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Geospatial distribution of periodontists and US adults with severe periodontitis

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Abstract

Background.—In this study, the authors report on the geospatial distributions of periodontists and adults with severe periodontitis in the United States.

Methods.—The authors used geospatial analysis to describe the distribution of periodontists and adults, periodontists vis-à-vis estimated density of adults with severe periodontitis, and their ratios to adults with severe periodontitis. The authors identified locations of 5,415 practicing periodontists through the 2014 National Provider Identifier Registry, linked them with the

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weighted census number of adults, and estimated the number of adults within a series of circular distance zones.

Results.—Approximately 60% of adults 30 through 79 years lived within 5 miles of a periodontist, 73% within 10 miles, 85% within 20 miles, and 97% within 50 miles. Proximity to a periodontist varied widely. In urban areas, 95% of adults resided within 10 miles of a periodontist and 100% within 20 miles. Only 24% of adults in rural areas lived within 10 miles of a periodontist. Most periodontists (96.1%) practiced in urban areas, clustering along the eastern and western coasts and in the Midwest, 3.1% in urban clusters elsewhere, and 0.8% in rural areas. Ratios of fewer than 8,000 adults with periodontitis to 1 or more periodontists within 10 miles were clustered mostly in the Northeast, central East Coast, Florida, West Coast, Arizona, and Midwest.

Conclusions.—In this study, the authors identified wide variations in geographic proximity to a practicing periodontist for adults with severe periodontitis.

Practical Implications.—Dental practitioners may provide preventive care and counseling for periodontitis and referrals for specialty care. Geographic proximity to specialized periodontal care may vary widely by locality.

Keywords

Demography; oral health care; dental clinics; dentists; oral health; periodontics; population groups; rural population; urban population

Severe periodontitis is the sixth most prevalent health condition in the world, and it affects approximately one-tenth (11.2%) of the adult population globally,[1] with approximately 538 million cases in 2015.[2] The global prevalence of severe periodontitis has not changed over the 25 years from 1990 through 2015, but the number of cases has increased drastically because of population growth and aging,[2] in combination with an increase in retention of natural teeth longer into older age.[2–4] Hence, severe periodontitis is a universal public health issue.

Periodontitis is prevalent in the United States with almost one-half (46.5%) of dentate adults 30 years or older affected by mild, moderate, or severe periodontitis[5] when assessed by means of full-mouth periodontal probing at 6 sites around all non–third molars according to the nationally representative National Health and Nutrition Examination Survey (NHANES)[6,7] and when applying the increasingly globally accepted standard case definitions for periodontitis surveillance suggested by the Centers for Disease Control and Prevention and the American Academy of Periodontology.[8,9] This full-mouth examination protocol greatly increases the accuracy of the periodontitis prevalence estimates compared with those in prior NHANES surveys.[10] Those with some form of periodontitis encompass 8.9% with severe periodontitis. Periodontitis affects approximately 2 in 3 (68.0%) of the US dentate population 65 years or older of whom 11.0% are in the severe category.[5,11]

In addition to potentially leading to tooth loss and its adverse consequences if left untreated, [12] periodontitis can affect overall health and well-being—and quality of life—with stronger effects with more severe disease.[13,14] Reducing the prevalence of moderate and severe

periodontitis among US adults aged 45 through 74 years is an oral health objective[15] included in the Healthy People 2020 initiative[16] as 1 of the indicators to track the nation's oral health.

Severe or complex cases of periodontitis invariably require specialized treatment by a periodontist. Periodontics is 1 of the 9 recognized specialties within dentistry in the United States[17] that requires certification after additional years of specialized education in the prevention, diagnosis, and treatment of periodontal diseases. Typically, a general dentist would refer a patient to see a periodontist when the patient seeks care for severe bone loss and advanced or severe periodontitis or on unsuccessful initial periodontal treatment that does not result in the desired outcome. To our knowledge, investigators never have explored geographic proximity focusing on the locations of periodontists' offices in relation to adult populations with severe periodontitis. In this study, we used geospatial analyses to determine the geographic proximity of US adults to a periodontist according to county, rural or urban location, and distribution of periodontists vis-à-vis the estimated density of severe periodontitis cases and the estimated ratios of periodontists to severe periodontitis in the population.

