



HHS Public Access

Author manuscript

Curr Oral Health Rep. Author manuscript; available in PMC 2024 August 23.

Published in final edited form as:

Curr Oral Health Rep. 2021 ; 8(1): 1–8. doi:10.1007/s40496-020-00290-2.

Public Health Aspects of Periodontitis: Recent Advances and Contributions by Dr. Robert J. Genco

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Abstract

Purpose of review—This review provides an overview of the objectives, activities and accomplishments of the CDC-AAP collaboration on public health aspects of periodontitis focusing mostly on surveillance. Dr. Robert Genco was co-chair of this effort.

Recent findings—This initiative developed new standard periodontitis case definitions for surveillance and implemented for the first time a full-mouth periodontal examination protocol for NHANES 2009–2014. Measurements from this survey resulted in significantly greater estimate for the national prevalence of periodontitis in US adults and our understanding of population risk factors associations with periodontitis. Notably, this initiative also developed, and validated field-testing a battery of eight questions for multivariable modeling of self-report measures for predicting periodontitis in populations.

Summary—This Initiative resulted in significant improvements of surveillance of periodontitis and produced unique findings with important implications for advancing our understanding of population aspects of periodontitis in US adults at the national, state, and local levels.

Keywords

adult; epidemiology; nutrition surveys; periodontal diseases; public health surveillance; risk factors

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Introduction

The Centers for Disease Control and Prevention (CDC), in collaboration with the American Academy of Periodontology (AAP), sponsored a conference held on April 8 – 9, 2003, in Atlanta, GA, entitled “Public Health Implications of Periodontal Infections in Adults” with a focus on examining potential public health aspects of the oral-systemic connections [1]. The dialogue and conclusions from this conference recognized the importance of having valid public health data on periodontal disease as a first step in examining the public health implications of periodontal infections. Consequently, a workgroup was convened and sponsored through a collaborative effort between CDC and AAP to address these and other related gaps in the current understanding of public health aspects of periodontal diseases. The CDC/AAP Periodontal Disease Surveillance initiative, commonly referred to as “The CDC/AAP Workgroup” (and referred to simply as the Workgroup in the following) was co-chaired from its origin by Robert Genco and Paul Eke. It included invited leading experts in oral health epidemiology, biostatistics, clinical periodontology, and representatives from professional stakeholder institutions [2, 3]. Dr. Genco’s leadership was crucial to the success of this effort.

Process

Acknowledging the lack of population level data on periodontal disease at the state and local levels at which public health programs often are executed, and the likely underestimation of periodontal disease prevalence from national surveys at the time, two broad, overarching tasks were identified by the Workgroup. These were (1) to develop alternative less resource demanding (i.e., non-clinical) surveillance measures to facilitate surveillance of periodontitis at the state and local levels, and (2) to improve on the validity of surveillance reports of periodontitis in current national surveys.

However, several important secondary pre-requisite steps and intermediate outcomes were necessary to implement these broader objectives.

First, there was the need to establish consensus on a set of standard clinical case definitions for population-based surveillance of periodontitis. Historically, the lack of a generally accepted periodontitis case definitions had hampered the validity and comparability across surveys.

Second, there was the need to reassess the true burden of periodontitis on a population basis applying these standard case definitions to measurements from the “gold standard” full-mouth periodontal examination in order to minimize misclassification of periodontitis cases. This approach required a transition from the partial-mouth periodontal examination protocols hitherto used in the U.S. National Health and Nutrition Examination Survey (NHANES) to a full-mouth periodontal examination protocol.

Thirdly, there was a need to validate the results from our studies involving non-clinical approaches for surveillance of periodontitis against clinical data from the full-mouth periodontal examination protocol.

