ACCESS TO ORAL HEALTH CARE IN NORTH CAROLINA: DEMOGRAPHIC AND GEOGRAPHIC TRENDS FOR THE PEDIATRIC, ORTHODONTIC, AND GENERAL DENTAL PRACTITIONER WORKFORCE

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ABSTRACT

James P. Martin: Access to oral health care in North Carolina: Demographic and geographic trends for the pediatric, orthodontic, and general dental practitioner workforce
(Under the direction of Ceib Phillips)

Introduction: Access to oral health care is a challenge for many. The purpose of this study was to assess the demographics and distribution of general dentists, orthodontists, and pediatric dentists in North Carolina over the last 30 years. **Methods:** Practitioner data were obtained from the N.C. Health Professions Data System, and county population data were obtained from the N.C. State Data Center. **Results:** There was a substantial increase in practitioner gender and racial diversity, though increased racial diversity was limited almost exclusively to metropolitan counties. Overall practitioner/patient ratios were higher in 2010 than 1990. However, these ratios were consistently higher in metropolitan counties than non-metropolitan counties. Mean age of general dentists and orthodontists increased each year, and in 2010 practitioners in non-metropolitan counties had higher average ages than those in metropolitan counties. **Conclusions:** Rural and underserved counties may have increased generalist and specialist workforce shortages in the near future.

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ADEX	American Board of Dental Examiners
CBSA	Core Based Statistical Area
CITA	Council of Interstate Testing Agencies
ECU	East Carolina University
GP	General Dental Practitioner
HPSA	Health Professional Shortage Areas
HRSA	Health Resources and Services Administration
LINC	Log Into North Carolina
LSU	Louisiana State University
MSA	Metropolitan Statistical Area
NC	North Carolina
NCHPDS	North Carolina Health Professions Date System
NCSBDE	North Carolina State Board of Dental Examiners
NHSC	National Health Service Corps
PHPSA	Persistent Health Professional Shortage Area
UAB	University of Alabama Birmingham
UNC	University of North Carolina

ACCESS TO ORAL HEALTH CARE IN NORTH CAROLINA: DEMOGRAPHIC AND GEOGRAPHIC TRENDS FOR THE PEDIATRIC, ORTHODONTIC, AND GENERAL DENTAL PRACTITIONER WORKFORCE

Introduction

This thesis document contains two manuscripts. Both manuscripts focus on the demographic and distributive patterns general dentists, orthodontists, and pediatric dentists in North Carolina. These three practitioner groups play a distinct and essential role on the dental team, especially in regards to oral health care for children. The first manuscript examines dental workforce trends for these groups in North Carolina over a 30 year period, while the second manuscript focuses on patterns within the state in 2010. Both manuscripts use county classifications to differentiate between urban and rural counties, examine practitioner location to population ratios at a county level, and apply mapping technologies to create a graphical representation of the dental workforce.

ACCESS TO ORAL HEALTH CARE IN NORTH CAROLINA: TEMPORAL CHANGES IN PEDIATRIC, ORTHODONTIC, AND GENERAL DENTAL PRACTITIONER CHARACTERISTICS AND PATIENT/PRACTITIONER RATIOS

Introduction

Oral health care is an essential component of an individual's overall health and wellness (1). Community environment can have a major impact on an individual's ability to access oral health care. Individuals living in rural areas far from urban or metropolitan centers encounter geographic barriers which limit access to health care personnel and facilities, and health disparities between the rural and urban populations have been extensively described in the literature (2, 3). Trends in health-related expenditure and health care professional workforce coverage are not encouraging, showing an increasing disparity between rural and urban health care resources (2). Rural adult residents are less likely to visit a dentist than their urban counterparts and are more likely to be episodic users of dental care (4). Availability of a dental workforce appears to play a significant role, with increased dentist to population ratios being related to higher rates of oral health care utilization (5). Geographic disparity in dental workforce is prevalent throughout the United States, and there are approximately 33% more dentists in metropolitan areas than in rural areas (6), a disparity which has been documented in other state-specific studies completed in Kentucky (7), California (8), Iowa (9), Mississippi (10), Illinois (5), Kansas (6), and Ohio (11).

North Carolina is a notably rural state. According to the US Census Bureau, in 2010 North Carolina (NC) had the second highest number of rural residents (behind only Texas) (12).

And North Carolina has been reported as having a much smaller than average dental workforce in comparison to other states. For example, in 2007 North Carolina was reported as having the 4th lowest (tied with Georgia) dentist-to-population ratio at 4.5 dentists per 10,000 people, in comparison to the national average of 6.0 dentists per 10,000 people (13). In non-metropolitan counties in North Carolina in 2007, there were 3.0 dentists per 10,000 people (as compared to a 4.9 per 10,000 people in metropolitan counties). In fact, in 2009 four counties in northeastern North Carolina did not have any active dentists at all (14).

While the disparity in distribution of dentists in North Carolina is well documented (14), there is little information on the status of the dental workforce in the state with regards to specialists. In 2009, dental specialists made up 22% of the North Carolina dental professional population (14). 247 orthodontists comprised 6% of all dental practitioners, while 153 pediatric dentists comprised 4% of all dental practitioners (14). A search of the literature found minimal existing demographic information for these specialty practitioners in North Carolina.

The goals of the project were to determine the demographic and distribution patterns of oral health care providers for the three largest dental practitioner groups (general dentists, orthodontists, and pediatric dentists) in North Carolina over a 30 year period, relate these trends to North Carolina's population changes at a county level, and graphically represent these changes using mapping technologies.

Methods and Materials

This cross-sectional study assessed the demographic and practitioner location characteristics of general dentists, orthodontists, and pediatric dentists in active practice in North Carolina in 1990, 2000, and 2010. Data was obtained from the North Carolina Health

Professions Data System (NCHPDS), maintained by the Cecil G. Sheps Center for Health Services Research at UNC-Chapel Hill. The NCHPDS maintains annual licensure files obtained from the North Carolina State Board of Dental Examiners (NCSBDE) and has continuous data from 1979 for dental professionals (15). Permission was obtained from the executive director of the NCSBDE to use the data for this project and the project was approved by a Biomedical Institutional Review Board.

For each practitioner, demographic data including sex, race/ethnicity, state in which dental degree was awarded, and age were obtained. Data collected by the NCSBDE changed slightly throughout the three time points. In 1990 and 2000, race/ethnicity options were White, Black, American Indian, Asian, and Other. In 2010, Hispanic was added. Additionally, county locations for the primary and any alternate/satellite offices were recorded for each practitioner. In 1990, practitioners were only able to record their primary office location, while in 2000 six additional satellite locations could be listed, and in 2010 practitioners were permitted to list seven satellite locations.

County population data were obtained from publicly available data provided by the North Carolina State Data Center. The NC Office of State Budget and Management serves as the lead agency for the State Data Center, and maintains an online system of most frequently requested data items called Log Into North Carolina (LINC) (16). County census information for total population in 1990, 2000, and 2010 was collected from the LINC data system, which can be accessed at http://linc.state.nc.us.

Practitioner location to population ratios were calculated by comparing the total practice locations (primary location + satellite locations) for practitioners with the population of each

county, and represented as dental practitioner practice locations per 10,000 population. Primary location information (indicating a dental professional's main office) was used to calculate 1990 practitioner/population ratios, and total practice counts were also taken into account for a calculation of location/population ratios, reported for 2000 and 2010 in the figures as "total location to population ratios".

Counties were classified as metropolitan or non-metropolitan using the Metropolitan Statistical Area classification developed by the US Census Bureau Office of Management and Budget (17). Metropolitan Statistical Areas (MSA) "have at least one urbanized area of 50,000 or more population, plus adjacent territory that has a high degree of social and economic integration with the core as measured by commuting ties (17)." In 2003, MSA classifications were discontinued and were replaced by CBSA (Core Based Statistical Area) classifications (18). However, the MSA status of North Carolina's 100 counties did not change between 1990 and 2000. Therefore, to keep the metropolitan and non-metropolitan classifications consistent with the classifications that were valid for 1990 and 2010, the previous MSA classifications were used for the 2010 data.

Descriptive statistics for practitioner demographic and practice characteristics were calculated by year, practitioner type, and MSA status using SAS version 9.2. Practitioner location to population ratios were also calculated. Maps were fabricated using MapInfo Professional 8.0 (Pitney Bowes) software.

Results

Temporal Changes in General Dentist Location Counts and Ratios

The total number of GP locations increased from 1990 to 2010 (Table 1). However, because of population increases during that time frame, the ratio of practice locations per 10,000 population did not change substantially. Only a slight increase in the ratio (+0.33) occurred even though 1254 locations were added (Table 1). Forty-three counties had a positive ratio change, while 54 counties had negative ratio changes (Map 1). Orange County had the highest total ratio in all years. In 1990 and 2000, there were 4 counties (Tyrell, Hyde, Camden, and Jones) with no GPs (or dentists of any specialty). In 2010, Tyrell, Hyde, and Camden sill had no GPs and Gates had lost all the GPs who had practiced in that county, leaving a total population 32,394 without access to a dentist in their county. Table 2 shows that while metropolitan counties had an increase in location ratios each decade (3.47, 3.75, and 3.94 respectively), the ratios decreased from 1990 to 2010 in non-metropolitan counties (2.78, 2.59, and 2.71). The difference between the metropolitan and non-metropolitan ratios widened each decade from 0.69 in 1990 to 1.23 in 2010.

Temporal Changes in Orthodontist Location Counts and Ratios

Between 1990 and 2010, 188 total orthodontist locations were added, and the total location ratio increase was +0.12 (Table 1). The number of orthodontist locations increased from 1990 to 2000 in metro and non-metro areas but there was no increase in non-metro counties from 2000 to 2010. Location ratios in both metropolitan and non-metro counties were slightly greater in 2000 (0.52 vs 0.25) than 2010 (0.45 vs 0.22), and the difference between the metropolitan and non-metropolitan ratios in 2010 was nearly the same as in 1990 (Table 2). 41 counties had a positive orthodontist ratio change throughout from 1990 to 2010, while 14 counties had negative ratio changes (Map 2). In 1990, there were 51 counties without any orthodontist locations, and the total population of these counties was 1,235,571. In 2000, there were 40 counties without

any orthodontist locations, and the total population of these counties decreased to 1,201,270. In 2010, the number of counties without an orthodontist location increased to 48, and the total population of these counties increased substantially to 1,472,712.

