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## Advances in Surveillance of Periodontitis: The Centers for Disease Control and Prevention Periodontal Disease Surveillance Project

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### Abstract

The Centers for Disease Control and Prevention (CDC) has as one of its strategic goals to support and improve surveillance of periodontal disease. In 2003, the CDC initiated the CDC Periodontal Disease Surveillance Project in collaboration with the American Academy of Periodontology to address population-based surveillance of periodontal disease at the local, state, and national levels. This initiative has made significant advancements toward the goal of improved surveillance, including developing valid self-reported measures that can be obtained from interview-based surveys to predict prevalence of periodontitis in populations. This will allow surveillance of periodontitis at the state and local levels and in countries where clinical resources for surveillance are scarce. This work has produced standard case definitions for surveillance of periodontitis that are now widely recognized and applied in population studies and research. At the national level, this initiative has evaluated the validity of previous clinical examination protocols and tested new protocols on the National Health and Nutrition Examination Survey (NHANES), recommending and supporting funding for the gold-standard full-mouth periodontal examination in NHANES 2009 to 2012. These examinations will generate accurate estimates of the prevalence of periodontitis in the US adult population and provide a superior dataset for surveillance and research. Also, this data will be used to generate the necessary coefficients for our self-report questions for use in subsets of the total US population. The impact of these findings on population-based surveillance of periodontitis and future directions of the project are discussed along with plans for dissemination and translation efforts for broader public health use.

### Keywords

Chronic periodontitis; nutrition surveys; population surveillance

One of seven key strategies of the Centers for Disease Control and Prevention's (CDC) for adult health care is to strengthen the surveillance systems that monitor health status of adults at the national, state, and local levels and to prepare these systems for meeting future challenges.<sup>1</sup> The Division of Oral Health (DOH) at CDC has been committed to exploring alternate scientifically based ways to ascertain oral health status that can be used in settings in which resources are limited but information collection remains important for monitoring the public's health.

Although oral health has improved over the past five decades, dental caries and periodontal diseases remain the most common oral diseases in the United States.<sup>2,3</sup> From 2005 to 2008, the DOH supported a basic screening examination in the National Health and Nutrition Examination Survey (NHANES) to maintain a minimal level of dental caries surveillance.<sup>4</sup> The examination was modeled on a similar screening tool<sup>5</sup> retrieved electronically and developed by the American Association of State and Territorial Dental Directors to promote dental caries surveillance at the state and local levels. Periodontal disease surveillance, however, historically has been difficult to implement and maintain, even at the federal level, because of the need for a clinical examination and the many resources needed.<sup>4</sup> Nevertheless, over the past decade, the DOH has strived to identify and promote mechanisms for surveillance at the national, state, and local levels.<sup>6</sup>

Surveillance is essential for the following: 1) describe the burden, distribution, and trends of periodontal disease in the US adult population; 2) track Healthy People 2020<sup>7</sup> objectives related to periodontal disease and tooth loss; 3) identify persons and populations at high risk; 4) measure the attributable risk; 5) elucidate relationships between periodontal disease and other chronic disease at the population level; 6) develop interventions, strategies, and programs and evaluate their effectiveness in preventing and controlling periodontal disease; and 7) evaluate the social and economic effects of periodontal disease in adults.

Overall, information arising from surveillance is applied to increase awareness, initiate or strengthen programs, and evaluate public health strategies for prevention.<sup>4</sup> This commentary discusses the CDC Periodontal Disease Surveillance Project and the importance of the project to our understanding of the burden and characteristics of periodontal disease in the US adult population.

## **CHALLENGES IN SURVEILLANCE OF PERIODONTAL DISEASE IN THE UNITED STATES**

In 2003, when this workgroup was initiated, a number of critical gaps and challenges in surveillance hindered public health action and research on periodontal disease: 1) the lack of useful state and local population data; surveillance of periodontal disease at the state and local levels is nonexistent; 2) the lack of alternative, less resource-intensive measures for surveillance that could be used when a clinical periodontal examination could not be performed; the need for clinical examination is a significant barrier for including periodontal disease in state and local surveys that are based primarily on interviews; 3) the limitations of periodontal disease examination protocols in NHANES that historically have been the only source of population-based national data on periodontal disease in the United States; and 4)

the lack of standardized measures, including universal case definitions for periodontal diseases, for use in population-based surveillance and studies.

