Oral Health Surveillance: Past, Present, and Future Challenges

Eugenio D. Beltrán-Aguilar, DMD, MPH, MS, DrPH; Dolores M. Malvitz, RDH, DrPH; Stuart A. Lockwood, DMD, MPH; R. Gary Rozier, DDS, MPH; Scott L. Tomar, DMD, MPH, DrPH

Abstract

We reviewed and summarized the efforts in the United States to collect data on oral diseases, conditions, and behaviors implemented at the national and state level. The main characteristics of these efforts were: (1) systematic collection of data from representative samples, mostly at the national level; (2) one-time or sporadic experiences when data are collected at state and local levels; (3) use of visual-tactile protocols implemented at the tooth-surface or tooth-site level for data collection; (4) focus mainly on dental caries and periodontal diseases; and (5) leap-time from data collection to publication of results. Using the definition of surveillance in public health (the ongoing and systematic collection, analysis, and interpretation of outcome-specific data for use in planning, implementing, and evaluating public health practice), we show there is an impending need to develop new techniques to build up surveillance systems for oral diseases, conditions, and behaviors at the national, state, and local levels. In the second part of this review, we presented a number of alternative techniques developed in the last 10 years to collect timely data for oral health. The main characteristics of these efforts include: (1) focusing on data collection at state and local level; (2) integration into existing and ongoing surveillance systems; (3) using visual-only protocols to collect data on oral disease status; (4) focusing on a variety of diseases, conditions, and behaviors; and (5) analyzing the data in a timely matter. Many of these efforts have been integrated into the National Oral Health Surveillance System, which has developed eight indicators in response to national health objectives. Finally, we envision the future of visual-tactile protocols in data collection of representative samples to monitor oral health status at the national level and as a research tool. At the state and local level, however, we envision an integrated system of data collection as a constantly evolving process as new techniques are developed in response to new demands. [J Public Health Dent 2003;63(3):141-9]

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In the United States, the beginning of dentistry as a profession can be traced back to the 1840s, when the first dental school and the first national dental journal appeared (1). The first systematic collection of data on oral health status, however, did not occur until the 1930s, when H. Trendley Dean studied the interrelationship between "mottled enamel," dental caries, and fluoride in the drinking water (2). Some of the techniques used by Dean, such as systematic and standardized collection of data and mapping, are tools epidemiologists use to monitor the distribution and trends of diseases at the population level. Also in the 1930s, Klein, Palmer, and Knutson (3) introduced the DMF Index, a count of the number of teeth affected by decay or its sequelae. The DMF Index called for the visual and tactile examination—using a dental explorer—of every tooth. These pioneer researchers used the new tool in a series of reports on the severity of dental caries among different populations and geographic locations (4-7). The DMF Index, *sensus strictum* an indicator of caries severity, was at that time a convenient tool to characterize individuals' disease burden in studying a condition that was universally present.

From the 1930s to the present, we have witnessed important changes in the prevalence and severity of dental caries and the need to monitor other oral conditions or risk factors. Our surveillance efforts, however, have changed very little in scope or format. The challenges many local and state programs face, in an increasingly competitive environment for public resources, require the development and implementation of alternative surveillance tools. State- and local-based data are needed to (1) assess oral health needs; (2) monitor oral health status, including disparities among population groups; (3) plan intervention programs at the state and local levels; (4) establish sound health policies; and (5) evaluate progress toward state health objectives.

This paper presents a comprehensive review of oral health surveillance efforts in the United States: (1) a review of our past efforts, including their limitations; (2) a review of alternative surveillance mechanisms; and (3) a description of the National Oral Health Surveillance System (NOHSS), the first coordinated effort to systematically and periodically obtain and disseminate state-based data on oral health conditions, diseases, and risk behaviors.

History of Data Collection on Oral Diseases, Conditions, and Risk Behaviors

Between 1960 and 1962, the National Center for Health Statistics conducted the first national survey that

Send correspondence and reprint requests to Dr. Eugenio Beltrán-Aguilar, Division of Oral Health, Centers for Disease Control and Prevention, 4770 Buford Highway, MS F-10, Chamblee, GA 30341. E-mail: ebeltran@cdc.gov. Drs. Beltrán-Aguilar and Malvitz are at the CDC Division of Oral Health. When this manuscript was written, Drs. Lockwood and Tomar also were at the CDC Division of Oral Health. Currently, Dr. Lockwood is the dental director for the state of Alabama and Dr. Tomar is at the University of Florida. Dr. Rozier is at the School of Public Health, University of North Carolina, Chapel Hill. Manuscript received: 5/24/02; returned to authors for revision: 7/3/02; accepted for publication: 10/10/02.

included clinically assessed oral conditions in a sample of adults (8). This survey was followed by two similar national surveys conducted between 1963 and 1970 among children aged 6 to 11 years (9) and among youths aged 12 to 17 years (10). These three surveys were part of the National Health Examination surveys—later reorganized and renamed the National Health and Nutrition Examination Surveys (NHANES). Three NHANES surveys have collected oral health data: NHANES I (1971–74), the Hispanic Health and Nutrition Examination Survey (HHANES, 1982–84), and NHANES III (1988–94) (11-16). The current NHANES (IV), which has been in the field since 1999, also includes oral health status data (17).[1]

The National Institute of Dental Research (NIDR) conducted two national surveys of schoolchildren aged 5 to 17 years (1979–80 and 1986–87) (18-20), and one survey of employed adults and seniors (1985–86) (21-22). In 1998 NIDR was renamed the National Institute of Dental and Craniofacial Research (NIDCR). Currently, NIDCR has no plans for additional in-house national surveys.

These national surveys share the following characteristics: (1) they collected data on a multistage representative sample of the US population with geographical regions as the lowest level of statistical representation; (2) they demanded a high level of both human and material resources; and (3) in the case of dental caries, they used visual-tactile assessments of all teeth or surfaces by trained and standardized dentists applying, in the case of dental caries, the diagnostic criteria attributed to Radike (20,22,23).

The need for state-specific data led state and local government agencies and academic institutions to implement visual-tactile surveys using, in most cases, the same protocol and diagnostic criteria used by federal agencies (24-37). These efforts usually have been sporadic experiences with limited ability to evaluate trends at state level and needs at the local level on a regular basis.

