higher rates of filled teeth but lower rates of decayed or missing teeth), and among persons living in urban (rather than rural) areas.

The prevalence of periodontal disease in the U.S. population is somewhat difficult to document precisely, but clearly it is quite high. NCHS estimates that as much as one-quarter of the population has gingivitis (i.e., very mild periodontal disease) and another one-quarter has moderate-to-severe periodontal disease. Prevalence rises notably with age, from about 15 percent at age 18 to about 50 percent at age 74. Periodontal disease tends to be more common among men than women, among blacks than whites, among persons of lower education and income, and among individuals residing in rural areas.

Both dental caries and periodontal disease can be forestalled or minimized with good oral hygiene practices and various preventive measures. Good dental health habits include regular teeth cleaning by brushing and flossing and avoiding between-meal snacks and "junk" food. Use of fluoride (in fluoridated drinking water, as a topical agent, or in other forms) is an important preventive measure; application of occlusal sealants (adhesive resins applied to the biting surfaces of the back teeth) is also considered a beneficial preventive step, especially when done in concert with systemic or topical fluorides for other tooth surfaces.

Treatment of decay involves arresting the dental caries process by removing the decayed and decalcified tooth structure and restoring the tooth's normal anatomy and function. For early decay, a small filling may be used; for more advanced decay, the restoration may be a multi-surface filling, inlay, or partial or full crown. For more serious problems, infected tissue within the tooth must be removed and the tooth restored with a complex filling or crown, or the tooth must be extracted, often necessitating construction of a fixed or removable prosthesis. In all cases, keeping the supporting tissues of all teeth in good periodontal health by appropriate preventive or therapeutic measures is important.

Daily removal of plaque by the individual and periodic removal of calculus by a dental professional can prevent gingival and periodontal disease at its earliest reversible stage. Certain new antimicrobial agents have also been shown to be effective in reducing plaque and gingivitis.

Treatment of periodontal disease is undertaken mainly for the more advanced, destructive stages of the problem, with the primary objective of removing whatever factors have caused the infection of the periodontal tissues. Instituting a program of good oral hygiene habits

by the patient, removing all plaque and calculus, and planing root surfaces beneath the gingival margin (gum line) are first steps in therapy. Gingival curettage (mechanically removing plaque, calculus, and other debris from the tooth surface and eliminating diseased tissue from periodontal pockets) is the next step. Should these conservative efforts fail, one of several surgical procedures can be attempted. Any necessary restorative procedures may then be executed, following which a regular program of maintenance by dental professionals must be established.

HEALTH INSURANCE EXPERIMENT METHODS

At enrollment, the HIE used two sources of information to estimate the prevalence of dental caries and periodontal disease: a Medical History Questionnaire (MHQ) and a dental screening examination. The Dental battery of the MHQ contained several questions about preventive oral health habits (frequency of brushing, flossing, and use of fluoride), participants' awareness of dental disease, and frequency of dental visits. Other MHQ batteries included items about consuming junk foods or snacks and eating between meals. The HIE used age-specific versions of the MHQs—a self-administered one for adults (persons 14 years of age and older) and proxy-completed ones (completed typically by the mother) for adolescents and children (persons 5 through 13) and for infants and younger children (persons 0 through 4).

The dental screening examination was part of a broader physical assessment of health status administered at enrollment to a randomly selected subsample of families. It was carried out by a dentist or by a dental hygienist under the supervision of a dentist. Dental caries experience was assessed according to a DMFT and DMFS index for all persons 6 years and older, and according to a deft and defs index for all those 3 through 11 years old. The examiner evaluated the condition of the gums and the possibility of deeper periodontal disease according to the PI (scored on a five-point scale from 0 (no disease) to 8 (severe periodontal disease with loss of chewing function)). Additionally, the examiner noted the presence and degree of plaque and calculus and assigned an oral hygiene score according to the 0-to-6 OHI-S scale. The PI was reported for individuals 12 years and older, the OHI-S for those 3 years and older. Finally, a Periodontal Profile Score (PPS) was assigned for all persons 12 and older. The PPS is a simple scheme for categorizing a person's possible periodontal treatment needs, expressed as the number of appointments needed to effect definitive care.

To assess the adverse effects of dental disease, we included questions in the Dental battery about pain and discomfort attributable to problems with teeth or gums, about worry or concern prompted by such problems, and about avoidance of social interactions (conversations). All three questions were asked of adults; for persons up to age 13, the parent was asked about the pain experienced by the child and about their own worry over the child's teeth.

HEALTH INSURANCE EXPERIMENT ENROLLMENT RESULTS

According to MHQ responses, a large percentage of the HIE population brushed their teeth at least once a day: 92 percent of adults (18 and older), 85 percent of youths (12 through 17 years), and 84 percent of children (5 through 11 years). The percentages who claimed to use dental floss at least once a week were much lower: 44, 30, and 22 percent for the same age groups. Over 90 percent of those in the pediatric age group (under 14 years of age) used a fluoride toothpaste and almost 50 percent had had their teeth painted with fluoride, but only small percentages took fluoride in any other way.

About 68 percent of those in the pediatric age group had eaten various pastries in the previous 24 hours, as had 55 percent of adults. Upwards of three-quarters had consumed such snacks between meals.

Among MHQ respondents who had ever obtained dental care, about 78 percent of those 5 through 13 had seen a dentist within the previous year; comparable figures were 69 percent for teenagers and 55 percent for adults. Sixty-two percent of adults and 49 percent of teenagers thought their teeth needed to be professionally cleaned.

As expected, dental caries problems were widespread in the HIE population. Mean DMFT28 scores (by age) were as follows: 2.3 (6 to 11 years), 8.1 (12 to 17 years), 15.9 (18 to 44 years), and 20.3 (45 to 64 years). Mean deft scores were 2.3 (3 to 5 years) and 2.6 (6 to 11 years).

Similarly, periodontal disease was not uncommon. The mean PI score for adults and youths corresponded roughly to a clinical category of beginning destructive periodontal disease; the actual scores rose noticeably with age. Percentages of HIE adults with no periodontal disease or simple gingivitis only were as follows: men 18 to 34 years, 46 percent; men 35 to 64 years, 40 percent; women 18 to 34 years, 55 percent; women 35 to 64 years, 47 percent. The overall mean value for the OHI-S measure was roughly equivalent to a clinical category of "fair" oral health for adults and youths, and again the precise scores

rose with age. The percentages of persons with good oral health according to this measure were 43 for those 12 to 17 years of age, 45 percent for those 18 to 34, and 36 percent for those 35 to 64. The HIE values for all these measures tended to be higher (i.e., to show worse dental health) than those reported by NCHS for a national probability sample.

Periodontal treatment needs, as measured by the PPS, were higher for older persons. For teenagers, the PPS scores corresponded roughly to a few overt deposits of calculus (requiring no more than one dental visit); for the older adults, the PPS scores were consistent with gingivitis throughout the mouth and more than a few overt calculus deposits (necessitating possibly two appointments for prophylaxis and gingival curettage).

Among all age groups, worry and concern about dental problems was the disease impact most frequently cited: 26 percent of parents (of offspring aged 5 to 13), 30 percent of the teenagers, and 41 percent of the adults noted at least a little worry about problems with teeth or gums. Pain or discomfort was the next most common concomitant of dental problems: 19 percent of parents believed their children had experienced such symptoms, and 23 percent of the teenagers and 28 percent of the adults reported them. Fourteen percent of the teenagers and 10 percent of the adults claimed that they avoided social conversations because of problems with teeth or gums. As measured by levels of disease severity (quartiles of the DMFT scores or tertiles of the PI scores), individuals with more serious dental problems were more likely to claim one or more of these adverse effects and more likely to report higher degrees of such effects.

QUALITY OF CARE FOR DENTAL DISEASE

Criteria by which the quality of dental care can be assessed at the end of the experiment are introduced. They concern long-term patient outcomes (e.g., tooth decay, periodontal disease, missing teeth) and intermediate outcomes (e.g., behaviors related to good dental hygiene habits), as well as processes of care (e.g., sequence and timing of preventive and therapeutic care, appropriateness of restorative services). Data are taken mainly from MHQs, dental screening examinations, and dental insurance claim forms submitted during the HIE.

ACKNOWLEDGMENTS

The authors thank John W. Stamm of the Department of Community Medicine, McGill University, for a thorough and constructive review of an earlier draft of this monograph, especially for the chapters dealing with clinical and epidemiological aspects of dental disease.

We are indebted as well to members of the Rand Dental Advisory Board—Ronald DeVincenzi of Monterey, California, James Mulvihill of the University of Connecticut Health Center in Farmington, and Max Schoen of the School of Dentistry, University of California at Los Angeles—for their aid in the early stages of this work. We are especially grateful to Howard Bailit of the Columbia University School of Public Health in his capacity as both a member of the Dental Advisory Board and a Rand consultant, and to other Rand colleagues Robert Brook, George Goldberg, and Joseph Newhouse for insightful suggestions and positive support throughout the study.

In addition, thanks are due Earl Gardner, Janet Hanley, Thomas Calabro, Eanswythe Leicester, and Clairessa Cantrell for their programming efforts, and Avi Black for analytic assistance. Finally, we acknowledge the efforts of Barbara Eubank in bringing numerous drafts of this manuscript into final form.

CONTENTS

TABLES

Chapter 1

INTRODUCTION

Dental caries (tooth decay) and periodontal disease are among the more widespread chronic diseases affecting mankind. Their primary targets of destruction are the teeth and supporting tissues within the oral cavity. The two conditions share some etiological characteristics, although they are in reality independent processes. Both may lead to serious complications that adversely affect the general physical and emotional well-being of an individual; if left untreated, both can ultimately lead to tooth loss.

The Rand Health Insurance Experiment (HIE) chose to study dental caries and periodontal disease for several reasons. Both conditions are widely prevalent and relatively easy to detect. They can be associated with considerable pain and discomfort as well as worry and concern, and they can interfere with interpersonal communication and usual daily activities. Finally, they are responsive to both preventive and therapeutic dental care.

This volume gives the definition of dental caries and periodontal disease and reviews problems in measurement of these disorders (Chapter 2). Special attention is given to aggregate indexes of disease that are often used in cross-sectional or longitudinal epidemiological studies. Chapter 3 discusses the suitability of these dental problems as indicators of oral health status from the point of view of prevalence, severity, and possible adverse consequences, and it describes their responses to dental care.

Chapter 4 presents the HIE definitions of these conditions and describes our methods for measuring their prevalence and adverse impacts. Chapter 5 presents data from the HIE enrollment procedures from all six sites (Dayton, Ohio; Seattle, Washington; Fitchburg, Massachusetts; Franklin County, Massachusetts; Charleston, South Carolina; and Georgetown County, South Carolina). Findings are based on information from a Medical History Questionnaire and a dental examination. Both children and adults are included in these analyses.

Finally, proposed quality-of-care criteria for the two diseases, which will be applied in analyses at the end of the experiment, are introduced in Chapter 6 and given in detail in an appendix. Readers are referred to the Preface (and to other monographs cited therein) for more

information on the design of the HIE and the overall strategy used in the study to assess changes in health status and quality of care as a function of level of insurance.

Chapter 2

DEFINITION AND MEASUREMENT OF DENTAL DISEASE

ETIOLOGY OF DENTAL CARIES

Dental caries (tooth decay) is a direct consequence of acid decalcification of the mineralized tooth structure (Miller, 1973). The tooth consists of a crown (the portion that appears in the mouth) and the roots (which anchor the tooth to the alveolar process of the jawbone). The outermost layer of the crown consists of enamel, which is the hardest calcified structure in the body. Immediately beneath the enamel is the dentin, another calcified tissue that is about 20 percent as hard as enamel (Zipkin, 1970). Dentin also forms the tooth root, which in turn is covered by a very thin layer of calcified tissue called the cementum. Enamel, dentin, and cementum are nonvascular and hence relatively inert tissues. By contrast, pulp tissue, which occupies the core space of each crown and root, provides a direct route into the body's circulatory and nervous systems.

Dental caries requires four major factors to be present simultaneously for decay to occur (Newbrun, 1979): (1) a susceptible tooth (host); (2) the presence of microorganisms; (3) a suitable environment for the microorganisms to survive and multiply (e.g., presence of a substrate such as sugar-containing food); and (4) sufficient time (i.e., length of time that the substrate is present on the tooth). The relative importance of genetics to a tooth's susceptibility to caries has not been clearly established (Finn, 1965).

The microorganisms associated with dental caries are indigenous to the oral cavity (Newbrun, 1979). Although no microorganism has been shown to be the sole causative agent, several have been identified as playing significant roles in the initiation of specific types of decay. For example, *Streptococcus mutans* is etiologically important in pit and fissure caries (decay that occurs on the chewing surfaces of the back teeth) and smooth surface caries (decay that occurs on the surfaces that contact other teeth or the tongue and cheeks); *Actinomyces viscosus* and *Actinomyces naeslundii* are important in root surface caries.

Sucrose, which is considered the most cariogenic carbohydrate, is readily used by caries-implicated microorganisms because of its small molecular weight, high solubility, and rapid diffusion rate. Cariogenic microorganisms use sucrose to synthesize polysaccharides (complex carbohydrates) that form the matrix of dental plaque (Miller, 1967; Newbrun, 1979).[1] Near the plaque-enamel interface these organisms also metabolize sucrose to lactic acid, which rapidly and temporarily lowers the acidity at the tooth surface to levels commensurate with decalcification (pH of 5.2 to 5.4).

Extensive repetition of this process over time will eventually result in a cavity. Counteracting this development is the saliva in the mouth, which has a buffering capacity that helps to neutralize the bacterially produced acid. Moreover, the physical form and consistency of the sucrose carrier influences the rate at which sucrose is cleared from the oral cavity and hence the availability of sucrose to the oral bacteria. For example, liquids containing sucrose are cleared more readily than semi-solid sticky substances such as toffee. Nevertheless, the ubiquitous presence of sucrose in the American diet means that decalcification occurs at almost each meal and between-meal snack (Bibby, 1975; Nizel, 1978).

Because of the intermittent exposure of the teeth to acid from sugar fermentation, tooth decay is a slow, chronic process. It takes an average of 18 months for decay to progress from the incipient stage to outright clinical caries (Parfitt, 1956). If nothing is done to arrest the decay in dentin, it will penetrate into the pulp and cause an acute localized infection (pulpitis). Unless sophisticated procedures are used at this point to save the tooth, the tooth will likely have to be extracted.

The susceptibility to decay varies by specific tooth and tooth surface. The hierarchy of decay by tooth surface is governed by the number and extent of physical imperfections on the tooth's surface, the length of time an adjacent tooth has been in contact, and possible salivary factors. For example, the occlusal (biting) surfaces of the posterior teeth, especially the molars, are the most vulnerable surfaces because of the numerous pits and fissures they contain. The first and second molars are considered the most susceptible to decay, and the lower six anterior teeth, the most resistant.

The sequence of decay by tooth is also predictable and, other factors being equal, roughly parallels the order of eruption. If a tooth does not

[1] *Plaque* is a highly adhesive, gelatinous substance that contains and holds the microorganisms at the tooth surface. *Debris* is an equivalent term that may be used interchangeably with plaque in this monograph.

become decayed within the first 4 to 6 years following eruption, it will very likely not become decayed (Carlos and Gittelsohn, 1965; Newbrun, 1979).

The only nutrient known to inhibit tooth decay is the element fluorine. To provide maximal protection, it must be ingested from birth to approximately 14 years of age in optimal amounts (i.e., neither too much nor too little). Fluoridation of water supplies that are naturally deficient in this important component has become increasingly widespread during the past 30 years. Fluoride as a preventive element in dental care is taken up again in Chapter 3.

MEASUREMENT OF DENTAL CARIES

Detection of Dental Disease

The dental examination for any of the caries indexes is customarily done with a mouth mirror, a sickle-shaped and sharp-pointed dental explorer, and an artificial light (Russell, 1969). Dental x-rays, or radiographs, provide information beyond that available from direct visual or tactile inspection alone. Specifically, they may reveal incipient carious lesions (i.e., decay that has penetrated the enamel but not the underlying dentin), and they are particularly valuable for viewing the posterior teeth, where two of the five surfaces (the interproximal, or connecting surfaces between two teeth) are not readily accessible by examination. Several studies (Blayney and Greco, 1952; Dunning and DeWilde, 1956) have demonstrated that diagnosing decay on the proximal surfaces of posterior teeth is improved by 30 to 35 percent with bite-wing radiographs. The percentage of improvement varies as a function of patient age and the intensity of caries experience (Klein and Bohannan, 1979).

The Health Insurance Experiment (HIE) definition of dental caries corresponds closely to that of the National Institute of Dental Research (NIDR, 1981), which holds that dental caries is present when at least one of the following criteria is met:[2] (1) enamel that yields to underlying soft material when examined with the dental explorer tip; (2) a pit, fissure, or hole in the enamel that catches the tip of a dental explorer and resists lateral displacement of the explorer with light

[2]These criteria apply both to teeth without previous fillings (i.e., virgin decay) and to those with previous fillings (i.e., recurrent decay).

finger pressure; (3) the presence of gross tooth decay that does not require the use of an explorer for detection; (4) a restoration (i.e., filling, partial veneer, or full crown) that is defective because of an obvious fracture, which engages the dental explorer or exposes the internal portions of the cavity preparation; and (5) an erosion-type lesion on the gingival one-third of the tooth (the third of the tooth closest to the gum line) that has a sharp, definite internal wall that exceeds a shallow concavity and requires restoration beyond the elective-procedure category.

Epidemiological surveys may underestimate dental caries prevalence for several reasons (Dunning, 1979): (1) Radiographs are not used to aid diagnosis; (2) time for the examination is usually constrained; and (3) the examiner classifies teeth for research purposes rather than for determining specific treatment needs. In general, these are minor factors, and several indexes of dental caries experience are sufficiently objective and reliable to be useful in determining the caries status of a population. These are described in greater detail in the following section.

Indexes of Dental Caries Experience

Dental caries experience refers to the *cumulative* effect of disease on the teeth and can be summarized in three widely used indexes. One is simply the number of persons observed with any present or past sign of tooth decay—percent prevalence. The second index is based on the number of decayed, missing, or filled teeth—the DMFT index.[3] The third is based on the number of decayed, missing, or filled surfaces—the DMFS index.

The caries experience[4] of children and adolescents should of course reflect only tooth decay. As an individual ages, however, teeth may be missing for reasons other than decay, particularly periodontal disease (Dunning, 1979), but also noneruption of the tooth, accidents, or extraction for orthodontia. Thus, the DMFT or DMFS index is a reasonably accurate estimator of dental caries disease up to about age 35.

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[3]By convention, the abbreviations used to denote the indexes are written in capital letters when referring to the permanent teeth and in lower-case letters when referring to the primary (baby) teeth.

[4]Dental caries experience is synonymous with DMF teeth and surfaces. It does not mean simply dental decay.

Percent Prevalence

The simplest index of dental caries experience is percent prevalence (Knutson, 1944). It refers to the proportion of the population that shows any evidence of caries experience (i.e., one or more decayed, missing, or filled teeth). It is especially sensitive for persons in the years immediately following the eruption of the permanent teeth when it accurately reflects tooth decay more than loss of teeth owing to periodontal disease or other factors. Thus, it is most useful when the dental caries experience is low or when a comparison is being made between a high- and low-prevalence population (Dunning, 1965).

DMFT and DMFS Indexes

The DMFT index is defined as the total number of decayed, missing, and filled permanent teeth per person (Klein and Palmer, 1938; 1940). For this index, a tooth is classified only once, and a decayed tooth always takes precedence over one filled. Unless radiographs are used in conjunction with the clinical examination to identify third molars (wisdom teeth), it is common to use 28 teeth in determining DMFT scores. Hence, the DMFT index typically ranges from 0 to 28. In tabulating its DMFT count, however, the National Center for Health Statistics uses 32 teeth (NCHS, 1979; 1981a).

In contrast to the percent prevalence index (which is a dichotomous measure), the DMFT index may be used to reflect both the prevalence and severity of dental disease. As noted, it is a reasonably accurate estimator of dental caries experience up to about 35 years. Its usefulness diminishes because the missing-teeth component of the index is least likely (of the three components) to reflect dental caries experience; as a population ages, the relative importance of the missing component (versus the other two components) rises. Thus, the DMFT index is most useful in populations with a high percentage of dental caries experience, when the percent prevalence index would be relatively uninformative.

The DMFT index has several drawbacks. First, without the aid of dental radiographs, the decayed (D) component of the DMFT index is likely to be underestimated. In addition, the missing (M) component can be misleading, because teeth can be missing for a number of reasons noted earlier. Third, the filled (F) component, which measures teeth with sound fillings or crowns and no recurrent decay, reflects prior dental treatment experience. Finally, once a tooth is categorized in the DMFT index, it is not possible to measure further caries increments on the same tooth.

The DMFS index is defined as the sum of decayed, missing, and filled tooth *surfaces* (Bodecker, 1939). In constructing a DMFS count, each tooth is assigned a number of surfaces. For example, the 16 posterior teeth can be assigned five surfaces each and the 12 anterior teeth four surfaces each. Using this approach the DMFS index can range from 0 to 128 ((16 × 5) + (12 × 4)), and a tooth that is both filled and has untreated surfaces of decay can be classified both ways.

The following example may clarify the main difference between the DMFT and DMFS indexes. In the DMFT index, a tooth with a two-surface filling and new decay on one additional surface would be classified as a decayed tooth. In the DMFS index, the tooth would be classified as two surfaces filled and one surface decayed. If, at a later period, the decay had spread from one to two surfaces, the tooth would still be classified as decayed by the DMFT index; by the DMFS index, it would be classified as two surfaces filled and two surfaces decayed.

In short, the advantages of the DMFS index over the DMFT index are that it is a more sensitive measure of the intensity of caries attack and that changes in caries experience within a tooth can be measured. The DMFS index's greatest utility is in clinical trials, where accurate measurement of dental caries is necessary. It is most useful in providing discrimination in populations of high caries intensity (Russell, 1969).

def and defs Indexes

Caries experience in the primary (baby or deciduous) teeth of children may be measured with the def or defs indexes, which are analogous to the above indexes for adults. The def index measures the total number of decayed teeth (d), teeth indicated for extraction (e), and filled (f) primary teeth per child (Russell, 1969). Missing teeth are omitted because of the difficulty in determining whether the tooth was lost normally or extracted because of decay. Because the decayed and extracted components both refer to a decayed tooth, they are occasionally combined and the indexes are reported as the df or the dfs index. Because only 20 teeth are present, the deft index ranges from 0 to 20, and the defs index from 0 to 88 ((8 × 5) + (12 × 4)).