METHODS

Periodontist location

We extracted the practice addresses of active periodontists from the January 12, 2014, public release version of the National Provider Identifier (NPI) Registry.[18] An NPI is a unique 10-digit identification number issued by the Centers for Medicare & Medicaid Services through the National Plan and Provider Enumeration System to each health care provider registered as actively practicing.[18] The NPI indicates an individual provider and hence does not depend on the practice type (solo, group).[18] The NPI Registry is updated weekly. We extracted periodontist data from the data released on January 12, 2014, by using the health care taxonomy code 1223P0300X for periodontist.[19] After excluding periodontists practicing outside the United States and in US territories, we identified 5,415 periodontists with practice addresses in the 50 US states and the District of Columbia. No information was available about the age, race or ethnicity, or board certification of the periodontists.

US population counts

We obtained the most recent census population counts from the 2010 US Census block-level population counts. Census blocks (N = 11,155,486 in 2010) are the smallest unit of census geography.[20,21] Because 44.4% of the 2010 census blocks were uninhabited, we retained a total of 6,207,027 blocks for this analysis. We used the census block as the initial geographic unit to calculate the population residing within each periodontist's catchment area and to aggregate data to larger geographic units, such as counties and areas defined by urban or rural status. Each census block is identified by the US Census Bureau as belonging to an urbanized area (multiple census blocks with combined populations 50,000 or more), urban cluster (multiple census blocks with combined populations of 2,500–49,999), or rural area (all remaining census blocks).[22] We used block-level 2010 population counts from the US Census Bureau to determine the number of all US adults aged 30 through 79 years living

both within and outside of each periodontist's catchment area. We also used these population counts as weights to estimate the share of the population located within overlapping catchment areas for multiple periodontists.

Adults aged 30 through 79 years with periodontitis

We estimated the number of adults aged 30 through 79 years with severe periodontitis in each of the 3,143 US counties by using a small area estimation method as reported previously.[23–25] Briefly, in our multilevel regression, we used data from NHANES, Behavioral Risk Factor Surveillance System, US Decennial Census, and American Community Survey. First, we used NHANES 2009 through 2012 data to construct regression models best representing the associations between proportions of periodontitis measures and person-level age, sex, race or ethnicity, poverty, and the major modifiable risk factor cigarette smoking.[26] Using this model, we then constructed population counts for periodontitis prevalence according to each of these variables at the US Census block level. Because the US Census does not collect smoking and poverty statuses, we used both Behavioral Risk Factor Surveillance System data[27] and the US Census 2010 Summary File 1 population data[28] to estimate population counts according to smoking status for the selected demographic characteristics (age, sex, race or ethnicity) at the census block level. We further assigned poverty status to these population counts according to smoking status via bootstrapping by using American Community Survey 2008 through 2012 poverty estimates at the census block level.[29] Finally, using the estimated population counts with demographic, smoking, and poverty statuses, we applied the fitted models from NHANES to generate the prevalence estimates of periodontitis at the census block level. We then aggregated these estimates upward to larger geographic levels of interest, such as counties, congressional districts, and states.[23]

Periodontist service zone

We geocoded each periodontist to his or her practice location street address. We created a series of concentric circular radii, called *buffer zones*, around each periodontist location by using a geographic information system for the selected distances of 5, 10, 15, 20, 30, and 50 miles to represent the Euclidean (straight-line) distance. This method is described in detail elsewhere.[30,31] In this study, we assumed the Euclidean distances of 5 or 10 miles to be reasonable proxies for travel by public transportation in urban areas; we assumed 15-, 20-, and 30-mile distances to approximate 30 through 45 minutes travel time by automobile, and we assumed a 50-mile distance to approximate 1 hour's travel by automobile, which might be more typical of travel time from a rural area to a regional medical center. For nonemergency service, both straight-line distance and driving distance provide similar precision.[32] Because some periodontists may practice in close proximity to one another, each of those periodontists may have a buffer zone that overlaps that of other periodontists.

Population weighted periodontist

For any census block or blocks located within a selected buffer zone distance, we defined all of the adult population and adults with severe periodontitis, respectively, as having potential access to that periodontist. We summarized the total block population (P_d) inside each buffer zone and distributed the periodontist to each person $1/P_d$ inside the buffer. Because a census

block may be located in multiple periodontists' buffer zones, the share of a periodontist for each person is the sum of $1/P_{d1} + 1/P_{d2} + \ldots + 1/P_{dn}$, where n equals the number of periodontists within the given distance. Then we calculated the number of periodontists for each census block as the product of each person's share in that block and the total population (P_b) of that block as $D_b = P_b(1/P_{d1} + 1/P_{d2} + \ldots + 1/P_{dn})$. We summarized the number of each census block's periodontists within a county to obtain the number of periodontists for that county $D_c = (D_{b1} + D_{b2} + \ldots + D_{bm})$, where m represents the number of blocks within a county.