Besides clinical surveys, questionnaires also have been used to collect oral health data at the national level. Since 1957, the National Health Interview Survey (NHIS) has used face-to-face interviews to collect annual self-reported data on a representative sample of the US population. The questionnaire uses a core and supplemental modules.[2] Oral health topics have been tracked periodically since 1983. Dental visits, the use of fluoride supplements, toothbrushing practices, dental insurance status, and screening for oral cancer have been part of basic, periodic, and topical sections (38,39).

All these efforts at the national level provide snapshots of the oral health status of the US population, primarily for dental caries, periodontal diseases, and reported use of preventive services. These surveys documented secular trends and have been used to monitor progress toward achieving national health objectives (40-43). Such data, however, even when collected at the state and local level, have limited use for policy makers because they are, for the most part, sporadic episodes.

What are the key characteristics and elements of public health surveillance systems?

> Good surveillance does not necessarily ensure the making of the right decisions, but it reduces the chances of wrong ones.—*Alexander D. Langmuir, 1963 (44)*

In the United States, the Centers for Disease Control and Prevention (CDC) is the federal agency responsible for monitoring diseases, conditions, and risk factors that affect the nation's health and for providing such data to policy makers and decision makers to serve as the basis for implementing public health interventions. These monitoring activities are identified by the term "epidemiologic surveillance" and have been defined as "the ongoing systematic collection, analysis, and interpretation of outcome-specific data for use in the planning, implementation, and evaluation of public health practice" (45). Surveillance activities are grouped into systems. A surveillance system can focus on one or more conditions, such as surveillance for sexually transmitted diseases or surveillance of oral diseases and conditions. Surveillance systems also can monitor different aggregates of the population, from the local, to state, national, and international level. Two critical elements in this definition are the ongoing (regularly recurring, not episodic) nature of data collection and the use of collected data for public health purposes. These critical elements, in turn, demand a system of efficient analysis and dissemination.

In the United States, national public health surveillance systems are monitored by the CDC Epidemiology Program Office (EPO) and the Council of State and Territorial Epidemiologists (CSTE). Because CDC is a nonregulatory agency, state surveillance systems vary in the number and scope of conditions monitored. However, CDC and CSTE have established a set of standards for case definition, data processing, and dissemination. Currently, CDC monitors approximately 102 surveillance systems.

To be effective, a surveillance system needs a functional structure that allows the collection, processing, and dissemination of the information (46). Such a structure requires the participation of professionals and experts within the health service system, including clinicians, epidemiologists, data managers, information specialists, and policy makers. Public health surveillance—like other public health programs—has specific objectives, activities, resources, and evaluation mechanisms (47).

Public health surveillance data are obtained from a variety of sources. Examples include vital statistics, notifiable diseases, registries, sample surveys, administrative data systems, and sentinel surveillance. In oral health, we have used vital statistics and cancer registries to monitor the incidence, mortality, and survival rates of oral and pharyngeal cancer (48-50). Also, many states have registries for children born with cleft lip and palate. However, efforts in moni-

[1]The website www.cdc.gov/nchs includes linkages to public datasets collected and administered by NCHS, including the dataset, documentation, and information regarding privacy rights of participants and responsibilities of researchers in data reporting. In addition, NCHS administers a Data Research Center that offers onsite access to variables in datasets not released to the public due to privacy issues. Analysis of these data, however, requires a signed agreement.

[2]In 1997, the NHIS was redesigned into a three-module protocol. The first or "basic" will function as the new "core" module. The second or "periodic" will collect more detailed information on some of the topics in the "basic" module. The third or "topical" module is analogous to the original "supplemental" module.

toring disease in oral health have, for the most part, focused on the conduct of clinical surveys or dental caries at the national and state level.

How effectively does the current approach to tracking oral diseases, conditions, and behaviors serve as a surveillance system?

Based on the characteristics demanded of data systems for surveillance (integrated, ongoing, cost efficient, and translatable into public health interventions), the infrequent collection of oral health data using visual-tactile examinations does not constitute an oral health surveillance system. The protocol used in visual-tactile surveys—to a large extent considered the "standard" in oral epidemiology—has several limitations for its use as a surveillance tool:

1. We rely almost completely on primary data collection. The underlying rationale for this approach has been that only dental professionals, calibrated to a standard, can make valid diagnoses of oral diseases and conditions. Very few public health surveillance systems rely so heavily on primary data. Also, all surveillance systems accept a certain level of error as a consequence of misdiagnosis, misclassification, or incompleteness of data. For example, mortality at the national and state level is measured and monitored with death certificates, which are completed by physicians, nurses, physician assistants, midwives, and medical coroners. Few of these professionals have received standardization training on how to complete a death certificate, but follow standard case definitions.

2. The protocol was developed primarily to measure dental caries. Dental caries continues to be the most prevalent of all oral conditions. However, the prevalence and severity of dental caries has declined dramatically during the past 30 years (51), and there is no indication that it will return to the levels of disease observed in the mid-20th century. Large segments of the US population are caries free or affected by a low severity; an increasing proportion of adults have lost few or no teeth (52-55). Because dental caries is no longer universal, we need surveillance tools to identify, at the population level, those who still are affected or at risk of dental caries, and tools to measure other oral conditions and their related risk factors.

3. There is no good surveillance tool to measure periodontal diseases. Probably as a consequence of our limited understanding of its pathogenesis and pathophysiology, we have developed a large number of indices to measure periodontal diseases. We have indices that measure soft and hard deposits in the supra- and subgingival area, indices of gingivitis, indices of periodontal involvement alone—loss of attachment (LOA) or pocket depth—or combined with measures of gingivitis, in addition to digital radiography, and enzymatic tests to detect specific microorganisms. None of these measures, however, appears appropriate to collect surveillance data because of issues of validity, reliability, and cost. In the case of periodontal diseases, for example, none of the available tools is capable of identifying a tooth site or a person with active disease.

4. Visual-tactile clinical surveys consume a large amount of resources. To conduct clinical examination surveys, state and local agencies need to recruit, train, and standardize examiners. Resources also are needed to secure and transport portable equipment, instruments, and infection control supplies. Finally, state and local departments need to fund consultation on sampling and data analysis. It is not surprising, therefore, that many state and local programs—often with limited budgets—cannot afford this type of data collection or can afford it infrequently.

5. It has become more and more difficult to secure participation in oral health surveys (56). Nonresponse rates are high, especially among older children and adolescents. Many factors may explain this behavior and their discussion is beyond the scope of this paper. Various approaches have been used to reduce this problem, from using negative consent—if the parent does not return a signed consent form, this provides implicit consent for the child to be examined—to monetary incentives, all with varying levels of success (57). If responders differ from nonresponders, there is a risk of response bias (56,58). In some cases, poststratification has been used to correct for selective underrepresentation (59); however, it cannot correct for nonresponse and, moreover, most clinical surveys do not collect data on nonresponders.