Reliability of Dental Caries Indexes

The value of these indexes depends greatly on the reliability of the examiner in classifying each tooth (or surface) correctly, but no agreement currently exists as to the most appropriate method for reporting

examiner reliability. For example, categorical indexes[5] of examiner variability are of value in comparing two examiners (or examinations), but they are not considered easily interpretable. In one study, reversal rates and other examiner errors reduced DMFT scores by less than 2 percent (Ship et al., 1966); in another, the percentage of teeth diagnosed inconsistently (consistency ratio) ranged from 5.8 to 7.0 percent (DePaola and Alman, 1972). Intra-examiner and inter-examiner reliability coefficients have been found to be quite acceptable (0.95 and 0.65, respectively) (NIDR, 1981), but their use has been questioned for data that are highly skewed (e.g., DMFT scores) (Klein and Bell, 1981).

Fleiss et al. (1979a) proposed the kappa statistic to estimate inter- and intra-examiner reliability. This method corrects the observed proportion of agreement by the proportion of agreement to be expected by chance alone. (Values of kappa between 0.61 and 0.80 indicate substantial reliability; those between 0.81 and 1.00 indicate almost perfect reliability.) In studies on individual teeth, these researchers reported kappa values of 0.78 to 1.00 for intra-examiner consistency and values of 0.80 to 1.00 for inter-examiner consistency (using two examiners) (Fleiss et al., 1979b).

Klein and Bell (1981) proposed using the average observed difference, average absolute difference, and average squared difference for nonnormal distributions such as DMFT scores.[6] The average squared difference is extremely sensitive to large disagreements among examiners. The average absolute difference is more sensitive to the frequency of examiner disagreement than to the size of disagreement. The average observed difference is useful in determining systematic examiner biases.

Finally, a simple enumeration of the percentage of disagreements can be used to estimate the reliability of a categorical variable such as DMFT scores. This measure is easy to implement and to interpret,

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[5]Categorical indexes include reversal rates (teeth classified as sound on one examination and as decayed or filled on a repeat examination); other examiner error (the second examination contradicts the biologic facts of the first examination—filled on one examination and missing on the other); examiner bias (the examiner consistently either over- or underscores the tooth condition); and consistency ratio (the frequency with which a tooth is classified as decayed on two duplicate examinations divided by the frequency with which it is classified as decayed on only the first or only the second examination).

[6]The average observed difference is the average of all of the differences when the second examination is subtracted from the first examination in a series of replicate examinations. The average absolute difference is similar to the average observed difference except that the sign (plus or minus) of the differences is ignored. The average squared difference is obtained in a similar manner except that the difference for each pair of examinations is squared before being averaged.

although it does not distinguish between minor disagreements (e.g., between adjacent score categories) and major disagreements (e.g., between extremes of the scoring continuum).

ETIOLOGY OF PERIODONTAL DISEASE

Periodontal disease includes all the diseases that affect the periodontium (supporting tissues) of the oral cavity. The periodontium consists of the gingiva (gums), alveolar bone, cementum, and periodontal ligament. The periodontal ligament attaches the tooth via the cementum to the alveolar bone.

Both systemic and local factors contribute to the susceptibility or resistance of the periodontium to disease (Carranza, 1979). The principal systemic factors are the general health of the individual and the overall ability of the tissues to resist disease. Systemic conditions such as hormonal imbalances (because of pregnancy, for example), diabetes mellitus, and nutritional deficiencies may influence the course that periodontal disease takes; however, these conditions have never been demonstrated to be the primary etiologic factors in periodontal disease.

Bacterial plaque is the major causal agent in periodontal disease. In fact, periodontal disease has rarely, if ever, been observed in the absence of plaque and calculus (Russell, 1967). Plaque accumulation is promoted by several factors: infrequent or inadequate oral hygiene; inadequate or poorly positioned contacts between adjacent teeth, which cause food impactions; tooth fillings (amalgam or gold) that have excessive overhangs near or beneath the gingival tissues; cast crowns that are overly contoured at the gingival one-third of the tooth surface; and calculus (tartar) deposits.

The plaque associated with periodontal disease differs from that of dental caries in two ways. First, whereas plaque contributes to decalcification in dental caries, in periodontal disease it acts to hold microorganisms that produce toxins, enzymes, and waste products close to the gum tissue and periodontal pockets. Second, with periodontal disease, only the plaque that accumulates on the gingiva and in the gingival crevice (rather than on the tooth surface) is of any etiologic consequence.

The sequence of periodontal disease is as follows. First, if supragingival plaque (plaque that covers the gingival one-third of the tooth crown) accumulates over a period of days, the gingiva responds with primary inflammation (called gingivitis). Although the color, shape, size, consistency, and surface texture of the gingiva all undergo some change during this early stage, the only symptom that an individual

may experience is occasional bleeding of the gingiva when brushing the teeth. Shortly thereafter, plaque begins to grow subgingivally (i.e., beneath the gum line) on the tooth's surface and in the space between the tooth and inner surface of the gingival crevice (a band of gingiva that circumscribes the tooth). The combination of the shape of the crevice, which makes removing plaque by brushing difficult, and the stagnant, anaerobic (airless) environment favors the growth of still other harmful microorganisms. Thus, subgingival plaque spreads the inflammation more deeply to the other tissues of the periodontium. If the plaque associated with chronic gingivitis is not removed, it may eventually calcify and form dental calculus. Concurrently, the inflammation may spread (over a period of months) to the periodontal ligament, alveolar bone, and cementum.

The longer that plaque is present, the greater its potential to destroy the periodontal ligament, thereby separating the tooth from its supporting bone. This results in periodontal pockets. Calculus further irritates the periodontium and can accentuate the accumulation of plaque and the formation of periodontal pockets. If the alveolar bone becomes infected, decreased bone support and increased tooth mobility may result. When both pockets and tooth mobility are present, the condition is called chronic destructive periodontal disease, or periodontitis.

Periodontal disease has a unique pattern related to individual teeth and surfaces. The gingival surfaces most severely affected by plaque and gingivitis are, in descending order, the interproximals (where the teeth contact each other), the facial (cheek) side of the teeth, and the lingual (tongue) side (Loe et al., 1965). Gingivitis may tend to appear more on the right than left side of the mouth, perhaps because right-handed persons have greater difficulty brushing the right side of the mouth (Beube et al., 1964; Suomi and Barbano, 1968). The teeth that are most severely affected by plaque, calculus, and hence periodontal disease are the lower anteriors and the upper molars. The least affected are the lower premolars and upper canines.

INDEXES OF PERIODONTAL DISEASE

Periodontal disease experience refers to the *cumulative* effect of disease on the periodontium. The majority of indexes for measuring periodontal disease assess both the presence and the severity of the condition. Some indexes focus on etiologic agents such as plaque and calculus. Others consider the presence of these agents' "intermediate outcomes" that may result in periodontal disease. The more common

and reliable indexes are briefly reviewed in the remainder of this section; a more complete description of numerous indexes of periodontal disease can be found in Carranza (1979).

Periodontal Index

The Periodontal Index (PI) uses a mouth mirror and artificial light to assess the presence and severity of gingival inflammation, pocket formation, and tooth mobility. With certain exceptions, the tissue surrounding each tooth is assigned a PI score.

The PI scores can range from 0 to 8 on a five-point weighted scale (Russell, 1956): 0, negative; 1, mild gingivitis; 2, gingivitis; 6, gingivitis with pocket formation; and 8, advanced destruction with loss of masticatory (chewing) function. The PI score for each individual is the sum of all that person's tooth scores divided by the number of teeth scored. To minimize the abstractness of these numerical PI values, especially in epidemiological studies, scores can be associated with clinically meaningful (but not mutually exclusive) categories that correspond to increasingly severe levels of periodontal disease. For example, Russell (1967) denoted PI scores for population groups as follows: (1) clinically normal gingival tissues, PI score of 0 to 0.2; (2) simple gingivitis, 0.3 to 0.9; (3) beginning destructive periodontal disease, 0.7 to 1.9; (4) established destructive periodontal disease, 1.6 to 5.0; and (5) terminal disease, 3.8 to 8.0. Categories 1, 2, and 3 are considered reversible stages of disease and categories 4 and 5 as irreversible.

The PI has some limitations for both clinical and epidemiological work. Because radiographs and a periodontal probe are not used in the PI examination, early bone loss tends to be underestimated more than is irreversible periodontal disease or terminal disease (Sheiham and Striffler, 1970). Moreover, it is not as useful on an individual basis as some other indexes because many of the signs of periodontal pathology are not included in the PI criteria. Finally, periodontal pockets are *implied* by the visible presence of overt deposits of calculus. This is considered a potential weakness of the PI because it is possible to have a periodontal pocket without the presence of gross decay.

The PI is one of the more subjective measurement tools that might be used in dental examinations of general population samples. For example, the loss of masticatory function is *inferred* from the presence of obvious mobility with light finger pressure. Second, the presence or absence of gingival inflammation is determined by the color of the gingival tissues at the gum line. Viewing color changes in the gingival tissues can be difficult, however, because color is greatly influenced by the

presence and volume of moisture in the mouth, the angle of the artificial light, and the length of time the inflammation has been present. In addition, certain stages of inflammation (e.g., chronic inflammation) may not present a color change that meets PI criteria. Finally, interpretation of the PI is not always straightforward. For example, having 24 of 28 teeth with mild gingivitis will result in the same score as 3 of 28 teeth with mobility. Yet one person has gingivitis and the other has periodontitis.

The PI has at least two advantages over other measures. First, it is reasonably reliable. Second, it has been widely used and thus provides a basis for comparing findings across studies and for examining changes over time.

Oral Hygiene Index

The PI is most meaningful when combined with data about oral hygiene status (Russell, 1969). The Oral Hygiene Index (OHI) is a fairly complex measure that provides such information; it is based on an assessment of the degree to which a tooth's surface area is covered by plaque (debris) and calculus (tartar) (Greene and Vermillion, 1960). The index is predicated on the assumption that the dirtier the mouth, the greater the tooth surface area covered by such deposits. This assumption implies a time factor, because the longer adequate oral hygiene practices are neglected, the greater the surface area of the tooth covered by debris or calculus.

A mouth mirror, dental explorer, and artificial light are used in performing the OHI examination. The presence and extent of debris and calculus are determined by direct visual and tactile inspection with the explorer. In the debris portion of the examination, the tooth surface is divided horizontally into thirds (incisal, middle, gingival) and the explorer is drawn from the tip (biting edge) of the tooth to the gum line. Scores are then assigned as follows: 0, no plaque on tooth or explorer; 1, plaque on the gingival one-third of the tooth *or* plaque absent from the visible tooth surface but present on the dental explorer when drawn subgingivally in a horizontal direction; 2, plaque on the middle one-third of the tooth surface; and 3, plaque on the incisal one-third.

Although both supragingival and subgingival calculus (i.e., above and below the gum line) are considered in the examination, only one calculus score is assigned to each tooth surface; the presence of subgingival calculus takes precedence over supragingival calculus. Supragingival calculus is assessed with the tooth surface divided into thirds, as

was done for the debris examination. To assess subgingival calculus, the examiner places the dental explorer in the gingival crevice near the contact area of the adjacent tooth and draws it gently halfway around the tooth. The presence of any subgingival calculus is assigned a score of 2. A score of 3 is assigned only if a continuous band (i.e., from one tooth contact to the adjacent tooth contact) of subgingival calculus is present.

Greene and Vermillion (1960) substantiated the clinical observation that periodontal disease rarely occurs in the absence of plaque or calculus, by showing that correlation coefficients between PI and OHI scores were statistically significant (0.78 for the OHI, 0.69 for debris, and 0.60 for calculus; all $p < 0.001$). Lilienthal et al. (1965) found that the debris and calculus components of the OHI varied in their ability to predict the PI, depending on the age of the person being examined. For instance, for children 5 to 9 years of age, only the debris index was related to the PI score; after 24 years of age, the calculus index was more significantly related to the PI than debris.

For the OHI, once all tooth surfaces have been scored for debris and calculus, those scores are condensed into one for 12 tooth-surface areas as follows: The mouth is divided into six areas (four posterior and two anterior), three on the upper jaw, three on the lower. Each area initially receives two debris and two calculus scores, one each on the cheek side and the tongue side. The debris and calculus score of the highest-scoring tooth (either cheek-side or tongue-side) in each area is assigned to the entire area, so the final score is derived from 12 tooth-surface area scores—six areas times two scores (one for debris and one for calculus). The OHI score per person is then the sum of the 12 tooth-surface area scores divided by 12.

Simplified Oral Hygiene Index

To arrive at an index that required less time to perform than the OHI examination and fewer decisions by the examiner, Greene and Vermillion (1964) developed the Simplified Oral Hygiene Index (OHI-S). The essential differences between the OHI and the OHI-S are number of tooth surfaces (only six in the OHI-S) and the method of selecting the tooth surfaces.

Specifically, the OHI-S examination assesses four posterior areas (the cheek side of the upper first molars and the tongue side of the lower first molars) and two anterior areas (the lip sides of the upper right incisor and the lower left incisor). The criteria used for evaluating debris and calculus remain the same.

Greene and Vermillion based their selection of these tooth surfaces on an examination of every tooth present in a group of 232 adults and children. In this study, they compared the oral hygiene scores using the OHI-S (six surfaces), the OHI (12 surface areas), and all tooth surfaces. The largest difference between the OHI-S and the OHI was a 5-percent variation in mean score, which is clinically insignificant.

The OHI-S has since become the accepted technique for assessing the oral hygiene levels of groups. There are several reasons for its widespread use. It can be performed in less than one minute. It is reasonably sensitive and the criteria are relatively objective. It is highly reproducible and can be done by examiners with only minimal training in its administration. A strong degree of association between OHI-S and PI scores has been demonstrated, with correlation coefficients from 0.69 to 0.80 (Shapiro et al., 1971). It has been used by numerous investigators throughout the world, giving it the same advantage as the PI in cross-sectional and longitudinal investigations.

Reliability of Periodontal Disease Indexes

Although the reliability literature for periodontal and oral hygiene measures is limited, a few attempts have been made to test the reliability of the PI and the OHI-S. For example, Davies et al. (1967) tested the intra-examiner reliability of the PI using the percentage discrepancy (the discrepancy between two examinations, with the repeat examination expressed as a percentage of the first). The 13 individual examiners' discrepancies ranged from 0 to 264 percent for the less serious disease category (no gingivitis to mild gingivitis) and from 0 to 60 percent for the more severe disease category (moderate gingivitis to loss of tooth function). Two other studies found the intra-examiner variability for the OHI-S, measured as percentage agreement among tooth surfaces, to be quite acceptable: 80 and 84 percent for assessing debris; 95 and 93 percent for supragingival calculus; and 81 and 76 percent for subgingival calculus (Greene, 1967; Smith et al., 1970).

Davies et al. (1974) examined the intra- and inter-examiner variability of the PI and OHI-S and determined that the examiners were applying the criteria for "groups" reliably and reproducibly. A comparison of the mean index scores for inter-examiner variability showed slight but insignificant differences.

Periodontal Profile Score

The Periodontal Profile Score (PPS), which is based on criteria developed for the *Ten-State Nutrition Study* (1972), is a simple method of estimating the periodontal treatment needs for enrollees in the Rand Health Insurance Experiment (Spolsky, 1974). It is predicated on the assumption that not every individual at any given time needs dental prophylaxis (teeth cleaning). Although all individuals are examined, only those who had conditions requiring professional intervention are given a PPS value. That is, the PPS is used only for persons who presumably cannot reverse the diseased condition of their gingival tissues by their own dental hygiene skills.

The PPS has four score categories: 0, several isolated areas of gingivitis and no overt deposits of calculus; 1, gingivitis throughout the mouth and overt deposits of calculus; 2, periodontal pockets present (inferred by the presence of calculus deposits large enough to distort the natural scalloped shape of the gum line); and 3, gross deposits of calculus, gingival inflammation, and numerous periodontal pockets. To aid the examiner in assigning scores and to minimize inter-examiner variability, each category was also defined in terms of the time necessary to treat the condition: 1, approximately 30 to 45 minutes of treatment time by a dental hygienist or dentist (approximately the amount of time to provide a thorough teeth cleaning); 2, prophylaxis and a gingival curettage, requiring no more than two appointments; and 3, prophylaxis, gingival curettage, and probably some surgical procedure requiring at least three appointments. The PPS underestimates the treatment needs for persons who require extensive periodontal therapy.

The PPS is a relatively new index and has not yet been subjected to reliability or validity testing (although such investigations are planned for the end of the HIE). Because it is still in its development stage, it is not a commonly used measure. It could, however, become a useful tool for specialized studies in which predicted treatment needs are an important variable.

Chapter 3

JUSTIFICATION FOR SELECTING DENTAL DISORDERS FOR HEALTH INSURANCE EXPERIMENT ANALYSIS

Dental services were one major category of benefits covered by the Health Insurance Experiment (HIE) insurance plans. Virtually any dental service except nonpreventive orthodontia was covered, subject to the relevant cost-sharing provisions of the family's particular plan. Thus, measures were needed that would provide an adequately comprehensive picture of the dental health status of the HIE enrolled population and of the changes in it over time as a function of insurance plans.

To achieve this comprehensiveness, we chose to investigate both dental caries and periodontal disease for several reasons. First, manifestations of both dental problems are highly prevalent in general populations. Second, if untreated, they can lead to considerable morbidity. Third, they are responsive to care. Moreover, they can be detected and assessed with reasonable ease and objectivity. The remainder of this chapter considers these topics in more detail.

PREVALENCE: DENTAL CARIES

The best source of data on the dental status of Americans is the periodic Health and Nutrition Examination Survey (formerly, Health Examination Survey) of the National Center for Health Statistics (NCHS, 1967, 1971, 1974a,b, 1979, 1981a). The HANES involves a national probability sample of children (ages 6 to 11), youths (ages 12 to 17), and adults (18 years of age and older). For youths and adults, permanent tooth status is assessed by the DMF (decayed-missing-filled) tooth index (also abbreviated DMFT). For children, the def tooth index is used for assessing the primary dentition (baby teeth).[1]

NCHS (1981a) has demonstrated that virtually no one escapes dental caries: Only 1.3 percent of the adult population in this survey had

[1]The dental caries indexes (DMF teeth, DMF surfaces, and def teeth and surfaces) were discussed in greater detail in Chapter 2.

32 sound teeth and no fillings (i.e., 0 DMF). Moreover, a large percentage of the adult population had severe disease: 55 percent of the adults had 18 or more DMF teeth (based on 32 teeth), and about 25 percent had 24 or more DMF teeth.

Because dental caries experience is a chronic, cumulative phenomenon that commences soon after teeth erupt, it is not surprising that it is strongly age-related (Bell et al., 1982; NCHS, 1981a). Children 4 years of age have, on average, less than 2 def teeth. By 8 years of age, this has increased to about 4 def teeth. This age-related phenomenon is also observed for permanent teeth. By 10 years of age, approximately 14 percent of permanent teeth have experienced dental caries; by 20 years, 36 percent. This figure rises to 55 percent by 35 years of age, and 62 percent by age 50. However, the *incidence* (i.e., the number of new DMF teeth per year) increases from 6 years of age until about age 24 (by 0.7 DMFT per year) and then decreases through age 50 (by 0.3 DMFT per year). The high attack rate for persons less than 24 years of age supports the observation that dental caries is primarily a disease of the young (NCHS, 1971, 1974a, 1981a).

Dental caries experience exhibits several relationships to demographic characteristics of the population. The more important include the following:

1. Women have a higher dental caries experience than men (NCHS, 1979). Girls tend to have earlier tooth eruption than boys, and thus have more teeth at risk of tooth decay (or the same number of teeth exposed for longer periods).
2. White adults generally have a higher dental caries experience than black adults. The magnitude of this racial difference among adults decreased from 50 percent (6.5 DMFT) higher to about 25 percent (4.2 DMFT) higher between 1960–1962 and 1972–1974 (NCHS, 1967, 1979, 1981a). Racial differences are small for persons 12 to 17 years of age (less than 1 DMFT) and almost nonexistent for 6- to 12-year-olds (NCHS, 1981a; NIDR, 1981). In fact, at least two surveys have found that DMFS (Bell et al., 1982) and defs (Infante and Owen, 1975) scores were *higher* among black children than among white children.
3. In general, total dental caries experience increases slightly with more education and income (NCHS, 1967, 1981a). The number of decayed and missing teeth is inversely related to education and income, whereas the number of filled teeth is directly related. Within the same education or income bracket, whites have higher DMFT scores than blacks.

Results from several other smaller studies, however, do not reflect a consistent pattern regarding DMFT differences between whites and blacks (McCauley and Frazier, 1957; Creighton, 1969; Bagramian and Russell, 1971; Heifetz et al., 1976). These results may arise because of the very small sample sizes in some of these studies.

4. Dental caries experience differs by geographic and rural/urban areas. The Northeast has the highest DMFT scores, followed (in decreasing order) by the Midwest, South, and West. In keeping with this pattern, persons who live in urban areas have a slightly higher dental caries experience than those living in rural areas. These locational differences are largest for persons over 11 years of age (NCHS, 1967, 1971, 1974a, 1981a).

The long-term trend for dental caries experience looks optimistic. Comparing the DMF scores from earlier national surveys (the HES) for adults (1960–1962) with those from the most recent HANES (1971–1974) shows a slight rise in the proportion of adults with zero DMF teeth and an overall decrease of one DMF tooth (NCHS, 1967, 1981a). In addition, recent data from the National Dental Caries Prevalence Survey (NIDR, 1981) document a definite lessening of caries intensity (mean DMF scores) among children. Finally, findings from the National Preventive Dentistry Demonstration Program (Bell et al., 1982) show a similar drop for those 6 to 13 years of age.

PREVALENCE: EDENTULOUSNESS

The prevalence of edentulousness (i.e., persons who are completely without upper and lower teeth) decreased from 18 to 15 percent of the U.S. population from 1960–1962 to 1971–1974 (NCHS, 1974b, 1981a). In 1971–1974, the prevalence of edentulousness in only one arch was just over 9 percent (NCHS, 1981a).

As would be expected, the prevalence of persons who are completely edentulous increases with age, from 4 percent for persons 18 to 44 years of age to 45 percent for persons ages 65 to 74 (NCHS, 1981a). Among all adults 18 to 74, women are more likely than men to be edentulous (16 versus 13 percent), as are whites compared with blacks (15 versus 9 percent) (PHS, 1960; NCHS, 1981a). The racial difference is particularly pronounced among white and black men—14 versus 4 percent, respectively, being without teeth (NCHS, 1981a). The white/black differential is present at all income levels but tends to decrease as income rises.

The future prevalence of edentulousness depends on two conflicting trends. On the one hand, as the proportion of persons who live to an older age increases, the number of edentulous persons may rise. On the other hand, as people retain more natural teeth because of more and better preventive and restorative dental care, the prevalence of edentulousness may decrease. The latter trend is generally believed to be the more powerful, as reflected in the drop in edentulousness cited by NCHS (1981a).