Temporal Changes in Pediatric Dentist Location Counts and Ratios

The availability of pediatric dentist locations increased substantially from 1990 to 2010, with the total location count in 2010 over triple the count in 1990. The count nearly doubled from 83 in 2000 to 165 in 2010. However, when combining data from all counties, the total location per 10,000 total population ratio change was only +0.09, with an overall increase of 114 total locations (Table 1). Pediatric practitioner count increased in all years in metropolitan counties. In non-metropolitan counties, the count over tripled between 1990 and 2000, only to decrease slightly between 2000 and 2010. Metropolitan and non-metropolitan ratios in 2010 were over double the 1990 ratios, and in 2000 non-metropolitan ratios were nearly equal with metropolitan ratios. However, there was a substantially larger difference between metropolitan and non-metropolitan ratios in 2010 than in 1990 (Table 2). 30 counties had a positive pediatric dentist location ratio change, 6 counties had negative ratio changes, and 64 counties did not have a practitioner in 1990 and 2010 (Map 3). In 1990, there were 79 counties without any pediatric locations, and the total population of these counties was 3,240,151. In 2000, there were 65 counties without any pediatric dentist locations, and the total population of these counties was 2,592,752. In 2010, the number of counties without a pediatric dentist location increased to 66, and the total population of these counties was 2,904,722,

Temporal Changes in General Dentist Demographic Characteristics

Overall mean age of general dentist practitioners increased every year (Figure 1), and the percent of counties with a GP with mean age over 50 increased from 7.3% in 1990 to 52.08% in 2010 (Figure 2). The difference in age between non-metro counties and metro counties grew each year (Figure 3). Of the 95 counties with a general dentist in 1990 and 2010, 75 counties had increases in average general dentist age (Map 4).

The general dentist practitioner population increased in percentage of non-white practitioners by 9.14% from 1990 to 2010 (Figure 4). As a percentage of the whole GP population from 1990 to 2010, White percentages decreased, Black slightly increased, and American Indian remained nearly level; Asian and Other had the largest percentage increase. Hispanic practitioners were not recognized in 1990 or 2000, so 2010 is the first record of a Hispanic GP (Figure 5). White GPs were the largest racial/ethnic group by percentage in non-metropolitan and metropolitan areas in all years, followed by Black GPs, while Asian GPs were third in metropolitan areas in all three years (and 2010 non-metro) (Figure 6). As a percentage of their own racial groups, in non-metropolitan areas from 1990 to 2010 White percentage slightly declined, while Black percentage, Asian percentage, and Other percentage declined at a far faster rate (Figure 7).

In 1990, females made up 8.11% of the GP population, and by 2010 they had increased to 24.93% (Figure 8). Within their own sex, percentage of females in non-metropolitan counties decreased at a similar rate to males, though there were more males in both non-metropolitan and metropolitan counties than females. In 2010, 83.01% of females were in metropolitan counties, compared to 74.50% of males (Figure 9).

Temporal Changes in Orthodontist Demographic Characteristics

The overall mean age of orthodontists increased every year (Figure 1), and the percent of counties with a practitioner with mean age over 50 increased from 16.33% in 1990 to 63.46% in 2010 (Figure 2). Orthodontist age in non-metropolitan counties was greater than metropolitan counties in every year except 1990. Between 1990 and 2000, the average age of orthodontists in non-metropolitan counties increased by nearly 10 years (Figure 10). There were 46 counties with an orthodontist in 1990 and 2010, and 39 had increases in the average orthodontist age (Map 5).

For orthodontists, percentage of non-white practitioners increased by 7.08% from 1990 to 2010 (Figure 4). There were only two ethnic groups represented in 1990 (White and Black). No American Indian practitioners were present in any year, and the only Other practitioner was in 2000. One Hispanic practitioner was recorded in 2010. From 1990 to 2010, the White percentage decreased, while Black percentage and Asian percentage (Asian practitioner first recorded in 2000) increased substantially (Figure 11). Whites comprised the majority group in metropolitan and non-metropolitan areas. Besides two Black practitioners in 2000, Whites were 100% of non-metropolitan areas in all years (Figure 12). As a percentage of their own ethnic group, Whites had an increase in percentage in non-metropolitan areas from 1990 to 2010, the only ethnic group with such an increase in the orthodontic specialty.

In 1990, females made up 4.02% of the orthodontist population, and by 2010 they had increased to 14.80% (Figure 8). There were no female practitioners in non-metropolitan counties in 1990, and only 1 in 2000; though the number increased to 8 in 2010. Within their own sex, percentage of females in non-metropolitan counties in 2010 (21.62%) was greater than males (19.25%) (Figure 13).

Temporal Changes in Pediatric Dentist Demographic Characteristics

Mean age of pediatric dentists in metro and non-metro counties increased from 1990 to 2010 (Figure 1), though there was a decrease between 2000 and 2010, a trend not observed in orthodontists or GPs. The percent of counties with a practitioner with mean age over 50 increased from 9.52% in 1990 to 32.35% in 2010 (Figure 2). Non-metropolitan age was greater than metropolitan age in 2000 and 2010 (Figure 14). Of the 19 counties with a pediatric dentist in 1990 and 2010, 16 counties had increases in average pediatric dentist age (Map 6).

Pediatric dentists saw the largest percentage non-white practitioner increase from 1990 to 2010 (17.82%) compared to the other specialties (Figure 4). Whites were the most represented group in pediatric dentistry in all years in metropolitan and non-metropolitan areas, though the percentage of total decreased from 92.16% to 74.34% from 1990 to 2010. One Hispanic practitioner was recorded in 2010. Comparing 1990 to 2010, Asian percentage decreased from 3.92% to 1.32%, while Black practitioner percentage saw a large increase from less than 2% to greater than 20% of all pediatric dentists (Figure 15). The non-white percentage in non-metropolitan areas was high in 1990 (28.57%), and by 2010 it decreased to 15.79% (Figure 16). As a percentage of their own ethnic group, Whites had an increase in percentage in non-metro areas from 1990 to 2010, the only ethnic group with such an increase in the pediatric specialty.

In 1990, females made up 7.84% of the pediatric population, and by 2010 they had increased to 48.30% (64 female practitioners were added between 2000 and 2010) (Figure 8). In 2010, 90.41% of female practitioners were in metropolitan counties, compared to 84.81% of male pediatric dentists (Figure 17).

Discussion and Conclusions

One limitation of this study is that specialty classifications for dentists were entirely self-reported at the time of their dental license renewal. Another limitation is that data acquisition was limited to all practitioners reporting as "active"; hours worked per week information was not analyzed, and there was no information available about the amount of time spent at each listed satellite location. This information could have differentiated practitioners based on the amount of patient care time they provide in a certain area; other studies have further classified practitioners into "full-time equivalent dentists" (6).

The location/population ratios used in this study were calculated using both the practitioner's primary location and any satellite locations, resulting in what we termed "total locations". This calculation was used throughout the project, as we felt it more accurately represented the wider distribution of patients that each practitioner was treating at all locations. However, since no satellite locations were recognized in 1990, using "total locations" for 2000 and 2010 most likely resulted in an underestimation of the dental workforce in 1990 compared to the other two years. Also, numerous satellite locations within one county will overestimate the number of practitioners in that county. For any reporting of practitioner demographic information (sex, age, and race) by metropolitan county, only the practitioners primary location was taken into account. This may have skewed the practitioner demographics for a specific county that has numerous satellite locations but few primary locations.

This study utilized the Metropolitan Statistical Area classification developed by the US Census Bureau Office of Management and Budget (17). In 2003, MSA classifications were discontinued and were replaced by CBSA (Core Based Statistical Area) classifications (18). However, the MSA status of North Carolina's 100 counties did not change between 1990 and 2000. Therefore, to keep the metropolitan and non-metropolitan classifications consistent with

the classifications that were valid for 1990 and 2010, the previous MSA classifications were used for the 2010 data.

The variable Metropolitan Statistical Areas was used in this study, though numerous other measures of community-level characteristics in the United States exist such as population density, urban/rural areas (developed by the US Census), Metropolitan Areas and Core-Based Statistical Areas (developed by White House's Office of Management and Budget), Urban Influence Codes and Rural-Urban Continuum Codes (developed by the Economic Research Service of the US Department of Agriculture), and rural-urban Commuting Area Codes (developed in part by the USDA) (19). Use of more than one of these diverse systems of community designations are often useful to discover hidden heterogeneity in the data, sometimes revealing increased health disparities in specific areas (19).

Newer methods of assessing the practice-to-population ratios include utilizing geo-coding technologies (GIS) to map the location of each practice, entering geographic boundary data for each collection district, and analyzing population characteristics for each district (20). Also, arguments have been made that analysis by census tracts, ZIP codes (21), or state-specific Medical Study Service Areas (8) can be a more meaningful for these access issues.

Another limitation results from the fact that patients may cross county lines to receive care (especially if adjacent to a metropolitan county), and the resultant physician-to-population county ratios may be misleading (22). There is evidence that residents are willing to travel outside of their county of residence to be seen by a health professional, and non-metropolitan residents are twice as likely to travel to another county to see their physician (23). Rosenthal et al. implore researchers to be cautious about measures used to study health professional supply

and distribution, and suggest using more sophisticated measures like an analysis of the distance to the nearest physician and simulated primary care physician caseloads (22).

Our study reports that there is an upward trend in the location ratios for general dentists and pediatric dentists. For orthodontists, the decrease in location ratio from 2000 to 2010 can be mostly attributable to the high number of alternate locations in 2000 (149) and the lower alternate location count in 2010 (112). The percent increase in practitioner count and location ratios is greatest for pediatric dentists, which is consistent with reports showing pediatric dentistry as North Carolina's second fastest growing specialty (behind public health dentistry) (24). Though this increase has been significant, the ratio of pediatric dentists to children is still lower than the US average. According to Nainar and Feigal, in the United States in 2000 there were 4.03 pediatric dentists for every 100,000 US children younger than 18 years of age. They found that North Carolina had 65 pediatric dentists for an under-18 population of 1,964,047, resulting in 3.31 practitioners for every 100,000 children, a ratio that ranks 36th of all fifty states and DC (25). This practitioner number and ratio is lower than our count for that year (75 practitioners and 3.819 ratio), but their study only included AAPD active and fellow members.