6. Most protocols collect information at the tooth or surface levels. The original Klein's DMF Index called for a toothwise assessment and coding. Later, probably because of the differential preventive effect of fluorides between pit and fissures and smooth surfaces, a surface-specific index was introduced and became the standard. With the changes in prevalence and severity for most survey participants, most of these 32 teeth or 148 surface variables are diagnosed and coded as sound. A similar situation is observed in site-specific assessment of loss of attachment and pocket depth. On the other hand, most oral health objectives use the person as the unit of measurement (40,43). Therefore, it may be unnecessary to collect surveillance information on dental caries at the tooth or surface level.

7. In assessing dental caries, we measure both past and "present" episodes of the disease. In public health surveillance, we are interested in detecting people who fit a case definition for a disease, condition, or risk factor. Surveillance generally does not measure past events, such as past episodes of influenza or active tuberculosis, or how many of those infections occurred in the lifespan of the individual. Although a true "present" time does not exist while assessing dental caries, as most clinical presentations of the disease represent past episodes, the need to count, code, and tabulate restorations or even missing teeth—as a direct consequence of dental caries—may be questionable and even invalid (60).

8. Late reporting. Because of the complicated process of planning, sampling, data collection, and data analysis, visual-tactile surveys often are reported years after initiation. More timely reporting of data is essential for local public health authorities to plan appropriate actions and to evaluate the outcomes of interventions.

In 1990 the Association of State and Territorial Dental Directors (ASTDD) conducted a survey of its members to assess their capacity to collect oral disease status data. States reported the need for various levels of assistance; more interestingly, however, all assumed the way to obtain such data was through visual-tactile examinations of survey participants. These findings reflect the commonly held belief that oral health surveillance data

collection requires the same level of rigor and precision as does research related to clinical treatment. Virtually no public health surveillance systems conduct primary collection of data with the same rigor as do researchers when conducting randomized clinical trials. On the other hand, surveillance methods in public health are not "quick and dirty" ways to obtain data (61). Surveillance systems use methods that provide timely data with sufficient validity and reliability to detect population changes that may require public health interventions.

Clearly, the DMF Index and the LOA or pocket depth will remain the standard for characterizing dental caries and periodontal diseases—especially when conducting periodic assessments of randomly chosen samples, making comparisons over time at the national and, resources permitting, at the state level, or characterizing severity within a population with high overall prevalence. The indices, however, are too resource intensive to be used as the primary oral health surveillance tool at the state and local level and put these programs in undue disadvantage against other public health programs with more up-to-date data. Cross-sectional prevalence data have not been used successfully for program planning (62) because these efforts often ended with the publication of data long after a planning decision should have been made.

Alternative Ways to Obtain Oral Health Data

In response to the interest in collecting oral disease status data at the state and local levels within limited resources, in 1995–96 the Health Resources and Services Administration (HRSA) funded ASTDD to develop the "Seven-step Model for Needs Assessment" (63,64). This step-by-step model assumed different levels of available resources and proposed data collection methods for each level. The scope of techniques described ranged from the most simple, such as expert opinion and focus groups, to the more complex—secondary data, screenings, and surveys. The model emphasizes the need to start with the simpler techniques and to move into more complex ones after data have been generated and there is justification to obtain additional information. A surveillance system is established when the needs assessment is used on an ongoing basis, rather than as a single experience. The model was tested in Louisiana and Nebraska and, even though the model has not been used extensively, it has helped some dental public health professionals to consider techniques other than visual-tactile examinations for obtaining oral disease data. *[Further information is available at www.astdd.org.]*

Visual-only screening models, defined as the intraoral assessment and reporting of status at the person level, have been used to collect data among schoolchildren and preschool children in Oregon (65,66) and later in a statewide screening of schoolchildren in the state of Washington (67). In 1995 CDC tested a visual-only screening protocol with precise case definitions that used a person-based assessment of oral health status. The assessment included dental caries, presence of dental sealants, urgency of treatment needs, enamel fluorosis, and injuries (61). The protocol was designed to require minimal instruction of the examiners (a dental hygienist and a registered nurse), take little time to conduct, and require no sophisticated equipment or instruments. Later, the same model was used in Louisiana (37) and Maine (unpublished) to assess the oral health status of schoolchildren and preschool children, respectively. A variation of this model was introduced into the Special Olympics programs, where athletes of all age groups were screened by a large group of dental volunteers with just 20 to 30 minutes for examiner training (68).

The acceptance of visual-only screenings as a valid tool to collect data on oral disease status moved CDC and ASTDD to formalize and field test the Basic Screening Survey (BSS), a standardized protocol using a video to train screeners (69). The protocol was used in 1999 to assess oral health status of approximately 21,000 children in grades 1 to 3 in Ohio at the county level. Due to its less demanding training process and lower time requirements, it is expected that screenings will help to identify people at risk as data are collected and analyzed more frequently and routinely. *[Further information is available at www.astdd.org.]*

Programmatic and administrative data also have been used for surveillance. In 1989, Malvitz and Broderick (70) used administrative data to evaluate outcomes of a preventive program within the Oklahoma City area of the Indian Health Service. In 1993, Reed and associates (71) developed and pilot tested a low-cost method for collecting oral health status data. They used a report form that was completed by dentists or dental hygienists providing dental care in 20 local health agencies in Michigan. The form included data for number of decayed and filled teeth, presence of early childhood caries (ECC), presence of sealants, root caries, and presence of two or more teeth in adults. In 2000, Griffin and associates (72) used Medicaid claims data to estimate the number of children affected by ECC and the resultant treatment costs. Medicaid claims data also have been used similarly in Iowa (73) and North Carolina (74). Insurance claims data were used by Eklund and associates (55) to examine trends in dental treatment provided to enrollees in a private dental insurance plan in Michigan. These efforts would benefit from a standardized diagnostic coding system. No such system currently exists in the United States; however, international agencies, such as the World Health Organization, have made attempts to standardize diagnostic codes for dentistry (75) based on the "International Statistical Classification of Diseases and Related Health Problems" (76). Furthermore, to constitute a true surveillance system, surveillance activities based on programmatic and administrative data ought to be implemented on a regular basis, and their results should be used for program planning and evaluation.