PREVALENCE: PERIODONTAL DISEASE

Obtaining a precise estimate for the prevalence of periodontal disease is difficult. First, the signs of periodontal disease (changes in color, swelling, bone levels) are more subjective than the objective evidence of visible caries. Second, the best measure of periodontal status (changes in the supporting bone) can be observed only indirectly (by probing the pockets or using radiographs). Third, it is reasonable to assume that a substantial proportion of completely edentulous persons lost their teeth *because of* periodontal disease (but they would not be included in estimates of the prevalence of periodontal disease). This assumption is supported by data showing that people with teeth in only one arch have more severe periodontal disease than people with some teeth in both arches.

Although periodontal disease is considered an adult disease, its *initial* state, gingival inflammation (gingivitis), begins in adolescence, reaches its highest prevalence in older youths, and then gradually decreases with increasing age (Massler et al., 1952; Parfitt, 1956; Russell, 1957; Zimmerman and Baker, 1960; Greene, 1960; *Ten-State Nutrition Study*, 1972; NCHS, 1979). NCHS surveys indicate that, as of the mid-1970s, one-quarter of the U.S. population had gingivitis (NCHS, 1979), with prevalence being highest among youths (32 percent) and decreasing thereafter (to 20 percent among persons 45 to 64). Other data reveal that about one-quarter of adults have moderate-to-severe periodontal disease (presence of one or more pockets), with prevalence rising more than threefold from age 18 to 74 (from 15 to 50 percent).

Important findings relating to periodontal disease include the following (NCHS, 1979):

1. Adult men have approximately a 22-percent higher prevalence of moderate-to-severe periodontal disease than women (one or more pockets), and they experience almost 30-percent higher prevalence of severe disease (four or more pockets).

2. The average PI score rises over threefold for both men and women ages 18 to 74 (0.91 to 2.1 for men, and 0.61 to 1.66 for women). Average OHI-S scores also rise with age, but more sharply for men than for women (1.16 to 1.76 and 0.86 to 1.16, respectively).
3. The average PI score is approximately 45 percent lower among adult whites than among adult blacks (1.08 and 1.93, respectively).
4. In general, periodontal disease is inversely related to increasing levels of education and income, with education having the slightly stronger relationship. When black and white adults of similar education levels are compared, the differences in periodontal disease severity disappear.
5. The prevalence and severity of periodontal disease appear to be slightly greater in individuals living in rural areas than among their urban counterparts.
6. Although the prevalence and severity of periodontal disease do not differ by geographic region for adults, they do for children and youths. Specifically, children and youths (6 to 17 years of age) living in the South have slightly higher PI scores than their counterparts living in the Northeast, Midwest, and West (NCHS, 1974c).

All other things equal, we might expect the long-term trend in periodontal disease to be upward, as people begin to retain more natural teeth throughout their lifetime and as the proportion of adults in the population increases. (Simply stated, more teeth are at risk to gingivitis and to periodontal disease.) In contrast, more and better care of teeth, both preventive and therapeutic, may reduce the risk of periodontal disease, thereby lowering its prevalence over time. NCHS data do not reflect any change in the prevalence of periodontal disease between 1960–1962 and 1971–1974, but changes in the prevalence of this condition might well take longer than 10 to 15 years to emerge.

EFFECTS OF DENTAL CARE: DENTAL CARIES

Prevention of Decay

Fluoride. International studies (Russell, 1963; WHO, 1970) and controlled trials in the United States (McClure, 1970; Newbrun, 1978) have determined that the only known nutrient that inhibits the process of dental caries is the element fluorine, when it is ingested at optimal

levels (usually one part per million) from birth through the period of tooth development (i.e., until approximately 14 years of age). Fluoride levels more than 0.3 to less than 0.7 parts per million confer some benefit, but the relationship between decreasing dental caries experience and increasing levels of fluoride in the drinking water is nonlinear.

When taken from birth, fluoridated drinking water may decrease the incidence of decay by approximately 50 percent. When a fluoridated central water supply is not available, fluoride drops or tablets may be administered (Newbrun, 1975).

When the permanent teeth begin to erupt (at about age 5 or 6), an important part of preventive behavior includes the use of topical fluoride agents (i.e., toothpastes containing fluoride, application of fluorides by dental professionals, and fluoride mouth rinses). Substantial decreases in the incidence of tooth decay have been found for persons who use fluoridated toothpastes daily (15 to 25 percent) (Heifetz and Horowitz, 1975), who receive semiannual topical applications of fluoride by a dental professional beginning at age 6 (35 to 40 percent) (Horowitz and Heifetz, 1975), or who use fluoride mouth rinses (35 to 40 percent) (Horowitz, 1980a).

The National Preventive Dentistry Program has yielded less optimistic findings about the effects of topical fluoride use on the incidence of dental caries (Bell et al., 1982). In 10 fluoridated and nonfluoridated sites, the investigators compared DMFS indexes among 9566 children who received one of six treatment regimens. They found that the use of fluoride tablets (in nonfluoridated sites) or mouth rinses made little difference in DMFS scores.

Brushing. As part of the health practices portion of the National Survey of Personal Health Practices, NCHS (1981b) determined that approximately 34 percent of dentulous adults brushed their teeth less than twice a day. (They did not report the percentage who brushed once a day.) Brushing twice a day or more was more prevalent among women than among men (74 versus 51 percent) and among persons with higher levels of education.

Studies have not been unanimous in finding a significant relationship between the removal of dental plaque by toothbrushing (without a fluoride toothpaste) and the reduction of dental caries. For example, Fosdick (1950) found that young adults (instructed to brush with a nonfluoridated toothpaste within 10 minutes of eating) had a significantly lower caries experience than a control group (instructed to continue their regular oral hygiene habits). Another study of adults found significantly fewer decayed and filled surfaces and fewer surfaces with

recurrent decay among a group who received regular prophylaxis and oral hygiene instruction than among a control group who received traditional dental treatments once a year (Axelsson and Lindhe, 1978). Leske et al. (1976) reported significant differences in DMFT and DMFS scores between school children who brushed twice a day and those who brushed once. However, other investigators (with sample sizes ranging from 385 to 1400 persons) have shown no or only a nonsignificant relationship between frequent brushing and DMFT or DMFT scores among adults (Dale, 1969) and children (Barenie et al., 1973; Silverstein et al., 1977; Horowitz et al., 1977).

Flossing. Flossing removes the plaque that accumulates between the teeth beyond the reach of the toothbrush. According to NCHS (1981b), approximately 52 percent of men and 38 percent of women with natural teeth *never* floss their teeth.

Studies of the effects of using dental floss to reduce dental caries have been inconclusive. Although Horowitz et al. (1977) and Silverstein et al. (1977) observed only a nonsignificant tendency toward lower increments of dental caries on the proximal surfaces of posterior teeth for schoolchildren who used dental floss, Wright et al. (1977) did show a significant decrease of new caries on posterior teeth for children. However, the results of this study must be interpreted with caution because research assistants performed the flossing.

Avoiding Between-Meal Snacks. Increasing levels of dental caries experience has been directly related to the frequency of between-meal snacks (Weiss and Trithard, 1960; Bibby, 1975), particularly the frequency of snacks that are sticky and high in sugar content (Lundquist, 1952; Gustafson et al., 1954). Thus, abstaining from between-meal snacks is often considered part of good prevention. Bagramian and Russell (1973), in a cross-sectional survey of high school students, did not find a significant relationship between the consumption of between-meal snacks containing sucrose and dental caries experience. Cross-sectional work can be questioned, however, if it attempts to associate a current practice (diet) with a disease process that has accumulated over many years.

Newbrun (1982) provides an excellent review of studies of the relationship between sugar and dental caries. He concludes that although cross-sectional and longitudinal surveys indicate that frequent intake of sugary foods predisposes to decay, these studies contain methodological problems. For example, accurate data on dietary intake may be hard to obtain and the diets of human subjects are difficult to control. In addition, ethical considerations preclude deliberately testing caries-promoting foods.

Occlusal Sealants. Occlusal sealants are adhesive resins applied to the pit and fissure surfaces of a posterior tooth (Ripa, 1975). They are an important addition to the preventive armamentarium because occlusal surfaces make up only 20 percent of all posterior tooth surfaces but occlusal decay accounts for 50 to 60 percent of all decay on posterior teeth (Horowitz, 1980b). The beneficial effect of these sealants is believed to rise with age, because the number of surfaces at risk to occlusal decay increases with age.

Sealants must be applied under controlled, dry conditions for the maximum bond to occur between sealant and tooth surfaces. Moisture contamination may cause premature loss of the sealant, leaving the pit or fissure exposed to plaque, saliva, and food. If applied to newly erupted posterior teeth and checked every 6 months, occlusal decay can be reduced almost 100 percent after 2 years (Buonocore, 1971). A single application, without biannual checks, results in a 39-percent reduction in occlusal decay after 5 years. Even if a sealant has not been retained for the full time, the susceptibility of the tooth to decay remains reduced (Horowitz et al., 1977). Inadvertent sealing of an incipiently decayed area has also been shown to arrest the progression of the decay process (Handelman, 1976).

Because protecting the occlusal surface is of little value if the smooth surfaces are left at risk to decay, sealants should be used in conjunction with systemic and topical fluorides. These two preventive agents complement each other because fluorides have their greatest impact on smooth tooth surfaces.

Despite the potential for sealants plus fluorides to reduce tooth decay substantially, these agents are not widely employed. Gift et al. (1975) cited several reasons advanced by dentists: The efficacy of sealants is unsubstantiated by research; decay might be sealed as well; and sealants do not last very long.

General Considerations. Use of all these preventive agents simultaneously will not have an additive effect on preventing dental caries. For instance, fluoridated drinking water (approximately 65-percent reduction in caries), professional application of a topical fluoride (40-percent reduction), and use of a fluoridated toothpaste (20-percent reduction) do not reduce tooth decay by 125 percent. Nevertheless, several studies have shown that children's DMFS scores drop markedly when multiple fluoride agents are used (Bagramian et al., 1979; Heifetz et al., 1979; Horowitz, 1980a).

Successful implementation of these preventive agents requires knowledge of their availability, belief in the efficacy of prevention, conscientious parents who encourage preventive activities of children, and

the financial ability to procure the services and products necessary. Because dental caries is a slow, progressive problem, the rewards of prevention are not immediate. That the results of prevention lie far in the future is a sizable barrier to motivating people to employ preventive dental care.

Treatment of Decay and Restorative Care

The majority of dental care rendered in the United States is directed at arresting the irreversible process of dental caries by removing the decayed and decalcified tooth structure and restoring the tooth's normal anatomy and function. When decay is detected early, a small restoration (filling) made of metal or plastic may be used. As the decay process spreads to more of a tooth's surfaces, the restoration becomes more complex. For example, inlays, onlays, partial crowns, or full crowns involve casting precious and semiprecious metals as well as several hours of processing.

If nothing is done to arrest the decay process, the dental pulp within the center of the crown and roots of a tooth becomes infected. This brings pain and discomfort and eventually destroys the pulp. If the infection is not localized by natural defense mechanisms, it diffuses locally or spreads to other areas of the head and neck. If the infection diffuses through tissue spaces, a soft tissue inflammation may occur, and if it diffuses within the confines of the lower or upper jaw, an inflammation of the bone and bone marrow (osteomyelitis) may develop and result in an irreversible loss of the jawbone. Other severe conditions, such as Ludwig's angina (a severe cellulitis of the soft tissue below the lower jaw from an infected lower molar) and sinus thrombosis (the formation of a blood clot in the sinuses above the upper jaw from an infected upper tooth), are rare; before the advent of antibiotics, however, they had a high mortality rate.

When the pulp becomes infected, either the tooth can be extracted or the infected tissue removed by endodontic therapy. If endodontics is elected, the tissue is removed and the pulp canals filled with a metallic or nonmetallic material. The crown of the tooth is then restored with a complex filling or crown.

If extraction is elected, the lost tooth should be replaced within several months or the adjacent teeth may tip or drift into the extracted tooth's space. Teeth in the opposing jaw may also extrude into the space of the missing tooth. The sequelae of unreplaced teeth vary by individual. However, any movement of the adjacent or opposing teeth may be minimized by keeping the supporting tissues of the teeth in a good state of periodontal health.

The decision to replace a missing tooth depends on the patient's age, ability to chew, aesthetic preferences, status of the periodontium, and financial situation. One routine treatment following tooth extraction is construction of a fixed or removable prosthesis (an artificial replacement for a missing tooth space or spaces that simulates the missing tooth). A fixed prosthesis (bridge) involves the restoration of the teeth adjacent to the empty tooth space (i.e., the abutments). The fixed bridge is usually made from a precious or semiprecious metal such as gold; if aesthetics are important to the patient, it may have a porcelain or plastic facing fused to metal. A removable prosthesis may or may not require the restoration of the abutment teeth with cast metallic restorations. The removable prosthesis is usually cast from a nonprecious metal and the teeth may be made of either plastic or porcelain.

The long-term effects of restorative dental care are not precisely known. Little experimental evidence indicates the longevity of fillings and prostheses or the long-term effects of prostheses on the adjacent and opposing teeth and on the periodontium. Most studies have concentrated on the effects of inadequate restorations on the periodontal tissues. For instance, researchers have found a strong relationship between restorations with overhanging gingival margins (in which the margin of the filling or crown extends beyond the normal margin of the tooth) and presence of gingivitis (Alexander, 1968; Wright, 1963), periodontal disease (Gilmore and Sheiham, 1971), and bone loss (Bjorn et al., 1970). Some evidence suggests that even high quality restorations that extend beneath the gingival margin will increase gingival inflammation and plaque accumulation (Norman et al., 1972; Renggli and Regolati, 1972). Some earlier investigators, however, did not observe these relationships (Shay and Smart, 1945; Suomi, 1969).

For patients with fixed bridges, Silness (1970a,b,c; Silness and Ohm, 1974) concluded that abutment teeth with subgingival crown margins (in which the margin of the crown is simply below the gum margin) had significantly more plaque accumulation and gingival inflammation than the uncrowned control teeth. Studies on the effects of removable prostheses on the periodontium have also showed increased levels of dental caries, inflammation, plaque, tooth mobility, and bone destruction on the abutment teeth adjacent to the prosthesis (Fenner et al., 1956; Carlsson et al., 1965; Bissada et al., 1974).

Several studies contradict these findings, however. When good oral hygiene was emphasized among persons with partial dentures, Bergman et al. (1971) found no significant deterioration of the periodontal status of abutment teeth, and Derry and Bertram (1970) found no signs of

inflammation or tissue destruction (gingivitis, dental caries, or tooth mobility (among persons who had worn partial dentures for 2 years.

Dental care for dental caries is directed at prevention and treatment. Early detection and treatment of tooth decay, replacement of missing teeth, and prevention of further deterioration of the teeth and supporting tissues are the major restorative aspects of dental care. These techniques contribute substantially to the ability to chew food, speak clearly, and maintain a pleasant facial appearance, and thus they also support the psychological well-being of an individual. The efficacy of dental care in treating dental caries, the high prevalence of tooth decay, and the relative high cost of dental care are of sufficient import to warrant examining the influence of health insurance on dental health.

EFFECTS OF DENTAL CARE: PERIODONTAL DISEASE

Prevention

Well-controlled longitudinal studies have demonstrated that daily removal of plaque and periodic removal of dental calculus (tartar) professionally can prevent gingival and periodontal disease at its earliest reversible stages. Such steps can also arrest the more advanced irreversible stages of periodontal disease so that bone and tooth loss can be prevented or minimized.[2] In addition, thorough and frequent prophylaxes decrease the loss of epithelial attachment and deepening of the gingival crevice between the tooth and gums that are common in periodontitis.

The value of periodontal treatment in forestalling tooth mortality can be illustrated by comparing the average number of teeth lost by persons who had received preventive periodontal treatment and maintenance care (Oliver, 1969; Ross et al., 1971; Hirschfeld and Wasserman, 1978) with the average tooth mortality for the U.S. general population (NCHS, 1979): about one tooth to about three teeth. (The average number of teeth lost was adjusted proportionally to 10 years following treatment for each study.) The impact that periodontal therapy can have on a general adult population is underlined by findings from studies spanning more than half a century, which demonstrate that more teeth have been lost from periodontal disease than

[2]For further detail, see Lovdal et al. (1961); Brandtzaeg and Jamison (1964); Loe et al. (1965); Koch and Lindhe (1965); Lightner et al. (1971); Suomi et al. (1971); Chawla et al. (1975); Lindhe et al. (1975); Axelsson and Lindhe (1978); and Carranza (1979).

from dental caries (Brekhus, 1929; Allen, 1944; Andrews and Krogh, 1961; Grewe et al., 1966; Carranza, 1979).

Numerous antimicrobials that prevent or retard the formation of plaque have been evaluated with mixed results (Lobene, 1979). Some promising antimicrobials, such as chlorhexidine and alexidine, have side effects (e.g., staining of the teeth) that might hinder their widespread use despite their ability to prevent or reduce plaque and gingivitis. Kanamycin has been highly effective as short-term therapy in reducing plaque and gingivitis in individuals who, because of poor manual dexterity or the inability to understand (i.e., who are physically or mentally handicapped), cannot perform thorough toothbrushing. Tetracycline has been used successfully as a short-term adjunct in the treatment of certain types of periodontal disease in adults who do not respond to conventional therapy (Fischman, 1979).

Treatment of Periodontal Disease

Periodontal treatment is directed mainly at the more advanced stages of destructive periodontal disease: inflammation of the supporting bone and tissues immediately surrounding the tooth; bone loss; the loss of attachment between the tooth and gums; the formation of a large volume of calculus (calcified dental plaque) between the tooth and gums; deep periodontal pockets, with suppuration (pus formation); and varying degrees of tooth mobility. The primary objective is to remove the irritating factors that caused the infection of the periodontal tissues and to create an environment that maintains a healthy periodontium and teeth.

The first treatment steps consist of implementing a program of oral hygiene procedures by the patient, thoroughly removing all plaque and calculus and mechanically planing the root surfaces beneath the gum line, particularly in the deep periodontal pockets. Irritational factors secondary to an inadequate restoration or prosthesis should be corrected. Teeth that occlude prematurely (i.e., make contact with opposing teeth before all the other teeth come together) are adjusted to prevent trauma to the supporting tissues. Mobile teeth may be splinted together or stabilized with a prosthesis.

Periodontal pockets can be eliminated by gingival curettage or surgical procedures (excisional or incisional flap). Gingival curettage (considered here as a nonsurgical procedure) is the most commonly used technique. It consists of mechanically removing the plaque, calculus, and other debris from the tooth surface and eliminating the diseased tissue that lines periodontal pockets.

If a healthy periodontium is not achieved with the conservative approach, one of several surgical procedures may be attempted. These include excision of the periodontal pocket wall (gingivectomy), usually before scaling and planing of the roots, and one or more types of surgical incisions (periodontal flaps) around the periodontal pocket. Incisions permit retraction of the gingiva so that inflamed tissues can be removed, with recontouring of the bone wall and root planing (if necessary). In addition, several procedures done in conjunction with surgical techniques provide optimal contour for the supporting tissues. These include recontouring of the soft tissues (gingivoplasty) or supporting bone (osteoplasty) and removal of any undesirable bone (osteoectomy).

The decision to employ excisional or incisional techniques depends on the specific area of the mouth involved and under treatment, the patient's ease of access to that area of the mouth, the type of periodontal defect present, the depth of the pockets, and the dentist's personal biases. In the front of the mouth, for example, the excisional technique is less desirable than the incisional technique because it frequently leads to exposure of the roots and thus to unesthetic results.

To clarify the issue of whether surgical or nonsurgical procedures are more efficacious for patients with periodontal disease, Ramfjord and colleagues (Ramfjord et al., 1968, 1973) compared the outcomes of various therapies over time. They found that, at 3 years, the results of curettage of deep periodontal pockets were better than those of gingivectomy, but that this difference disappeared by the seventh year of the study. In addition, after 7 years, pocket reduction was greater for gingivectomy than curettage.

Knowles et al. (1979) compared three methods for treating periodontal pockets: gingival curettage, a surgical incisional method (Widman flap), and gingivectomy. The Widman flap method and gingivectomy were more effective than curettage for reducing moderately deep pockets, but curettage and the Widman flap approach resulted in significantly increased attachment between the tooth and tissue. In general, the Widman flap with curettage is better for reestablishing attachment levels than flap procedures with osseous surgery. The latter approach, however, is better for pocket elimination than the Widman flap with curettage (Ramfjord et al., 1975).

After the diseased pocket has been eliminated or successfully treated and restorative procedures have been executed, maintenance becomes paramount. During this phase, the patient is recalled for periodic scaling and root planing, and for reevaluation of all teeth and supporting tissues. The importance of periodic scaling and root planing has been demonstrated in patients with severe periodontal disease (pockets

greater than 4 mm). Among patients who received scaling, planing, and oral hygiene care every 3 months, a significant loss or breakdown of the remaining tissues was prevented up to 8 years after the initial therapy was completed (Knowles et al., 1980).

Removal of dental plaque by tooth cleaning by the patient, periodic professional cleaning and scaling of the teeth, and removing or correcting irritational factors can prevent or control gingivitis and thus forestall advanced periodontal disease. In the more severe stages of periodontitis, where the supporting structures of the teeth have been reduced, gingival curettage and surgical procedures may arrest the disease. Further deterioration of the periodontium may be controlled by eliminating other irritational factors, maintaining good oral hygiene, and scaling and root planing of the teeth. The efficacy of the various treatment modalities is sufficiently high to warrant the study of periodontal disease as a means of gauging the influence of dental insurance on dental status.

Chapter 4

HEALTH INSURANCE EXPERIMENT METHODS

GENERAL CONSIDERATIONS

Medical History Questionnaire

Two sources were used by the Health Insurance Experiment (HIE) to measure the prevalence of tooth decay and periodontal disease at enrollment: a Medical History Questionnaire (MHQ) and a dental screening examination. The MHQ was administered at enrollment and at the end of the study, 3 or 5 years later. Adults, defined as persons 14 years and older, filled out their own questionnaires; a parent, usually the mother, completed those of their children under 14. The children's forms came in two versions: "pediatric," for children 5 to 13 years old, and "infant," for children 0 to 4. Each of the three age-specific instruments had two parts, Form A and Form B. For all sites except Dayton, Ohio, all participants were expected to complete both forms. In Dayton (enrollment only), Form A was given to all participants and Form B to a random subsample; at exit, all participants were asked to complete both forms of the MHQ.