These broad objectives of this initiative were shared with key stakeholders for input through professional publications and presentations, such as during annual IADR meetings [4–10]. This work was preceded by an extensive literature review of prior efforts to use alternative measures (non-clinical measurements) and data collection modes for surveillance of periodontal disease in populations [11]. From this review, we inferred that the use of multiple self-report measures as surrogate measures for predicting periodontitis presence was the most promising approach to expanding surveillance of periodontal disease, mostly because these measures can be collected via responses to questions administered in interview-based surveys that already existed at the state and local levels. This strategy was further encouraged in part by viable approaches in building successful multivariable predictive models using self-report measures [12] and risk factors and the availability of the CDC's state based Behavioral Risk Factor Surveillance System (BRFSS) as a potential survey vehicle for collecting the information. There is compelling evidence of the high reliability and validity in surveillance of chronic health behaviors and disease outcomes using this approach as demonstrated by the CDC-sponsored BRFSS.

Extensive exploration and analyses of several national, state, and local project datasets that included responses to self-report measures and objective, clinical periodontal measures together resulted in the identification of eight self-report measures that were most promising for use in estimating the prevalence of periodontitis in adult populations based on meeting thresholds of statistical correlations with clinical measures of periodontitis [13–16].

These promising questions were then cognitively tested in English and Spanish [17] and pre-pilot tested in the U.S in one NHANES stand [18] and in the Australia National Adult Oral Health Survey [19].

Starting as early 2007, efforts were initiated to change the partial-mouth periodontal examination protocol in NHANES. This was undertaken by first conducting a pre-pilot study in a convenience sample of US adults to examine the feasibility of using self-report measures in predicting periodontitis, and to test the modalities and timeliness of a full-mouth periodontal examination protocol in the mobile examination clinics (MEC) used by NHANES [18]. By analyzing these data while applying the prior protocols from NHANES III and NHANES 2001–2004 that both were based on partial-mouth periodontal examinations, we calculated the underestimation caused by misclassification due to the partial mouth examinations of the periodontitis prevalence to be as high as 50% or more [20]. Also, on the positive findings of this pre-pilot study, a pilot study of the full-mouth periodontal examination protocol was undertaken in two stands of the 2008 NHANES. Thereafter, the NHANES clinical examination guidelines were modified to only accommodate full-mouth (excluding third molars) “gold standard” periodontal examination. For the first time in the history of NHANES, a full-mouth periodontal examination protocol was followed by the NHANES 2009–2010 survey cycle [21] and continued through the following two additional NHANES 2-year survey cycles in 2011–2012 [22] and 2013–2014 [23].

Additional Reporting

In addition to the main results regarding the prevalence of periodontitis, the purpose and progress of this Initiative at various stages were described elsewhere [3, 24–28], and a review of various methods for periodontitis for surveillance was undertaken [29]. Interim results and status reports from the Workgroup's efforts were also presented at national (AAP annual meetings) and international meetings (International Association of Dental Research).

Major Accomplishments

Case Definition for Surveillance of Periodontitis

The CDC/AAP Initiative undertook extensive analyses of datasets and consultations with experts in periodontology to arrive at case definitions for a range of severity levels including moderate and severe periodontitis [11, 25], and later separated categories for non and mild periodontitis in 2012 due to need expressed by users [30]. An overview of the periodontitis case definitions and their derived terminology used in the reports from the Workgroup is provided in Table 1 [31].

Briefly, the case definitions required measurements of the periodontal probing depth (PPD) and the distance from the free marginal gingivitis to the cemento-enamel junction for calculation of the clinical attachment loss at the same interproximal sites at 2 non-adjacent teeth using measurements from a full-mouth periodontal examination protocol. These definitions were based on moderate agreement in the literature that clinical attachment loss of 6 mm is a reasonable cutoff point to differentiate severe from moderate periodontitis; the latter term is usually applied to a clinical attachment loss of 4 mm or 5 mm. Measurements from interproximal sites are used in contrast to mid-buccal and mid-lingual sites because the disease usually begins at and is most severe at interproximal sites and because buccal attachment loss may result from vigorous tooth brushing, not from disease.