Finally, we summarized the census block population within and outside the buffer zone for each county to calculate the percentage of adults who had geographic access to at least 1 periodontist at the county level. Because each census block also is characterized by the US Census Bureau as urban or rural, we also calculated the percentage of US adults who had access to at least 1 periodontist in urbanized areas, urban clusters, and rural areas.

Ratio of adults with severe periodontitis to a periodontist

We calculated the ratio (R_c) of the estimated number (C_c) of adults aged 30 through 79 years and those with severe periodontitis to the number of periodontists D_c for each county ($R_c = C_c/D_c$) within each selected distance. For the blocks that were not inside any periodontist's buffer zone, the number of periodontists for that block is 0. For a county that did not have any blocks inside any periodontist's buffer zone, we defined the population in that county as having no available periodontist within the selected distance.

RESULTS

We identified 5,415 periodontists in 4,124 locations within the 50 US states and Washington, DC, in the January 12, 2014, NPI release. Among them, 78.7% were male and 21.3% were female; 44.7% were in solo practice and 49.3% were in group practice, with 6.0% having an unknown practice type. Among the 171.6 million US adults aged 30 through 79 years living in the 50 states and Washington, DC, 69.8% resided in urbanized areas, 9.1% in urban clusters, and 21.1% in rural areas.[28]

Figure 1 shows the cumulative proportion of US adults aged 30 through 79 years with potential access to at least 1 periodontist according to distance and urban or rural status. Approximately 60% of adults 30 years or older lived within a 5-mile radius proximity of a periodontist, 73% within a 10-mile radius, 85% within a 20-mile radius, and 97% within a 50-mile radius. Geographic accessibility to a periodontist was influenced by living in a rural or urban area. In urban areas, 95% of adults were within a 10-mile radius proximity to a periodontist, and 100% were within 20 miles. In contrast, approximately 24% of adults in rural areas were within a 10-mile radius of a periodontist. However, approximately 90% of adults in urban clusters and rural areas were within a 50-mile radius accessibility to at least 1 periodontist.

Figure 2 shows US county-specific population counts for adults with severe periodontitis overlaid by numbers of periodontists. Overall, most periodontists (96.1%) were located in urbanized areas clustering around the East Coast, West Coast, and Midwest, whereas 3.1%

practiced in urban clusters, and 0.8% practiced in rural areas. The 6 greatest numbers of periodontists with practice locations clustered in the same location were 3 (n = 39, 27, 15) in Boston, Massachusetts; 1 (n = 17) in Gainesville, Florida; 1 (n = 14) in Richmond, Virginia; and 1 (n = 13) in Columbus, Ohio. In general, most locations (98.7%) include only 1 to 3 periodontists. State-level numbers of periodontists ranged from 5 each in North Dakota and Wyoming to 495 in New York to 785 in California.

Figure 3 illustrates county-specific ratios of the adult population with severe periodontitis to 1 or more periodontists according to the radius distances of 10 (Figure 3A), 20 (Figure 3B), and 50 (Figure 3C) miles. Communities with ratios of 1 periodontist to fewer than 8,000 adults within a 10-mile radius were clustered mostly in the Northeast, central East Coast, Florida, the West Coast, Arizona, and the Midwest. Communities with ratios of 1 periodontist to fewer than 8,000 adults within 50 miles were distributed widely across the United States, including central US states and counties.

DISCUSSION

To our knowledge, this is the first study of the geographic proximity of adults with severe periodontitis and their ratios to periodontists in the United States. Overall, most periodontists practiced in urbanized areas and covered approximately 95% of adults with severe periodontitis within a 10-mile radius. In contrast, approximately 4% of all periodontists practiced in urban clusters or rural areas and covered approximately 20% of adults with periodontitis within 10 miles. However, approximately 90% of adults in rural areas were within a 50-mile radius of a periodontist. The findings of this study are consistent with the Health Resources and Services Administration determinations that most rural areas are Health Professional Shortage Areas.[33]