Dental-related questions were contained in several places in the MHQs (in both Forms A and B), but the majority of questions were found in the battery on teeth and gums (hereafter Dental battery), which appeared on Form B of the adult and pediatric MHQs in all sites. The Dental battery contained items about preventive oral health habits (frequency of brushing, flossing, and use of fluoride); respondents' awareness of dental disease; frequency of dental visits; and the amount of pain, worry, and avoidance of conversation attributable to dental disease. This battery is reproduced in Appendix A. Four versions are given: adult and pediatric versions for Dayton and non-Dayton sites. The non-Dayton MHQs contain minor modifications to the Dayton version, based on field experience with the Dayton battery.

Additional dental-related questions were asked in other batteries. For instance, the Eating Habits and Diet battery, which was in Form A for adults in all sites except Dayton, included questions about eating between meals and eating junk foods or snacks. For children in the

non-Dayton sites, a Fluoride and Diet battery on both the pediatric and infant MHQs comprised similar items plus use of fluoride. These batteries are also reproduced in Appendix A.

Screening Examination

The second source of information used to measure oral health status was a dental screening examination, which involved an assessment of hard and soft tooth tissues. Depending on the HIE site, a random sample of 50 to 75 percent of participants ages 3 years and older received a dental examination at enrollment.[1] (In Dayton, some adults and children who completed Form B at home did not receive an examination because of scheduling problems.) A more detailed description of screening examination procedures is available in Smith et al. (1978).

Dentists examined each participant during the enrollment examinations at four sites; at the two other sites a hygienist, supervised by a dentist, gathered the clinical information. Four main types of evaluations were made of the dental health status of these participants: (1) The examiner categorized each tooth as permanent, primary, or unerupted and then scored each tooth and tooth surface as decayed, missing, or filled, according to the DMFT index and DMFS index (or the equivalent deft and defs indexes for young children). In addition, each tooth was scored as to whether or not it was grossly decayed using a Grossly Decayed Index (GDI). (2) The examiner assessed the condition of the gums and possible deeper periodontal disease according to the Periodontal Index (PI). Russell's (1956) five-point scale was used for scoring the PI in the HIE. (3) The examiner measured the presence or absence (and degree) of plaque and calculus and then scored the level of oral hygiene by the Simplified Oral Hygiene Index (OHI-S). (4) Finally, the degree of treatment needs, if any, was estimated using the Periodontal Profile Score (PPS). These measures were described more fully in Chapter 2. Their application in the HIE is presented below and in Table 1.

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[1]This random sample of participants will be used later in the experiment to study the effect of undergoing the examination on the subsequent use of dental services and on dental health status at the time of exit from the HIE.

Table 1

DEFINITION, SCORING RULES, AND CLINICAL INTERPRETATION OF ORAL HEALTH INDEXES

Index	Definition	Scoring Rules	Clinical Interpretation
DMFT index	Total number of decayed (D), missing (M), and filled (F) teeth.	Sum of DMF teeth; range = 0 to 28	The higher the index score, the more severe the dental caries experience, at least up to about age 35.
DMFS index modified	Total number of decayed (D), missing (M), and filled (F) surfaces.	Sum of DMF surfaces; range = 0 to 128	Same as DMFT but more indicative of the intensity of dental caries experience.
deft, defs indexes	Total number of primary decayed (d), indicated for extraction (e), and filled (f) teeth or surfaces.	deft: Sum of def teeth; range = 0 to 20 defs: Sum of def surfaces; range = 0 to 88	The higher the score, the more severe the dental caries experience; defs reflects intensity of dental caries experience.
Simplified Oral Hygiene Index (OHI-S)	Assessment of degree to which tooth surface areas are covered by plaque and calculus. Supplements PI score.	6 tooth surfaces are assessed, as follows. Plaque: 0 No plaque. 1 Plaque on gingival one-third of tooth or absent from visible tooth surface but present subgingivally. 2 Plaque on middle one-third of tooth surface. 3 Plaque on incisal one-third. Calculus: Both supragingival and subgingival calculus are assessed; subgingival takes precedence over supragingival.	0-1.2 Good 1.3-3 Fair 3.1-6 Poor

Table 1—continued

Index	Definition	Scoring Rules	Clinical Interpretation
OHI-S, cont.		Subgingival calculus: Same as plaque examination. Supragingival calculus: 2 Presence of any subgingival calculus. 3 Presence of a continuous band of subgingival calculus.	
Periodontal Index (PI)	Sum of scores for tissues surrounding each tooth, divided by the number of teeth scored.	0 Negative. 1 Mild gingivitis. 2 Gingivitis. 6 Gingivitis with pocket formation. 8 Advanced destruction with loss of masticatory function.	0.3-0.9 Simple gingivitis. 0.7-1.9 Beginning destructive periodontal disease. 1.6-5.0 Established destructive periodontal disease. 3.8-8.0 Terminal disease.
Periodontal Profile Score (PPS)	Estimate of periodontal status in relation to treatment needs.	0 Only isolated gingivitis and no calculus. 1 Gingivitis and overt calculus. 2 Periodontal pockets. 3 Numerous periodontal pockets, calculus, gingivitis.	No professional intervention needed. Thorough teeth cleaning needed. Prophylaxis, gingival curettage. Prophylaxis, curettage, and probably some surgery.
Gross Decay Index (GDI)	Count of number of teeth with gross (crass) decay.	0 No decay or defective restoration obvious. 1 Decay or defective restoration visible without an explorer.	Score of 1 implies immediate treatment needed.

DENTAL CARIES EXPERIENCE

The HIE defines dental caries (tooth decay) as present according to the five criteria described in Chapter 2. Briefly, these included enamel that yields to underlying soft material; a pit, fissure, or hole in the enamel; presence of gross decay; a defective restoration; or an erosion-type lesion on the gingival one-third of the tooth.

The DMFT index is the simple sum of decayed, missing, and filled teeth and applies to permanent teeth. Unless otherwise specified (as in comparisons with NCHS data), the DMFT index is based on 28 teeth. The deft index is equivalent to the DMFT (with "e" referring to teeth indicated for extraction) and applies to primary teeth.

The HIE used a modified DMFS index in its dental examination to classify each tooth surface as decayed, missing, or filled. When a tooth had both decay and a filling present, a hierarchy was established whereby the number of tooth surfaces that needed restoration took precedence over the number of filled surfaces. Thus, if a single tooth surface was filled and a subsequent surface on the same tooth became decayed, both surfaces would be designated as decayed. If, at a later time, all decayed surfaces were filled, they would be designated as filled, not decayed. The defs is equivalent to the DMFS and applies to primary teeth.

There were two reasons for adopting this strategy for scoring the DMFS. First, because different examiners were used at each of the six HIE examination sites, the modification of the DMFS index minimized possible inter-examiner variability. Second, because one of the purposes of the HIE was to study the influence of dental insurance on health status, it was deemed more important to observe changes in the treatment needs (decayed category) of each tooth than to dilute those needs with past treatment experience (filled category). As a result, the decayed category may be slightly overestimated and the filled category slightly underestimated. Examination of data from the dental insurance claims that accrued during the HIE should help to determine the extent of the under- and overestimation.

At the exit examination, the dental caries experience was again assessed for each participant over 6 years of age. The DMFT and DMFS (or deft and defs) indexes were scored as appropriate to the age of the individual.

To summarize: The DMFT and DMFS indexes were based on 28 teeth and 128 surfaces, respectively, and were scored for all persons 6 years and older. The deft and defs indexes were based on 20 teeth and 88 surfaces and were scored for all infants and children 3 through 11

years of age. We thus have DMFT, DMFS, deft, and defs data for children ages 6 to 11.

PERIODONTAL DISEASE

The HIE definition of periodontal disease includes the causal agents—dental plaque (debris) and calculus (tartar)—and the host's response to these local irritants—gingival inflammation (gingivitis) and chronic destructive periodontal disease (periodontitis). We defined plaque as any soft, sticky deposit and calculus as any hard deposit on the tooth surface (i.e., supragingival) or in the gingival crevice (i.e., subgingival). These definitions are consistent with classic terminology.

The presence of gingivitis and deeper periodontal disease is measured by the PI.[2] Mild-to-moderate gingivitis (Russell's PI score of 1 or 2) is indicated solely by a red or bluish-red color on the margin of the gingival tissues; periodontitis is indicated by the presence of periodontal pockets and tooth mobility (scores of 6 or 8). Periodontal pockets are inferred by the direct visual presence of calculus that distorts the natural scallop-shaped outline of the gum line.[3] Tooth mobility, which implies the loss of masticatory function (ability to chew), is determined by light finger pressure; it is almost always accompanied by periodontal pockets.

Dental plaque and calculus were further measured by the OHI-S. This index assesses four posterior and two anterior areas of the mouth and assigns debris and plaque scores that range from 0 to 3. The total OHI-S score, which is the sum of calculus and plaque scores, thus ranges from 0 to 6.

The OHI-S and PI were also scored at the exit screening examination. One slight modification to the PI was made. Omitting the scoring of teeth with large fillings near the gum line, partial or complete crowns, or pontics (artificial replacement teeth that are permanently fixed to adjacent teeth) may bias an examinee's PI score upward. This is because plaque accumulation may be more prevalent on teeth with fillings or crowns that contact the gingiva. To assess the influence on

[2]Ordinarily, the only exception in scoring the PI is to disregard a badly decayed tooth with only its roots remaining. In the HIE, teeth not assigned a PI score included the usual exception and the following: a tooth with a gingival restoration or a partial or complete veneer crown, a tooth with an orthodontic band or wire near the gingival tissue, and a tooth that is depressed or not completely erupted to the occlusal (bite) plane. These additional exceptions were made so that examiners would be able to maintain criteria identical to the OHI-S. The excepted teeth are noted during the examination but are not included (in the denominator or numerator) in the calculation of the PI score.

[3]The potential weakness of this method was discussed in Chapter 2.

the PI score of omitting these teeth, the HIE assigns them unique PI scores at the exit screening examination. The PI is then calculated with and without the omitted teeth.

To summarize: Periodontal disease per se is reported in terms of the PI for all enrollees 12 years of age and older. The *general* state of the mouth is indicated by the OHI-S, which is scored for all enrollees 3 years and older.

TREATMENT NEEDS

The PPS was developed for the HIE as a simple way of categorizing a patient's possible periodontal treatment needs. This index assesses the entire mouth on a scale of 0 to 3 (as defined in Chapter 2). As a way of clarifying the precise meaning of the scores, the definitions of each scale category were described for HIE examiners in terms of treatment time or number of appointments. The PPS is expected to correlate positively with the PI and the OHI-S but to underestimate the needs of persons requiring extensive therapy.

Finally, the number of teeth with crass (gross) decay was recorded using the GDI. The GDI was a scale designed to identify immediately those teeth requiring professional treatment. Each primary and permanent tooth was scored as 0 (no decay or defective restoration obvious) or 1 (decay or defective restoration obvious without an explorer). The GDI was performed for all persons 6 years of age and older at enrollment and exit from the HIE.

DISEASE IMPACT

At least three factors contribute to the adverse effects of dental disease on individuals, all of which were addressed in the MHQ. First, depending on the severity of their condition, persons with large carious lesions and periodontal diseases are expected to experience increasing levels of pain. In particular, acute pain is expected to be associated with pulpitis and periodontal abscesses, and chronic pain with tooth mobility. Other symptoms associated with oral disease (e.g., bleeding gums) may also cause worry and anxiety. In addition, loss of multiple teeth may cause discomfort because of difficulty in chewing. Finally, caries and periodontal disease and their sequelae, loss of teeth, may cause concern with appearance, lower self-esteem, and negative effects on social activities and personal interactions.

To assess these adverse effects, three questions on the MHQ were asked of all persons 14 years of age and older who responded positively to the question about the presence of natural teeth. (In the Dayton site, all persons, whether or not they had natural teeth, were expected to answer the three questions.) Specifically, data were obtained on the amount of pain, worry, and concern with social interactions (i.e., avoidance of conversation) attributed to problems with teeth or gums.[4] (See Appendix A for the exact wording of the questions.) For persons less than 14 years of age, parents were asked about the amount of pain suffered by their children, as well as the amount of worry they themselves experienced about their children's teeth.

Responses to the pain and worry questions ranged from "not at all" (or equivalent wording) to "a great deal." Responses to the question about conversation avoidance ranged from "none of the time" to "most of the time." A composite measure called "any impact" was also constructed; a person was assigned a positive score for "any impact" if he or she gave a response other than "none" to at least one of the three questions.

The three impact questions are part of a standard set of questions that appear repeatedly in the MHQ in association with various diseases and conditions. They were not specifically constructed to measure the symptoms or adverse consequences of dental disease (or of any other particular condition) but rather were intended to facilitate comparisons of similar kinds of impact among several diseases and conditions. As just noted, however, all three questions are directly related to major consequences of dental disease: pain, worry, and reduced social interactions.

We compared levels of disease impact for all adults 18 years of age and older who had completed the Dental battery and for those who had both completed the battery and received the screening examination. In the latter case, to differentiate among persons with increasing degrees of dental disease, we divided the continuums of scores from the DMFT index and the PI into DMFT quartiles or PI tertiles. We calculated the percentages of responses to each question at each level from "none" to "a great deal" (or equivalent) and compared the amount of pain, worry, and conversation avoidance for people in each of the disease severity groups.[5]

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[4]The questions on pain differed between the Dayton and non-Dayton sites. In Dayton, enrollees were asked about the amount of pain they had in their teeth or gums when they ate certain foods. In the non-Dayton sites, the question asked about any pain caused by gums or teeth.

[5]The cutoff points for the DMFT index quartiles were as follows: Quartile 1, 0–12; Quartile 2, 13–17; Quartile 3, 18–22; Quartile 4, 23–28. For the PI tertiles, the breakdown was as follows: Tertile 1, 0–1; Tertile 2, >1–1.5; Tertile 3, >1.5.

POTENTIAL EFFECTS OF HEALTH INSURANCE

These disease impact measures are expected to be affected by the level of health insurance in several ways. Although many people see the dentist only when they are in pain, a person with more generous insurance should have fewer emergency visits for acute problems and more routine maintenance and recall visits. The patient may begin to see the dentist as someone who can prevent dental disease, rather than as a resource for treating teeth or gums after symptoms or signs have appeared. Subsequently, the patient is expected to seek dental care more regularly and to receive more preventive measures such as fluoride treatment, diet and oral hygiene counseling, teeth cleanings and, if necessary, repair or replacement of decayed teeth. Thus, in the long run, the amount of pain associated with dental disease should be reduced. Finally, effective treatment may lead to less worry or anxiety about oral conditions.

It is possible, however, that more generous health insurance may have some negative effects. For example, in the short term patients may experience pain from the treatment itself, especially if they have neglected their mouths. In addition, seeing the dentist more often may create awareness of problems that may have otherwise not received attention, thus causing anxiety and worry. Overtreatment is a possibility as well. That is, with greater financial access to care, the treatment provided may be more complex than is warranted by the problem or may in fact be unnecessary. Finally, although the treatment may be legitimate and the oral problem corrected, loss of teeth itself because of extraction is a hardship.

RELIABILITY

Reliability of the dental indexes refers to the ability of an index to measure a condition twice and produce the same result. To be able to monitor intra-examiner reliability for the enrollment procedures, each HIE examiner performed repeat examinations on a randomly selected portion (approximately 2 percent) of the enrollees who received a dental screening examination. To avoid possible memory bias, repeat examinations were never done in sequence. At least one (and usually several) other examinees were seen between the two examinations. Only one type of examination was repeated at a single examination (e.g., only DMFS, PI, etc.). At the exit screening examinations, repeat assessments were done by the same examiner or by a second examiner (on the same enrollee), so that both intra- and inter-examiner reliability could be tested.

Chapter 5

HEALTH INSURANCE EXPERIMENT ENROLLMENT RESULTS

CHARACTERISTICS OF HIE SITES

As shown in Table 2, the HIE sites vary in the amount of probable slack in the dental delivery system, as seen in the number of dental providers in each site. For example, Seattle had almost twice the number of dentists per 100,000 people as did Dayton.[1] This variation is reflected in the average number of patients seen each week, the number of days a new patient would have to wait for an appointment, and the length of the appointment. In Seattle, where the number of dentists is large relative to the population size, only 60 patients are seen per week and the average wait (in days) for an appointment by a new patient is just over 8 days. The length of the appointment is almost 50 minutes. By contrast, in Dayton, which has far fewer dentists (47 per 100,000 population), each dentist sees an average of 78 patients per week, with new patients waiting almost 12 days for an appointment. The average appointment length is about 35 minutes.

The water fluoridation status of the sites also differed. Two sites (Franklin County, Massachusetts, and Charleston, South Carolina) were not fluoridated, and two sites were fluoridated too late for the benefits to have accrued to HIE children at enrollment (Dayton in 1977 and Fitchburg in 1975). Thus, the presumably positive results of fluoridation would be observed only in Seattle and Georgetown County. Consequently, the benefits of artificial fluoridation will best be observed at exit from the study. At that time, def scores from four of the six sites will be available after fluoridation has been instituted for an appropriate period of time.

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[1]Not surprisingly, the rates for urban areas (Fitchburg, Seattle, Charleston, Dayton) are higher than their statewide rates would indicate.

Table 2

CHARACTERISTICS OF HIE SITES RELATED TO DENTAL CARE

Site Characteristic	Seattle	Dayton	Charleston	Georgetown County	Fitchburg	Franklin County
Census region	West	North Central	South	South	Northeast	Northeast
Population of urbanized area or county (1976)[a]	1,419,000	830,000	378,000	34,000	97,000	59,000
Dentists per 100,000 population (1975)[b]	86	47	53	51[c] 32	79	73[c] 63
Dentists per 100,000 population statewide (1977)[a]	67	47	36		67	
Water fluoride status	Fluoridated, 1970 Enrollment, 1976	Fluoridated, 1977 Enrollment, 1974	Not fluoridated	Naturally fluoridated	Fluoridated, 1975 Enrollment, 1976	Not fluoridated
Average number of patients seen per week (1978)	60	78	65		61	
Average number of days to dentist appointment: new patient (1978)	8.3	11.8	7.9		12.6	
Average length of appointment (minutes)	48.2	35.5	44.9		39.6	

[a] Source: U.S. Bureau of the Census (1980).

[b] Based on data made available to the HIE by the American Dental Association.

[c] Weighted average between two sites.

ENROLLMENT SAMPLE

The HIE administered various enrollment instruments or procedures to a total of 5051 adults (18 years and older), 1203 adolescents (12 to 17 years of age), and 1803 children (ages 3 to 11) at six sites. Just over 50 percent were female and about 15 percent were nonwhite. For persons 18 years of age and older, the mean years of schooling completed was 12, and the average family income (in 1973–1974 dollars) was about $13,000. The experimental population was entirely under age 62 at enrollment, although the Dayton control group had two individuals over 62.

Table 3 gives the number of enrollees in various age groups who completed the two forms of the MHQ in Dayton and in the other sites. Respondents or proxy respondents (a parent, typically the mother, for

Table 3

NUMBER OF ENROLLEES BY AGE GROUP, SITE, AND COMPLETION OF MHQ FORMS AT ENROLLMENT

Age Group (in years)	Version of MHQ[a]	Site	Number Enrolled	MHQ-A Completed	MHQ-B Completed
18+	Adult	Dayton	1041	1002	690
		Non-Dayton	4010	3958	3956
		All Sites	5051	4960	4646
14-17	Adult	Dayton	184	174	123
		Non-Dayton	600	579	579
		All Sites	784	753	702
12-13	Pediatric	Dayton	82	79	61
		Non-Dayton	337	334	333
		All Sites	419	413	394
5-11	Pediatric	Dayton	285	278	178
		Non-Dayton	1144	1134	1131
		All Sites	1429	1412	1309
3-4	Infant	Dayton	91	86	54
		Non-Dayton	283	280	280
		All Sites	374	366	334

[a]Adult MHQs were self-administered; pediatric (5-13 years old) and infant (0-4 years old) MHQs were completed by a proxy, usually the mother.

the pediatric and infant MHQs) include individuals in the experimental insurance plans, the Dayton control group, and the "pre-enrollment group" in South Carolina. In Dayton, only a random sample of enrollees completed Form B; in all other sites, all persons were expected to complete it. Form response rates were very high, ranging from 96 to 99 percent (depending on the age group) for Form A and 98 percent for Form B (of those eligible to complete it).

The screening examination was administered to 2877 adults, 700 adolescents, and 1098 children (for a total of 4675 persons) at the six sites. Those who received the examination represented a random subsample of between 50 and 70 percent of the entire sample (depending on site).

Because the age groupings on which we report our findings differ according to whether MHQ or screening examination data are involved and according to which dental caries and periodontal health index is being used, we have adopted certain conventions by which to refer to various age groups. Unless otherwise explicitly stated, "adults" will refer to individuals 18 and older; "teenagers" to persons 14 through 17; "adolescents" to persons 12 and 13; "youths" to the larger category of individuals 12 through 17; "children" to children 5 through 11; "toddlers" to youngsters 3 and 4; and "pediatric age group" to the subgroup comprising enrollees 3 through 13. Because of power considerations, we chose to present results on the largest possible groups. Thus, in some cases, teenagers are combined with adults (because all persons of those ages were eligible to complete the adult MHQ). In addition, we frequently report on persons over and under age 35 separately, because the effects of periodontal disease begin to appear at about age 35.

DENTAL HEALTH HABITS ACCORDING TO THE MHQ

The MHQ contained several questions about the dental health habits of enrollees, either in the Dental battery or in the Diet and Eating Habits battery. These are essentially related to prevention of dental problems and involve both self- (or parent-) directed actions and use of dental services.

Brushing and Flossing

Two questions in the Dental battery asked about the frequency of brushing and of flossing. As seen in Table 4, 95 percent of the teenagers and 89 percent of the adults had some natural teeth (a total of 668 and 4142 persons, respectively), and went on to answer these

Table 4

DISTRIBUTION OF RESPONSES TO QUESTIONS ABOUT DENTAL HEALTH HABITS FROM THE MHQ, BY AGE GROUP

Question and Response	5-11 Years		12-13 Years		14-17 Years		18-64 Years	
	Number	Percent[a]	Number	Percent	Number	Percent[a]	Number	Percent[a]
Do you have any natural teeth at all?								
Yes	(b)	(b)	(b)	(b)	668	95	4142	89
No					32	4	500[c]	11
Missing					2	(d)	4	(d)
					702	99	4646	100
How often do you (does this child) usually brush your teeth?								
Never	6	(d)	3	1	5	1	24	1
Once a week or less	33	2	12	3	28	4	71	2
Once every few days	148	11	37	9	68	10	227	5
Once a day	579	44	178	45	261	39	1562	38
More than once a day	521	40	162	41	305	46	2249	54
Missing	22	2	2	1	1	(d)	9	(d)
	1309	99	394	100	668	100	4142	100

Table 4—continued

Question and Response	5-11 Years		12-13 Years		14-17 Years		18-64 Years	
	Number	Percent[a]	Number	Percent	Number	Percent[a]	Number	Percent[a]
How often do you (does this child) use dental floss?								
Never	788	60	229	58	324	48	1629	39
Once a month or less	210	16	66	17	121	18	671	16
Once a week	109	8	39	10	74	11	481	12
Once every few days	101	8	38	10	91	14	804	19
At least once a day	76	6	21	5	55	8	551	13
Missing	25	2	1	(d)	3	(d)	6	(d)
	1309	100	394	100	668	99	4142	99

[a]Percentages may not sum to 100 because of rounding.