Our study found a substantial disparity in practitioner count and location ratios between metropolitan and non-metropolitan counties. This finding is concordant with other state specific studies which have documented the lack of presence of dental practitioners in rural areas (7, 9). For each specialty, the difference in ratios is easily appreciated, and GP non-metropolitan ratios are lower in 2010 than in 1990. This widening gap in dentist/population ratios in metropolitan/non-metropolitan counties agrees with a study looking at NC dentist/population ratios from 1993 to 2010 (24).

Though the statewide general dentist location/population ratio increased every year, the increase appears to have been selective to several counties. Between 1990 and 2010 more counties decreased in location ratios than increased . In 2010 four counties in eastern North Carolina did not have a general dentist (or dentist of any kind). Two of those counties (Tyrrell and Camden) have not had an active dentist since data collection began in 1979, Hyde County has not had a dentist since 1989, and Gates County did not have an active dentist from 2005 to 2011 (24). While few counties saw an orthodontist location ratio decrease from 1990 to 2010, the total population of counties without an orthodontist increased from 1,235,571 to 1,472,712 over the thirty year period. The pediatric dentist workforce saw several positive trends, as counties without a pediatric dentist decreased from 79 in 1990 to 66 in 2010, and the population of counties without a pediatric dentist dropped from 3,240,151 to 2,904,722. However, even in 2010 many counties still did not have an orthodontist or pediatric dentist.

Average practitioner age is increasing, though the trend is most pronounced for orthodontists and least for pediatric dentists. Also, non-metropolitan dentists tend to be older than their urban counterparts. Other states have seen an increase in dental practitioners' ages over the last several decades, which has been partially attributable to the large dental class sizes in the 1970s (9). These older dentists are closer to retirement than their younger colleagues, and counties with higher average aged dentists like eastern North Carolina are at risk of losing even more dentists if a replacement is unable to be found (24). Another likely contributing factor is that dentists are delaying retirement after the 2007-2008 economic recession, and may be on the brink of retirement (24), further exacerbating workforce issues in the near future.

The dental workforce experienced substantial racial/ethnic diversity from 1990 to 2010, with pediatric dentistry having the highest percent increase (17.82%) in non-white practitioners

during that timeframe. Our results are coincident with another study that found that dentists were 16% non-white in 2009 compared to a 33% non-white NC population. This minority percentage for dentists is comparable to the other health care professionals in the state (26).

This increase in diversity has been seen most prominently in metropolitan counties. The percentage of non-white practitioners has been increasing rapidly in metropolitan counties but has held virtually constant for GPs and pediatric dentists from 2000 to 2010. For orthodontists, there were no non-white practitioners in any non-metropolitan county in 2010. Additionally, there has been a rapid decline of the two largest non-white racial/ethnic groups (Black and Asian) in non-metropolitan areas. This trend has been noted in other health professions, as a NC health workforce study found that in 2009, 79% of all non-white health professionals were located in metropolitan counties, with half located in Mecklenburg, Wake, Durham, Guilford, Forsyth, Pitt, and Cumberland counties (26).

There has also been a major increase in the percentage of female GPs, orthodontists, and pediatric dentists. From 1990 – 2010, pediatric dentists saw the largest increase in female practitioner percentage (40.19%), and females comprised nearly half (48.30%) of the entire pediatric dentist population in 2010. However, as a percentage of their own sex, males tended to be in non-metropolitan counties more than females (with the exception of 2010 for orthodontists), a trend which has been noted in other studies (24). The impact of females on the dental workforce is still debated. There is some evidence that male dentists work more hours per week and are less likely to be part-time (27), though a 2010 study in NC reported that dentists who are female work nearly the same average number of hours as men (24). The same study noted that female dentists are more likely to practice in metropolitan counties, and "increasing

proportions of female dentists may exacerbate the existing geographic maldistribution of the workforce (24)."

For all three specialties (GP, orthodontists, and pediatric dentists), there were also no alternate (satellite) locations in counties that did not have a primary location, despite the 4 (GP), 48 (orthodontist), and 66 (pediatric dentistry) counties that did not have a practitioner in 2010. This is surprising since these underserved counties seem like a prime location for a satellite practice.

The conclusions reached regarding the disparity in dental workforce between urban and rural areas is not specific to North Carolina, and has been studied in several other states. There are several reasons for said disparity. Rural individuals self-report lower levels of unmet need for dental care among adults, indicating a lack of preference for dental care among those populations (6). Coupled with low population densities, the result is that there is typically less demand for dental services in remote rural areas (28), reducing the economic attractiveness of those areas. The consequence is less oral health care supply and more untreated oral disease in the population (28).

Certain recent trends are not encouraging, as 2006 ADEA Survey of dental school seniors reports that over 2/3 of the class planned to practice in metropolitan areas with over 50,000 people, but that only 5% planned to practice in an area with less than 10,000 people (29). Solomon and Ceen found that the five most likely predictors of a viable orthodontic location in a certain ZIP code are a high number of general dental practices, high population, low percent of population without a high school diploma, high percent of the population with a college degree,

and a high median housing value (30). These descriptors are not highly characteristic of the rural communities that need dental care the most.

For North Carolina specifically, a decreasing number of dentists trained at the UNC School of Dentistry are staying in North Carolina after graduation. From 2003 to 2009, NC retention of UNC graduates declined about 20 percentage points to its current rate of 63%. This figure is actually higher than the 40% retention rate of the four NC medical schools (Wake Forest, Duke, East Carolina University, and University of North Carolina) (24).

These trends have not gone unnoticed, and this knowledge has contributed to the decision by the University of North Carolina's Board of Governors to establish a second dental school in the state at East Carolina University. Expansion of facilities at the University of North Carolina at Chapel Hill was also recommended to allow for an increase in class size from 80 to 100 students (31). East Carolina University accepts 52 students each year, will graduate its first class in 2015, and is limiting enrollment to residents of North Carolina (32). "ECU's plan to provide care and educate students in community-based settings around the state may also play an important role in improving distribution in rural counties (24)." A recent study used a projection model for North Carolina's dental workforce to forecast future supply. Taking into account the new dental school at East Carolina University (but not the delayed expansion of the UNC School of Dentistry), the ratio of dentists per 10,000 population will decrease from 4.4 in 2010 to 4.1 in 2020 (and without ECU the ratio would be 3.9) (24).

Additionally, recent changes in dental licensure requirements have the potential to bolster North Carolina's dental workforce. Licensure by credentials, which began in 2003, has allowed North Carolina to be a net importer of dentists in recent years. This program allows dentists who

have practiced in another state for 5 years to obtain a North Carolina dental license without taking another dental licensure exam (24). Recently the North Carolina State Board of Dental Examiners has included the ADEX dental examination (taken after 9/25/2013) as acceptable for licensure in addition to the CITA dental examination (33). Beginning in 2014, CITA will offer the ADEX examination for the 2014 testing season (34). The CITA examination itself was administered at four dental schools (UNC, UAB, LSU, and Puerto Rico) and recognized in 26 jurisdictions. In comparison, the ADEX examination is recognized in 45 jurisdictions (35) and available at 38 dental schools (comprising close to 70% of graduating dental students), making it the largest, most accepted dental examination in the nation (36). The administration of ADEX at NC dental schools (UNC and ECU) will allow graduating dental students at those schools easier access to licensure in more jurisdictions and therefore may lead to greater export of graduating UNC and ECU dentists. However, the acceptance of the ADEX examination by the NCSBDE and the ability of 70% of dental students to take the examination at their home school (instead of taking CITA at four schools in the Southeast) will likely lead to a net import of new dentists from around the country.

Of course, that does not necessarily mean that they will practice in rural locations. The financial disincentives are significant, and as the debt burden on young clinicians is growing ever larger (29), the economics of a practice location become more important. There are many types of policies in place to ensure equity for rural communities. Medicaid and Medicare are indirect policies which increase the demand for service and may act to redistribute the supply of health professionals. Other programs, such as the National Health Service Corps (NHSC), use loan forgiveness or tuition support to influence choice of practice locations (37).

In addition to the NHSC, there are several categories of state programs to redistribute health professionals to areas that are underserved. Three main categories are scholarships, loan repayment programs, and resident support. The first category provides financial support to a student/resident with service expected after training. The second category provides loan repayment incentives upon completion of education, and the third provides direct financial incentives to either graduating residents or practitioners (38). Loan repayment commitments are seen as an especially applicable program, as graduating residents and practitioners can make more informed practice commitments once their education has been completed or is nearing completion (38).

Clinicians are often attracted to underserved areas by state-sponsored loan repayment incentives. Some programs are state-funded, some are jointly state and NHSC-funded, and some feature direct financial incentives. In 2010, every state except Connecticut, Florida, Hawaii, Mississippi, Tennessee, and Utah offered at least one program. 3325 clinicians (including 406 dentists) are involved in these programs nationwide (39), up from 777 primary care clinicians in 1996 (38). In North Carolina alone, 235 clinicians were involved in loan-repayment plans (the third highest count of any state) (39).

Another strategy is to promote the profession to those likely to practice in rural areas. This study has documented the demographics of practitioners in non-metropolitan areas, though it becomes problematic to assume that a certain individual will conform to the patterns of their demographic. Alternatively, it appears that one of the most powerful factors in a new dentist's practice location is their place of rearing (40), the knowledge of which likely informed ECU's decision to accept only North Carolina residents as dental students. Lastly, areas with a low dental workforce could take steps to foster an interest in the profession in young people on

several levels, including high school and state colleges (41). This may promote a future dental workforce that may stay in the area (42).

The number of practitioners and the practitioner/population ratios increased for all practitioner groups from 1990 to 2010 in North Carolina. However, the disparity between non-metropolitan and metropolitan counties appears to be increasing for all practitioner groups, and an aging dental population (especially in non-metropolitan counties) will only exacerbate any workforce shortage those areas might have. Recent changes to licensure requirements and the opening of the dental school at ECU will most likely have a positive effect on the dental workforce as a whole, but the effect on the rural areas is less certain. Non-metropolitan counties may have increased generalist and specialist dental workforce shortages in the near future, which will likely impact the oral health of children and adults in the state.