## **OBJECTIVES OF THE CDC PERIODONTAL DISEASE SURVEILLANCE PROJECT**

The primary goal of the Periodontal Disease Surveillance Project<sup>8</sup> was to address some of these key challenges by: 1) creating a workgroup comprising partners from the American Academy of Periodontology (AAP) and experts in periodontal epidemiology and surveillance; 2) developing valid measures, including nonclinical measures, for surveillance of periodontitis in adult populations in state and local surveys that could be used when clinical examination resources are scarce; 3) integrating these nonclinical measures into local- and state-based surveillance systems, such as the Behavioral Risk Factor Surveillance System (BRFSS),<sup>9</sup> to generate population estimates at the state and local levels; 4) sustaining and improving the validity of surveillance data for periodontitis generated from NHANES; and 5) developing standard case definitions for population-based surveillance of periodontal disease for public health practice and research.

It was anticipated that the outcomes of this initiative would expand surveillance of periodontal disease to the state and local levels, improve the validity of national data for use in public health practice and research, and provide a lower cost structure that would enable future surveillance to be sustained at both the national and local levels.

A detailed background description of the Periodontal Disease Surveillance Project was reported previously.<sup>8</sup> Briefly, in April 2003, the DOH convened Public Health Implications of Chronic Periodontal Infections in Adults, a conference of experts, researchers, and public and private stakeholders.<sup>10</sup> Issues emerging from this conference converged on the scarcity of valid population-based data on periodontal disease and how that scarcity limited additional research and action, especially at the state and local levels. At the conference, the DOH convened a workgroup consisting of experts in periodontal surveillance and research and key stakeholders, such as the AAP and the National Institute of Dental and Craniofacial Research (NIDCR), to discuss strategies for addressing the need for broad and accurate surveillance of periodontal diseases.

The initial focus of the workgroup was to address the need for surveillance of periodontitis at the state and local levels. Two committees were set up to explore feasibility and options for surveillance, including both sentinel site surveys and population-based surveys. Findings from these committees identified the use of population-based surveys as the most promising approach. An important consideration was the availability of several federally funded, state-based population surveys, such as the BRFSS. However, these surveys relied on collecting self-reported measures and did not support clinical examinations. Thus, the workgroup focused on the possible use of self-reported measures as an alternative, less resource-intensive method of surveillance of periodontitis. Their intention was to achieve valid results by integrating self-reported questions that track measures of periodontitis into existing interview-based state and local surveys.

Work group plans and strategies were communicated to key stakeholders in academia, public health, and professional organizations at a symposium, Use and Validity of Oral Health Measures in Public Health and Epidemiology, during the 2004 International Association of Dental Research (IADR) meeting.<sup>11</sup> The symposium provided presentations and opportunities for additional input from leaders in BRFSS, the World Health Organization Global Oral Health Program, and dental public health. Additional evidence was presented from an extensive literature review<sup>12</sup> of previous validation studies of self-reported measures for surveillance of chronic diseases, including periodontal disease. This review was undertaken in collaboration with the Harvard School of Dental Medicine. The review<sup>12</sup> indicated that some self-reported measures were valid for surveillance of periodontitis, but results varied across populations and measures. Higher validity could potentially be obtained using combinations of self-reported measures and demographic characteristics. The findings from this review and symposium further confirmed the decision to pursue the use of multivariable modeling of self-reported measures as the best approach for predicting population prevalence of periodontitis in state and local surveys.

## **DEVELOPMENT OF SELF-REPORTED MEASURES FOR MODELING PREVALENCE OF PERIODONTITIS**

The first step was to identify a collection of self-reported measures that showed some promise as indicators of periodontitis. The DOH funded bivariate and multivariable analyses of self-reported measures compared to clinical measures of periodontitis in nine datasets from previous studies conducted inside and outside the United States. These datasets were from the following studies: 1) Florida Dental Care Study;<sup>13</sup> 2) the Myocardial Infarction–Periodontal Disease Study;<sup>14</sup> 3) the Erie County Study; 4) the Predictors of Oral Health of African Americans;<sup>15</sup> 5) the Nurses’ Health Study; 6) the Health Professional Follow-Up Study; 7) the German Study of Dental Patients Referred to Endodontists;<sup>16</sup> 8) the Dental-Atherosclerosis Risk in Community Study; and 9) the NHANES.

