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The United States Surgeon General's Office in 2000 issued the first ever report on the oral health of the American public [1]. The report concluded that oral health is an essential component of general health and that advances in dental practice over the past century have made the attainment of oral health a reality for the entire American population. The report also noted, however, that significant disparities exist in the level of oral health within the United States. The report stated that such disparities constitute "a silent epidemic of oral diseases affecting our most vulnerable citizens—poor children, the elderly and many members of racial and ethnic minority groups" [1]. The objective of the present article is to examine the evidence that supports the associated finding by the Surgeon General's report of increased prevalence and severity of destructive periodontal diseases in some American

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minority populations. Toward that objective, the findings of the studies reviewed in this article are organized to address the following questions:

- 1. Are the differences in destructive periodontal disease prevalence and severity observed in American minority populations due to genetic or other confounding variables associated with ethnicity/race? Answers to this question are critical in terms of the direction of future research and the allocation of public and private resources to address the problem of disparities in destructive periodontal disease prevalence and severity. If differences among ethnic/racial groups are primarily due to confounding variables that may be associated with ethnicity/racesuch as access to dental care services, socioeconomic status (SES), or oral health knowledge and beliefs-then social programs developed to address these needs would effectively combat disparities in destructive periodontal diseases in these populations. Alternatively, if differences among ethnic/racial groups are indeed primarily genetic, then increased basic research would first be needed to identify and define the underlying biologic mechanisms responsible for ethnic/racial differences in destructive periodontal disease prevalence and severity. Based on the findings of these basic biologic studies, social programs could then be developed to address this problem.
- 2. Do risk factors for destructive periodontal diseases differ among American minority populations or differ from the American population at large? It is now apparent that destructive periodontal diseases do not equally afflict all individuals within a population, and that destructive periodontal disease progression—as defined by the active loss of periodontal connective tissue attachment—appears to be episodic in nature, with most sites remaining stable for extended periods of time. Based on this current understanding of destructive periodontal disease status and progression, new strategies developed to treat destructive periodontal diseases are increasingly being targeted to those individuals and sites within individuals at risk for disease and disease progression. If risk factors for disease progression are found to differ across ethnic/ racial groups, it is possible that inappropriate or ineffective therapies may be utilized in those populations.

Incidence and progression of destructive periodontal diseases in American minority populations

Disparities in destructive periodontal disease incidence and severity have been reported for juvenile, adult, and elderly ethnic/racial minority populations in the United States. For juvenile American populations, Loe and Brown [2] reported on data collected by a multi-stage sampling design using 11,007 children aged 14 to 17 by the National Institute of Dental Research (NIDR) during the period of 1986–1987. For the entire population, a prevalence of 0.53% was reported for localized juvenile periodontitis, 0.13% for generalized juvenile periodontitis, and 1.61% for incidental loss of attachment. When stratified by race, African Americans had a prevalence of 2.05% for localized juvenile periodontitis, 0.59% for generalized juvenile periodontitis, and 4.63% for incidental loss of attachment. The increased relative risk of disease for African American compared with white participants in this study was 15.1 for juvenile periodontitis, 24.6 for generalized juvenile periodontitis, and 5.5 for incidental loss of attachment. Hispanic children were also reported to be 2.4 times more likely to have localized juvenile periodontitis than were non-Hispanic children [3]. Melvin, Sandifer, and Grav [4] screened panoramic radiographs of 5013 military recruits for vertical bony defects suggestive of localized juvenile periodontitis. These authors reported an overall prevalence of localized juvenile periodontitis of 0.76% in this population, but marked differences were also noted based upon race. White recruits had a prevalence of 0.09%, whereas African American recruits had a prevalence of 2.9%. Recruits whose ethnic/racial background was reported as "other" had a prevalence of 0.80%. African American males had a higher prevalence (3.81%) than did African American females (1.99%) in this study; however the effect of gender was reversed for white recruits. White males had a prevalence of 0.042%, whereas white females had a prevalence of 0.18% [4].