Another possible source of oral health status data is self- or parent-reports. Using global descriptors (i.e., excellent to fair and poor) both self- and parent-reporting have shown strong correlation with clinical oral health status data (77,78). Preliminary data on a sample of children at higher risk of ECC in the state of Washington (prevalence of ECC of 15%) show that mothers can accurately assess the oral health status of their children's teeth (79).

Self-reported behaviors have been measured using face-to-face interviews or telephone surveys. In 1981, CDC's National Center for Health Pro-

motion and Education, now the National Center for Chronic Disease Prevention and Health Promotion (NCCDPHP), began providing technical assistance to state health departments to conduct telephone surveys, using random-digit selection, that would generate prevalence estimates of chronic disease risk factors at the state level (80-82). Later, the system evolved into the Behavioral Risk Factor Surveillance System (BRFSS). The BRFSS questionnaire has a core set of questions and a number of optional modules. States also are allowed to add their own questions.

In 1995 an optional module of oral health-related questions was introduced (Table 1). Over a four-year period (1995–98), 48 states used the module. In 1999 three oral health-related questions were included on the BRFSS core questionnaire. Thus, data are available for every state for that year and will be included again in 2002. These epidemiologic indicators have been reported elsewhere (83-85). For example, Figures 1 and 2 show data for the proportion of adults who reported dental visits in the past year and total tooth loss reported in 1999 by BRFSS. *[For additional information, visit the following Internet site: www.cdc.gov/brfss/.]*

In 1997 and 1998, four states (Arizona, Illinois, Louisiana, and New Mexico) included questions regarding oral health status and dental visits in the Pregnancy Risk Assessment Monitoring System (PRAMS). This surveillance system, funded by CDC, collects state-specific information on health-related behaviors and experiences on a representative sample of mothers who delivered live infants. In the four states, about one-third of mothers reported a dental visit during pregnancy; of those who said that they needed to see a dentist for a problem, only about half had a dental visit during their pregnancy (86). *[For additional information, visit the following Internet site: www.cdc.gov/nccdphp/drh/srv_prams.htm#1.]*

Another CDC surveillance system with the potential for tracking oral health information is the Youth Risk Behavior Surveillance System (YRBSS). This school-based survey is administered biennially through state departments of education to assess the prevalence of health risk behaviors among high school students. Data on tobacco product use and other behaviors and trends have been obtained from these surveys (87). *[For additional information, visit the following Internet site: www.cdc. gov/nccdphp/dash/yrbs/.]*

TABLE 1
Oral Health Questions Included in Behavioral Risk Factor Surveillance System

Module and Dates	Question
Optional 1995–98 2000–01	How long has it been since you last visited the dentist or a dental clinic? • Within the past year (1 to 12 months ago) • Within the past 2 years (1 to 2 years ago) • Within the past 5 years (2 to 5 years ago)
Core 1999, 2002	• 5 or more years ago • Don't know/not sure • Never • Refused
Optional 1995–98 2000–01	How many of your permanent teeth have been removed because of tooth decay or gum disease? Do not include teeth lost for other reasons, such as injury or orthodontics. • 5 or fewer • More but not all
Core 1999, 2002	• All • None • Don't know/not sure • Refused
Core 1999, 2002	How long has it been since you had your teeth cleaned by a dentist or a dental hygienist? • Within the past year (1 to 12 months ago) • Within the past 2 years (1 to 2 years ago) • Within the past 5 years (2 to 5 years ago) • 5 or more years ago • Don't know/not sure • Never • Refused
Optional 1995–98 2000–01	What is the main reason you have not visited the dentist in the last year? • Fear, apprehension, nervousness, pain, dislike going • Cost • Do not have/know a dentist • Cannot get to the office/clinic (too far away, no transportation, no appointments available • No reason to go (no problems, no teeth) • Other priorities • Have not thought of it • Other • Don't know/not sure • Refused

These procedures, from self-reported to programmatic- and screening-based data, have extremely important characteristics for use in surveillance of oral diseases, conditions, and risk behaviors: (1) they are integrated into existing data collection mechanisms; (2) data collection is frequent and systematic, thus providing timely data; (3) data do not rely on visual-tactile examinations; and (4) when clinical data were needed, secondary data sources or visual screenings were used.

Other alternative techniques for oral health surveillance are being tested. For example, Geographic Information System (GIS) could be useful to identify geographic areas, administrative areas, counties, or census tracts with populations at higher risk of disease. Currently, HRSA is using GIS techniques to examine the distribution

FIGURE 1
Dental Visits in Past Year, Adults Aged 35 Years and Older, Behavioral Risk Factors Surveillance System (1999)

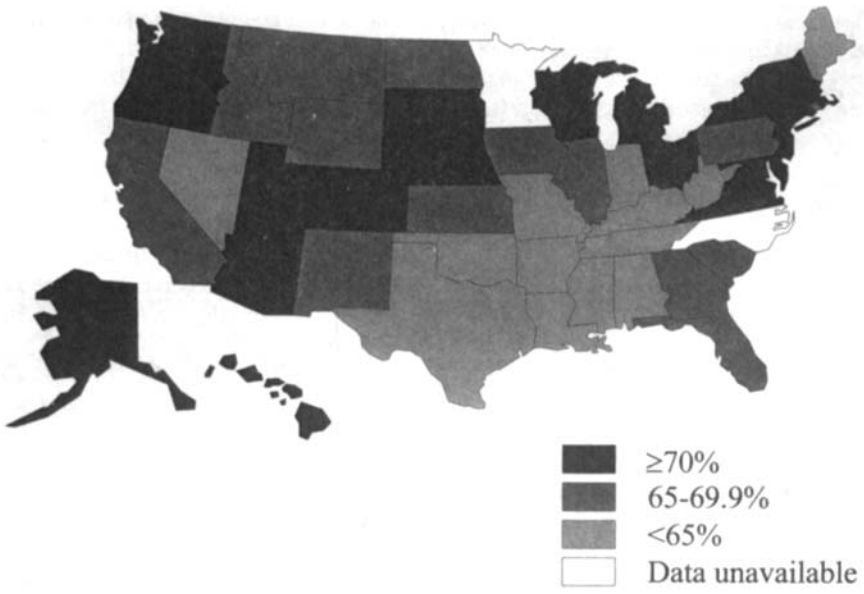
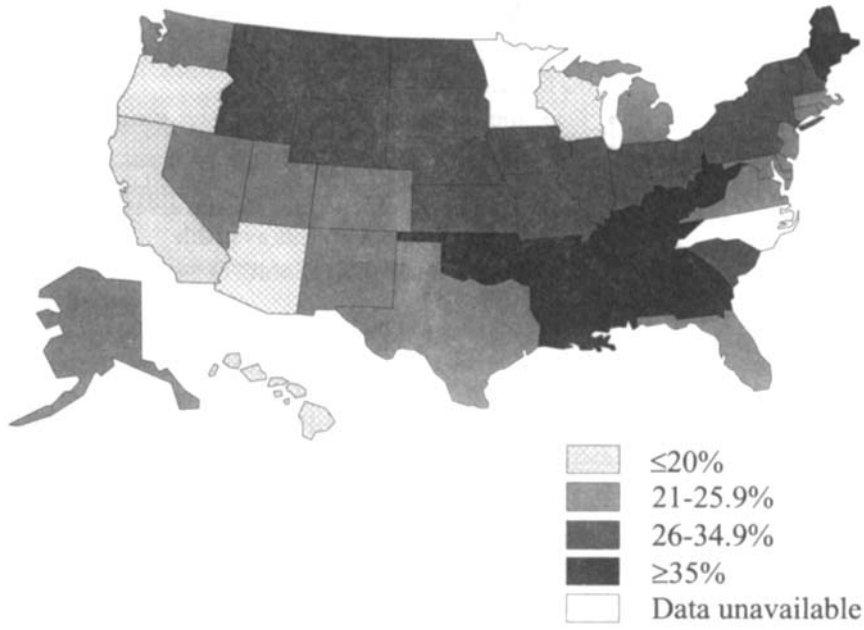