[b]Not asked for these age groups.

[c]In the non-Dayton sites, 413 edentulous persons skipped out of the Dental battery.

[d]Less than 0.5 percent.

two health habit questions. (Enrollees under age 14 were not asked if they had natural teeth.)

A larger percentage of adults than youths or children indicated that they brushed at least once a day (92, 85, and 84 percent, respectively). Only 1 percent of the entire sample said they never brushed. Far fewer persons flossed their teeth than brushed them. Adults were more likely to floss their teeth at least once a week than youths or children (44, 30, and 22 percent, respectively). Of more significance, 39, 52, and 60 percent, respectively, of adults, youths, and children said that they *never* flossed.

Fluoride Use

Questions about use of fluoride were asked only for individuals under 14 years of age and, for enrollment, only of those in the non-Dayton sites. As seen in Table 5, almost all of those in the pediatric age group—91 percent—used a fluoride toothpaste, and 49 percent had had their teeth painted at least once with fluoride by a dentist. Far smaller percentages regularly used a fluoride mouthwash or took fluoride tablets, vitamins, or drops.

Eating Habits

Table 6 provides the distribution of responses to diet questions pertinent to dental health for toddlers and children, youths, and adults. Persons through the teenage years were far more likely to eat cookies, candies, and other "junk" foods than were adults. When asked if they had eaten various foods during the previous 24 hours, 68 percent of the nonadult age groups replied they had eaten cookies and similar foods, compared with 55 percent of adults. The contrast was even greater for candy: Almost twice as many nonadults as adults (48 and 28 percent, respectively) had eaten candy during the previous day.

Eating such foods, especially in moderation, cannot be condemned out of hand. Of greater concern is whether they were consumed with meals or as snacks between meals—the latter being more injurious to dental health. The likelihood that these foods were eaten outside of mealtimes was quite high for all age groups (see Table 6). Leaving aside individuals who had not eaten them at all (or who did not answer the question), 77 percent of adults, 90 percent of youths, and 84 percent of toddlers and children evidently ate such snacks and sweets between meals (i.e., between meals only or both during and between meals).

Table 5

DISTRIBUTION OF RESPONSES TO QUESTIONS ABOUT DENTAL HEALTH FROM THE MHQ: USE OF FLUORIDE AMONG PERSONS 3 TO 13 YEARS OF AGE
Non-Dayton Sites

Question	Response	Number	Percent[a]
Does this child use fluoride in any of these ways?			
Fluoridated tooth paste?	Yes	1596	91
	No	120	7
	Don't know	22	1
	Missing	10	1
		1748	100
Ever have teeth painted with fluoride?	Yes	853	49
	No	774	44
	Don't know	99	6
	Missing	22	1
		1748	100
Fluoride mouthwash on a regular basis?	Yes	119	7
	No	1555	89
	Don't know	20	1
	Missing	54	3
		1748	100
Fluoride tablets on a regular basis?	Yes	119	7
	No	1567	90
	Don't know	23	1
	Missing	39	2
		1748	100
Fluoride-vitamin preparation?	Yes	136	8
	No	1543	88
	Don't know	29	2
	Missing	40	2
		1748	100
Fluoride drops on a regular basis?	Yes	41	2
	No	1651	94
	Don't know	18	1
	Missing	38	2
		1748	99

[a]Percentages may not sum to 100 because of rounding.

Table 6

DISTRIBUTION OF RESPONSES TO QUESTIONS ABOUT DENTAL HEALTH FROM THE MHQ: DIETARY HABITS, BY AGE GROUP

Non-Dayton Sites

Question and Response[a,b]	3-11 Years		12-17 Years		18+ Years	
	Number	Percent[c]	Number	Percent[c]	Number	Percent[c]
During the past 24 hours, did you eat any of the foods listed below?						
Cookies, cake, pie, doughnuts?						
Yes	994	70	595	65	2168	55
No	412	29	308	34	1759	44
Missing	8	1	10	1	31	1
	1414	100	913	100	3958	100
Candy?						
Yes	669	47	452	50	1094	28
No	734	52	444	49	2796	71
Missing	11	1	17	2	68	2
	1414	100	913	101	3958	101

Table 6—continued

Question and Response[a,b]	3-11 Years		12-17 Years		18+ Years	
	Number	Percent[c]	Number	Percent[c]	Number	Percent[c]
If you ate any of these foods in the past 24 hours, did you eat them:						
Only during regular meals	219	15	91	10	820	21
Only between meals	241	17	225	25	936	24
Both during and between meals	893	63	561	61	1875	47
Did not eat in past 24 hours	28	2	26	3	255	6
Missing	33	2	10	1	72	2
	1414	99	913	100	3958	100

[a]For the pediatric and infant MHQs (ages 3-13), the question was phrased with reference to "this child."

[b]Full question included gum; sugar-coated cereal; soda pop; peanut butter; jelly or honey; raisins, figs, or prunes; and table sugar.

[c]Percentages may not sum to 100 because of rounding.

Use of Dental Services

Table 7 presents responses to the MHQ questions about use of dental services. In the non-Dayton sites only (Dayton enrollees were not asked this question), almost all adults (98 percent) had seen a dentist sometime in their lives. This figure is, not surprisingly, higher than that for teenagers or children and adolescents—92 and 86 percent, respectively.

The data in Table 7 allow calculation of the percentages of persons who visited a dentist within various time periods in the past, including persons who had never seen a dentist. Among just those who had ever obtained dental care, the youngest age group was the most likely to have done so within the previous year. Specifically, 78 percent of 1461 children and adolescents had gone to a dentist within the prior 12 months; the comparable figures (for having teeth cleaned) for 553 teenagers was 69 percent and for 3731 adults, 55 percent. Using the same denominators but extending the time frame, we calculate that 93 percent of the 5- to 13-year-olds had seen a dentist within the previous 2 years; 88 percent of teenagers and 76 percent of adults had had their teeth cleaned within the previous 2 years.

Given this pattern of lower use of dental care (at least for cleaning) reported by the older age groups, it is not surprising that more adults than teenagers (62 and 49 percent) thought their teeth needed to be cleaned (see Table 8). In addition and as expected, persons over 35 years of age were far more likely than younger persons to report that a dentist had told them they had gum problems.

PREVALENCE OF DENTAL DISEASE ACCORDING TO THE SCREENING EXAMINATION FINDINGS

Dental Caries Experience

Data on decayed, missing, and filled teeth, periodontal disease, and oral hygiene were collected at the screening examination; they are presented in a variety of tables in the remainder of this section. In some cases, data from the 1971–74 HANES survey of 20,749 persons are also provided (NCHS, 1979). To be able to compare the NCHS data with the HIE data, we calculated age-adjusted mean scores by

Table 7

DISTRIBUTION OF RESPONSES TO QUESTIONS ABOUT DENTAL HEALTH FROM THE MHQ: USE OF DENTAL SERVICES, BY AGE GROUP

Question and Response	5-13 Years		14-17 Years		18-64 Years	
	Number	Percent	Number	Percent	Number	Percent[a]
Have you ever been to a dentist?[b]						
Yes	(c)		510	92	3476	98
No			42	8	58	2
Missing			0	0	5	(d)
			552	100	3539	100
When was the last time this child went to the dentist?						
Within past 12 months	1135	67	(c)		(c)	
1-2 years ago	226	13				
More than 2 but less than 5 years ago	72	4				
5+ years ago	28	2				
Never	217	13				
Missing	25	1				
	1703	100				

Table 7—continued

Question and Response	5-13 Years		14-17 Years		18-64 Years	
	Number	Percent	Number	Percent	Number	Percent[a]
When did you most recently have your teeth cleaned by a dentist or dental assistant?[e]						
Within past 12 months	(c)		383	61	2040	50
1-2 years ago			103	16	785	19
More than 2 but less than 5 years ago			38	6	496	12
5+ years ago			29	5	410	10
Never			69	11	340	8
Missing			4	1	8	(d)
			626	100	4079	99

[a]Percentages may not sum to 100 because of rounding.

[b]Only asked in the non-Dayton sites.

[c]Not asked for these age groups.

[d]Less than 0.5 percent.

[e]This question was answered by the 510 non-Dayton teenagers who had ever visited a dentist and by all 116 Dayton teenagers, and analogously by 3476 non-Dayton adults and 603 Dayton adults.

Table 8

DISTRIBUTION OF RESPONSES TO QUESTIONS ABOUT DENTAL HEALTH FROM THE MHQ: PERCEPTIONS OF DENTAL HEALTH STATUS, BY AGE GROUP

Question and Response	14-17 Years		18-34 Years		35-64 Years	
	Number	Percent	Number	Percent	Number	Percent
Do you think your teeth need cleaning?						
Yes	329	49	1597	65	978	58
No	338	51	854	35	711	42
Missing	1	(a)	1	(a)	1	(a)
	668	100	2452	100	1690	100
Did a dentist ever tell you that you have a gum problem?						
Yes	29	4	391	16	406	24
No	638	96	2058	84	1282	76
Missing	1	(a)	3	(a)	2	(a)
	668	100	2452	100	1690	100

[a]Less than 0.5 percent.

weighting the NCHS published scores by the proportion of HIE enrollees in each age group.[2] Where these weighted mean figures are given, they appear in the next-to-last row of the tables. We also calculated a ratio of the HIE grand mean (i.e., average for the entire HIE population under consideration) to the NCHS weighted mean, to show in one summary figure whether the HIE rates tended to be higher or lower than the NCHS rates. For simplicity, rates and scores are shown to only one decimal place, but the calculations were done on data to two decimal places wherever available.

Table 9 gives the age-specific mean DMFT32 index scores for the 4036 edentulous and dentulous enrollees in the HIE sample who completed the dental screening examination; this includes children age 6 and older through adults age 64.[3] The HIE and the NCHS data demonstrate similar trends. In both cases the DMFT32 index increased with age, indicating the chronic, cumulative nature of dental disease. The highest prevalence of decay alone (shown as D-32 in Table 9) occurred in the 12-to-17 age category—3.4 decayed teeth per person for the HIE. In contrast, the number of missing teeth (M-32) increased after age 18, and the highest prevalence of filled teeth (F-32) was seen in persons 18 to 44 years of age—9.1 filled teeth for the HIE. As the number of missing teeth rose sharply, the number of teeth at risk for decay or fillings decreased, especially for persons over age 45. This is reflected in the decrease of both decayed and filled teeth for the older persons.

The prevalence of decayed, missing, and filled teeth was consistently higher in the HIE than in the NCHS survey. For example, the mean DMFT32 score in the HIE was 15.0, as contrasted with 13.0 (unadjusted) or with 12.1 (adjusted) for NCHS. The largest difference was in the decayed component, where the ratio of the HIE grand mean to the age-adjusted NCHS mean was 1.8. There was virtually no difference between the surveys in the number of filled teeth (ratio of 1.0).

The differences between the HIE and the NCHS survey results may be explained, in part, by the fact that NCHS dentists probed only those teeth with obvious decay. In contrast, the HIE dental examiners routinely probed all teeth surfaces, increasing the probability of identifying smaller lesions. This methodological factor is not a likely explanation, however, for the higher number of missing teeth in the HIE. Barring some other explanation, there may have been true differences

[2]This weighted mean was calculated by multiplying the NCHS mean for each age group by the HIE sample size in that age group, summing the products, and dividing by the total HIE sample.

[3]The examination was *administered* to 4092 persons; 56 did not receive complete DMFT scores. Of the 1393 persons 6 to 17 years of age, 1 (or 0.07 percent) was edentulous; of the 2699 adults, 218 (or 8.1 percent) were edentulous.

Table 9

MEAN VALUES FOR DMF PERMANENT TEETH INDEX AND COMPONENTS, BY AGE GROUP
HIE 1974–76; NCHS 1971–74

Age Group (in years)	HIE Sample Size[a]	HIE Mean Value				NCHS Mean Value			
		DMFT32	D-32	M-32	F-32	DMFT32	D-32	M-32	F-32
1-5	0	--	--	--	--	0.1	0.1	0	0
6-11	703	2.4 (.09)[b]	1.3 (.07)	0.1 (.02)	0.9 (.06)	1.7	0.7	0.1	0.8
12-17	659	8.4 (.20)	3.4 (.15)	1.1 (.08)	3.9 (.16)	6.2	1.8	0.6	3.7
18-44	2034	18.8 (.15)	2.8 (.08)	6.9 (.17)	9.1 (.15)	14.9	1.7	4.9	8.3
45-64	640	23.8 (.28)	1.6 (.09)	15.4 (.43)	6.9 (.28)	20.4	0.9	11.3	8.1
65-74	0	--	--	--	--	22.2	0.6	15.2	6.4
Total or grand mean	4036	15.0 (.15)	2.5 (.05)	6.1 (.14)	6.4 (.10)	13.0	1.3	5.3	6.4
Weighted NCHS mean[c]	--	--	--	--	--	12.1	1.4	4.4	6.2
HIE/NCHS ratio[d]	--	1.2	1.8	1.4	1.0	--	--	--	--

[a] HIE sample includes dentulous and edentulous persons 6 to 64 years of age.

[b] Standard errors in parentheses.

[c] Age-adjusted to the HIE sample sizes in each age group.

[d] HIE grand mean to NCHS weighted mean.

between the HIE and NCHS populations in the DMFT index (or at least some of its components).

Table 10 presents the percentage breakdown of DMFT32 scores for the HIE and NCHS adult populations. The HIE sample had proportionately more people with scores of 15 and higher DMFT32 teeth than did the NCHS sample and fewer at the lower range. Approximately three-fourths of the HIE sample had DMFT scores of 15 or higher, whereas three-fifths of the NCHS sample had such scores.

Table 10

PERCENTAGE DISTRIBUTION OF DMFT32 SCORES, FOR PERSONS 18 TO 74 YEARS OF AGE
HIE 1974-76; NCHS 1971-74

DMFT32 Score	HIE		NCHS
	Number	Percent[a]	Percent
0	9	0.3	1.3
1-4	38	1.4	4.6
5-9	158	5.9	13.7
10-14	431	16.1	18.3
15-19	631	23.6	21.4
20+	1407	52.6	40.1
Total	2674	99.9	100.0

[a]Percentage does not sum to 100 because of rounding.

Other DMF or def Index Scores

Although the NCHS surveyed 32 teeth in its dental examination, the clinical estimate of dental caries experience is more accurate when 28 teeth are used in constructing a DMFT score. Without the use of radiographs, the DMFT32 overestimates the number of missing teeth, because it counts unerupted third molars as missing.

Comparison of the data in Tables 9 and 11 illustrates the point. For example, based on the DMFT32 index, the average number of missing teeth for persons 18 to 44 years of age is 6.9 (Table 9), whereas it is 4.7 based on the DMFT28 index (Table 11). The differences between the total DMFT32 and DMFT28 indexes are of course more apparent in the two older age groups. Specifically, the mean scores for the DMFT32 and DMFT28 were almost identical for persons under age 18. For those 18 to 44 and 45 to 64 years of age, they were, respectively, 19 and 16 DMF teeth and 24 and 20 DMF teeth.

In the remaining analyses detailed in this monograph, we use the DMFT28 index. For analogous reasons, we also report on only the DMFS28 index (recalling that it can range from 0 to 128).

Table 12 provides the DMFS scores for the same persons reported in Table 11. As expected, the DMFS scores are consistently higher than

Table 11

MEAN VALUES ON DMFT28 INDEX, BY AGE GROUP[a]

Age Group (in years)	Mean Value			
	DMFT28	D-28	M-28	F-28
6-11	2.3 (.09)[b]	1.3 (.07)	0.1 (.02)	0.9 (.06)
12-17	8.1 (.19)	3.4 (.15)	0.9 (.07)	3.8 (.16)
18-44	15.9 (.14)	2.4 (.07)	4.7 (.16)	8.8 (.15)
45-64	20.3 (.26)	1.4 (.09)	12.2 (.41)	6.6 (.27)
6-64	13.0 (.13)	2.2 (.05)	4.5 (.12)	6.3 (.10)

[a]Edentulous persons are included. For sample sizes, see Table 9.

[b]Standard errors in parentheses.

the corresponding DMFT scores. In addition, the ratios of the two indexes (i.e., the DMFS scores divided by the DMFT scores) rise with age. This is because, as a person ages, a single tooth will be more likely to have multiple decayed or filled surfaces and more teeth will be missing. For example, the DMFS-to-DMFT ratio for persons 6 to 11 years of age was 1.7 (3.9/2.3); it rose to 3.8 (77.3/20.3) for persons over age 44. As expected, only the ratio for missing teeth and surfaces did not rise with age.

The def index describes the number of decayed teeth, teeth to be extracted because of decay, and filled teeth in children (counting primary teeth only). As seen in Table 13, HIE youngsters in the under-6 age range had def indexes similar to (although higher than) those of youngsters included in the NCHS survey. The higher HIE scores may be because the HIE examined children 3 years of age and older, whereas the NCHS began with one-year-olds. Thus, the NCHS averages are diluted with more "virgin" teeth. HIE children 6 to 11 years had slightly lower deft, dt, and et scores compared with NCHS, and slightly higher ft scores. Overall, the differences between HIE and

Table 12

MEAN VALUES ON DMFS28 INDEX, BY AGE GROUP[a]

Age Group (in years)	Mean Value			
	DMFS28	DS-28	MS-28	FS-28
6-11	3.9 (.18)[b]	1.7 (.10)	0.7 (.11)	1.5 (.10)
12-17	15.8 (.52)	4.8 (.26)	4.4 (.34)	6.6 (.31)
18-44	46.8 (.67)	4.3 (.15)	2.2 (.73)	20.3 (.41)
45-64	77.3 (1.43)	2.7 (.19)	57.1 (1.86)	17.6 (.80)
6-64	39.1 (.56)	3.7 (.09)	21.1 (.55)	14.4 (.28)

[a]Edentulous persons are included. For sample sizes, see Table 9.

[b]Standard errors in parentheses.

NCHS, as measured by the ratio of HIE grand mean to NCHS weighted mean were small, and generally smaller than those for the DMFT32 index. Although the HIE infants and children had, on average, 2.5 primary teeth with evidence of dental caries (treated or untreated), just over one of those teeth, on average, had been filled.

Because children to about age 10 tend to have both primary and permanent teeth, we performed both deft and DMFT examinations on children 6 to 11 years of age. The deft mean scores were slightly higher than the DMFT mean scores. This is not surprising given that primary teeth have existed longer than permanent teeth in children. The difference could be ascribed mainly to the larger number of filled primary teeth than filled permanent teeth (1.4 versus 0.9). In addition, whereas primary teeth tended to have higher ft (filled) mean scores than dt or et scores, among permanent teeth the mean number of decayed teeth is larger than missing or filled teeth.

Table 13

MEAN VALUES FOR DECAYED TEETH, TEETH INDICATED FOR EXTRACTION, FILLED PRIMARY TEETH INDEX AND COMPONENTS HIE 1974-76; NCHS 1971-74

Age Group (in years)	HIE Sample Size[a]	HIE Mean Value				NCHS Mean Value			
		deft	dt	et	ft	deft	dt	et	ft
1-5	280	2.3 (.20)[b]	1.3 (.13)	0.1 (.07)	0.9 (.14)	1.0	0.7	0.1	0.2
6-11	703	2.6 (.11)	1.0 (.07)	0.2 (.03)	1.4 (.08)	2.7	1.2	0.3	1.2
Total or grand mean	983	2.5 (.09)	1.1 (.06)	0.1 (.03)	1.2 (.07)	2.3	1.1	0.3	1.0
Weighted NCHS mean[c]	--	--	--	--	--	2.2	1.1	0.2	0.9
HIE/NCHS ratio[d]	--	1.0	0.5	0.6	1.3	--	--	--	--

[a]HIE sample includes children 3 and older and 1 edentulous child.

[b]Standard errors in parentheses.

[c]Age-adjusted to the HIE sample size in each age group.

[d]HIE grand mean to NCHS weighted mean.

Periodontal Index

Tables 14 and 15 present data on the condition of the periodontal tissues as reflected in the PI. Mean PI scores for youths and adults are given in Table 14 for both the HIE and the NCHS populations. HIE data are provided only for 2883 dentulous persons aged 12 and older.

Although the age patterns of the PI scores are similar in the two surveys, the HIE scores are higher than the NCHS values for persons up to age 44. These differences between the surveys may be attributed to differences in examination criteria and other factors noted earlier with regard to dental caries prevalence.

The mean PI score for the HIE sample was 1.3, which is equivalent to a clinical classification of beginning destructive periodontal disease (Table 1). All three age groups would fall into this same clinical category, although the degree of severity of disease did rise with age.

Table 14

MEAN VALUES FOR PERIODONTAL INDEX, BY AGE GROUP
HIE 1974-76; NCHS 1971-74

Age Group (in years)	HIE Sample Size[a]	Mean PI Score	
		HIE	NCHS
12-17	423	1.1 (.02)[b]	0.3
18-44	1954	1.3 (.02)	0.8
45-64	506	1.6 (.06)	1.6
Total or grand mean	2883	1.3 (.02)	0.9
Weighted NCHS mean[c]	--	--	0.8
HIE/NCHS ratio[d]	--	1.6	--

[a]Includes only dentulous persons with complete PI and age data.

[b]Standard errors in parentheses.

[c]Age-adjusted to the HIE sample size in each age group.

[d]HIE grand mean to NCHS weighted mean.

Table 15 gives the actual PI scores for the 2460 adults 18 and older according to sex and age group. Advanced periodontal disease (i.e., scores of 6s or 8s), which implies loss of chewing function, more than doubles after age 35 for both sexes—reaching about one-fifth of all the people in that age group.

In addition, periodontal disease appears to be more severe among men than among women: 57 percent of men and 48 percent of women had scores higher than 1.0. The largest differential in serious disease between men and women was at scores 1.1 to 2.0 for persons 18 to 34.