Tables

Table 1 – Total Location Counts and Ratios (practitioners per 10,000 population)

	1990	2000	2010
Population	6.63M	8.04M	9.53M
GP Total Location Counts	2146	2712	3400
GP Total Location Ratio	3.24	3.37	3.57
Ortho Total Location Counts	174	347	362
Ortho Total Location Ratio	0.26	0.43	0.38
Pedo Total Location Counts	51	83	165
Pedo Total Location Ratio	0.08	0.10	0.17

Table 2 – Total Location Counts and Ratios by Metropolitan Classification (practitioners per 10,000 population)

	MSA Non-Metropolitan Counties			MSA Metropolitan Counties		
	1990	2000	2010	1990	2000	2010
Population	2.25M	2.61M	2.90M	4.38M	5.43M	6.64M
GP Total Location Counts	627	677	786	1519	2035	2614
GP Total Location Ratio	2.78	2.59	2.71	3.47	3.75	3.94
Ortho Total Location Counts	30	65	65	144	282	297
Ortho Total Location Ratio	0.13	0.25	0.22	0.33	0.52	0.45
Pedo Total Location Counts	7	25	19	44	58	146
Pedo Total Location Ratio	0.03	0.10	0.07	0.10	0.11	0.22

Figures

Figure 1 - Practitioner Mean Age

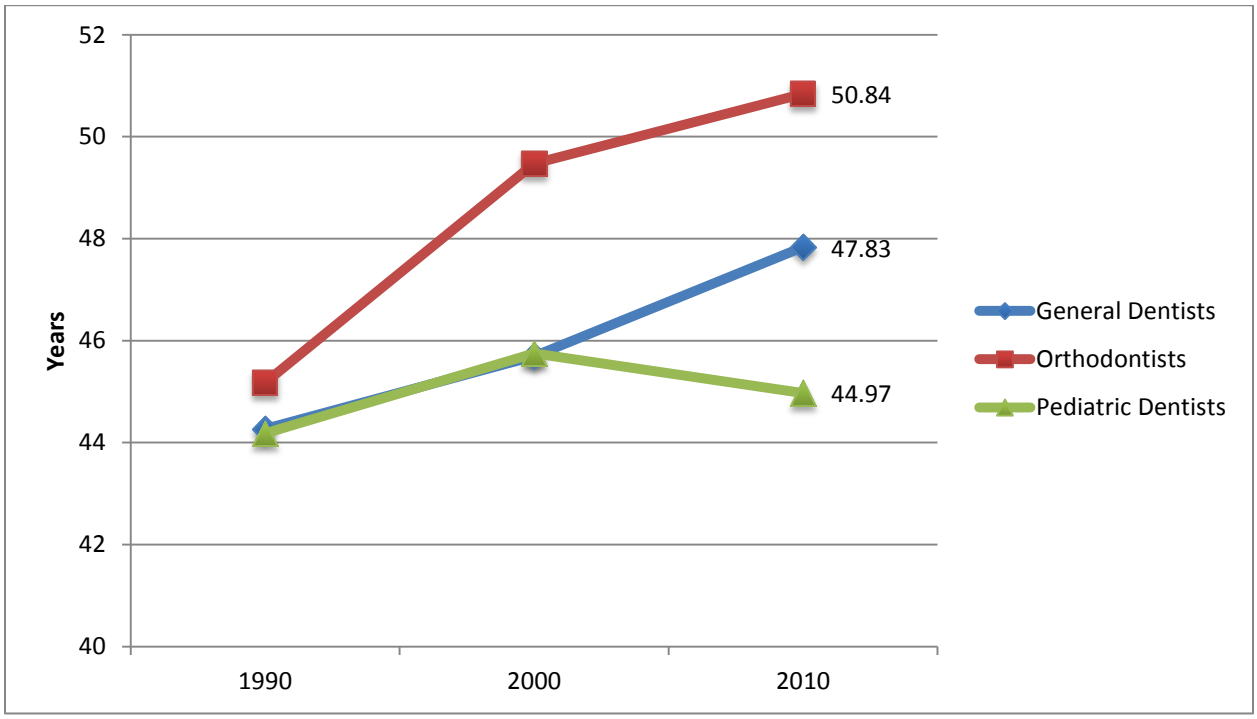


Figure 2 - Percent of Counties with an Average Practitioner Age of 50 + Years (counties with a practitioner)

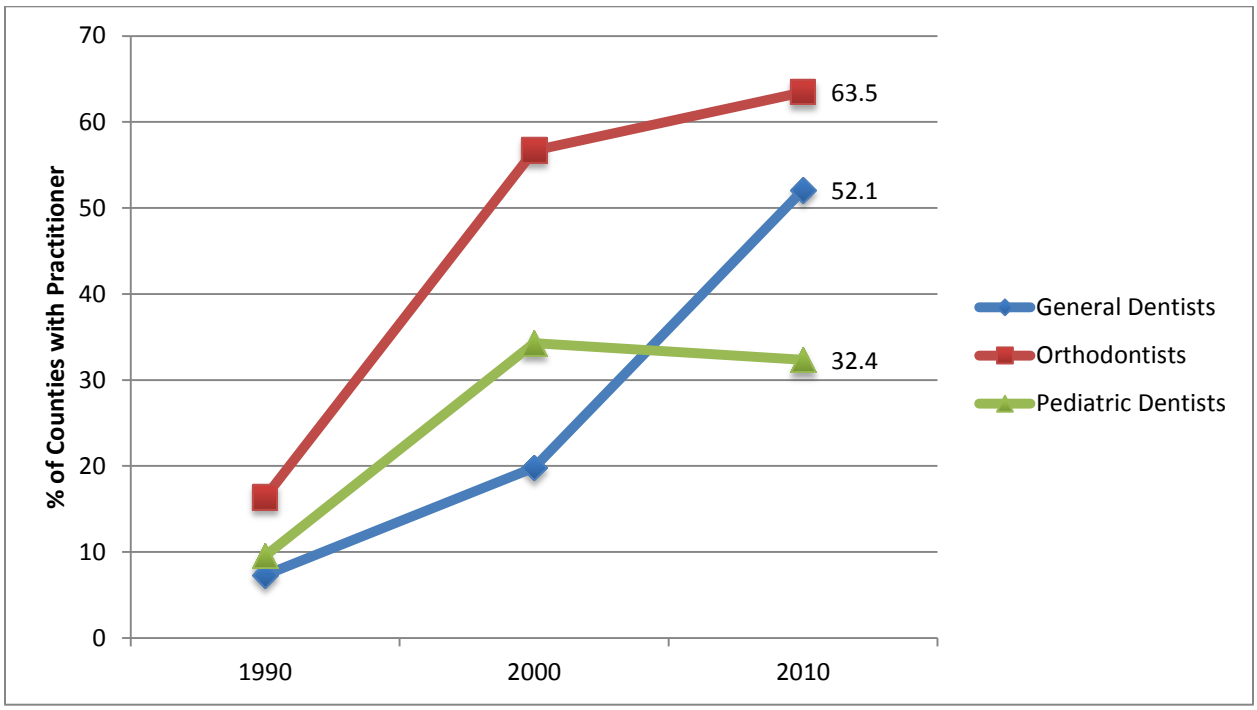


Figure 3 – General Dentist Mean Age by MSA County Classification

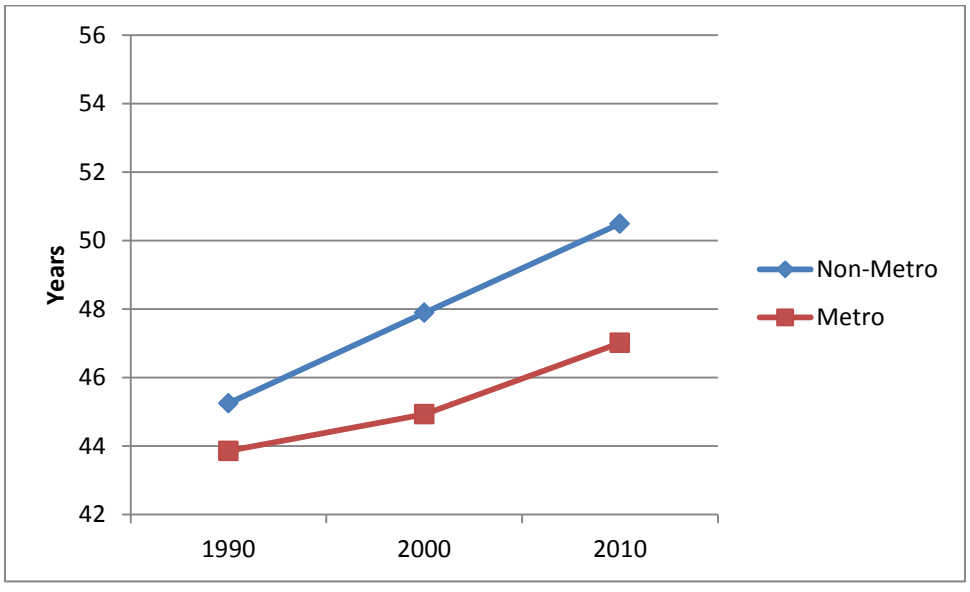


Figure 4 - Non-White Practitioners (as percent of own specialty)