Notably, these case definitions, often referred to as the CDC/AAP periodontitis case definitions, were specifically intended for use in field surveys and not for clinical practice. Several studies have since validated these case definitions relative to clinical observations and report strong correlations between the periodontal inflamed surface area and case status based on this classification [36]. These case definitions are gradually being adopted globally as the standard for reporting prevalence of periodontitis in surveillance and population studies and have been used in a multitude of studies around the world. Of great importance is that the Joint Europe/USA Periodontal Epidemiology Working Group proposed applying the CDC/AAP periodontitis as standard case definitions when reporting prevalence of periodontitis in the future [37]. Such reporting using the same periodontitis case definitions ensures the most valid comparisons of periodontitis prevalence between different geographic locations as well as between studies conducted in the same population at different time points. For the first time, it is now possible to gain knowledge of differences and similarities in the periodontitis prevalence and distribution of the different severities of periodontitis between population groups and also to study any changes in the prevalence over time to explore any trends. The lack of such valid comparisons has hitherto hampered the study of periodontology [31].

Full Mouth Periodontal Assessment in NHANES

The NHANES 2009–2010 survey cycle was the first national probability sample survey to use the full-mouth periodontal examination protocol to collect periodontal probing measurements from 6 sites around all non-third molar teeth present in US adults. This exact protocol was continued in the NHANES 2011–2012 and NHANES 2013–2014 survey cycles, which enables data from all three 2-year survey cycles to be combined for analysis. Using this “gold standard” protocol of periodontal measurements from six sites per tooth for all non-third molar teeth to identify periodontitis cases vastly improved the validity of estimates for periodontitis harvested from our national surveys.

Consequently, the application of the full mouth periodontal examination protocol and using the CDC/AAP periodontitis case definitions resulted in significant upward revisions of the estimates of periodontitis prevalence in US adults overall and for demographic groups, such as older adults. We reported on an interim basis the prevalence of periodontitis among dentate adults aged 30–70 years based on data from the NHANES 2009–2010 [21] and 2009–2012 [22]. Our final report based on the pooled data from all the 6 years that followed the full-mouth periodontal examination protocol, 2009–2014, estimated that 42.2% of US adults was now determined to have some form of periodontitis (*mild, moderate, or severe*), with 7.8% having *severe* periodontitis, a much greater burden of periodontitis in US adults than previously reported [23]. Especially the older populations groups are affected by periodontitis with about two-thirds having periodontitis [33].

Finally, the data were applied to reassess the associations of traditional risk indicators for periodontitis after controlling for socio-demographics, behaviors, and comorbid conditions, using multivariable logistic regression modeling [38].

Self-report Measures for Predicting Prevalence of Periodontitis

Using multivariable prediction models, the performance of these self-report measures were first tested in the 2007 pre-pilot study in U.S adults [18], then evaluated fully in the Australian National Adult Oral Health Survey [19] and in a convenience sample of adults in Brazil [36]. In these preliminary assessments [13], the response rates to all self-report questions in-home interviews were high, namely at >95%. All self-reported measures were independently associated with periodontitis, except for the use of mouthwash. Self-reported questions had no significant correlations with one another, with the exception of the use of mouthwash and evidence of bone loss. In multivariable modeling, the combined effects of demographic measures and measures from five self-report questions in detecting unweighted total periodontitis performed at a sensitivity of 84%, specificity of 60%, and receiver operating characteristic of 0.81. Three questions performed at a sensitivity of 95%, specificity of 28%, and receiver operating characteristic of 0.82 in predicting clinical attachment loss of ≥3mm. In validation tests, the two models performed at prediction accuracies of 70% and 89%, respectively [39]. A study in Spain (N=112) also concluded that self-reported periodontal disease is predicting periodontitis prevalence with moderate accuracy when defined by the CDC/AAP case classifications [40]. A research team further validated 8 items similar to the CDC/AAP-developed items [35] with the CDC/AAP case definitions [11] in a Dutch population. The most accurate and valid model to predict

moderate or severe periodontitis included some demographic information and was developed into an online screening tool for rapid use by medical health care professionals that is available at the website <https://www.perioscreening.com/> [41].

Overall, these results confirmed that self-report measures were promising in predicting the prevalence of periodontitis in the US adult population. Our further studies suggest the performance of these questions may exceed the accuracy of estimates from partial-mouth periodontal examination protocols commonly used in surveillance of periodontitis, especially for severe periodontitis (20).