Table 15

PERIODONTAL INDEX SCORES, BY SEX AND AGE GROUP[a]

	Men				Women			
	18-34		35-64		18-34		35-64	
PI Score[b]	Number	Percent	Number	Percent	Number	Percent[c]	Number	Percent
0-0.2	5	1	9	2	15	2	13	2
0.3-0.5	23	4	11	2	36	4	20	4
0.6-1.0	263	41	173	36	394	49	224	41
1.1-2.0	285	45	182	37	293	37	185	34
Any 6s or 8s	58	9	111	23	58	7	102	19
Total	634	100	486	100	796	99	544	100

[a] Includes only dentulous persons with complete PI, sex, and age data.

[b] See Table 1 for clinical interpretation of PI scores.

[c] Percentage does not sum to 100 because of rounding.

Simplified Oral Hygiene Index

OHI-S scores reflect oral hygiene status assessed during the dental examination and refer to both plaque and calculus. As with the other dental measures, the HIE had consistently and markedly higher OHI-S scores than the NCHS (see Table 16). In all cases, the HIE scores fell into a clinical category of "fair" oral hygiene; in contrast, all NCHS scores could be classified as "good" (except for scores for the elderly, who are not included in the HIE). In both samples, the means showed the same propensity to rise with age. We have no immediate explanation for why the HIE values should be so consistently higher than those of NCHS, but inter-examiner variability in addition to differences in criteria or methods for judging oral health might have been at work.

To gain some insight into this problem, we compared the two components of the OHI-S (DI-S for plaque or debris, CI-S for tartar or calculus) for the HIE and NCHS. Although both mean DI-S and mean CI-S scores were higher in the HIE than in the NCHS, the ratio of HIE-to-NCHS scores was slightly higher for CI-S scores than for DI-S scores (2.0 to 1 and 1.7 to 1, respectively) (see Table 17). Furthermore, although the age trends were as would be expected for both HIE and NCHS calculus scores, the trends observed for debris scores were not as expected for the NCHS. Specifically, one would expect calculus scores to increase with age, as more of a buildup is unattended to professionally. This indeed occurred in both the HIE and NCHS. Debris scores, however, could be expected to decrease with age as adults learn to brush more vigorously or regularly than children. Although this trend did occur among HIE enrollees, it was not observed in the NCHS.

Table 18 gives the actual OHI-S scores for the 658 youths and 2318 adults according to three age groups. Oral hygiene habits apparently worsen with age. The percentage of persons who had poor habits (scores of 3.1 to 6.0) was twice as large among persons over age 34 as among those under age 18. Only one-third of persons over age 34 had evidence of good oral hygiene habits.

CORRELATIONS AMONG DENTAL HEALTH MEASURES

The main dental caries and periodontal disease indexes used in the HIE measure different aspects of dental status, but their relationships are fairly well known. Decay and periodontal disease are essentially independent processes, and hence one would not expect the relevant indexes necessarily to be correlated. In contrast, oral health habits and periodontal disease are known to be correlated, and thus one would

Table 16

MEAN VALUES FOR SIMPLIFIED ORAL HYGIENE INDEX, BY AGE GROUP
HIE 1974-76; NCHS 1971-74

Age Group (in years)	HIE Sample Size[a]	Mean OHI-S Score	
		HIE	NCHS
6-11	718	1.4 (.03)[b]	0.8 (.03)
12-17	658	1.6 (.04)	0.9 (.04)
18-44	1881	1.7 (.03)	1.0 (.04)
45-64	437	1.9 (.06)	1.2 (.05)
65-74	0	--	1.4 (.07)
Total or grand mean	3694	1.7 (.02)	1.0 (.03)
Weighted NCHS mean[c]	--	--	1.0
HIE/NCHS ratio[d]	--	1.7	--

[a]Includes only dentulous persons with complete OHI-S and age data.

[b]Standard errors in parentheses.

[c]Age-adjusted to the HIE sample size in each age group.

[d]HIE grand mean to NCHS weighted mean.

Table 17

MEAN VALUES FOR SIMPLIFIED DEBRIS AND CALCULUS INDEXES, BY AGE GROUP
HIE 1974-76; NCHS 1971-74

Age Group (in years)[a]	Mean DI-S Score		Mean CI-S Score	
	HIE	NCHS	HIE	NCHS
6-11	1.3 (.02)[b]	0.7 (.03)	0.2 (.01)	0.0 (.01)
12-17	1.1 (.02)	0.7 (.03)	0.5 (.02)	0.2 (.02)
18-44	0.9 (.01)	0.6 (.03)	0.8 (.02)	0.4 (.02)
45-64	0.9 (.02)	0.6 (.02)	1.0 (.04)	0.6 (.03)
65-74	---	0.8 (.04)	---	0.7 (.04)
Grand mean	1.0 (.01)	0.7 (.02)	0.6 (.01)	0.4 (.02)
Weighted NCHS mean[c]	---	0.6	---	0.3
HIE/NCHS ratio[d]	1.7	---	2.0	---

[a]For sample sizes see Table 16. One additional person in age groups 12-17 and 18-44 had a CI-S score.

[b]Standard errors in parentheses.

[c]Age-adjusted to the HIE sample size in each age group.

[d]HIE grand mean to NCHS weighted mean.

Table 18

SIMPLIFIED ORAL HYGIENE INDEX SCORES, BY AGE GROUP[a]

OHI-S Score[b]	12-17		18-34		35-64	
	Number	Percent	Number	Percent	Number	Percent[c]
0-1.2	286	43	634	45	334	36
1.3-3.0	321	49	597	43	434	47
3.1-6.0	51	8	168	12	151	16
Total	658	100	1399	100	919	99

[a]Includes only dentulous persons with complete OHI-S and age data.

[b]See Table 1 for clinical interpretation of OHI-S scores.

[c]Percentage does not sum to 100 because of rounding.

expect the OHI-S and PI to be substantially and positively associated (i.e., the higher the PI score, the higher the OHI-S score). To ascertain if the HIE data reflected these expected patterns, we tabulated mean DMFT28 and mean OHI-S scores against the five levels of PI scores used in Table 15, and used a one-way analysis of variance to test for significant differences among means.[4] Only dentulous adults are included in this analysis. Generally, the HIE data behaved as anticipated.

The overall mean DMFT28 score for the 18-to-64 age group (2435 persons) was 15.9. The DMFT scores did generally rise as PI scores worsened except for the 1.1–2.0 PI category (see Table 19), but the differences among the DMFT scores at each PI level were not statistically significant (at conventional levels). When the population was divided into two age groups (18–34 and 35–64), the same nonsignificant trend was observed.

By contrast, the PI and mean OHI-S scores were highly significantly related—an expected finding because both assess dental disease involving (directly or indirectly) plaque and calculus on teeth or surrounding

[4]The actual procedure used was the General Linear Model (GLM). This method, when used for an ANOVA with "unbalanced data" such as those found here (i.e., different numbers of values in each cell), is a conservative categorical test for significant differences among pairs as well as for an overall trend or association.

Table 19

DMFT28 MEAN SCORES, BY SEVERITY OF PERIODONTAL DISEASE (PI SCORES)

PI Score	Number of Adults	DMFT28 Mean Score[a]
0-0.2	42	15.4
0.3-0.5	90	15.9
0.6-1.0	1044	16.0
1.1-2.0	932	15.7
Any 6s or 8s	327	16.2

[a]Rise in DMFT28 score is nonsignificant.

tissues. For the 2317 adults with complete data for this analysis (see Table 20), the mean OHI-S score was 1.7 ("fair" oral hygiene). As PI scores rose (worsened), mean OHI-S scores also rose significantly ($p < 0.0001$), particularly for PI scores higher than 0.5. In the case of PI values involving any gingival tissues scored 6 or 8 (gingivitis with

Table 20

OHI-S MEAN SCORES, BY SEVERITY OF PERIODONTAL DISEASE (PI SCORES)

PI Score	Number of Adults	Mean Score[a]		
		OHI-S	DI-S	CI-S
0-0.2	40	0.6	0.5	0.2
0.3-0.5	89	0.7	0.5	0.2
0.6-1.0	1009[b]	1.2	0.7	0.5
1.1-2.0	895	2.1	1.0	1.0
Any 6s or 8s	285	3.0	1.3	1.7

[a]Rise in score significant at $p < 0.0001$.

[b]A calculus score was missing for one person.

pocket formation or advanced destruction), the OHI-S score was actually 3.0, verging on "poor" oral hygiene. A significant rise in mean scores was also observed for DI-S and CI-S scores separately.

DENTAL HEALTH HABITS AND HEALTH STATUS

To explore further the effect of oral hygiene practices on oral health, we created a Health Habits (HH) score. This measure consisted of an unweighted linear combination of three MHQ questions: frequency of brushing and of flossing and recency of having had one's teeth cleaned professionally. (See Appendix A for exact wording of the questions.) Scores for brushing and flossing ranged from 1 (never) to 5 (more than once a day). Because the worst score for professional teeth cleaning was 5 (never), we reversed the scoring on that variable. Thus, all three measures had five possible scores, with 1 being worst and 5 best and the HH score could range from 3 (worst) to 15 (best).

We then divided the HH score into population quartiles, yielding the following worst-to-best score categories: Score 1, 3–9 points; Score 2, 10–11; Score 3, 12–13; and Score 4, 14–15. We used a one-way analysis of variance to test for significant differences among mean DMFT and PI scores for persons in the four HH score quartiles.

As seen in Table 21, persons with the best HH scores have significantly *higher* ($p < 0.0001$) DMFT28 scores than persons with the worst HH scores. A negative relationship persisted even when the population was broken into two age groups: 18–34 ($p < 0.05$) and 35–64 ($p < 0.0001$). To explore reasons for this somewhat surprising result, we examined the HH score components (i.e., brushing, flossing, professional cleaning) by DMFT scores. The data (not shown) indicated that persons with worse (higher) DMFT scores flossed more frequently and had had their teeth cleaned more recently than persons with better DMFT scores, and in fact this inverse relationship was significant (chi-square test, $p < 0.0001$).

Because enrollment data (being one-point-in-time) are cross-sectional in nature, we cannot sort out cause and effect with these findings alone. We might hypothesize that persons with the worst teeth carry out dental health habits such as flossing or having prophylaxis performed *in response to* already poor dental health. The ambiguity of such a result emphasizes the value of experimental, longitudinal data.

It must be remembered, however, that the DMFT index loses some sensitivity and interpretability for persons older than about age 35, as the missing (and perhaps filled) components begin to drive the total

Table 21

RELATIONSHIP OF DENTAL CARIES EXPERIENCE (DMFT28 SCORES) AND PERIODONTAL DISEASE (PI SCORES) TO DENTAL HEALTH HABITS

Health Habits Score and Interpretation	DMFT28		PI	
	No. of Adults[a]	Mean Score[b]	No. of Adults[a]	Mean Score[c]
1 Worst	692	15.4	689	1.8
2	678	15.8	680	1.3
3	517	16.7	521	1.1
4 Best	434	17.2	436	1.0
Total	2321	16.1	2326	1.3

[a]Includes dentulous adults 18 to 64 with complete data for the comparison under consideration.

[b]Negative association with HH score significant at $p < 0.0001$.

[c]Positive association with HH score significant at $p < 0.0001$.

index score higher. Thus, adults may have high DMFT scores precisely because of some good dental care practices on their part—namely, obtaining professional care such as fillings or needed extractions at the time their caries activity diminishes. Such behavior would be quite consistent with the higher health habits scores. In short, the apparent opposite direction of the DMFT and HH scores may be partly an artifact of the DMFT index and of the effect of age. At the end of the experiment, we may be able to clarify these relationships more fully.

The PI scores, by contrast and as expected, are positively associated with the Health Habits scores. For the 2326 adults with complete data, the overall PI score was 1.3, and the distribution of scores ranged from 1.8 for those with the worst health habits to 1.0 for those with the best habits. The differences in the mean PI scores were significant ($p < 0.0001$). This strong relationship between PI scores and Health Habits scores is in line with that reported in the literature (see Chapter 2).

TREATMENT NEEDS

Gross Decay Index

The Gross Decay Index (GDI) is a count of the number of primary or permanent teeth with obvious decay. It thus provides an indication of the number of teeth requiring immediate treatment. Such treatment would necessarily involve therapy for dental caries, and might involve therapy for periodontal disease as well.

Table 22 gives the percentage of persons who had 0, 1, or more than 1 grossly decayed teeth. Between 20 and 24 percent of the four age groups presented had at least 1 such tooth. The percentages did not vary significantly by age. This is rather surprising given that the incidence of caries decreases with age. One would have expected the percentage of persons with no grossly decayed teeth to rise with age as needed treatment is sought.

Table 22

PERCENTAGE DISTRIBUTION OF GROSSLY DECAYED TEETH, BY AGE GROUP

Age Group (in years)	HIE Sample Size	Number of Grossly Decayed Teeth		
		0	1	>1
6-11	599	80	8	12
12-17	526	77	9	14
18-34	1212	77	9	15
35-64	815	77	10	13

Periodontal Profile Scores

Periodontal treatment needs clearly rise with age, as demonstrated by the data in Table 23. For example, almost no one under age 18 had a PP score over 1. By contrast, 13 percent of persons ages 18 to 34 had scores of 2 or 3, and 9 percent of those 35 to 64 years of age had a score of 3. Almost 30 percent of older adults had periodontal pockets present (score of 2 or 3).

Periodontal Profile scores are interpreted best as treatment needs. They imply that the younger persons in general might require no more than one dental visit (if even that level of care), whereas the older adults might need two or more appointments for prophylaxis, gingival curettage, and perhaps surgery.

Table 23

PERCENTAGE DISTRIBUTION OF PERIODONTAL TREATMENT NEEDS FROM PERIODONTAL PROFILE SCORES, BY AGE GROUP

Age Group (in years)	HIE Sample Size[b]	Periodontal Profile Score[a]			
		0	1	2	3
3-5	282	91	9	0	0
6-11	716	82	18	0	(c)
12-17	665	56	42	2	(c)
18-34	1433	34	52	11	2
35-64	1034	25	46	20	9
3-64	4130	48	40	9	3

[a]See Table 1 for clinical interpretation.

[b]Includes only dentulous persons with complete PPS and age data.

[c]Less than 0.5 percent.

SUMMARY OF EPIDEMIOLOGICAL FINDINGS

As expected from previous data based on national surveys, problems in dental health were widespread in the HIE sample, and the nature of the problems corresponded to commonly accepted patterns of dental disease and age. Regarding dental caries experience for adults, about three-fourths had 15 or more DMFT32 teeth. The mean DMFT28 scores (by age) were as follows: 2 (6–11 years), 8 (12–17), 16 (18–44), and 20 (45–64). Noteworthy was the twofold rise in missing teeth after age 44. Mean deft scores were 2.3 (3–5 years) and 2.6 (6–11). All dental caries experience values tended to be higher than those reported by NCHS.

The mean PI score for adults and youths in the HIE was 1.3 (roughly, beginning destructive periodontal disease), or 1.1 (12–17 years), 1.3 (18–44), and 1.6 (45–64). The overall mean OHI-S value was 1.7 (roughly, "fair" oral health), or 1.4 (6–11 years), 1.6 (12–17), 1.7 (18–44), and 1.9 (45–64). As with the dental decay findings, HIE data tended to show more dental health problems in a general population than do NCHS data.

Mean OHI-S scores rose significantly as PI scores worsened. The slight positive relationship between mean DMFT28 and PI scores was not significant. These patterns are consistent with expectations. Mean DMFT28 scores were negatively associated with Health Habits (i.e., the better the HH value, the more extensive the dental caries experience—perhaps reflecting higher missing or filled teeth secondary to obtaining appropriate dental care rather than decayed teeth). The relationship between the PI and HH scores was strongly positive.

DISEASE IMPACT

To assess the impact of dental disease among all persons who completed the Dental battery and among those who had DMFT28 and PI scores available from the screening examination, we asked three questions on the MHQ concerning (a) the amount of pain caused by teeth or gums; (b) the extent of worry or concern; and (c) the degree to which people avoided conversations because of the appearance of their teeth or gums. A composite disease impact measure, "any impact," was also constructed. (See Appendix A for the exact wording of the questions.)

In the non-Dayton sites, persons who responded positively to the initial question in the Dental battery (regarding whether they had any natural teeth) answered these questions, regardless of whether they received screening examinations. In Dayton, although all people, whether or not they had any natural teeth, were asked the disease impact questions, we report data on disease impact only for dentulous people. The wording of the pain items differed substantially for the Dayton and non-Dayton sites in the adult MHQ, and the items thus are shown separately.

For persons less than 14 years of age, parents were asked to assess the impact of dental disease on their children's lives. Specifically, they were asked how much pain their children suffered, and how much they themselves worried about their child's teeth or gums.

The distributions of responses to these disease impact questions are shown in Table 24 (children and adolescents) and Table 25 (teenagers and adults). Among all age groups, worry was the most common adverse effect noted by MHQ respondents: 26 percent of the parents of children and adolescents, 30 percent of the teenagers, and 41 percent of the adults noted at least a little worry about their (or their child's) dental condition. Nineteen percent of parents believed their children had experienced pain or distress from problems with teeth or gums; 23 percent of the teenagers and 28 percent of the adults reported pain or

Table 24

DISTRIBUTION OF RESPONSES TO QUESTIONS ABOUT DISEASE IMPACT FROM THE MHQ: CHILDREN AND ADOLESCENTS 5 TO 13 YEARS OF AGE

Question	Response	Number	Percent[a]
During the past 3 months, how much pain or distress have this child's teeth or gums caused him or her?	A lot	6	(b)
	Some	73	4
	A little	252	15
	None	1347	79
	Missing	25	1
		1703	99
During the past 3 months, how much have this child's teeth or gums worried or concerned you?	A lot	43	3
	Some	88	5
	A little	314	18
	None	1231	72
	Missing	27	2
		1703	100

[a]Percentages may not sum to 100 because of rounding.

[b]Less than 0.5 percent.

trouble from their teeth. In contrast, the degree to which people avoided conversation with others was somewhat lower among the adults than the teenagers—10 percent of the older group and 14 percent of the younger group avoiding conversations at least a little of the time. Hence, whereas the levels of pain and worry both rose slightly with age, the impacts on social interactions evidently dropped with age.

Such aggregate data tell us little about the association between the adverse effects of dental disease and degree of dental disease. Thus, we looked more carefully at the percentages of persons reporting the various types of impact for increasingly severe levels of disease. Table 26 uses a continuum of disease severity according to the DMFT index (in quartiles), and Table 27 according to the Periodontal Index (in tertiles).[5] The tables show the percentages of dentulous adults ages 18 to

[5]Because the indexes are scored in integers and are highly skewed to the less-serious-disease end of the spectrum, the quartiles (or tertiles) will not have equivalent numbers in each group. Changing the scores in each quartile (or tertile) simply unbalances the numbers in a different way. Thus, we opted for cutpoints that were believed to be clinically significant.

Table 25

DISTRIBUTION OF RESPONSES TO QUESTIONS ABOUT DISEASE IMPACT FROM THE MHQ: TEENAGERS AND ADULTS

Question	Response	14-17		18-64	
		Number	Percent[a]	Number	Percent[a]
During the past 3 months, how much trouble or pain do you have when you chew or bite firm meat, etc.? (Dayton only)	A lot	3	3	13	2
	Some	5	4	40	7
	A little	17	15	88	15
	None	91	78	462	77
		116	100	603	101
During the past 3 months, how much pain or distress have your teeth or gums caused you? (Non-Dayton)	A lot	9	2	61	2
	Some	34	6	235	7
	A little	88	16	713	20
	None	420	76	2520	71
	Missing	1	(b)	10	(b)
		552	100	3539	100

Table 25—continued

Question	Response	14-17 Number	14-17 Percent[a]	18-64 Number	18-64 Percent[a]
During the past 3 months, how much have your teeth or gums worried or concerned you?	A lot	18	3	188	5
	Some	34	5	355	9
	A little	146	22	1139	27
	None	468	70	2453	59
	Missing	2	(b)	7	(b)
		668	100	4142	100
During the past 3 months, how much of the time have problems with the way your teeth or gums look caused you to avoid conversations with people?	Most	8	1	44	1
	Some	20	3	119	3
	A little	66	10	252	6
	None	573	86	3722	90
	Missing	1	(b)	5	(b)
		668	100	4142	100

[a]Percentages may not sum to 100 because of rounding.

[b]Less than 0.5 percent.

Table 26

PERCENTAGE OF ADULTS REPORTING PAIN, WORRY, CONVERSATION AVOIDANCE, AND ANY IMPACT, ACCORDING TO DMFT QUARTILE

Type of Disease Impact[b]	DMFT Quartile[a] 1 (685)[c]	2 (674)	3 (677)	4 (332)	Total (2368)
Pain or distress	24	27	29	31	27
Worry or concern	37	38	40	49	40
Conversation avoidance	8	10	11	17	11
Any impact	42	45	47	56	47

[a]Cutoff points for the DMFT index quartiles were as follows: 1, 0-12 DMF teeth; 2, 13-17; 3, 18-22; 4, 23-28.

[b]The distributions of responses to the disease impact questions are given in Appendix B, Tables B.1 and B.2.

[c]Number of persons in each quartile in parentheses.

64 in each disease-severity group who responded positively (answered something other than "none") to each of the three questions.[6] (Tables B.1 to B.4 in Appendix B show the detailed distribution of responses to these questions.)

Adults assessed at the screening examination as having more severe disease plainly suffered more adverse effects of their condition than did persons with a less serious problem.[7] Moving along the continuum from less to more disease (i.e., from left to right), in every case the percentage of persons reporting at least a little pain, worry, or conversation avoidance increases.

Taking the DMFT index quartiles as an example (Table 26), 24 percent of persons in DMFT Quartile 1 claimed at least a little pain, compared with 31 percent of persons in DMFT Quartile 4. Pain and worry

[6]The sample sizes are different in Tables 26 and 27 because of differences in the number of persons with missing data.

[7]Almost everyone had some degree of disease. Only 9 of 2674 adults (0.3 percent) had DMFT scores of 0.

Table 27

PERCENTAGE OF ADULTS REPORTING PAIN, WORRY, CONVERSATION AVOIDANCE, AND ANY IMPACT, ACCORDING TO PI TERTILE

Type of Disease Impact[b]	PI Tertile[a] 1 (1148)[c]	2 (637)	3 (587)	Total (2372)
Pain or distress	22	30	35	27
Worry or concern	34	42	49	40
Conversation avoidance	6	11	18	10
Any impact	40	50	56	47

[a]Cutoff points for the PI tertiles were as follows: 1, 0-1; 2, >1-1.5; 3, >1.5.

[b]The distributions of responses to the disease impact questions are given in Appendix B, Tables B.3 and B.4.

[c]Number of persons in each tertile in parentheses.

were always more likely to be reported than was conversation avoidance.