FIGURE 2
Total Tooth Loss, Adults Aged 65 Years and Older, Behavioral Risk Factors Surveillance System (1999)



of dentists by aggregate measures of factors associated with caries, e.g., percentage of the schoolchild population eligible to receive free and reduced-cost lunch. *[See www.hrsa.gov.]*

Another technique is sentinel surveillance, which collects information on health events and risk factors in a group of sites such as hospitals, clinics, health centers, data registries, and schools where people at risk receive care (88). Sentinel surveillance routinely is used to monitor multiple conditions including influenza, HIV, and cancer. Due to its low national prevalence and association with poverty (89), ECC could be monitored by sentinel surveillance. Most children with ECC are treated at pediatric dental offices, dental schools, or community clinics. Therefore, a careful selection of these sites could provide information to ascertain the prevalence and trends of ECC. The state of Ohio has designed a sentinel surveillance system to monitor oral disease status following a comprehensive statewide survey that collected data at the county level using the BSS protocol. A similar system has been planned for the New York State (90).

The ASTDD-CDC National Oral Health Surveillance System

The challenge to dental public health professionals is to develop user-friendly, resource-sparing, and integrated oral health surveillance systems. In response to this challenge, the ASTDD and CDC's Division of Oral Health (DOH) have consulted with representatives from various agencies and professional organizations to design the NOHSS. This evolving data system has been designed to help state and local public health programs to monitor the burden of oral diseases, the use of oral health care delivery systems, and the status of community water fluoridation in their jurisdictions. The NOHSS presently include eight basic oral health indicators: (1) adult dental visits, (2) adult tooth cleaning, (3) adult tooth loss, (4) fluoridation status, (5) child caries experience, (6) child untreated caries, (7) child dental sealants, and (8) cancer of the oral cavity and pharynx. Additional state-based data will be added, as data are available.

Simultaneously, ASTDD and DOH proposed to CSTE a set of oral health indicators as part of the diseases and conditions recommended for monitoring at the state level. In June 1999, CSTE approved the first seven indicators; the eighth, oral cancer, had been approved with a large number of chronic indicators in 1997. Table 2 includes the NOHSS and the CSTE-approved indicators, their source of data, and the age-specific groups to which they are applied. For example, data for dental visits, tooth cleaning, and tooth loss are obtained from existing surveillance systems, such as NHIS and BRFSS; data on caries experience, untreated caries, and dental sealants will require local and state authorities to

TABLE 2
Indicators of Oral Health Status in the National Oral Health Surveillance System (NOHSS) (www.cdc.gov/nohss), Indicators Approved by Council of State and Territorial Epidemiologists (CSTE) and Their Associated Healthy People 2010 (HP 2010) Objectives

Indicator	NOHSS	CSTE	HP 2010	Source of Data
Dental visits: percentage of people who visited the dentist or dental clinic within past year	✓	✓	21–10	NHIS (ages 2–17) BRFSS (ages 18+)
Teeth cleaning: percentage of people who had a teeth cleaning within a year of the survey	✓	✓		BRFSS (ages 25+)
No tooth loss: percentage of people (aged 35-44 years) who have never lost a tooth due to caries		✓	21–31	BRFSS
Complete tooth loss: percentage of people (aged 65 years and older) who have lost all natural permanent teeth	✓	✓	21–4	BRFSS
Fluoridation status: percentage of the US population on public water supply systems receiving fluoridated water	✓	✓	21–9	WFRS
Caries experience: percentage of the population with one or more decayed, missing,or filled teeth	✓	✓	21–1	BSS (Grades K–3)
Untreated caries: percentage of the population with one or more untreated decayed teeth	✓	✓	21–2	BSS (Grades K–3)
Sealants: percentage of the population with any sealant	✓	✓	21—8	BSS (Grades K–3)
Cancer of the oral cavity and pharynx: incidence and mortality rates	✓	✓	3–6	NCHS—Vital statistics (mortality) Cancer registries (incidence)

NHIS= National Health Interview Survey; BRFSS= Behavior Risk Factor Surveillance System; WFRS= Water Fluoridation Reporting System; BSS= ASTDD Basic Screening Survey protocol; NCHS= National Center for Health Statistics.

implement screening using BSS. In addition, NOHSS tracks water fluoridation status through the CDC Water Fluoridation Reporting System (WFRS)[3]; cancer mortality comes from vital statistics and incidence data come from cancer registries.