These self-report questions are currently included in the home interview questionnaire for the NHANES. The data will be used for the final validation of the performance of these self-report questions against clinically determined periodontitis. Analyses of the data is currently in progress to generate the model coefficients for use in estimating periodontitis prevalence in U.S adult populations based on responses to self-report questions. In anticipation of the performance of these questions, the self-report questions will be incorporated in NHANES and will be used in the future for monitoring the prevalence of periodontitis and assess the trends over time [31].

Estimation of Periodontitis at the State and Local levels

With the availability of more comprehensive NHANES periodontal measurements and the concurrent availability of other data, such as the US Census and the Behavioral Risk Factor Surveillance system data, we are now able to link or layer these datasets to estimate periodontitis prevalence at the state and local levels. We used multilevel regression and post-stratification analyses to estimate the prevalence of periodontitis among adults aged 30–79 years at state, county, congressional district, and census tract levels. This modeling approach used age, race, sex, smoking, and poverty variables to estimate the prevalence of periodontitis as defined by the CDC/AAP case definitions at the census tract levels, which subsequently were aggregated to larger administrative and geographic areas of interest. We reported for the first time ever estimates of the prevalence of periodontitis at the state and local levels [34]. This represents an important adjunct to public health surveillance efforts to identify areas with great burdens of periodontitis.

Recognition

Special Issue of Journal of Periodontology

The Journal of Periodontology dedicated a special supplement to the July 2007 issue to the CDC/AAP Initiative to highlight the importance of its work [3, 11, 12, 14–17, 19, 24, 26, 28, 42], importantly including the initial clinical periodontitis case definitions for surveillance [11]. The members of the workgroup are also listed [2]. Three contributions were also published in the main issue for July 2007 to provide a background for the supplement [27, 43, 44].

Awards

The accomplishments and products from this project have been recognized by the formal award of American Academy of periodontology (AAP) Special Citation in 2012 as well as the AAP Clinical Research Award in 2013 and 2016 during annual AAP meetings. Additionally, the Initiative's work has been recognized by numerous internal CDC awards.

Global Impact

Our first report of the periodontitis prevalence based on data from the NHANES 2009–2010 was published online on August 30, 2012, at the website of the Journal of Dental Research, the highest impact dental journal that accepts unsolicited manuscripts [21]. Already by August 1, 2013, this publication had become the most cited online paper the previous 12 months. By February 14, 2020, the paper had been cited by more than 400 PubMed Central articles. The 2015 update on the 2009 – 2012 NHANES data was cited about 1,000 times by July 2020.

Similarly, a comprehensive overview of risk factors for periodontitis authored by a subset of the CDC/AAP Workgroup [45] and published in 2013. In 2020 this paper was honored with the distinction of being the top-most cited paper in the last three years among all articles published in Periodontology 2000 (<https://onlinelibrary.wiley.com/journal/16000757?tabActivePane=>), the dental journal with the highest impact factor, which publishes only invited contributions. By July 2020, this paper was cited about 1,000 times according to Google Scholar and CrossRef.

The future

This Initiative has addressed important limitations from using partial-mouth periodontal examination protocols for survey of periodontal disease used previously in NHANES. However, full-mouth periodontal examinations are costly and resource intensive and thus are not feasible for regular annual national surveys. Consequently, other less resource intensive approaches for surveillance of periodontitis are needed. The future of low-cost interview-based surveillance approaches for periodontitis is now promising because of the evidence from this Initiative.

This Initiative has provided a valid, reliable, and cost-effective surveillance approach for estimating the prevalence of periodontitis using only responses to questions administered in interviews from existing interview based surveys such as the BRFSS that also collect information on demographic characteristics. Coefficients generated from our study of these questions in NHANES will be applied to self-report data collected to estimate prevalence in U.S adults at the state and local levels. Estimates generated can be included in the in the National Oral Health Surveillance System and could be used to link periodontitis to several state and local factors, as well as to public health preventive or interventional programs.