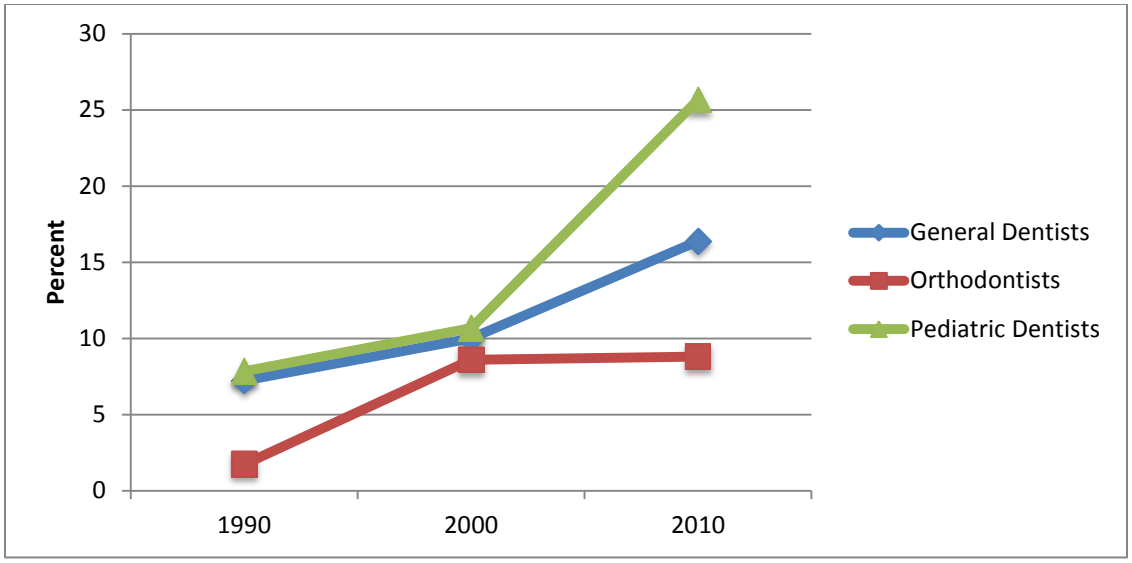


Figure 5 – General Dentist Race/Ethnicity

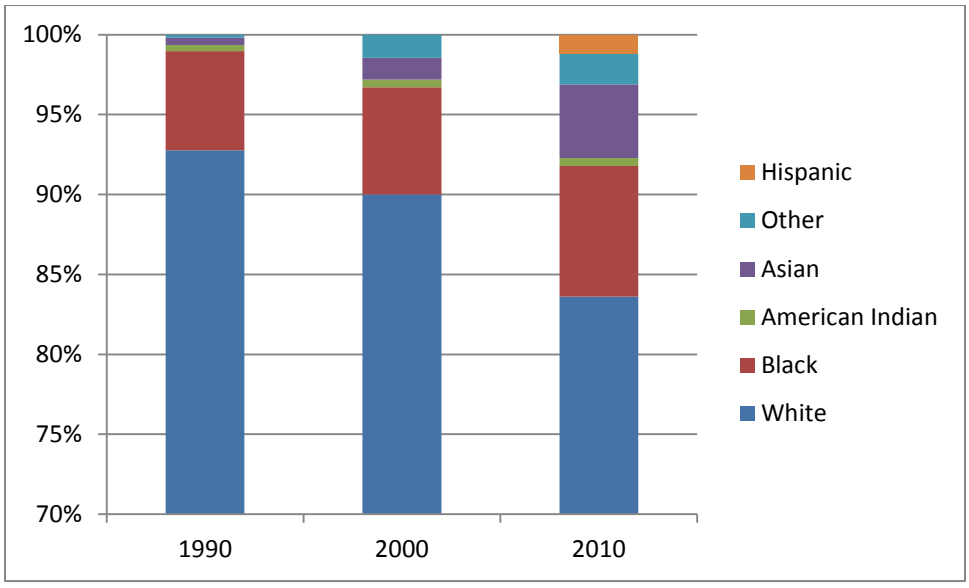


Figure 6 – General Dentist Race/Ethnicity by MSA County Classification

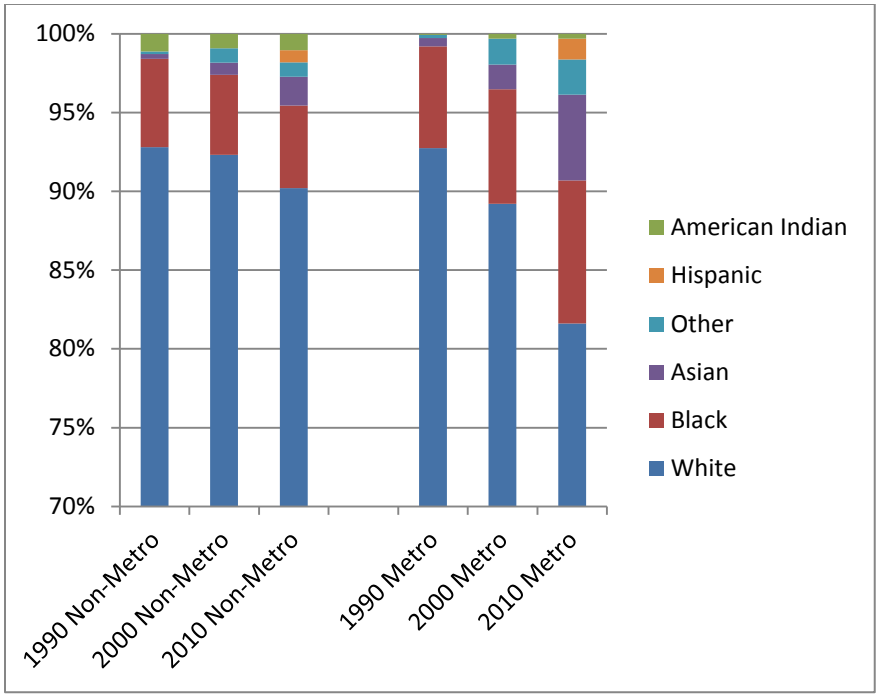


Figure 7 - General Dentist Race/Ethnicity in Non-Metro Counties (as percent of own race/ethnicity)

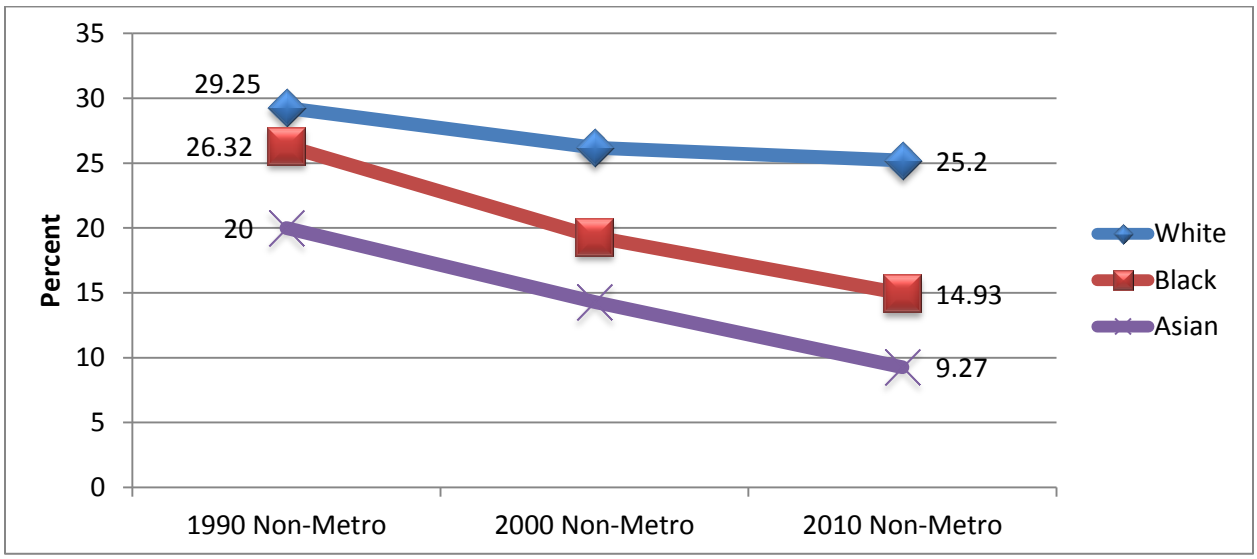


Figure 8 - Percent Female by Specialty

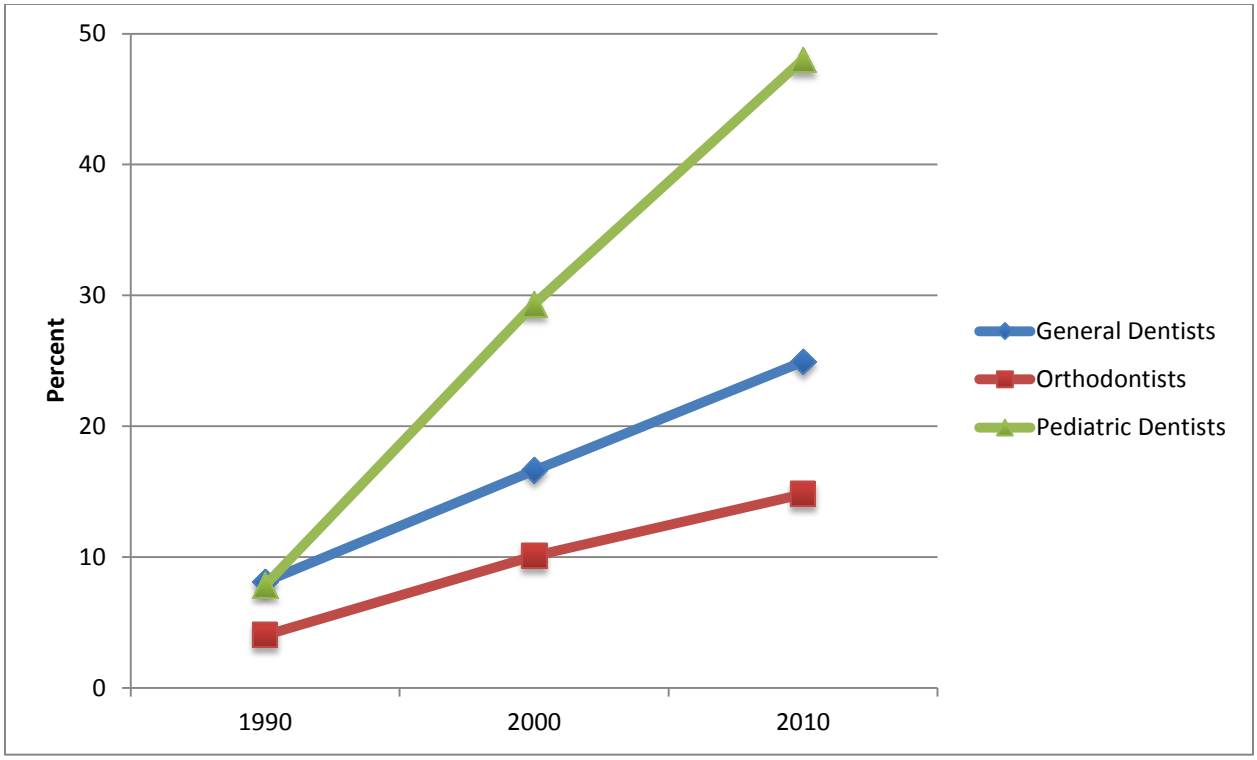


Figure 9 - General Dentist Gender in Non-Metropolitan Counties (as percent of own gender)