Besides the surveillance data, the NOHSS includes links to information on state demographics, oral health program infrastructure, administration, and activities at the state level. *[More information on NOHSS can be found at the following Internet site: www.cdc.gov/nohss/.]*

Conclusions

Surveillance data is directly associated with the implementation of public health interventions, including program evaluation. Surveillance generates "data for action." CDC and ASTDD have developed the NOHSS, which includes existing surveillance data from BRFSS, NHIS, and WFRS, and calls for the use of the BSS to collect person-based data for a set of oral health disease indicators. These indicators have been approved by the CSTE and recommended at the state level. Therefore, the NOHSS is the first step in the development of comprehensive state and local surveillance systems. Thus, it is expected that more state programs will be able to generate their own data for action. We also expect that state programs would seek technical support from their own program staff, including epidemiologists and data managers. Additional technical support could be obtained from the ASTDD, which maintains written and video training materials on the BSS protocol and consultants to answer specific technical questions.

Surveillance has taken on increased importance in the dental public health community (91). Most local, state, and national agencies and professional organizations recognize the need for timely data for action. Anecdotal information indicates that some states have been able to generate support for their dental public health programs using surveillance data. States have been able to survive administrative reorganizations and increase funding after documenting statewide needs. A number of these experiences are showcased at the ASTDD National Oral Health Conference.

Monitoring oral diseases, conditions, and risk factors will always be a "work in progress." A few challenges in the immediate future include, for example, testing the validity of self-reporting and visual assessment in seniors, developing a screening protocol for periodontal diseases, and implementing standardized codes for treatment claims data. In addition, surveillance activities for oral diseases will require a permanent process to share information and support from the research community on validation of new surveillance tools. The NIDCR/CDC Dental, Oral, and Craniofacial Data Resource Center has been developed to promote access to surveillance data and collaboration among researchers.[4] We envision a system that could generate data from the local level to the state, regional,

[3]The current fluoride levels of water systems, as reported by state and local health professionals, have been integrated into the Water Fluoridation Reporting System (WFRS).

[4]For further information, contact Pamela Martinez, Senior Research Librarian, 1700 Research Boulevard, Suite 400, Rockville, MD 20850. E-mail: oralhealthdrc@northropgrumman.com or visit the website: http://drc.nidcr.nih.gov.

and national levels, constantly evolving to address new challenges.

References

1. Burt BA, Eklund SA. The professions of dentistry and dental hygiene. In: Burt BA, Eklund SA, eds. Dentistry, dental practice, and the community. 5th ed. Philadelphia: WB Saunders, 1999:3-12.
2. Dean HT. Epidemiological studies of fluoride waters and dental caries. Washington, DC: Federal Security Agency, 1945.
3. Klein H, Palmer CE, Knutson JW. Studies on dental caries. I. Dental status and dental needs of elementary schoolchildren. Public Health Rep 1938;53:751-65.
4. Klein H, Palmer CE. Studies on dental caries. V. Familiar resemblance in the caries experience of siblings. Public Health Rep 1938;53:1353-64.
5. Klein H, Palmer CE. Studies on dental caries. VII. Sex differences in dental caries experience of elementary schoolchildren. Public Health Rep 1938;53:1685-90.
6. Klein H, Palmer CE. Studies on dental caries. XII. Comparison of the caries susceptibility of the various morphological types of permanent teeth. J Dent Res 1941;20:203-16.
7. Klein H, Shimizu T. The family and dental disease. I. DMF experience among husbands and wives. J Am Dental Assoc 1945;32:945-55.
8. US Public Health Service, National Center for Health Statistics. Decayed, missing, and filled teeth in adults, United States, 1960-1962. Washington, DC: Government Printing Office, 1967; PHS pub no 1000, Series 11, no 23.
9. US Public Health Service, National Center for Health Statistics. Decayed, missing, and filled teeth among children, United States. Washington, DC: Government Printing Office, 1971; DHEW pub no (HSM) 72-1003, Series 11, no 106.
10. US Public Health Service, National Center for Health Statistics. Decayed, missing, and filled teeth among youths 12-17 years, United States. Washington, DC: Government Printing Office, 1974; DHEW pub no (HRA) 75-1626, Series 11, no 44.
11. US Public Health Service, National Center for Health Statistics. Basic data on dental examination findings of persons aged 1-74 years, United States, 1971-1974. Washington, DC: Government Printing Office, 1979; DHEW pub no (PHS) 79-1662, Series 11, no 214.
12. US Public Health Service, National Center for Health Statistics. Decayed, missing, and filled teeth among persons aged 1-74 years, United States 1971-1974. Washington, DC: Government Printing Office, 1981; DHHS pub no (PHS) 81-1678, Series 11, no 223.
13. US Public Health Service, National Center for Health Statistics. Plan and operation of the Hispanic Health and Nutrition Examination Survey, 1982-1984. Washington, DC: Government Printing Office, 1985; DHHS pub no (PHS) 85-1321, Vital Health Stat 1985;1(19).