In addition, this screening tool could be used for etiologic studies pertinent to periodontitis and associated systemic conditions. For example, this tool could be used by health professionals to predict the likelihood of periodontitis in individuals thought to be at high risk for periodontitis and its sequelae. Furthermore, it could enable large-scale, cost-effective

screening for periodontitis or used by physicians treating patients suffering from chronic diseases associated with periodontitis, such as diabetes and atherosclerotic cardiovascular disease. It is reasonable to expect that these questions may have some utility as a screening tool for health care professionals, or even for consumers, for use in predicting periodontitis presence in individuals.

The joint European and US formal encouragement of using the CDC/AAP-developed standard case definition for periodontitis -- that already widely used internationally -- is expected to introduce some uniformity in case definitions of periodontitis across surveys globally. Such application addresses the historic important limitation for comparing periodontitis data across populations and for more and consistent classification of cases for etiologic research.

Conclusion

The findings and products resulting from this CDC/AAP Initiative under the leadership of Dr. Genco has resulted in very significant contributions and updates to our knowledge of population aspects of periodontitis in U. S adults – and abroad. Overall, the Initiative developed and used new more valid surveillance protocols and cases definition of periodontitis to determine the burden of periodontitis in U.S adults and further used this information to re-evaluate associations with putative risk factors in populations. Finally, the self-report surveillance model developed through this initiative has provided the opportunity for future surveillance of periodontitis at the state and local levels to support potential public health action to prevent and control periodontitis.

Acknowledgement

The authors wish to acknowledge all members and *ad hoc* contributors to the work of the CDC/AAP Workgroup as partly reflected in the authors of the cited publications. We thank Dr. Genco for his endless support and commitment to this project. None of the authors has any conflict of interest with this report.

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such questions that can be posed via telephone or other remote communication, which does not require the prohibitively costly clinical periodontal examinations, represent a breakthrough in periodontitis surveillance. Such self-reported measures are especially helpful in communities and populations that are less resourceful, because the prevalence of periodontitis can be estimated based on responses to questionnaire items without the costly clinical examination.

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- 45**. Genco RJ, Borgnakke WS. Risk factors for periodontal disease. *Periodontol* 2000. 2013;62(1):59–94. doi: 10.1111/j.1600-0757.2012.00457.x. [PubMed: 23574464] Unexpectedly, this paper became an instant classic as described in the text.



Figure 1. First CDC-AAP Workgroup meeting on April 9, 2003 (Clockwise): Roy Page, Gordon Douglas, Kaumudi Joshipura, Paul Eke, Bob Genco, Jim Beck, Jeff Hyman, and George Taylor.

Table 1.

CDC/AAP periodontitis case definitions for use in surveillance and subsequent categories used in reporting by the CDC/AAP Initiative [31].

| Periodontitis Case Definitions [30] | Criteria [30] | Subsequently-Derived Periodontitis Categories | |
|-------------------------------------|--|---|---|
| | | Total* vs None | Severe vs Non-severe [†] vs None |
| Severe | 2 interproximal sites with ≥ 6 mm CAL (not on the same tooth) AND 1 or more interproximal site(s) with ≥ 5 mm PPD | Severe | Severe |
| Moderate | <u>Among those who did not meet the severe periodontitis case definition:</u> 2 interproximal sites with ≥ 4 mm CAL (not on the same tooth) OR 2 interproximal sites with PPD ≥ 5 mm (not on the same tooth) | Moderate | Moderate |
| Mild | <u>Among those who met neither the severe nor moderate periodontitis case definitions:</u> 2 interproximal sites with ≥ 3 mm CAL AND (2 interproximal sites with ≥ 4 mm PPD (not on the same tooth) OR 1 site with ≥ 5 mm PPD) | Mild | Mild |
| None | Does not meet the severe or moderate or mild periodontitis case definitions | None | None |

* Total periodontitis was defined as severe or moderate periodontitis in the 2010 report on accuracy of estimates based on earlier NHANES protocols [20], because the CDC/AAP periodontitis case definitions consisted of only the categories severe, moderate, and mild/none at the time [11]. The mild category was separated out from the original mild/none periodontitis category in 2012 [30].

Total periodontitis (= “any” periodontitis): severe or moderate or mild periodontitis [18, 21–23, 32–35];

[†] Non-severe periodontitis (= “other” periodontitis): moderate or mild periodontitis [23].

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