The same general findings emerge from the PI analysis (Table 27). Twenty-two percent of persons in PI Tertile 1 and 35 percent in PI Tertile 3 reported pain, and the same large magnitude of effect on conversation avoidance was observed. In short, as severity of periodontal disease rises, so do the perceived negative effects on people's lives.

Even people with the least severe levels of dental disease are fairly likely to claim some negative effects. For example, 37 percent of people in DMFT Quartile 1 and 34 percent in PI Tertile 1 stated that they worried about their teeth or gums. In addition, approximately 40 percent of persons in DMFT Quartile 1 and PI Tertile 1 reported at least one type of impact ("any impact").

We performed several chi-square analyses to determine if persons in the highest disease categories (i.e., DMFT Quartile 4 and PI Tertile 3) were significantly more likely to claim pain, worry, or conversation avoidance than were persons in the lowest categories (i.e., DMFT Quartile 1 or PI Tertile 1). In all cases, persons with the most severe

condition had significantly more adverse effects than persons with the least ($p < 0.05$ in all cases).

To determine if the trend of increasing impact persisted when controlling for age, we divided the sample into two groups: those 18 to 34 years of age and those 35 to 64. As seen in Tables 28 and 29, the impacts did indeed increase steadily with disease severity, with two exceptions. For persons 35 to 64 years of age, the amount of pain did not rise with any consistency as the DMFT quartile increased. Furthermore, the percentage of persons who reported worry was *lower* for those in DMFT Quartiles 2 and 3 than for those in DMFT Quartile 1. This suggests that, at least in the middle ranges of disease severity,

Table 28

PERCENTAGE OF ADULTS REPORTING PAIN, WORRY, CONVERSATION AVOIDANCE, AND ANY IMPACT, BY AGE GROUP AND DMFT QUARTILE

	DMFT Quartile, Persons 18-34				
Type of Disease Impact	1 (516)[a]	2 (400)	3 (322)	4 (120)	Total (1358)
Pain or distress	24	27	36	37	29
Worry or concern	36	42	46	56	42
Conversation avoidance	7	10	15	19	11
Any impact	41	49	55	63	49

	DMFT Quartile, Persons 35-64				
Type of Disease Impact	1 (169)[a]	2 (274)	3 (355)	4 (212)	Total (1010)
Pain or distress	25	27	23	28	26
Worry or concern	40	33	35	45	37
Conversation avoidance	9	9	8	16	10
Any impact	46	40	40	51	43

[a]Number of persons in each quartile in parentheses.

Table 29

PERCENTAGE OF ADULTS REPORTING PAIN, WORRY, CONVERSATION AVOIDANCE, AND ANY IMPACT, BY AGE GROUP AND PI TERTILE

Type of Disease Impact	PI Tertile, Persons 18-34			
	1 (709)[a]	2 (390)	3 (266)	Total (1365)
Pain or distress	24	32	37	29
Worry or concern	36	44	55	42
Conversation avoidance	6	13	21	11
Any impact	41	53	62	49

Type of Disease Impact	PI Tertile, Persons 35-64			
	1 (439)[a]	2 (247)	3 (321)	Total (1007)
Pain or distress	20	26	34	26
Worry or concern	32	38	44	37
Conversation avoidance	6	9	16	10
Any impact	37	46	50	43

[a]Number of persons in each tertile in parentheses.

older persons may be receiving needed fillings and extractions, thus decreasing the amount of pain and worry they experience. This hypothesis is supported by the fact that younger persons, particularly those in the higher DMFT quartiles and PI tertiles, report more impact than older persons.

Tables 26–29 showed the percentage of persons reporting *any* adverse effects of dental disease. Another dimension to disease impact is the magnitude or severity of the effects, which we explored by

comparing the percentage of persons who reported substantial adverse effects with the amount of clinically determined disease. To accomplish this comparison, we determined the percentage of people in the DMFT quartiles and PI tertiles who reported either "some" or "a great deal" of impact (see Table 30). In almost all cases, this degree of serious symptoms or social withdrawal was at least twice as common for persons with the most severe dental problems as for persons with the least severe problems. However, even persons with relatively mild disease reported a substantial degree of harmful effects on their lives. For example, 10 percent of persons in PI Tertile 1 reported some or a great deal of worry.

Reasons for this substantial amount of impact among persons with presumably little dental disease are not at first obvious. It is possible that the presence of dental features such as crooked or unesthetic teeth prompted the unexpectedly high scores for worry or conversation avoidance. Unfortunately, we did not specify these kinds of reasons for the reported impact in the MHQ. We did, however, ask if enrollees had been told they had gum problems by a dentist and, further, whether they could lose their teeth because of these problems. We compared these responses with the clinically measured PI score. A surprisingly high number of persons in PI Tertile 1 had been told they had gum problems. Specifically, for persons 35 to 64 years of age, 21 percent in PI Tertile 1 had been so told. This compares with 25 percent in PI Tertile 2 and 27 percent in PI Tertile 3. Thus, it is possible that having been told of gum problems *in the past* created a degree of

Table 30

PERCENTAGE OF ADULTS REPORTING SOME OR A LOT OF PAIN, WORRY, OR CONVERSATION AVOIDANCE, ACCORDING TO DMFT QUARTILE OR PI TERTILE

Type of Severe Impact	DMFT Quartile				PI Tertile		
	1	2	3	4	1	2	3
Pain or distress	6	8	9	9	5	8	13
Worry or concern	9	13	14	19	10	14	19
Conversation avoidance	3	4	5	8	3	3	9

impact that would seem unwarranted merely from the clinical measure obtained at the screening examination.

SUMMARY OF FINDINGS ON EFFECTS OF DENTAL DISEASE

The amount of pain from dental disease was substantial in the HIE population, ranging from 19 percent of children and adolescents to 29 percent of non-Dayton adults. Worry about teeth or gums was the most frequently cited effect—up to 41 percent of adults citing such concerns. Interestingly, avoidance of conversation was higher among teenagers (14 percent) than among adults (10 percent).

All impacts increased as the level of disease worsened. These various adverse sequelae of dental problems were much more widespread among persons in DMFT Quartile 4 and PI Tertile 3 than among persons with the least disease. Finally, persons with the highest degree of disease (DMFT Quartile 4 or PI Tertile 3) reported substantially more severe impact than persons with the least disease.

PREVALENCE OF DENTAL DISEASE ACCORDING TO HIE INSURANCE PLANS

Tables 31 and 32 show the distribution at enrollment of the mean DMFT28, PI, and OHI-S indexes according to HIE experimental insurance plans. The 16 plans (described in the Preface) have been aggregated into five fee-for-service plans (in all six sites), depending on level of coinsurance or maximum dollar expenditure, and two prepaid medical group practice plans (Group Health Cooperative of Puget Sound, hereafter GHC, which is located only in the Seattle site). The GHC experimentals and controls obtained their dental care from the fee-for-service system before and during the experiment. The former group had free fee-for-service dental coverage from the HIE; the latter used whatever private dental insurance they may have had.

To determine if the prevalence of oral disease differed among the several plans at enrollment, we compared the mean values on the three indexes among plans, using a one-way analysis of variance. Only persons who had been assigned to one of these plans and who could be classified according to these dental indexes (from screening examination data) are included in these analyses. Three groups of comparisons were done for this analysis.

Table 31

DMFT28 MEAN SCORES, BY HIE EXPERIMENTAL INSURANCE PLAN

Experimental Insurance Plan[a]	HIE Sample Size	Mean Score			
		DMFT28	D-28	M-28	F-28
Fee-for-service					
Free dental care	907	12.8	2.1	4.8	5.9
25-percent coinsurance	284	12.9	2.0	4.7	6.1
50-percent coinsurance	416	13.3	2.1	5.2	6.0
95-percent coinsurance	531	12.2	2.2	4.2	5.8
Individual deductible	593	12.7	2.3	4.6	5.8
Prepaid group practice[b]					
GHC experimentals	485	14.1	2.4	3.5	8.2
GHC controls	297	14.2	1.9	3.2	9.1

[a]For definitions, see the Preface (on insurance plan) and Chapter 4 or 5 (on DMFT28 index).

[b]Seattle only. For a comparison of the prepaid group practice and Seattle fee-for-service plans, see the text.

First, we examined the five fee-for-service plans aggregated across sites. There were no significant differences among the five plans in any of the dental caries indexes (Table 31) or in the periodontal or oral hygiene indexes (Table 32). Second, we compared the GHC experimentals and fee-for-service plans in the Seattle site only. Mean scores on the dental caries, periodontal, or oral hygiene measures did not differ significantly among those six plans. Finally, we compared the GHC controls and fee-for-service plans in Seattle. Again, mean scores did not differ for any of the dental indexes.

Overall, these findings are as expected, and reflect the unbiased assignment of people to the various HIE plans at the time of enrollment into the HIE, before data on dental health status from the screening examination were collected. Thus, the HIE should be able to determine whether the occurrence and course of dental caries or periodontal disease vary as a function of differences in the amount or type of care associated with different levels of insurance coverage.

Table 32

PI AND OHI-S MEAN SCORES, BY EXPERIMENTAL INSURANCE PLAN

Experimental Insurance Plan[a]	PI		OHI-S	
	Sample Size	Mean Score	Sample Size	Mean Score
Fee-for-service				
Free dental care	645	1.3	897	1.6
25-percent coinsurance	201	1.3	282	1.6
50-percent coinsurance	287	1.3	409	1.6
95-percent coinsurance	374	1.4	525	1.6
Individual deductible	429	1.3	583	1.6
Prepaid group practice[b]				
GHC experimentals	341	1.2	481	1.7
GHC controls	232	1.1	296	1.5

[a]For definitions, see the Preface (on insurance plan) and Chapter 4 or 5 (on PI and OHI-S index).

[b]Seattle only. For a comparison of the prepaid group practice and Seattle fee-for-service plans, see the text.

RELIABILITY

As described in Chapter 4, the reliability of the dental screening examination was determined by repeat examinations performed by the same dentist (intra-examiner reliability) on approximately 2 percent of the HIE sample. We present reliability data for the 110 people who received repeat DMFT or DMFS index ratings. Data for the OHI-S and PI were not available. At exit we will be able to determine the inter- *and* intra-examiner reliability of the DMFT, PI, and OHI-S indexes.

We used three methods to determine the reliability of the repeat examinations. First, we performed a simple correlation between the first and second examination for the DMFT28, DMFS28, DMFT32, and DMFS32 indexes. The two tests were highly correlated for all indexes. Almost all the coefficients were over 0.99. Only the index for decayed teeth (DT-28, DT-32) was below this level, and only slightly so (0.97).

Second, we did an Average Absolute Difference (AAD) test, using a method described by Klein and Bell (1981). The AAD test pairs the

two findings for each examinee, calculates any difference, and then computes the average of those differences across the population. Based on 28 teeth, the AAD for the DMFT index was 0.46, or about half a tooth difference per person. Not unexpectedly, differences were lowest for missing teeth (0.12) and highest for decayed teeth (0.37).

The final test for intra-examiner reliability we performed was a consistency ratio on the number of carious teeth found at the first and second examinations. The calculation was done on the basis of number of teeth rather than number of tooth surfaces because we could not match surfaces directly.

The consistency ratio is based on a simple formula:

$$\frac{cc}{cc + cs + sc}$$

where *cc* is the number of carious teeth found at the first *and* second examination, *cs* is the number found at the first but not the second examination (one carious, one sound), and *sc* is the number found at the second but not the first examination. Using carious teeth, we determined the consistency ratio to be 0.86.

On the basis of all three of these methods, we conclude that the DMF index as performed at the HIE enrollment screening examination is of acceptable reliability for our analyses.

Chapter 6

QUALITY-OF-CARE CRITERIA FOR DENTAL DISEASES

Conceptually, the quality of dental services may be examined along three dimensions of care: structure, process, and outcome. Structure refers to the systems through which dental care might be provided and to the professional or demographic characteristics of dentists and dental practices. We do not evaluate structural aspects of care directly in the Health Insurance Experiment (HIE) and thus will not discuss this dimension further.

Processes of dental care may be divided into at least two technical aspects—treatment planning and use of dental services. Treatment planning refers to the necessity and appropriateness of treatment, including its sequence and timing. Use of dental services encompasses demand for preventive services that apply to almost all individuals (e.g., prophylaxis, diagnosis, oral hygiene instruction) and for restorative and periodontal services that apply to a smaller proportion of individuals (e.g., fillings, crowns, bridges, and dentures, scalings, and curettages).

The outcome category may be divided into long-term and intermediate-term outcomes. Long-term patient outcomes refer to the person's ultimate dental health status—tissue morbidity and mortality (e.g., tooth decay, periodontal disease, missing teeth)—and, to a lesser extent, to disability (e.g., work loss) and personal functioning (e.g., social interaction). Intermediate outcomes refer to changes in behavior that influence a person's oral health. Examples might include oral hygiene habits, use of fluoride agents, diet modification, and the ability to recognize the early symptoms of dental diseases.

One major objective of the HIE is to examine the influence of generosity of dental insurance on the quality of care obtained by enrollees. The quality-of-care criteria developed for the HIE pertain more to the quality of care provided by the dental delivery system in general than to that rendered by any one dentist in particular. We take this approach because, although the HIE data base is fairly extensive for dental care, we do not have access to all the information that would be needed to make a definitive evaluation of the care provided to HIE

enrollees by a given dentist or set of dental providers. Specifically, the HIE data base lacks information mainly in the form of history, physical findings, and laboratory test results from private dentists' offices.

The HIE data base does, nonetheless, contain much information to assess quality of care. This includes, first of all, the physiologic measures of dental health taken at the enrollment and exit examinations. The basic measures are those already described in Chapter 4—indexes of dental caries experience (DMFT, DMFS, deft, defs), the Periodontal Index (PI), and the Simplified Oral Hygiene Index (OHI-S).

Because we were particularly interested in the quality of dental restorative care, three selected clinical features of restorations (fillings, crowns, and pontics) were assessed at the exit examinations of five sites (Seattle, Fitchburg, Franklin County, Charleston, and Georgetown County) using a modified version of the Ryge and Snyder method (Ryge and Snyder, 1973).[1] Time limitations in performing the examination precluded assessing a substantially larger number of features.

The three clinical features were the following: (1) overhanging fillings; (2) open margins; and (3) crowns that are overly contoured or bulbous at the gingival one-third of the tooth. An overhanging filling (i.e., one that is not continuous with the natural surface of the tooth) may irritate gingival tissue and create a trap for plaque accumulation. The result is usually an inflammation of the gingiva and eventual resorption of the supporting bone tissue. An open margin represents a space between the filling and the tooth, exposing the internal portions of the tooth structure. It may arise from recurrent decay (i.e., new decay around an old filling), fracture of the filling material (which is common with a metallic silver filling), or washing out of the cement (in the case of a cast precious metal crown or filling). An overly contoured crown (i.e., one that deviates from the natural contour of the tooth in the direction of being bulbous or bulky at the gingival line) may accumulate plaque and prevent the self-cleansing action of the cheeks, tongue, and lips. These three criteria should provoke little disagreement (i.e., there is consensus on the desirability of avoiding these problems) because of their direct relationship to gingival health and recurrent decay.

Additionally, the HIE data base contains self-reported (or, for enrollees of the pediatric age group, proxy-reported) information on dental history, behaviors related to seeking dental care and to carrying out preventive activities, and eating and dietary habits related to dental health. These Medical History Questionnaire (MHQ) data are

[1]These assessments were instituted after the enrollment screening examination in Dayton was begun.

supplemented by measures of disease impact (pain or distress attributable to problems with teeth or gums; worry or concern about dental conditions; and restrictions on social conversation). These MHQ data are available at both enrollment and exit.

Enrolled families completed periodic (usually biweekly) Health Reports during their years of participation. These reports will provide information on whether any family member had a day lost from work or other usual activity or a day in which daily activities were restricted because of dental problems or their treatment.

Finally, types of dental services actually obtained during the HIE are known from dental insurance claim forms submitted for payment during the HIE. These forms contain information on the patient's stated reason for visit, type of care rendered (e.g., routine treatment given but not completed; urgent care only); and exact type of services rendered (by tooth and surface).

Tentative HIE criteria pertaining to dental care, which are stated in a form that assumes care was good, are given in Appendix C. They cover two main dimensions of care: outcomes and process of care. Long-term patient outcomes relate to dental caries and periodontal disease; intermediate outcomes relate to, among other things, extractions, symptoms, and effects of dental problems, and the major types of oral disorders. Processes of care pertain to such factors as preventive activities, timing of followup and therapy for diagnosed dental problems, and the like.

Appendix A

DENTAL, EATING HABITS, AND DIET BATTERIES FROM THE MEDICAL HISTORY QUESTIONNAIRE

ENROLLMENT MEDICAL HISTORY QUESTIONNAIRE[1]
NON-DAYTON, AGES 14 AND OLDER

TEETH, GUMS

DO NOT WRITE IN THIS SPACE

37. DO YOU HAVE ANY NATURAL TEETH AT ALL? (YOUR OWN TEETH, NOT ARTIFICIAL?)

Yes	1	*—Answer 38*	69/
No	2	*—Go to 48, page 14*	

---

38. HOW OFTEN DO YOU USUALLY BRUSH YOUR TEETH?
(Circle one)

Never	1	70/
Once a week or less	2	
Once every few days	3	
Once a day	4	
More than once a day	5	

---

39. HOW OFTEN DO YOU USE DENTAL FLOSS (STRING USED TO REMOVE PARTICLES OF FOOD FROM BETWEEN THE TEETH)?
(Circle one)

Never	1	71/
Once a month or less	2	
Once a week or 2 - 3 times a month	3	
Once every few days	4	
At least once a day	5	

---

40. HAVE YOU EVER BEEN TO A DENTIST?

Yes	1	*—Answer 41*	72/
No	2	*—Go to 42, next page*	

[1]Used at all HIE sites except Dayton at enrollment and in all sites upon exit. Revisions incorporated in this version were based on experience with the initial Dayton battery.

DO NOT WRITE IN THIS SPACE

41. WHEN DID YOU MOST RECENTLY HAVE YOUR TEETH CLEANED BY A DENTIST OR DENTAL TECHNICIAN? 73/

(Circle one)

- Within the past 12 months 1
- 1 - 2 years ago 2
- More than 2 but less than 5 years ago 3
- 5 or more years ago 4
- Never 5

---

42. DO YOU THINK THAT YOUR TEETH NEED CLEANING NOW BY A DENTIST OR DENTAL TECHNICIAN? 74/

- Yes 1
- No 2

---

43. HAS A DENTIST EVER TOLD YOU THAT YOU HAVE GUM PROBLEMS? CARD 03 13/

- Yes ..... 1 *—Answer 44*
- No ..... 2 *—Go to 45*

---

44. DID HE SAY THAT YOUR GUM PROBLEMS COULD CAUSE YOU TO LOSE YOUR TEETH EARLIER THAN MOST PEOPLE? 14/

- Yes 1
- No 2

---

45. DURING THE PAST 3 MONTHS, HOW MUCH PAIN HAVE YOUR GUMS OR TEETH CAUSED YOU? 15/

(Circle one)

- A great deal of pain 1
- Some pain 2
- A little pain 3
- No pain at all 4

---

46. DURING THE PAST 3 MONTHS, HOW MUCH HAVE YOUR TEETH OR GUMS WORRIED OR CONCERNED YOU? 16/

(Circle one)

- A great deal 1
- Somewhat 2
- A little 3
- Not at all 4

47. **DURING THE PAST 3 MONTHS, HOW MUCH OF THE TIME HAVE PROBLEMS WITH THE WAY YOUR TEETH OR GUMS LOOK CAUSED YOU TO AVOID CONVERSATION WITH PEOPLE?**

(Circle one)

Most of the time	1	17/
Some of the time	2	
A little of the time	3	
None of the time	4	

ENROLLMENT MEDICAL HISTORY QUESTIONNAIRE
DAYTON, AGES 14 AND OLDER

TEETH, GUMS

24. DO YOU HAVE ANY NATURAL TEETH AT ALL? 4242

NO ..... 2—— *(GO to q. 31, next page)*

YES ..... 1—— *(GO to q. 25)*

25. How often do you usually brush your teeth? 4243

(Circle one.)

Never 1
Once a week or less 2
Once every few days 3
Once a day 4
More than once a day 5

26. How often do you use dental floss? 4244

(Circle one.)

Never 1
Once a month or less 2
Once a week 3
Once every few days 4
At least once a day 5

27. When did you most recently have your teeth cleaned by a dentist or dental assistant? 4245

(Circle one.)

Within the past 12 months 1
1 to 2 years ago 2
More than 2, but less than 5 years ago 3
5 or more years ago 4
Never 5

28. Do you think that your teeth need cleaning now by a dentist or dental assistant? 4246

Yes 1
No 2

29. Has a dentist ever told you that you have gum problems? 4247

No ..... 2—— *(GO to q. 31)*

Yes ..... 1—— *(GO to q. 30)*

30. **Did he say your gum problems could cause you to lose your teeth earlier than most people?** 4248

Yes 1

No 2

31. **DURING THE PAST 3 MONTHS, HOW MUCH TROUBLE OR PAIN DO YOU HAVE IN YOUR GUMS OR TEETH WHEN YOU CHEW OR BITE FIRM MEAT (LIKE STEAKS OR CHOPS), APPLES, CORN-ON-THE-COB, OR ANY OTHER FOOD?** 4249

(Circle on.)

A LOT 1

SOME 2

A LITTLE 3

NONE AT ALL 4

32. **DURING THE PAST 3 MONTHS, HOW MUCH HAVE YOUR TEETH OR GUMS WORRIED OR CONCERNED YOU?** 4250

(Circle one.)

A LOT 1

SOMEWHAT 2

A LITTLE 3

NOT AT ALL 4

33. **DURING THE PAST 3 MONTHS, HAVE PROBLEMS WITH THE WAY YOUR TEETH OR GUMS LOOK CAUSED YOU TO MISS OR AVOID CONVERSATION WITH PEOPLE?** 4251

(Circle one.)