14. Ismail AI, Szpunar SM. The prevalence of total tooth loss, dental caries, and periodontal disease among Mexican Americans, Cuban Americans, and Puerto Ricans: findings from HHANES 1982-1984. Am J Public Health 1990;80(Suppl):66-70.
15. US Department of Health and Human Services, National Center for Health Statistics. Plan and operation of the Third National Health and Nutrition Examination Survey, 1988-94. National Center for Health Statistics. Vital Health Stat 1994;1(32).
16. Drury EF, Winn DM, Snowden CB, Kingman A, Kleinman DV, Lewis B. An overview of the oral health component of the 1988-1991 National Health and Nutrition Examination Survey (NHANES III-Phase 1). J Dent Res 1996;75(Spec Iss): 620-30.
17. National Center for Health Statistics. National Health and Nutrition Examination Survey. Dental examiners procedures manual. Hyattsville, MD: NCHS, 2003.
18. US Public Health Service, National Institute of Dental Research. The prevalence of dental caries in United States children, 1979-1980. Washington, DC: Government Printing Office, 1981; NIH pub no 82-2245.
19. US Public Health Service, National Institute of Dental Research. Dental treatment needs of United States children, 1979-1980. Washington, DC: Government Printing Office, 1982; NIH pub no 83-2246.
20. US Public Health Service, National Institute of Dental Research. Oral health of United States children. The national survey of dental caries in US schoolchildren: 1986-1987. National and regional findings. Washington, DC: Government Printing Office, 1989; NIH pub no 89-2247.
21. US Public Health Service, National Institute of Dental Research. Oral health of United States adults. The National Survey of Oral Health in US Employed Adults and Seniors: 1985-1986. National findings. Washington, DC: Government Printing Office, 1987; NIH pub no 87-2868.
22. US Public Health Service, National Institute of Dental Research. Oral health of United States adults. The National Survey of Oral Health in US Employed Adults and Seniors: 1985-1986. Regional findings. Washington, DC: Government Printing Office, 1988; NIH pub no 88-2869.
23. Radike AW. Criteria for diagnosis of dental caries. Proceedings of the conference on the clinical testing of cariostatic agents. Chicago, IL: American Dental Association, 1968.
24. Hughes JT, Rozier RG, Ramsey DL. Natural history of dental diseases in North Carolina, 1976-1977. Durham, NC: Carolina Academic Press, 1982.
25. Rozier RG, Dudney GG, Spratt CJ. The 1986-87 North Carolina School Oral Health Survey. Raleigh, NC: North Carolina Department of Environment, Health, and Natural Resources, Division of Dental Health, 1991.
26. South Carolina Department of Health and Environmental Control. The South Carolina Dental Health and Pediatric Blood Pressure Survey 1982-83. Columbia, SC: South Carolina Department of Health and Environmental Control.
27. University of Iowa College of Dentistry, Iowa Dental Association. The Iowa Survey of Oral Health: 1980. Iowa City: University of Iowa, 1982.
28. Warren JJ, Levy SM, Hand JS, Maurer WC, Beltran ED. Results of the 1994 Iowa oral health survey. Iowa Dent J 1996;82: 55-61.
29. Maine Department of Human Services, Office of Dental Health. Survey of the oral health of Maine's fifth-grade public schoolchildren. Augusta, ME: Maine Department of Human Services, 1985.
30. Kentucky Cabinet for Human Resources. The Kentucky Oral Health Survey 1987. Kentucky Cabinet for Human Resources, 1989.
31. Davis AC, Lockwood SA. Dental disease prevalence in Alabama school-aged children. J Alabama Dent Assoc 1991;75:18-31.
32. Department of Human Resources, Nevada State Health Division, Maternal and Child Health. A youth oral health needs assessment for the state of Nevada. Las Vegas, NV: Cristman Associates, 1992.
33. Alderman EJ, White SL, Johnson WT. Georgia dental disease prevalence survey. Georgia Dent Assoc Action 1994:17-9.
34. Ohio Department of Health, Bureau of Dental Health. The oral health of Ohioans, 1993. Columbus, OH: Ohio Department of Health, 1995.
35. Illinois Department of Public Health, Division of Dental Health. Oral Health Survey, Illinois schoolchildren, 1993-94. Springfield, IL: Illinois Department of Public Health, 1996.
36. Dental Health Foundation. The Oral Health of California's children. A neglected epidemic. Selected findings and recommendations from the California Oral Health Needs Assessment of Children, 1993-94. San Rafael, CA: Dental Health Foundation, 1997.
37. Sutherland JN, Romaguera R. Oral health needs among children attending Louisiana public schools with health centers: phase I. Louisiana Dent J 1997;56:14-16.
38. Wagener DK, Nourjah P, Horowitz A. Trends in childhood use of dental care products containing fluoride: United States 1983-89. Hyattsville, MD: National Center for Health Statistics, 1992. Adv Data 1992;(219):1-15.
39. Bloom G, Gift HC, Jack SS. Dental services and oral health: United States, 1989. Vital Health Stat 1992;10(183).
40. US Department of Health and Human Services, Public Health Service. Healthy People 2000. National health promotion and disease prevention objectives. Washington, DC: Government Printing Office, 1991.
41. National Center for Health Statistics. Healthy People 2000 review, 1995-96. Hyattsville, MD: US Public Health Service, 1996.
42. National Center for Health Statistics. Healthy People 2000 review, 1998-99. Hyattsville, MD: US Public Health Service, 1999.
43. US Department of Health and Human Services, Public Health Service. Healthy