The 1976–1977 North Carolina study [5] was one of the earliest epidemiologic studies to report ethnic/racial differences in destructive periodontal disease prevalence and severity in adult populations. Using the periodontal index as a measure of periodontal disease status, destructive periodontal diseases in white participants were reported to begin generally after the age of 40. Established periodontitis was not commonly observed among whites participants prior to the age of 60. In contrast, destructive periodontal diseases in African American populations were reported to begin at a much younger age and to progress at a far more rapid rate [6]. The NIDR 1985–1986 survey of employed United States adults aged 18 to 64 [7] used probing depth and attachment level measurements to assess destructive periodontal disease status. Although destructive periodontal disease prevalence and severity was strongly correlated with increasing age, at all ages examined periodontal pockets greater than or equal to 4 mm were reported to be two times more likely in African American than in white participants. The prevalence of attachment loss greater than or equal to 3 mm was reported to be 42% for white and 51% for African American populations. Phase I of the third National Health and Nutrition Examination Survey (NHANES III), conducted from 1988 to 1991, included a periodontal examination of two randomly selected quadrants for a maximum total of 14 permanent teeth for 7447 participants aged 13 and older [8]. NHANES III used a stratified, multistage probability sample drawn from all 50 states as an estimate of the periodontal status of approximately 160.3 million Americans. The prevalence of attachment loss greater than or equal to 3 mm was reported to be 53% for non-Hispanic blacks and 43% for non-Hispanic whites. The prevalence of attachment loss greater than or equal to 5 mm was reported to be 17% for non-Hispanic blacks and 15% for non-Hispanic whites. Data for Mexican Americans were reported to be intermediate to data for non-Hispanic blacks and non-Hispanic whites. For all age groups, the prevalence of probing depths greater than or equal to 4 mm was 34% for Mexican Americans compared with 27% for non-Hispanic whites. This difference in prevalence persisted for probing depths greater than or equal to 6 mm. Few differences were noted between these two groups with respect to attachment loss in this study [8]. Phase II of the NHANES III survey was conducted from 1992 to 1994. Albandar, Brunelle, and Kingman [9] reported the periodontal findings of 9689 participants from the combined phases of the NHANES III survey. The prevalence of attachment loss at interproximal sites greater than or equal to 5 mm was 15.2% for non-Hispanic blacks, 10.1% for Mexican Americans, and 9.1% for non-Hispanic whites. The difference between non-Hispanic blacks and non-Hispanic whites was found to be highly significant (P < 0.001). Non-Hispanic blacks had the highest prevalence and extent of gingival recession and calculus, whereas Mexican Americans had the highest prevalence and extent of bleeding upon probing [10].

Differences in destructive periodontal disease prevalence and severity among American ethnic/racial groups have also been reported for older populations. The Piedmont 65+ Dental Study [11] was a longitudinal study of the health status of a stratified random sample of participants aged 65 or greater from five contiguous counties in North Carolina. The study was designed to compare two older populations: urban whites and urban and rural African Americans. Baseline data consisting of 821 dentate participants showed that African American participants had fewer teeth than did white participants. In addition, black participants had 78% of all sites exhibiting attachment loss, with an average loss of attachment of 4 mm. In comparison, white participants had 65% of all sites exhibiting attachment loss, with an average loss of attachment of 3.1 mm [11]. In a follow-up report from the Piedmont 65+ Dental Study [12], African American participants were reported more likely to experience disease progression as defined by a loss of greater than 3 mm of clinical attachment. During the 18-month interval from baseline, 58% of African American participants and 46% of white participants experienced a single site of attachment loss, 36% of African Americans and 27% of whites experienced two sites of attachment loss. and 24% of African Americans and 16% of whites experienced three or more sites of attachment loss [12]. The finding of greater destructive periodontal disease prevalence and severity in African American when compared with white participants was supported by a subsequent report on tooth loss from the Piedmont 65+ Dental Study [13]. Over the 3-year period of the report,

African Americans were more likely to lose additional teeth (53%) than were whites (29%), and the mean number of teeth lost by African Americans (2.2) was greater than for whites (0.9). When the data were expressed in relation to the number of teeth present upon entry into the study, African American participants lost 13% of their remaining teeth as compared with white participants, who lost just 4% of their remaining teeth [13].