The Health Resources and Services Administration National Center for Health Workforce Analysis specifically concludes that all 3 key dental professionals (dentists, dental hygienists, and dental assistants) have significantly lower per capita numbers of practitioners practicing in rural areas where only 11% (18,673 of 168,299) of the dentists were located, with only 3.6 dentists per 10,000 rural inhabitants versus 5.9 per 10,000 in urban areas.[34] In particular, the shortage of general dentists in these rural areas could affect periodontal care further because they typically see the patient first and then recommend the patient to see a periodontist, either immediately when the patient seeks care for severe bone loss and advanced or severe periodontitis or when the initial periodontal treatment is not successful. According to the 2010 US Census, approximately 19.3% of the US population lived in rural areas and the remaining 80.7% in urban areas, with 71.2% in urbanized areas and 9.5% in urban clusters.[22]

The prevalence of oral diseases in adults is consistently greater in rural than in urban areas.[23] Typically, adult populations in rural areas are at higher risk of developing periodontitis because they are older; have high proportions of racial and ethnic minorities and people of low socioeconomic status; have low oral health literacy levels, particularly awareness of periodontitis; and have higher rates of disabilities, diabetes, and smoking. Notably, the cost of medical and dental treatment, as well as logistics, such as transportation and longer travel

time, can be extra challenging for rural adults[35] who often are covered only by Medicare, which does not include coverage for any dental treatment.

Adult populations in urban clusters defined as multiple census blocks with combined populations of 2,500 to 49,999 had lower proximity to a periodontist than did adults living in rural areas. This finding is unexpected and indicates a hitherto unknown gap in access to periodontal specialist care in geographic areas with this population density characteristic. Geographic proximity can constitute an important factor modulating access and disparities in specialized periodontal care within populations. Also, understanding local and community-level proximity to care is important for community health needs assessments for planning and improving community-based intervention programs. Although outside of the scope of this study, it might be interesting to overlay geospatial data with socioeconomic status in the various population clusters in a future study to determine the availability of periodontists for those who are most likely to need advanced periodontal care.

The buffer zone methodology we used in this study is a strength because it involves using defined distance zones, which avoids problems when aggregating data according to existing census geographic units, such as states and counties, which vary in size and population heterogeneity. The buffer approach also accounts for potential cross-boundary health care seeking behaviors that are not confined within geopolitical boundaries, especially for residents in isolated rural areas, for those living near county or state boundaries, or for those seeking more specialized care at regional medical centers. However, because we used Euclidean distance as a proxy for travel distance, geographic accessibility to a periodontist at various distances may be overestimated in rural or mountainous areas where road networks are more limited and less straight than in urban areas.

There are limitations to consider for the NPI from the Centers for Medicare & Medicaid Services, which include potential under- or overestimates of periodontal practice data sets, compared with other data sets, such as information from membership lists from the American Dental Association or the American Academy of Periodontology. All registered health care providers must obtain a unique NPI number and provide only 1 location address to facilitate electronic transmission of claims and other health care information. Hence, the public use NPI Registry does not provide information about multiple practice sites, the periodontist’s age or race or ethnicity, the proportion of time spent distributed between care provision at the office or practice, or hospital versus administrative duties, research, or teaching—all factors that can affect the availability of a periodontist to treat patients and thereby can affect the likelihood that an adult with periodontitis will seek care from the nearest periodontist.

In addition, we note a limitation of our model estimates for periodontitis at the state and local levels. Although the performance of our model has been validated at the national level by using NHANES data, any similar validation against state and local geographic levels has not been performed because clinical estimates of periodontitis prevalence at these levels are unavailable. Finally, our calculations in this report are based on periodontal examination data from the 4 years of NHANES from 2009 through 2012 published in 2015.[5] After we conducted these analyses, we reported the estimated prevalence of periodontitis on the basis

of all 6 years during which the clinical periodontal measures were recorded—namely, 2009 through 2014.[36] However, the differences between the estimates for the first 4 years presented in this article and for all 6 years are minimal and do not influence the results and our conclusions in this article.

CONCLUSIONS

The findings from this study can provide information for statewide and local oral health programs about areas presenting potential challenges regarding access to specialist periodontal care because of reduced proximity to a periodontal practice. These findings thereby can help identify areas in need of facilitating interactions between at-risk populations and community and clinic resources to prevent, manage, and treat periodontitis. ■

ABBREVIATION KEY

NHANES	National Health and Nutrition Examination Survey.
NPI	National Provider Identifier.