People 2010. 2nd ed. Washington, DC: Government Printing Office, 2000.
44. Langmuir AD. The surveillance of communicable diseases of national importance. N Engl J Med 1963;268:182-92.
45. Thacker SB, Berkelman RL. Public health surveillance in the United States. Epidemiol Rev 1988;10:164-90.
46. Thacker SB. Historial development. In: Teutsch SM, Churchill RE, eds. Principles and practice of public health surveillance. New York: Oxford University Press, 1994:3-17.
47. Centers for Disease Control and Prevention. Updated guidelines for evaluating public health surveillance systems. Recommendations from the Guidelines Working Group. Morbid Mortal Wkly Rep MMWR 2001;50(RR13):1-35.
48. Centers for Disease Control, National Institutes of Health. Cancers of the oral cavity and pharynx: a statistical review monograph, 1973-1987. Atlanta, GA: Centers for Disease Control, 1991.
49. Shiboski CH, Shiboski SC, Silverman S Jr. Trends in oral cancer rates in the United States, 1973-1996. Community Dent Oral Epidemiol 2000;28:249-56.
50. Ries LAG, Eisner MP, Kosary CL, Hankey BF, Miller BA, Clegg LX, et al. (eds). SEER Cancer Statistics Review, 1973-1997. Bethesda, MD: National Institutes of Health, 2000; NIH pub no 00-2789.
51. Burt BA, Eklund SA. Dental caries. In: Burt BA, Eklund SA, eds. Dentistry, dental practice, and the community. 5th ed. Philadelphia: WB Saunders, 1999:212-36.
52. Kaste LM, Selwitz RH, Oldakowski RJ, Brunelle JA, Winn DM, Brown LJ. Coronal caries in the primary and permanent dentition of children and adolescents 1-17 years of age: United States, 1988-1991. J Dent Res 1996;75(Spec Iss):631-41.
53. Winn DM, Brunelle JA, Selwitz RH, Kaste LM, Oldakowski RJ, Kingman A, et al. Coronal and root caries in the dentition of adults in the United States, 1988-1991. J Dent Res 1996;75(Spec Iss):642-51.
54. Drury TF, Brown LJ, Zion GR. Tooth retention and tooth loss in the permanent dentition of adults: United States, 1988-1991. J Dent Res 1996;75(Spec Iss):684-95.
55. Eklund SA, Pittman JL, Smith RC. Trends in dental care among insured Americans: 1980 to 1995. J Am Dent Assoc 1997; 128:171-8.
56. Locker D. Response and nonresponse bias in oral health surveys. J Public Health Dent 2000;60:72-81.
57. Kessler RC, Little RJ, Groves RM. Advances in strategies for minimizing and adjusting for survey nonresponse. Epidemiol Rev 1995;17:192-204.
58. Locker D, Grushka M. Response trends and nonresponse bias in a mail survey of oral and facial pain. J Public Health Dent 1988;48:20-5.
59. van't Hof M, Truin GJ, Kalsbeek H, Burgersdijk R, Visser R, Heling G.. The problem of participation in the Dutch national dental survey. Community Dent Oral Epidemiol 1991;19:57-60.
60. Bader JD, Shugars DA. Agreement among dentists' recommendations for restorative treatment. J Dent Res 1993;72: 891-6.
61. Beltrán ED, Malvitz DM, Eklund SA. Validity of two methods for assessing oral health status in populations. J Public Health Dent 1997;57:206-14.
62. Burt BA. How useful are cross-sectional data from surveys of dental caries? Community Dent Oral Epidemiol 1997;25:36-41.
63. Kuthy RA, Siegal MD, Phipps K. Assessing oral health needs: ASTDD seven-step model. Columbus, OH: Association of State and Territorial Dental Directors, 1996. [Available at www.astdd.org.]
64. Kuthy RA, Siegal MD, Wulf CA. Establishing maternal and child health data collection priorities for state and local oral health programs. J Public Health Dent 1997;57:197-205.
65. Centers for Disease Control and Prevention. Dental health of schoolchildren-Oregon, 1991-92. Morbid Mortal Wkly Rev MMWR 1993;42:887-91.
66. Phipps KR, Mason JD. Oral health needs assessment, 1991-93. Portland, OR: Oregon Department of Human Resources, Child Health Section, 1993.
67. Phipps K, Hines B, Scheer M. Washington State Smile Survey. A children's oral health assessment report. Olympia, WA: Maternal and Child Health, Oral Health Program, 1996.
68. White JA, Beltrán ED, Malvitz DM, Perlman SP. Oral health status of special athletes in the San Francisco Bay Area. J Calif Dent Assoc 1998;26:347-54.
69. Association of State and Territorial Dental Directors. Basic screening surveys: an approach to monitoring community oral health. Columbus, OH: Association of State and Territorial Dental Directors, 1999.
70. Malvitz DM, Broderick EB. Assessment of a dental disease prevention program after three years. J Public Health Dent 1989;49:54-8.
71. Reed SG, Tallman JA, Burt BA. Collecting state-level oral health data when resources are limited: an approach to oral health surveillance. J Public Health Dent 1993;53:253-7.
72. Griffin SO, Gooch BF, Beltrán ED, Sutherland JN, Barsley R. Dental services, costs, and factors associated with hospitalization for Medicaid-eligible children, Louisiana, 1996-1997. J Public Health Dent 2000;60:21-7.
73. Damiano PC, Kanellis MJ, Willard JC, Momany ET. A report on the Iowa Title XIX dental program. Iowa City: University of Iowa Public Policy Center, 1996.
74. Robison VA, Rozier RG, Weintraub JA. A longitudinal study of schoolchildren's experience in the North Carolina Dental Medicaid Program, 1984 through 1992. Am J Public Health 1998;88:1669-73.
75. World Health Organization. Application of the International Classification of Diseases to Dentistry and Stomatology (ICD-DA). 3d ed. Geneva: World Health Organization, 1995.
76. World Health Organization. International statistical classification of diseases and related health problems. 10th revision. Geneva: World Health Organization, 1995.
77. Gift HC, Atchison KA, Drury TF. Perceptions of the natural dentition in the context of multiple variables. J Dent Res 1998;77:1529-38.
78. Gooch BF, Beltrn ED, Kaste LM, Gift HC. Predictors of perceived oral health in US children [Abstract]. J Dent Res 2000;79 (Spec Iss):205.
79. Phipps K, Beltrán E, Hines B. ECC in infants and toddlers—a statewide perspective [Abstract 17]. National Oral Health Conference, Apr 30–May 2, Portland, OR, 2001.
80. Marks JS, Hogelin GC, Gentry EM, Jones JT, Gaines KL, Forman MR, et al. The behavioral risk factor surveys: I. State-specific prevalence estimates of behavioral risk factors. Am J Prev Med 1985;1:1-8.
81. Gentry EM, Kalsbeek WD, Hogelin GC, Jones JT, Gaines KL, Forman MR, et al. The behavioral risk factors surveys. II. Design, methods, and estimates from combined state data. Am J Prev Med 1985;1:9-14.
82. Bradstock MK, Marks JS, Forman MR, Gentry EM, Hogelin GC, Trowbride FL, et al. The behavioral risk factor surveys. Part III. Chronic heavy alcohol use in the United States. Am J Prev Med 1985;1:15-20.
83. Centers for Disease Control and Prevention. Dental service use and dental insurance coverage—United States, Behavioral Risk Factor Surveillance System, 1995. Morbid Mortal Wkly Rep MMWR 1997;46:1199-203.
84. Centers for Disease Control and Prevention. Total tooth loss among persons aged greater than or equal to 54 Years—selected states, 1995-1997. Morbid Mortal Wkly Rep MMWR 1999;48:206-10.
85. Janes GR, Blackman DK, Bolen JC, Kamimotot LA, Rhodes L, Caplan LS, et al. Surveillance for use of preventive healthcare practices by older adults, 1995-1997. CDC Surveillance Summaries. Morbid Mortal Wkly Rep MMWR 1999;48(Suppl SS-8):51-88.
86. Gaffield ML, Colley Gilbert BJ, Malvitz DM, Romaguera R. Oral health during pregnancy. An analysis of information collected by the Pregnancy Risk Assessment Monitoring System. J Am Dent Assoc 2001;132:1009-16.
87. Kann L, Kinchen SA, Williams BI, Ross JG, Lowry R, Grunbaum JA, et al. Youth risk behavior surveillance—United States, 1999. Morbid Mortal Wkly Rep MMWR 2000;49(SS-5).
88. Stroup NE, Zack MM, Wharton M. Sources of routinely collected data for surveillance. In: Teutsch SM, Churchill RE, eds. Principles and practice of public health surveillance. New York: Oxford University Press, 1994:31-82.
89. Kaste LM, Drury TF, Horowitz AM, Beltran E. An evaluation of NHANES III estimates of early childhood caries. J Public Health Dent 1999;59:198-200.
90. Kennedy D, Kumar JV. Toward developing a county-specific surveillance system [Abstract 21]. National Oral Health Conference, Apr 29–May 1, 2002, Danvers, MA.
91. Rozier RG. Methods in dental public health research and practice: a new feature for the JPHD. J Public Health Dent 1997;57:195-6.