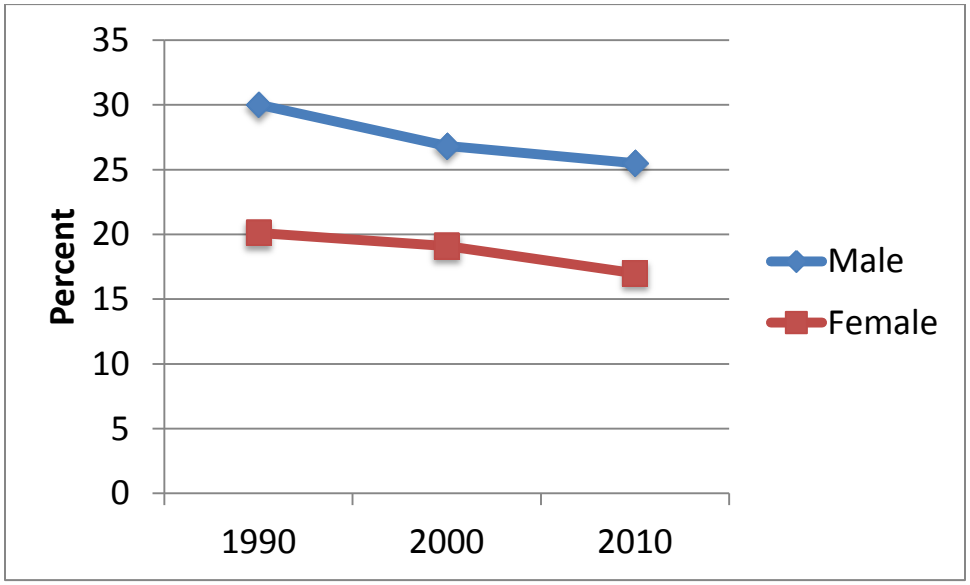


Figure 10 - Orthodontist Mean Age by MSA County Classification

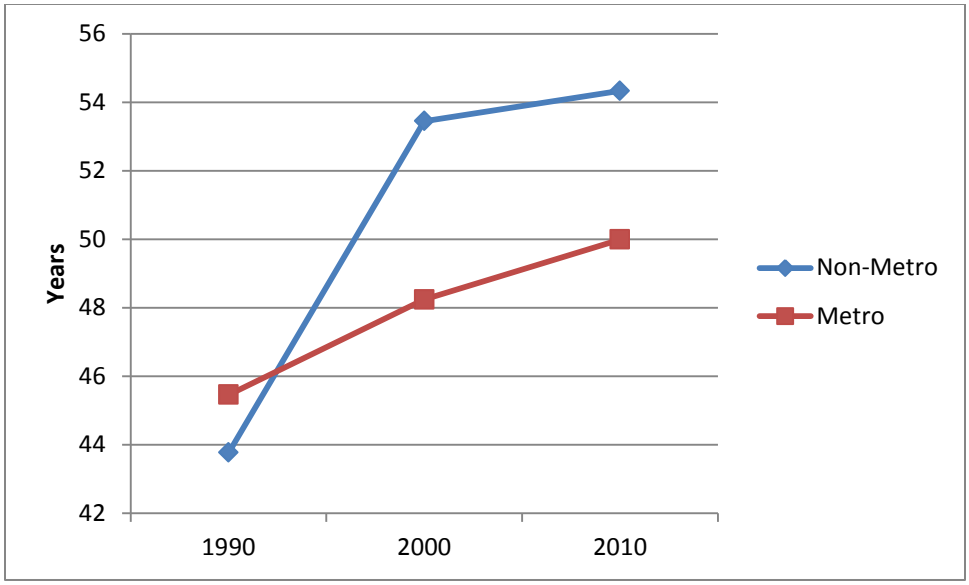


Figure 11 – Orthodontist Race/Ethnicity

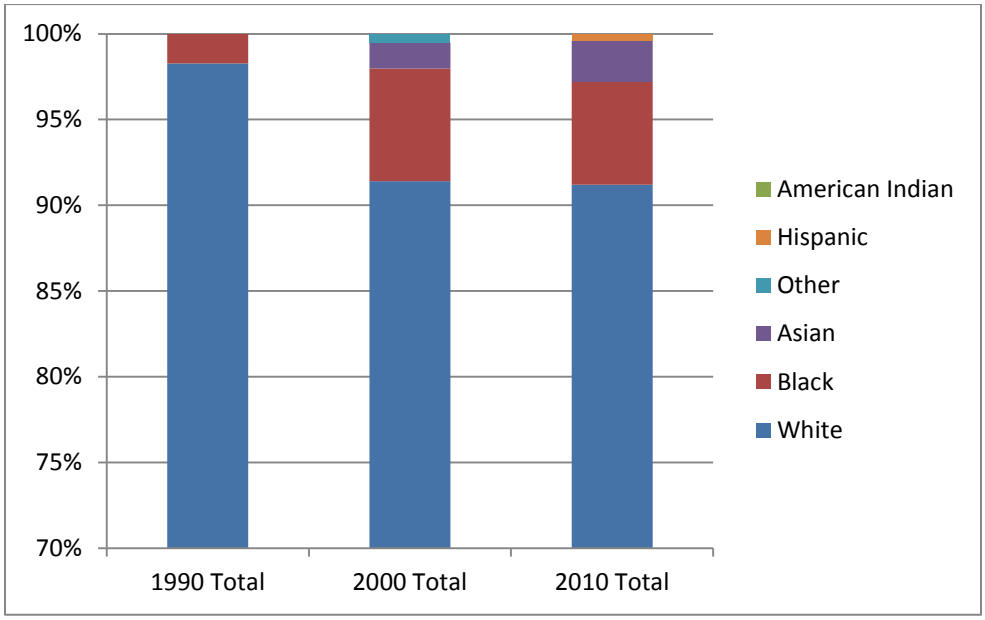


Figure 12 – Orthodontist Race/Ethnicity by MSA County Classification

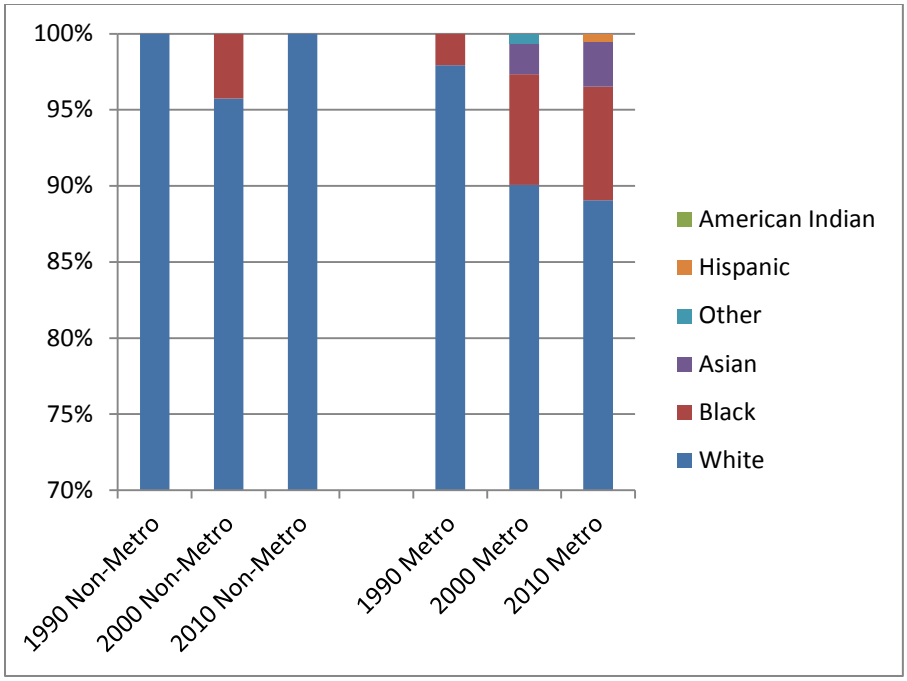


Figure 13 – Orthodontist Gender in Non-Metropolitan Counties (as percent of own gender)