MOST OF THE TIME 1

SOME OF THE TIME 2

A LITTLE OF THE TIME 3

NONE OF THE TIME 4

ENROLLMENT MEDICAL HISTORY QUESTIONNAIRE
NON-DAYTON, AGES 5 TO 13

DO NOT WRITE IN THIS SPACE

CARD 02

TEETH AND GUMS

1. HOW OFTEN DOES THIS CHILD USUALLY BRUSH HIS OR HER TEETH?

(Circle one)

Never	1	13/
Once a week or less	2	
Once every few days	3	
Once a day	4	
More than once a day	5	

---

2. HOW OFTEN DOES THIS CHILD USE DENTAL FLOSS?

(Circle one)

Never	1	14/
Once a month or less	2	
Once a week or less	3	
Once every few days	4	
At least once a day	5	

---

3. WHEN WAS THE LAST TIME THIS CHILD WENT TO THE DENTIST?

(Circle one)

Within the past 12 months	1	15/
1 - 2 years ago	2	
More than 2 but less than 5 years ago	3	
5 or more years ago	4	
Never	5	

---

4. DURING THE PAST 3 MONTHS, HOW MUCH PAIN OR DISTRESS HAVE THIS CHILD'S TEETH OR GUMS CAUSED HIM OR HER?

(Circle one)

A great deal	1	16/
Some pain or distress	2	
A little pain or distress	3	
No pain or distress at all	4	

---

5. DURING THE PAST 3 MONTHS, HOW MUCH HAVE THIS CHILD'S TEETH OR GUMS WORRIED OR CONCERNED YOU?

(Circle one)

A great deal	1	17/
Somewhat	2	
A little	3	
Not at all	4	

ENROLLMENT MEDICAL HISTORY QUESTIONNAIRE
DAYTON, AGES 5 TO 13

TEETH OR GUMS

25. HOW OFTEN DOES THIS CHILD USUALLY BRUSH HIS TEETH? 4154

(Circle one.)

NEVER 1
ONCE A WEEK OR LESS 2
ONCE EVERY FEW DAYS 3
ONCE A DAY 4
MORE THAN ONCE A DAY 5

26. HOW OFTEN DOES THIS CHILD USE DENTAL FLOSS? 4155

(Circle one.)

NEVER 1
ONCE A MONTH OR LESS 2
ONCE A WEEK OR LESS 3
ONCE EVERY FEW DAYS 4
AT LEAST ONCE A DAY 5

27. WHEN WAS THE LAST TIME THIS CHILD WENT TO THE DENTIST? 4156

(Circle one.)

WITHIN THE PAST 12 MONTHS 1
1 TO 2 YEARS AGO 2
MORE THAN 2, BUT LESS THAN 5 YEARS AGO 3
5 OR MORE YEARS AGO 4
NEVER 5

28. DURING THE PAST 3 MONTHS, HOW MUCH PAIN HAVE THIS CHILD'S TEETH OR GUMS CAUSED HIM OR HER? 4157

(Circle one.)

A LOT 1
SOME 2
A LITTLE 3
NONE AT ALL 4

29. DURING THE PAST 3 MONTHS, HOW MUCH HAVE THIS CHILD'S TEETH OR GUMS WORRIED OR CONCERNED YOU? 4158

(Circle one.)

A LOT 1
SOMEWHAT 2
A LITTLE 3
NOT AT ALL 4

ENROLLMENT MEDICAL HISTORY QUESTIONNAIRE
NON-DAYTON, AGES 14 AND OLDER

EATING HABITS AND DIET

DO NOT WRITE IN THIS SPACE

21. HOW OFTEN DO YOU EAT BREAKFAST?

(Circle one)

Almost every day	1	51/
Sometimes	2	
Rarely or never	3	

22. HOW OFTEN DO YOU EAT SOMETHING IN BETWEEN YOUR REGULAR MEALS?

(Circle one)

About 3 times a day or more	1	52/
About twice a day	2	
Maybe once a day	3	
Occasionally, not every day	4	
Rarely or never eat between meals	5	

23. DURING THE PAST 24 HOURS, DID YOU EAT ANY OF THE FOODS LISTED BELOW? (Circle one number on each line. If you ate even a little, circle "1" for "Yes." If you did not eat it at all, circle "2" for "No.")

	Yes	No	
A. Sugar-coated cereal	1	2	53/
B. Cookies, cake, pie, doughnuts	1	2	54/
C. Soda pop, cola drink	1	2	55/
D. Peanut butter	1	2	56/
E. Jelly or honey	1	2	57/
F. Raisins, figs, prunes	1	2	58/
G. Chewing gum	1	2	59/
H. Candy	1	2	60/
I. Sugar (table sugar)	1	2	61/

24. IF YOU ATE ANY OF THESE FOODS IN THE PAST 24 HOURS, DID YOU EAT THEM ONLY DURING YOUR REGULAR MEALS (BREAKFAST, LUNCH OR DINNER), OR DID YOU EAT THEM ONLY BETWEEN YOUR REGULAR MEALS, OR DID YOU EAT THEM BOTH DURING AND BETWEEN MEALS?

(Circle one)

Regular meals only	1	62/
Between meals only	2	
Both during meals and between meals	3	
Did not eat any of the above foods in past 24 hours	4	

DO NOT WRITE IN THIS SPACE

CARD 03

25. ARE YOU ON ANY KIND OF SPECIAL DIET — EITHER TO LOSE WEIGHT, OR FOR REASONS OF HEALTH? 13/

Yes ..... 1 *—Answer 25-A-B-C-D-E*

No ..... 2 *—Go to 26, next page*

25-A. WHY ARE YOU ON A SPECIAL DIET? (Circle one number on each line)

	Yes	No	
To lose weight	1	2	14/
Diabetes	1	2	15/
Kidney failure	1	2	16/
Ulcers	1	2	17/
High cholesterol	1	2	18/
Heart trouble or high blood pressure	1	2	19/
Pregnancy	1	2	20/
Some other reason	1	2	21/

What? _____

25-B. WHAT KIND OF DIET IS IT? (Circle one number on each line.)

	Yes	No	
Low calorie	1	2	22/
Low fat or cholesterol	1	2	23/
Low protein	1	2	24/
Low salt	1	2	25/
Low carbohydrate	1	2	26/
Bland diet	1	2	27/
Some other	1	2	28/

What? _____

25-C. WAS THIS DIET ORDERED BY A DOCTOR, NURSE, CLINIC, OR DIETICIAN?

Yes 1 29/

No 2

25-D. HOW CAREFULLY DO YOU FOLLOW YOUR DIET? DO YOU FOLLOW IT . . .

(Circle one)

All of the time	1	30/
Most of the time	2	
Some of the time	3	
A little of the time	4	
None of the time	5	

25-E. HOW MUCH BOTHER IS THIS DIET? DOES IT BOTHER YOU . . .

(Circle one)

A great deal	1	31/
Somewhat	2	
A little	3	
Not at all	4	

DO NOT WRITE IN THIS SPACE

ENROLLMENT MEDICAL HISTORY QUESTIONNAIRE
NON-DAYTON, AGES 5 TO 13

FLUORIDES, DIET

DO NOT WRITE IN THIS SPACE

21. DOES THIS CHILD USE FLUORIDE (FLORE-eyed) IN ANY OF THESE WAYS? Please circle one number on each line.

	Yes	No	Don't know	
A. Fluoridated toothpaste?	1	2	3	53/
B. Fluoride tablets on a regular basis?	1	2	3	54/
C. Fluoride mouthwash on a regular basis?	1	2	3	55/
D. Did the child ever have his teeth painted with fluoride by a dentist or dental assistant?	1	2	3	56/
E. Does the child use any fluoride-vitamin preparation?	1	2	3	57/
F. Fluoride drops on a regular basis?	1	2	3	58/

22. HOW OFTEN DOES THIS CHILD EAT SOMETHING IN BETWEEN REGULAR MEALS?

(Circle one)

4 or more times a day	1	59/
3 times a day	2	
About twice a day	3	
Maybe once a day	4	
Occasionally, not every day	5	
Rarely or never eats between meals	6	

23. DURING THE PAST 24 HOURS, DID THIS CHILD EAT ANY OF THE FOODS LISTED BELOW? (Circle one number on each line. If the child ate even a little, circle 1 for "Yes." If he or she did not eat it at all, circle 2 for "No.")

	Yes	No	
A. Sugar-coated cereal	1	2	60/
B. Cookies, cake, pie, doughnuts	1	2	61/
C. Soda pop, cola drink	1	2	62/
D. Peanut butter	1	2	63/
E. Jelly or honey	1	2	64/
F. Raisins, figs, prunes	1	2	65/
G. Chewing gum	1	2	66/
H. Candy	1	2	67/
I. Sugar (table sugar)	1	2	68/

DO NOT WRITE IN THIS SPACE

24. IF THE CHILD ATE ANY OF THESE FOODS IN THE PAST 24 HOURS, DID HE OR SHE EAT THEM ONLY DURING REGULAR MEALS (BREAKFAST, LUNCH OR DINNER), OR ONLY BETWEEN REGULAR MEALS, OR BOTH DURING AND BETWEEN MEALS?

69/

(Circle one)

Regular meals only 1
Between meals only 2
Both during meals and between meals 3
Did not eat any of these foods in past 24 hours .. 4

---

25. DURING THE PAST 24 HOURS, HOW MANY TIMES DID THE CHILD EAT OR DRINK THE FOODS LISTED BELOW? (Circle one number on each line)

	None	One time	Twice	Three times	Four or more	Don't know	
A. Milk (whole milk, skim milk, or low-fat)	0	1	2	3	4	5	70/
B. Custard	0	1	2	3	4	5	71/
C. Cheese	0	1	2	3	4	5	72/
D. A milk-shake (or frappe)	0	1	2	3	4	5	73/
E. A malted milk	0	1	2	3	4	5	74/

Appendix B

DISTRIBUTION OF RESPONSES TO DISEASE IMPACT QUESTIONS ON DENTAL HEALTH STATUS

The numbers and percentages of responses to the disease impact questions in the Dental battery of the Medical History Questionnaire (MHQ) are shown in the following four tables. Tables B.1 and B.2 use the DMFT28 Quartiles, and Tables B.3 and B.4 the PI Tertiles that were also used in Chapter 5.

The distributions pertaining to pain and distress are shown separately for Dayton and non-Dayton sites because the item differed substantially in those two versions of the MHQ. The total numbers of enrollees in each disease category are shown in separate columns in Tables B.1 and B.3, and in parentheses in Tables B.2 and B.4. The numbers given for each response may not sum to these totals because persons with missing responses are not included in the distributions. (They typically amounted to only about 1 percent of all responses.)

The entries in the "level of impact" columns are given in abbreviated form. For the full wording of the questions and responses, see Appendix A.

Table B.1

DISTRIBUTION OF RESPONSES TO DISEASE IMPACT QUESTIONS ON PAIN OR DISTRESS, BY DMFT28 INDEX QUARTILES

DMFT28 Quartile[a]	Dayton				Non-Dayton				All Sites			
	n	Level of Impact	No.	Percent	n	Level of Impact	No.	Percent	n	Level of Impact	No.	Percent
1	141	None	112	79	544	None	405	75	685	None	517	75
		Little	22	16		Little	103	19		Little	125	18
		Some	6	4		Some	29	5		Some	35	5
		A lot	1	1		Great	5	1		Great	6	1
2	132	None	101	77	542	None	393	73	674	None	494	73
		Little	21	16		Little	105	19		Little	126	19
		Some	7	5		Some	35	6		Some	42	6
		A lot	3	2		Great	9	2		Great	12	2
3	106	None	82	77	571	None	395	70	677	None	477	70
		Little	16	15		Little	122	21		Little	138	20
		Some	7	7		Some	41	7		Some	48	7
		A lot	1	1		Great	10	2		Great	11	2
4	64	None	43	67	268	None	184	69	332	None	227	68
		Little	14	22		Little	59	22		Little	73	22
		Some	5	8		Some	19	7		Some	24	7
		A lot	2	3		Great	5	2		Great	7	2

[a]DMFT28 quartiles represented the following scores: 1, 0-12; 2, 13-17; 3, 18-22; 4, 23-28.

Table B.2

DISTRIBUTION OF RESPONSES TO DISEASE IMPACT QUESTIONS ON WORRY AND AVOIDANCE OF CONVERSATION, BY DMFT28 INDEX QUARTILES

	Worry			Conversation Avoidance		
DMFT28 Quartile[a]	Level of Impact	No.	Percent	Level of Impact	No.	Percent
1	None	429	63	None	630	92
(n = 685)	Little	191	28	Little	36	5
	Some	49	7	Some	14	2
	A lot	14	2	Most	3	<.05
2	None	415	62	None	609	90
(n = 674)	Little	170	25	Little	43	6
	Some	61	9	Some	11	2
	A lot	27	4	Most	11	2
3	None	404	60	None	600	89
(n = 677)	Little	179	26	Little	48	7
	Some	52	8	Some	21	3
	A lot	40	6	Most	6	1
4	None	169	51	None	276	83
(n = 332)	Little	100	30	Little	28	8
	Some	43	13	Some	24	7
	A lot	20	6	Most	4	1

[a]DMFT28 quartiles represented the following scores: 1, 0-12; 2, 13-17; 3, 18-22; 4, 23-28.

Table B.3

DISTRIBUTION OF RESPONSES TO DISEASE IMPACT QUESTIONS ON PAIN OR DISTRESS, BY PERIODONTAL INDEX TERTILES

PI Tertile[a]	Dayton				Non-Dayton				All Sites			
	n	Level of Impact	No.	Percent	n	Level of Impact	No.	Percent	n	Level of Impact	No.	Percent
1	181	None	149	82	967	None	742	77	1148	None	891	78
		Little	23	13		Little	170	18		Little	193	17
		Some	7	4		Some	45	5		Some	52	5
		A lot	2	1		Great	7	1		Great	9	1
2	119	None	87	73	518	None	360	70	637	None	447	70
		Little	20	17		Little	117	23		Little	137	22
		Some	10	8		Some	31	6		Some	41	6
		A lot	2	2		Great	9	2		Great	11	2
3	147	None	105	71	440	None	274	62	587	None	379	65
		Little	30	20		Little	101	23		Little	131	22
		Some	9	6		Some	50	11		Some	59	10
		A lot	3	2		Great	13	3		Great	16	3

[a]PI tertiles represented the following scores: 1, 0-1; 2, >1-1.5; 3, >1.5.

Table B.4

DISTRIBUTION OF RESPONSES TO DISEASE IMPACT QUESTIONS ON WORRY AND AVOIDANCE OF CONVERSATION, BY PERIODONTAL INDEX TERTILES

PI Tertile[a]	Worry			Conversation Avoidance		
	Level of Impact	No.	Percent	Level of Impact	No.	Percent
1	None	755	66	None	1078	94
(n = 1148)	Little	276	24	Little	47	4
	Some	85	7	Some	18	2
	A lot	31	3	Most	4	<.05
2	None	368	58	None	563	88
(n = 637)	Little	182	29	Little	57	9
	Some	52	8	Some	11	2
	A lot	34	5	Most	5	1
3	None	296	50	None	480	82
(n = 587)	Little	179	30	Little	51	9
	Some	70	12	Some	40	7
	A lot	39	7	Most	14	2

[a]PI tertiles represented the following scores: 1, 0-1; 2, >1-1.5; 3, >1.5.

Appendix C

QUALITY-OF-CARE CRITERIA FOR DENTAL DISORDERS

The following criteria are organized by two main dimensions of quality of care: patient outcomes and processes of care. Within each dimension, the topics relate to major oral diseases (caries, periodontal disease, or missing teeth). We rely mainly on the Decayed, Missing, Filled Index (DMFT28), the Periodontal Index (PI), and the Simplified Oral Hygiene Index (OHI-S).

Unless otherwise specified, the criteria apply to HIE participants of all ages who are eligible to receive dental care and who are dentulous. Third molar teeth are excluded, unless they are specifically noted in the criteria. Some criteria applicable to both the pediatric age group and adults refer to responses to items on the exit Medical History Questionnaire (MHQ); one refers to a biweekly Health Report completed by a head of household throughout the experiment. For nonadults, the enrollee specified in such criteria is the child, and the mother is assumed to be the proxy respondent. "He" refers to both men and women (or boys and girls).

PATIENT OUTCOMES

1. The enrollee has a DMFT index at the exit examination that is equal to his DMFT at the enrollment examination.

   a. The number of decayed plus filled teeth at the exit examination equals the number at the enrollment examination.
   b. The number of missing teeth at the exit examination equals the number at the enrollment examination.

2. The enrollee has no grossly decayed teeth at the exit examination (i.e., a score of 0 on the Grossly Decayed Index).

3. The enrollee has one or no decayed teeth at the exit examination.

4. The enrollee has no teeth with a PI score of 6 or 8 at the exit examination.

5. The enrollee between the ages of 12 and 17 years (inclusive) and 18 years and older has a PI score of less than 1.0 or 1.9, respectively, at the exit examination.

6. The enrollee has a Periodontal Profile Score (PPS) of 1 or 0 at the exit examination.

7. The enrollee reports "none of the time" when asked on the exit MHQ how much time within the past 3 months problems with the appearance of teeth or gums caused him to avoid conversations with people.

8. The enrollee reports "no days" when asked on the biweekly Health Reports for the 3 months before exit how many days of work loss and restricted activity he had that were attributable to problems with teeth or gums.

9. The enrollee reports "none" when asked on the exit MHQ how much pain he experienced from problems with teeth or gums within the past 3 months.

10. The enrollee reports "none" when asked on the exit MHQ how much concern or worry he experienced from problems with teeth or gums within the past 3 months.

11. The enrollee reports no bleeding gums at the exit examination.

12. The enrollee age 5 and older reports using a toothbrush at least once a day when asked on the exit MHQ how often he brushes his teeth.

13. The enrollee age 5 and older reports using floss at least once every few days when asked on the exit MHQ how frequently he flosses his teeth.

14. The enrollee up through the age of 13 years who resides in an unfluoridated area reports taking some form of systemic fluoride when asked on the exit MHQ about his use of fluorides.

15. The enrollee between the ages of 5 and 13 (inclusive) reports regularly using some form of topical fluoride, excluding a fluoridated toothpaste, when asked on the exit MHQ about his use of fluorides.

16. The enrollee has an OHI-S score of 1.2 or less at the exit examination.

17. The enrollee reports not eating any of the following cariogenic foods in the previous 24 hours when asked on the exit MHQ about eating certain foods: sugar-coated cereal, pastries, soda, jelly/honey, chewing gum, and candy.

18. The enrollee age 3 and older reports "once a day," "occasionally (not every day)," or "rarely" when asked on the exit MHQ how often he eats between regular meals.

PROCESS OF DENTAL CARE—THERAPY

19. If the enrollee had a PI score of less than 4.0 and no grossly decayed teeth at the enrollment examination, then no teeth were extracted during the 3 or 5 years of the HIE, except for the treatment of malocclusions (orthodontia) or trauma.

20. If the enrollee had a PI score of 8 on any tooth at the enrollment examination, then the tooth was extracted within 12 months.

21. If the enrollee is edentulous in any arch at the exit examination, then he wears a denture.

22. If the enrollee has one or more missing permanent maxillary (upper) anterior teeth at the exit examination, then they have been replaced with a fixed or removable prosthesis.

23. If the enrollee has five or more missing teeth in any arch at the exit examination, then they have been replaced with a fixed or removable prosthesis.

24. If the enrollee had one or more grossly decayed teeth at the enrollment examination, they were treated within 6 months.

25. If the enrollee had one or more decayed teeth (excluding grossly decayed teeth) at the enrollment examination, then they were restored within 12 months.

26. No sound tooth (noncarious and nonfilled) at the enrollment examination received a Class I or V restoration within the next 6 months.

27. If the enrollee had a tooth with a Class I or V restoration at the enrollment examination, then the tooth did not receive a crown during the HIE.

28. If the enrollee had a PI score between 0.5 and 0.9, 0.7 and 1.9, or 1.6 and 4.0 at the enrollment examination, then he received periodontal care at levels I, II, or III, respectively, within 12 months.

a. The enrollee with a PI score between 0.7 and 0.9, or between 1.6 and 1.9, meets the criterion if he received periodontal care at levels I or II, or II or III, respectively.
b. The services in each periodontal care level are as follows:
   I—Prophylaxes and oral hygiene instructions.
   II—Level I services and scalings (root planings) and curettages.
   III—Levels I and II services and periodontal surgery.

29. If the enrollee has a PI score of 1.9 or greater at the exit examination, then he received periodontal care at levels II or III within the previous 12 months.

30. If the enrollee has a PI score of 1.9 or greater at the exit examination, then he reports on the exit MHQ being informed by a dentist that he has periodontal disease requiring treatment.

31. If the enrollee had a PI score of less than 1.0 at the enrollment examination, then he did not receive periodontal care at levels II or III within the next 12 months.

32. If the enrollee had a PI score of less than 2.0 at the enrollment examination, then he did not receive periodontal care at level III within the next 12 months.

33. If the enrollee had periodontal surgery between the time of the enrollment examination and the 12 months preceding the exit examination, then he had at least two visits for prophylaxes within 12 months following surgery.

34. If the enrollee had an OHI-S score between 1.3 to 3.0, or a score of 3.1 or greater, at the enrollment examination, then he received at least one prophylaxis within 12 or 6 months, respectively.

35. If the enrollee had a PI score of 6 at the enrollment examination on one or more teeth that were later used for abutments in a fixed or removable prosthesis, then he received periodontal care at levels II or III in the 12 months before the insertion of the prosthesis.

36. If the enrollee was edentulous but without a denture at the enrollment examination or became edentulous during the HIE, then he obtained a denture within the next 6 months.

37. If the enrollee between the ages of 5 and 17 years (inclusive) had three or more carious teeth at the enrollment examination, then he received at least one topical fluoride treatment within the next 12 months.

38. If the enrollee between the ages of 5 and 17 (inclusive) resided in an area without water fluoridation, then he received at least one professional topical fluoride application each year that he was enrolled in the HIE.

39. If an enrollee between the ages of 5 and 8 (inclusive) had a missing second primary molar and an erupted first permanent molar in the same arch at the enrollment examination, then he received an orthodontic appliance.

40. If the enrollee between the ages of 5 and 13 (inclusive) at the exit examination reported on the exit MHQ taking some form of systemic or topical fluoride, then he had had occlusal sealants applied to his permanent molars at least once during the HIE.

41. The enrollee had no more than one full mouth set of radiographs taken within a 3-year period.

42. The enrollee had no more than one set of bite-wing radiographs taken within a 6-month period.

43. If the enrollee between the ages of 5 and 17 (inclusive) had a DMFT index of 3 or less at the enrollment examination, then he did not have more than one set of bite-wing radiographs taken within a 12-month period.

44. The enrollee with at least one filling at the exit examination has none with open margins.

45. The enrollee with at least one Class II or V filling at the exit examination has none with overhanging gingival margins.

46. The enrollee with at least one cast crown at the exit examination has none with open margins.

47. The enrollee with at least one cast crown at the exit examination has none that are overly contoured.

48. The enrollee with at least one pontic at the exit examination has none that are overly contoured.

PROCESS OF DENTAL CARE—USE

49. If the enrollee age 5 years or older at the exit examination is dentulous, then he visited the dentist at least once per year for each year enrolled in the HIE and received diagnostic and preventive services, including prophylaxes, on at least one of the visits made each year.

50. If the enrollee was edentulous at the enrollment examination, then he visited the dentist at least once during the 3 years or twice during the 5 years he was enrolled in the HIE.

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