A selection of existing socio-demographic questions common in self-reported surveys, such as the BRFSS, was used as a guide for selecting additional variables to include in our modeling. Before these analyses, there was extensive consultation on population statistics (specifically, the Director of the Collaborating Studies Coordinating Center, Department of Biostatistics, University of North Carolina) on the best analytic approach and modeling for assessment.<sup>17</sup> Overall, eight question constructs were identified from these analyses as promising self-reported measures for periodontitis. Thereafter, the workgroup developed the best questions to capture these self-reported measures in surveys. These questions were translated into Spanish and tested for their content validity in both English and Spanish.<sup>18</sup> Cognitive assessment was done at the CDC National Center for Health Statistics (NCHS) cognitive research laboratory, and the questions were further refined as recommended. The compilation of work completed at this stage and the final set of questions developed were published as a supplement to the *Journal of Periodontology*, accompanied by editorial articles and commentary.<sup>13-25</sup>

Comparisons of findings across these datasets (listed previously) were limited because of variations among the case definitions designed and applied by each investigator. This awareness brought to the forefront the need for standard case definitions for population-based surveillance of periodontitis and was critical to further validating the performance of our self-reported measures. In addition, the lack of standard case definitions for population-based surveillance of periodontitis had been identified by the DOH as one of the limitations of existing surveillance. Using a combination of internal research from NHANES and other datasets and best practices from the AAP, standard case definitions for population-based surveillance of periodontitis (now commonly referred to as the CDC–AAP cases definitions) were developed and published.<sup>21</sup> Our initial report<sup>21</sup> focused on moderate and severe periodontitis because evidence from our projects had suggested that the use of self-reported measures was most likely to predict severe and moderate disease. Our definition for mild periodontitis was published online recently.<sup>26</sup>

## PILOT FIELD STUDIES

Having identified some promising self-reported measures for predicting prevalence of periodontitis<sup>8</sup> and having developed standard case definitions,<sup>21</sup> our next step was to pilot test these measures in the field. Two essential requirements for the field test were that the eight measures would be tested collectively against standard clinical case definitions, adjusting for demographic variables, and that measures of clinical periodontitis were sufficient to meet the “gold-standard” periodontal examination protocol (i.e., examine disease at six sites per tooth for all teeth) required to minimize misclassification of periodontitis cases. Determining a true case and the true prevalence of periodontitis using standard case definitions based on full-mouth periodontal examinations was critical to validation of the performance of our questions in predicting prevalence of periodontitis in the field study.

Our first opportunity to field test these questions was in the Australian National Survey of Adult Oral Health (ANSAOH).<sup>22</sup> ANSAOH is a cross-sectional study of a representative sample of Australian adults and adolescents 15 years of age. Individuals were selected using a multistage probability sampling design. With support from the principal investigator (a member of the workgroup) and some CDC funding, all eight measures were included in the survey. The findings from this prepilot study showed that multiple self-reported measures seemed promising in the ability to predict population prevalence of periodontitis. The findings were discussed at a special 2006 IADR symposium in Orlando, Florida, Development of Self-Reported Measures for Surveillance of Periodontitis, and were published in this journal.<sup>22</sup> However, clinical periodontal measurements in the ANSAOH were not optimal because they only took measurements at three sites (mesio-buccal, mid-buccal, and disto-buccal sides of all teeth); similar to the NHANES protocol.

Updates on progress with the project were presented to NIDCR and CDC/NCHS. Based on preliminary findings from the ANSAOH survey, a Letter of Intent was sent to NCHS proposing a prepilot test of our self-reported measures in the US adult population, followed by pilot testing in the full NHANES. The workgroup developed a 35-page formal proposal and supporting documentation for Institutional Review Board approval and submitted it to

NCHS. The AAP provided indirect support for the prepilot through a contribution to the CDC Foundation, which made available additional financial support for the project. A prepilot study was conducted by NCHS using a convenience sample of 540 adults (English- and His-panic-speaking), replicating the NHANES procedures and environment, clinical periodontal measures, and home interview. However, the prepilot was improved by assessing the gold-standard periodontal clinical measure, the six sites per tooth full-mouth periodontal examination. In addition, this prepilot served to test some clinical and information technology operational aspects for proposed future changes to NHANES periodontal examination protocols.

The US prepilot test was completed in July 2007, and the results confirmed that multivariable modeling of self-reported measures, such as gum disease, loose teeth, and tooth appearance, were useful in predicting prevalence of severe periodontitis. Furthermore, the accuracy of these measures improved with the addition of demographic and risk factor variables to the model.<sup>27</sup> In addition, data from this study were used to assess the accuracy of the NHANES (III and 1999 to 2004) partial-mouth periodontal examination protocol compared to the six sites per tooth full-mouth periodontal examination protocol.<sup>28</sup>

Analyses demonstrated that the NHANES partial-mouth examination protocols produced high levels of misclassification of periodontitis cases and could significantly underestimate prevalence, indicating low validity of the data for surveillance and research. The findings of this study were presented at the IADR General Session in 2009 and were published as an article in the *Journal of Dental Research*<sup>28</sup> and as a commentary in this journal.<sup>29</sup> The findings of this study set the stage for changes in the clinical examination protocol for future surveillance of periodontitis in NHANES.