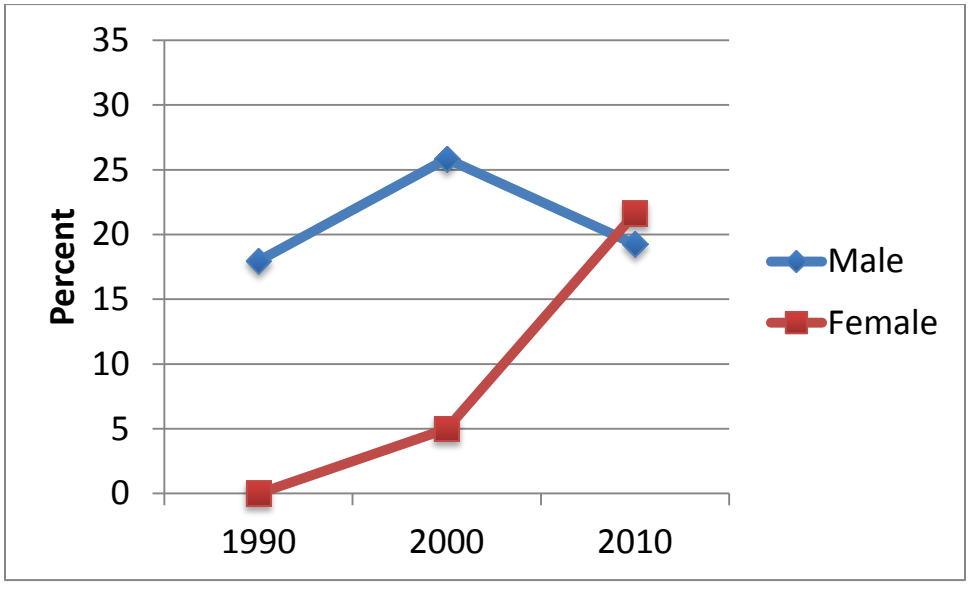


Figure 14 – Pediatric Dentist Mean Age by MSA County Classification

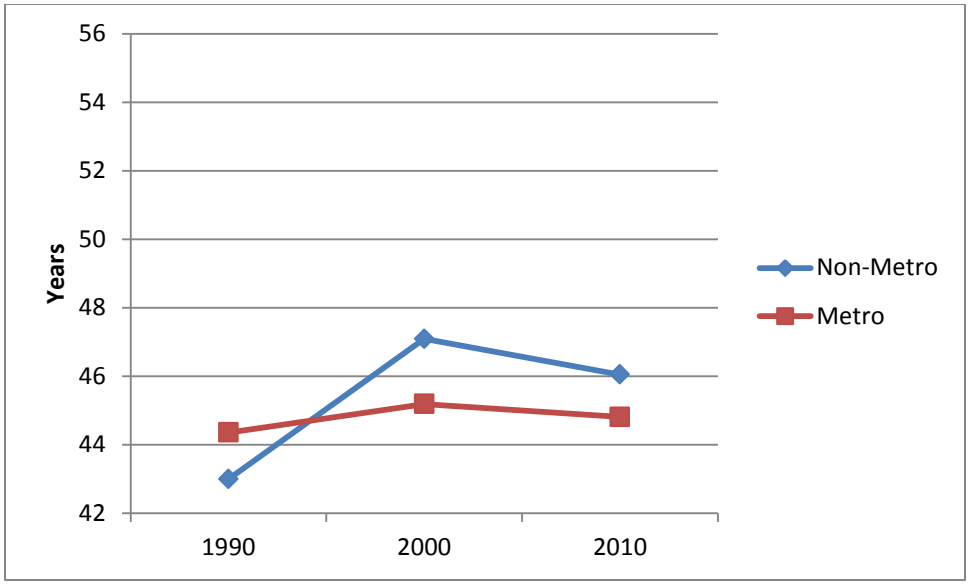


Figure 15 – Pediatric Dentist Race/Ethnicity

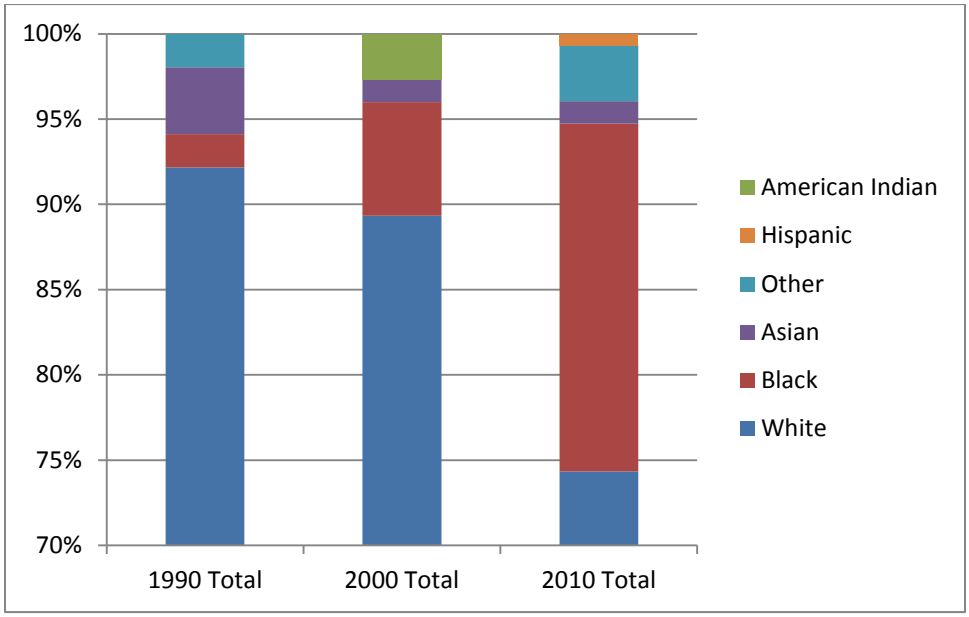


Figure 16 – Pediatric Dentist Race/Ethnicity by MSA County Classification

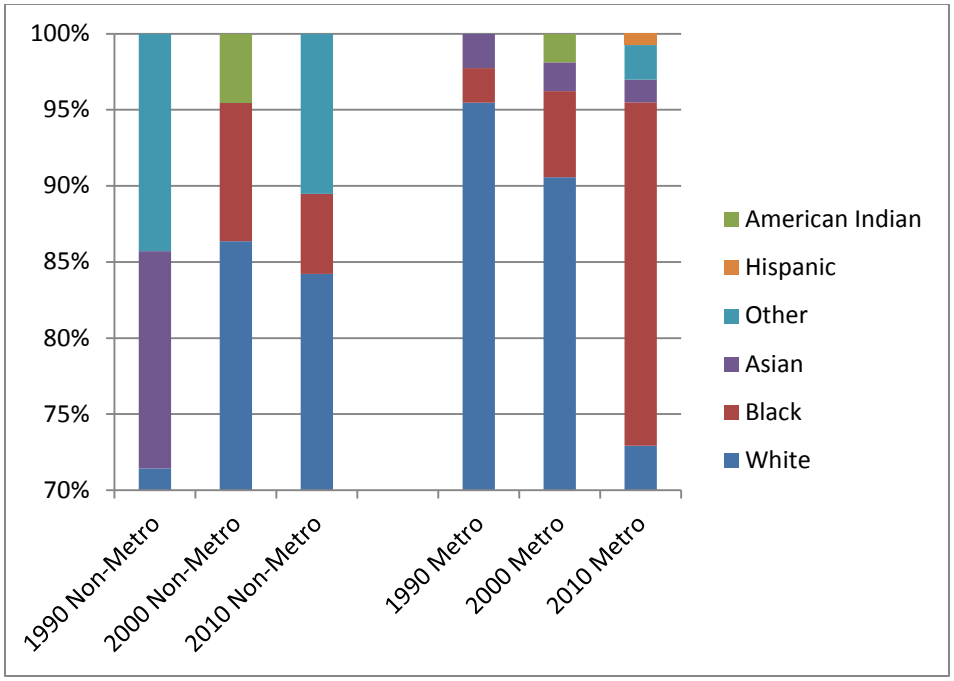
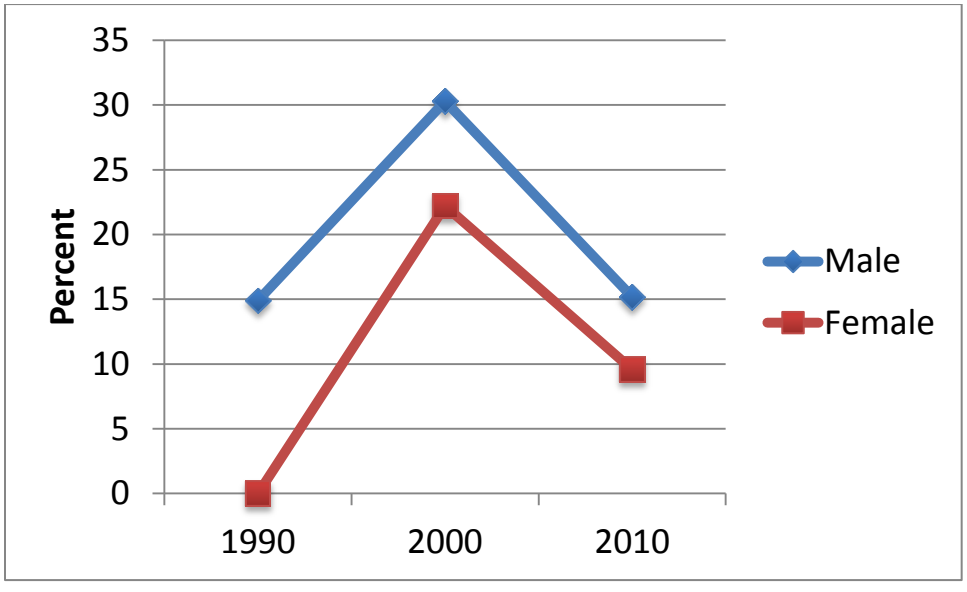
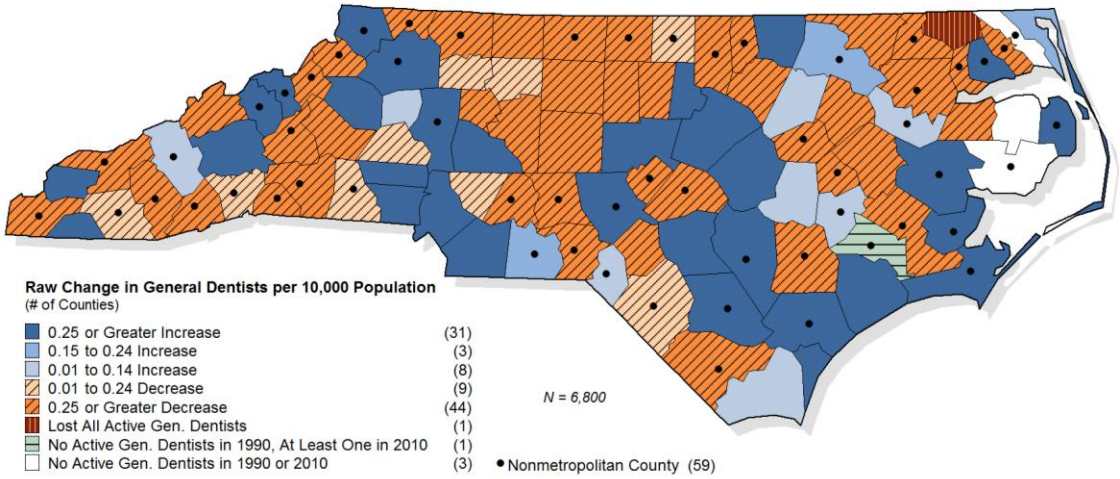


Figure 17 – Pediatric Dentist Gender in Non-Metropolitan Counties (as percent of own gender)