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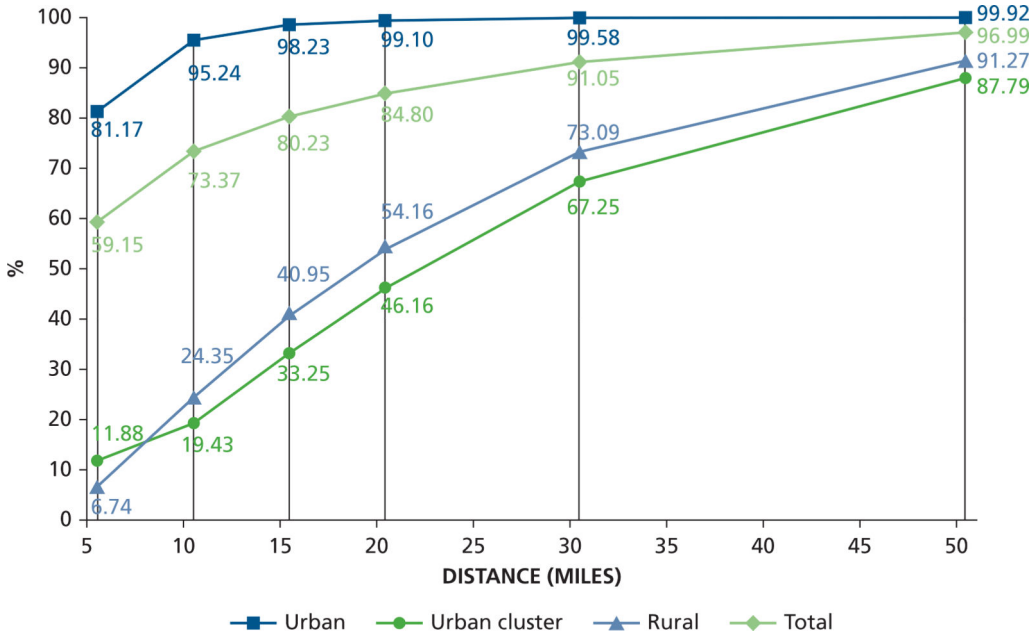

Figure 1.

Proportion of the US population aged 30 through 79 years with access to at least 1 periodontal practice.