## NHANES SURVEILLANCE OF PERIODONTITIS

NHANES has been the major federal survey of periodontal disease in the United States; however, periodontal assessments have been intermittent since the 1970s and ceased after the 2003 to 2004 data-collection cycle even as NHANES remained a continuously fielded survey. Given limited resources, the workgroup was challenged to provide justification for funding support for surveillance of periodontitis in NHANES.

Two main reasons were presented. First, there was a gap in the understanding of the true burden of periodontitis in the US adult population. The findings from our US prepilot study had shown that NHANES partial-mouth examination protocols produced high levels of misclassification of periodontitis cases and significantly underestimated prevalence, indicating low validity of the data for surveillance and research. Thus, it became necessary to advocate for a new periodontal examination protocol in NHANES based on the gold-standard six sites per tooth full-mouth periodontal examination that would provide a true prevalence measure of periodontitis. It also could be used to calculate correction factors for previous NHANES estimates for periodontitis and could generate a reliable dataset for research. The gold-standard examination protocol had never been used in any national health examination survey in the United States. The operational aspects had been pilot tested in our US prepilot study and were feasible.

Second, NHANES was the most effective option for testing the performance of our self-reported questions in a representative sample of the US population while also using the gold-standard method. This final test was necessary for obtaining US population coefficients as well as coefficients to predict prevalence in various subsets of the US population (e.g., in state and local surveys).

In 2008, the DOH, with additional support from NIDCR, proposed to NCHS the inclusion of the gold-standard full-mouth periodontal examination protocol in the NHANES 2009 to 2010 data-collection cycle. The full-mouth periodontal assessment was implemented in 2009 and has been extended into the 2011 to 2012 data-collection cycle. Since 2009, NHANES has included the previously tested eight periodontal questions in the home interview portion of the survey. Data from the 2009 to 2010 survey cycle will be used to produce both interim findings of the prevalence of periodontitis in the US adult population using full-mouth examination data and preliminary findings regarding the performance of the eight questions in predicting periodontitis prevalence.

## FUTURE STUDIES

After each NHANES data cycle, the DOH, in collaboration with the workgroup, plans to sponsor activities and conduct analyses of the data to support surveillance of periodontal disease in the United States and facilitate additional research. These activities will update prevalence and trend data on periodontitis in the US adult population, including estimates for various minority subpopulations, and reassess the validity of the self-reported periodontitis questions, including readjusting the correction factor as needed. It is envisioned that a questionnaire module consisting of the validated self-reported periodontitis questions will be integrated into existing state-based surveillance systems, such as BRFSS, to estimate state and local burdens of periodontitis. Coefficients and algorithms for using these questions will be made available for other research and public health surveillance uses. Risk factors for periodontitis and relationships with systemic disease will be reevaluated with minimum misclassification errors. Data from the full-mouth periodontal examination will be analyzed to determine the optimally effective partial-mouth periodontal examination protocols for surveillance of disease in future NHANES when resources for full-mouth examination may be limited. Finally, the self-reported periodontitis questions will be assessed as a screening tool by examining individual risk for periodontitis in a non-dental setting.

## IMPACT

This project is a rigorous ongoing effort to improve and expand surveillance of periodontitis in the US adult population. The impact of this project has been wide reaching and includes advances in the areas of oral health collaboration, research, communication, and evidence-based program implementation. This project has fostered new partnerships to address the many challenges that have inhibited surveillance of periodontal diseases at the population level. These collaborations have ensured that all steps and decisions were guided by current evidence from scientific research and practice. This project has identified and developed self-reported periodontitis questions that can be integrated into interview-based surveys to

predict prevalence of periodontitis, allowing surveillance at the state and local levels. In addition, this low-resource approach is currently being tested in Brazil<sup>30</sup> (personal communication). The case definitions<sup>21</sup> developed are now widely recognized and have been applied in various surveillance and research activities.<sup>31,32</sup> Finally, data collected from NHANES during 2009 to 2012 will generate estimates of the true prevalence of periodontitis in the US adult population for the first time, which will be invaluable for addressing research and public health needs.

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