Collectively, the above studies document that disparities in destructive periodontal disease status and progression exist for some American ethnic/racial groups. This finding is particularly apparent for African Americans; however, African Americans have been the most extensively studied ethnic/racial group. Is it therefore possible that genetic factors could be responsible for the increased prevalence, severity, and progression of destructive periodontal diseases observed in some American minority groups. Recent reports [14] that half of the variance observed in destructive periodontal diseases in twins can be attributed to genetic variance lend support to this possibility. With the possible exception of early onset periodontitis [15], however, few studies have been able to report a mechanistic link between destructive periodontal diseases and a specific racial stock. In addition, not all epidemiologic studies have reported increased destructive periodontal diseases in American ethnic/racial groups when confounding variables that may be associated with ethnicity/race-such as SES, access to oral health care services, and level of education-are adequately controlled. For example, the ongoing New York State Erie County Dental Study did not find increased destructive periodontal disease for African American participants in either cross-sectional [16,17] or longitudinal reports [18,19]. A major difference in the Erie County Dental Study compared with the previously described studies was that African American participants in the Erie County Dental Study were not clustered within the lower socioeconomic groups, in effect controlling for this variable. Rather, the results of the Erie County Dental Study suggest that factors other than ethnicity/race may be responsible for the increased prevalence and severity of destructive periodontal diseases observed in some American minority populations [20]. In support of this possibility, a recently reported study of 56 Asian American, 71 African American, and 58 Hispanic participants resident within the greater New York City region [21] found increased numbers of missing teeth and greater mean probing depths and attachment loss in the African American group compared with the other two minority groups. As shown in Table 1, however, the African American group had a greater proportion of individuals in unskilled versus professional or skilled occupations, and participants in this group were less likely to report having a private dentist and more likely to be smokers. Using a log-linear analysis and configural frequency analysis to examine the relationships among destructive periodontal status, ethnic/racial group, and occupational status, a strong association between occupational status and ethnic/racial group was found. After adjustment for this association, the association between

Asian American	African American	Hispanic American
33.9	57.7	58.6
30.6 ± 8.1	36.8 ± 9.1	31.9 ± 8.7
0.9 ± 1.4	2.6 ± 2.7	2.3 ± 2.9
2.4 ± 0.3	2.8 ± 0.6	2.6 ± 0.5
2.4 ± 0.4	2.9 ± 0.8	2.6 ± 0.7
70.6 ± 27.5	74.9 ± 22.5	68.9 ± 27.4
54.0 ± 30.5	58.6 ± 26.5	52.3 ± 28.7
36.4 ± 22.1	44.5 ± 24.4	41.3 ± 25.8
0.6 ± 2.0	2.6 ± 7.4	2.3 ± 7.9
42.9	81.7	63.8
58.9	21.1	36.4
76.8	15.5	31.0
19.6	31.0	31.0
3.6	53.5	37.9
62.5	15.7	24.6
25.0	17.1	24.6
12.5	67.5	50.9
12.7	32.4	28.1
	Asian American 56 33.9 30.6 ± 8.1 0.9 ± 1.4 2.4 ± 0.3 2.4 ± 0.4 70.6 ± 27.5 54.0 ± 30.5 36.4 ± 22.1 0.6 ± 2.0 42.9 58.9 76.8 19.6 3.6 62.5 25.0 12.5 12.7	Asian AmericanAfrican American 56 71 33.9 57.7 30.6 ± 8.1 36.8 ± 9.1 0.9 ± 1.4 2.6 ± 2.7 2.4 ± 0.3 2.8 ± 0.6 2.4 ± 0.4 2.9 ± 0.8 70.6 ± 27.5 74.9 ± 22.5 54.0 ± 30.5 58.6 ± 26.5 36.4 ± 22.1 44.5 ± 24.4 0.6 ± 2.0 2.6 ± 7.4 42.9 81.7 58.9 21.1 76.8 15.5 19.6 31.0 3.6 53.5 62.5 15.7 25.0 17.1 12.5 67.5 12.7 32.4

Table 1

Clinical and demographic parameters subset according to ethnic/racial group

Values represent means \pm SD.

Significant differences among groups after adjusting for age using ANCOVA:

^a P < 0.05.

^b Age differed significantly (P > 0.001) among groups using the Kruskal Wallis test.

- $^{\rm c} P < 0.01.$
- ^d P < 0.001.

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ethnic/racial group and periodontal disease status was no longer significant. In other words, occupational status—which reflects SES and level of education—was a more robust predictor of periodontal disease status than was ethnic/racial group in this population [21]. Baelum et al [22] indirectly addressed whether disparities in destructive periodontal disease prevalence and severity were due to genetic factors by questioning whether Asian and African populations in fact experienced increased destructive periodontal disease prevalence and severity. In this retrospective study, attachment level data from earlier Kenyan and Chinese epidemiologic studies were first recalculated to be able to compare data sets between groups. These data sets were then compared with six other populations from around the world. Although attachment loss profiles differed among the eight groups, the Asian or African groups were not found to exhibit increased attachment loss in comparison with the other six groups.