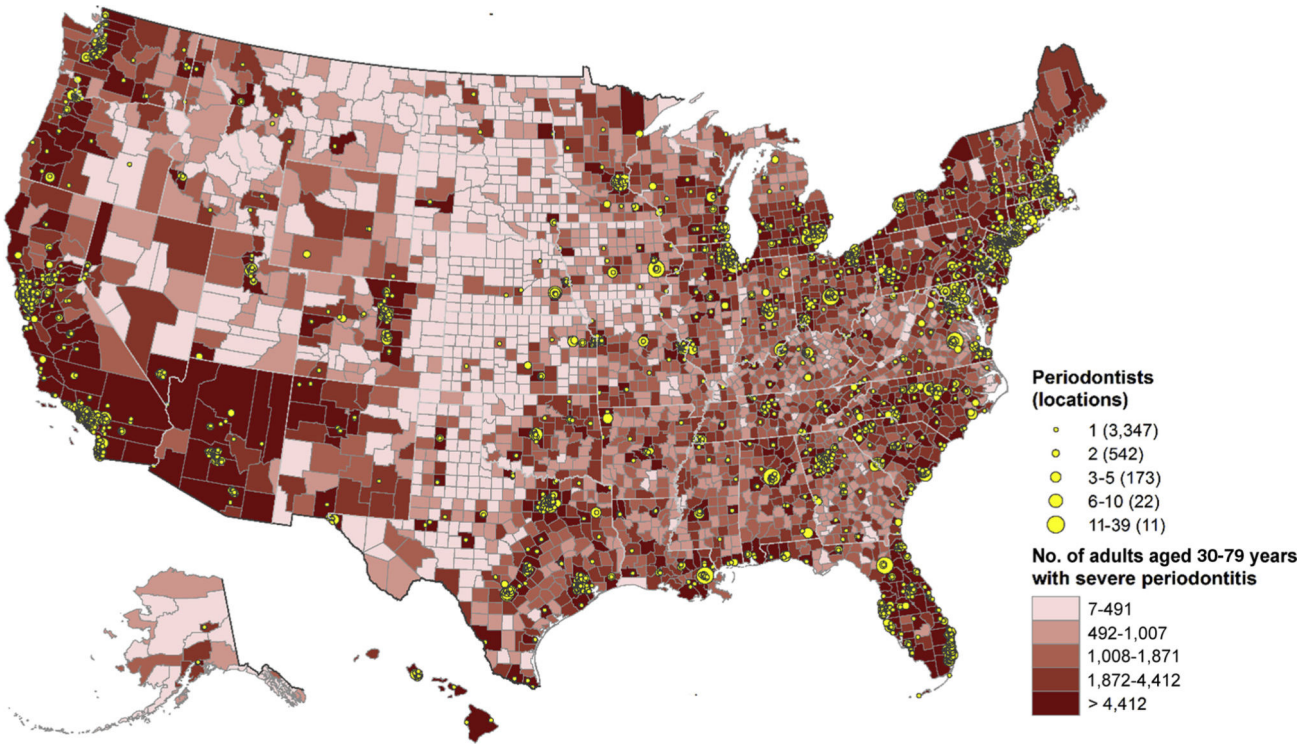

Figure 2.
Periodontists' locations overlaid with county estimates of the number of adults aged 30 through 79 years with severe periodontitis, United States, 2012.

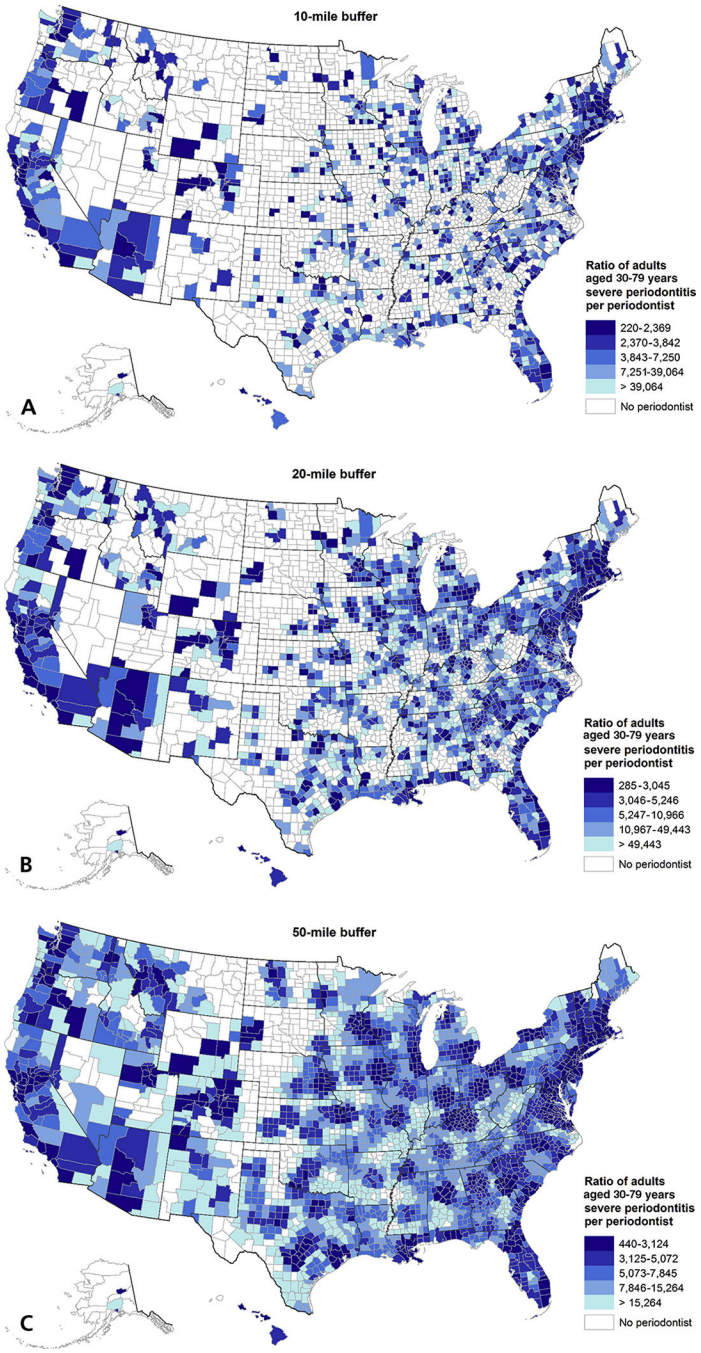

Figure 3.

Ratio of adults aged 30 through 79 years with severe periodontitis per periodontist within a 10- (**A**), 20- (**B**), and 50- (**C**) mile radius, according to county, United States, 2012.