108

Although the epidemiologic studies reviewed above clearly document an increased destructive periodontal disease prevalence and severity for some ethnic/racial groups in the United States, few studies at present support the contention that these differences primarily arise due to genetic factors. Rather, confounding variables that are frequently associated with ethnicity/race such as level of education, access to dental care services, and health practices and beliefs—which are also closely associated with SES—appear to contribute to increased destructive periodontal disease status and progression observed in these populations.

Risk indicators and risk factors associated with destructive periodontal diseases in minority populations

In addition to differences in destructive periodontal disease prevalence and severity, differences in the profiles of factors associated with destructive periodontal disease status (risk indicators) and factors associated with disease progression (risk factors) have also been reported for various American ethnic/racial groups. For older populations, the Piedmont 65+ Dental Study [11], using a logistic regression model, identified the following factors and associated odds ratios (ORs) as risk indicators for African American participants: tobacco use (OR = 2.9), colony counts greater than 2% for *Porphyr*omonas gingivalis (OR = 2.4) and Prevotella intermedia (OR = 1.9), last dental visit greater than 3 years previously (OR = 2.3), and a self-report of gingival bleeding within the last 2 weeks (OR = 2.4). The following factors and associated ORs were identified as risk indicators for white participants: tobacco use (OR = 6.2), colony counts of *P* gingivalis greater than 2%(OR = 2.4), and the combined variables of elevated N-benzovl-DL-arginine-2-naphthylamide (BANA) score and a last visit to the dentist more than 3 years previously (OR = 16.8). A second report on baseline microbial data from the Piedmont Study [23] also found differences in risk indicators between African American and white participants. The prevalence of Actinobacillus actinomycetemcomitans, P intermedia, and P gingivalis was greater in African American than in white participants. African American participants also had greater destructive periodontal disease, as evidenced by greater pocket depth and attachment loss. Using logistic regression analysis to identify factors associated with severe attachment loss, race was not found to be a contributory variable, once *P* gingivalis, *P* intermedia, last visit to the dentist, and tobacco use were present in the model [23]. In a subsequent report from the Piedmont 65+ Dental Study [12], risk factors were reported for participants with two or more sites losing 3 mm or more of attachment after 18 months. For African American participants, colony counts at baseline greater than 2% for *P* ginigivalis and *P* intermedia, failure to use dental floss, decreased memory, and the report of a last visit to the dentist more than 3 years previously were all associated with disease progression. For white participants, smoking, colony counts of P gingivalis greater than 2%, medical care in the last 6 months, and a self-report of depression were associated with disease progression [12]. In a report from the Piedmont Study after 5 years [24], African American participants had a higher rate of attachment loss than did white participants, and African American participants who sought professional dental care tended to have less loss of attachment than those who sought care irregularly. In a final report after 7 years [25], separate multivariable Poisson models for disease progression were developed for African American and white participants. For African American participants, molar and interproximal sites, colony counts of *P gingivalis* greater than 2%, an elevated BANA score, lower SES, a report of never having visited a dentist, and current smoking were all risk factors or disease progression. For white participants, molar sites and sites with interproximal caries, colony counts of *P* gingivalis greater than 2%, never having visited a dentist, self-reported depression, having less than 12 years of formal education, higher BANA score, and current smoking were all risk factors for disease progression [25].

The New York State Erie County Dental Study published a series of reports [16–19] on risk indicators and factors for destructive periodontal diseases in an adult population that complements the Piedmont study of the elderly. Few differences were noted between ethnic/racial groups in the Erie County Dental Study, although African Americans may have been underrepresented (6.5%) of the total participant population) in this study [17]. At baseline, risk indicators for attachment loss for the entire population included increasing age, diabetes mellitus, tobacco use, and the presence of P gingivalis and Bacteroides forsythus [17]. At 1 year, risk factors for disease progression included smoking, past severity of attachment loss, and the presence of B forsythus, P gingivalis, and P intermedia. No associations were found for race, gender, or socioeconomic factors [18]. At 2 to 5 years, risk factors for disease initiation or progression in individuals who were periodontally healthy or who had mild periodontitis at baseline included a report of current smoking, greater baseline attachment loss, greater probing depths, and the presence of *B forsythus* [19].

Differences in host response to subgingival bacterial challenge have also been reported among ethnic/racial groups. A cross-sectional study of 117 participants recruited from a dental clinic in Minnesota [26] reported that neutral elastase, β -glucuronidase, and myeloperoxidase from gingival crevicular fluid samples were lower in white than in African American, Native American, or Asian participants. Unfortunately, whether these data correlated with destructive periodontal disease status or severity in these four ethnic/racial groups was not reported in this study. For the entire population, age, gingival crevicular fluid neutral elastase, β -glucuronidase, and myeloperoxidase, and elevated *Fusobacterium nucleatum*, *P gingivalis*, and *P intermedia* were all identified as risk indicators for destructive periodontal diseases [26]. Schenkein et al [6] reported differences in subgingival bacterial species—in particular, increased levels of *P gingivalis*—in African American as compared with white participants. Whether this finding correlated with destructive periodontal disease status was also not reported. Umeda et al [27] found differences in the frequency of six microbial periodontal pathogenic species, as determined using oligonucleotide primers and the reverse transcriptase polymerase chain reaction, in four ethnic/racial groups resident in the greater Los Angeles area. Probing depth and destructive periodontal disease severity was positively associated with each of the six species. Asian American participants were found at increased risk to harbor A actinomycetemcomitans and P gingivalis in subgingival sites, whereas African American participants were at increased risk to harbor P gingivalis and Treponema denticola in oral sites [27]. In a second study from the same laboratory [28], analysis of the A actinomycetemcomitans leukotoxin promoter found a 530 base-pair deletion present in 11 out of 26 African American participants and 1 out of 43 Hispanic American participants, but not in 69 white or 27 Asian American participants. The 530 base-pair deletion had previously been associated with increased leukotoxin expression. The authors suggested that the deletion in the leukotoxin promoter appears to be a characteristic of individuals of African descent [28]. The previously cited New York City study [21] also found differences in subgingival microbial profiles among the three ethnic/racial groups examined. A actinomycetemcomitans, Neisseria mucosa, Selenomonas noxia, and T socranskii were all elevated in the Asian American group, whereas Peptostreptococcus micros was elevated in the African American group. When the data were subset by occupational status, however, the unskilled group had elevated numbers of species associated with destructive periodontal diseases [21].

Differences in serum antibody response to subgingival species have also been reported for ethnic/racial groups. Serum antibody to A actinomycetem*comitans* serotypes a, b, and c were reported to be higher in African American than in white participants when subset on the basis of periodontal disease status [29,30], and increased serum IgG2 levels have been reported for African Americans when compared with white participants [31]. Differences in serum IgG antibody profiles were also reported for 23 Asian American, 48 African American, and 37 Hispanic American participants from the aforementioned New York City study [32]. Serum IgG antibody to *P gingivalis* was reported to be greater in the African American group, whereas serum IgG antibody to B forsythus was lower in the Hispanic group. The African American group also had the most destructive periodontal disease, as evidenced by the greatest mean probing depth, loss of attachment, and number of missing teeth; as well as the greatest number of unskilled individuals. Elevation of serum IgG antibody, defined as a value greater than 2 standard deviations from the mean value for the periodontally healthy group, was correlated with destructive periodontal disease status and progression for each of the three ethnic/ racial groups. The authors suggest that environmental and socioeconomic factors may have a greater effect than ethnicity/race as risk factors for destructive periodontal diseases in these populations [32].

The above-cited studies clearly document that differences can be found in the profile of risk indicators and risk factors for destructive periodontal diseases in American ethnic/racial populations. The relative contribution of specific factors to overall risk for destructive periodontal diseases has not been completed for the general population, however. It is therefore impossible to conclude at this time that the differences noted in some ethnic/racial populations are indeed different from the American population at large or differ between specific ethnic/racial groups. The answer to this question awaits the results of additional risk-assessment studies. What is apparent from the above-cited studies is that an array of risk factors is associated with destructive periodontal diseases, many of which are interrelated. These include the presence of specific microbial species, in particular, A actinomycetemcomitans, P gingivalis, B forsythus, and T denticola, elements of the host response, including antibody response to periodontal pathogens, prior disease, age, gender, access to oral health care services, and health behaviors such as smoking. Many studies have found close associations between cigarette smoking and periodontal attachment loss [11,12,16, 17,25], and cigarette smoking has also been inversely related to the level of education [33,34]. In addition, many of the above-cited studies found SES, or surrogate variables for SES such as occupational status, to be more robust risk indicators or risk factors of destructive periodontal disease status and progression than was ethnicity/race [17–19,21,23,32]. It has been suggested that lower occupational status may limit access to oral health care services or influence preventative health care behaviors such as oral hygiene practices [11,21,25,34]. The magnitude of the effect of socioeconomic factors on destructive periodontal disease status and progression in American ethnic/racial minority populations highlight the need to carefully control for socioeconomic factors in future risk assessment studies in these populations.

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