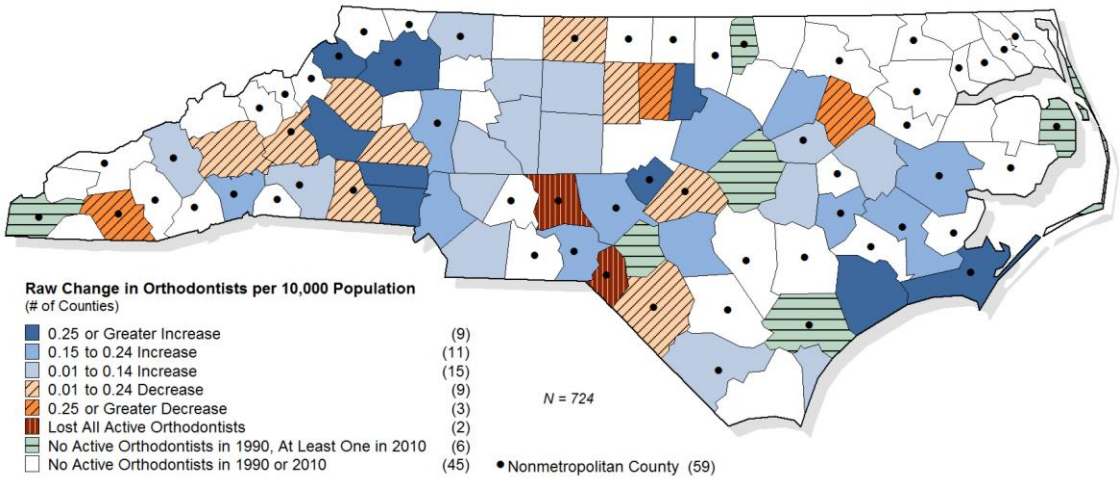


Maps

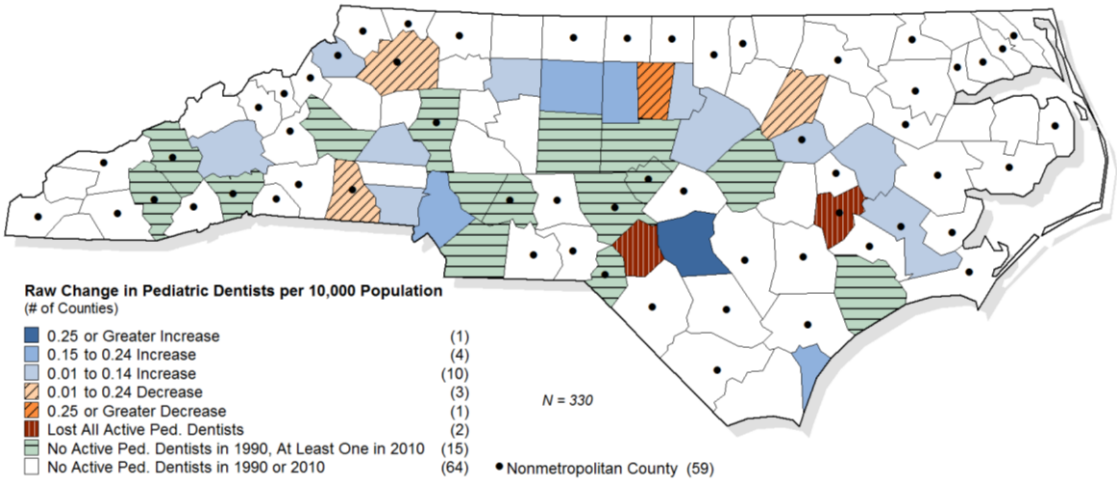
Map 1 – Change in Ratio of Active General Dentists per 10,000 Population (1990 – 2010)



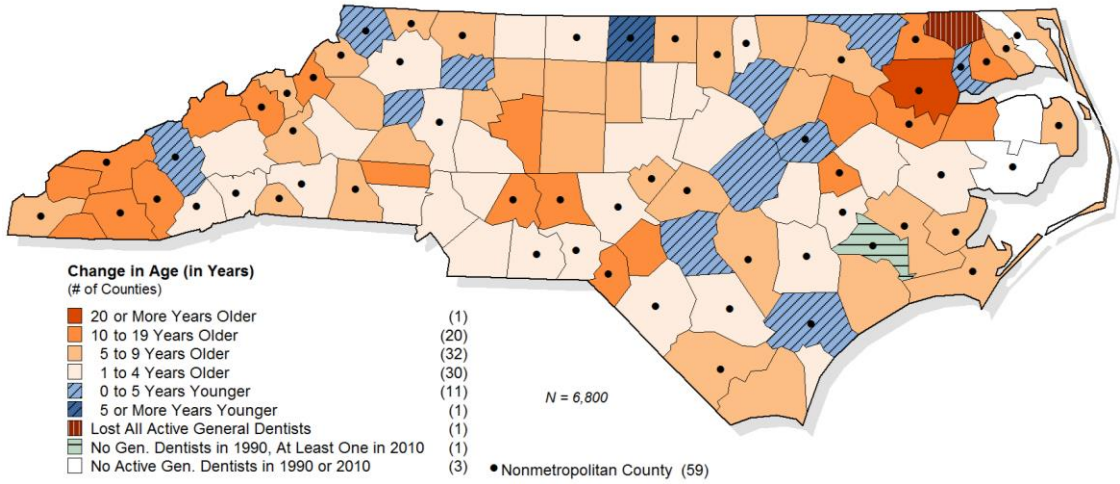
Map 2 – Change in Ratio of Active Orthodontists per 10,000 Population (1990 – 2010)



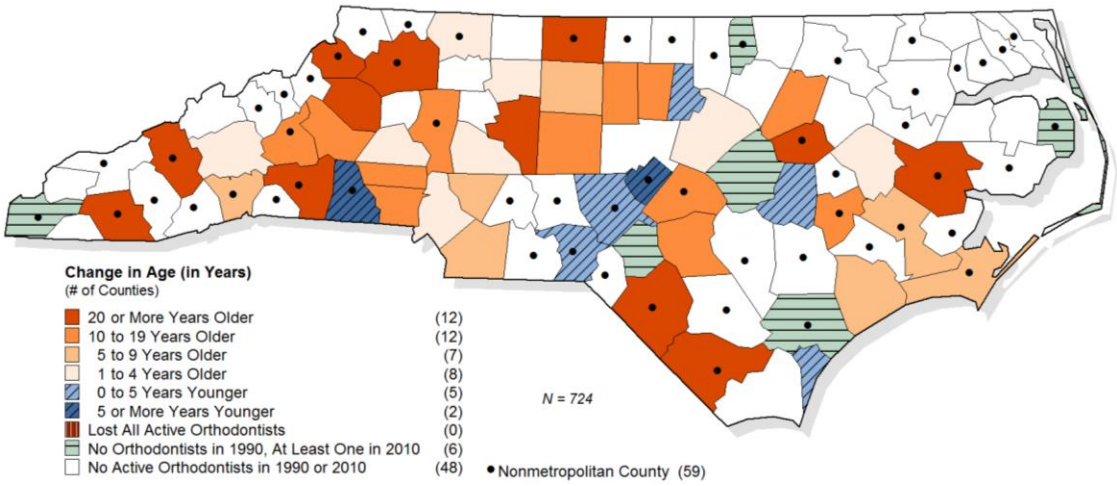
Map 3 – Change in Ratio of Active Pediatric Dentists per 10,000 Population (1990 – 2010)



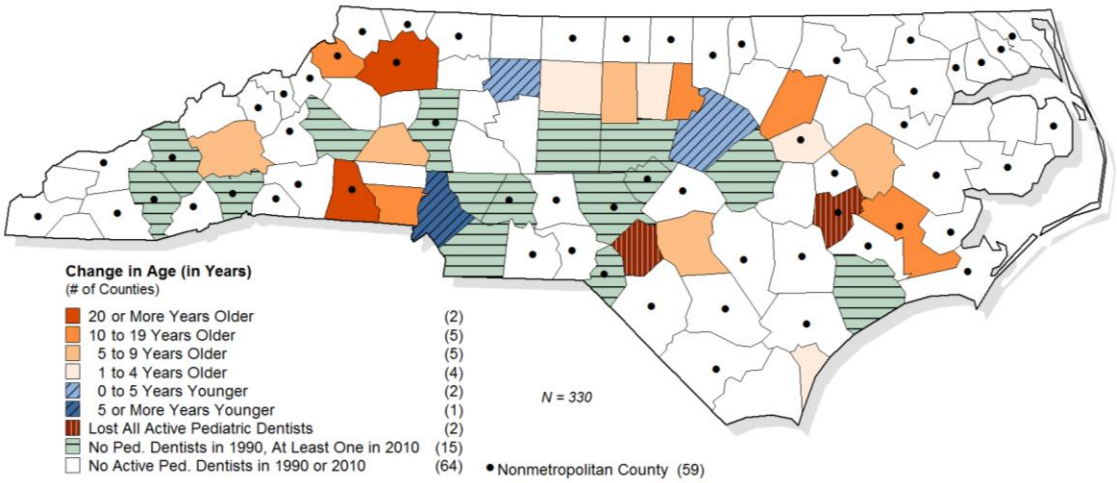
Map 4 – Change in Age of Active General Dentists (1990 – 2010)



Map 5 – Change in Age of Active Orthodontists (1990 – 2010)



Map 6 – Change in Age of Active Pediatric Dentists (1990 – 2010)



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PEDIATRIC, ORTHODONTIC, AND GENERAL DENTAL PRACTITIONER CHARACTERISTICS IN NORTH CAROLINA NON-METROPOLITAN COUNTIES AND PERSISTENT HEALTH PROFESSIONAL SHORTAGE AREAS IN 2010

Introduction

Social, functional, and psychological aspects of a child's well-being are affected by oral health (1). While important for all ages, lack of dental health care for children can lead to significant time missed from school (2) as well as pain, expense, poor sleep habits, and a decrease in amount of food eaten (3). While certain measures of oral health have shown improvement in recent years (4), dental caries continues to be the most prevalent disease in children (5), with most children experiencing this condition before they reach adulthood (6). Oral health care for children is a continuing challenge in the United States (7), and factors involved with access to care for children include parents' income, race/ethnicity, country of birth, insurance status, social environment, and proximity to a practicing dentist (8).

Proximity of dental practitioners is a significant factor in a child's oral health. Geographic barriers exist for individuals living in rural areas far from urban or metropolitan centers, limiting access to health care personnel and facilities (9, 10). For example, rural counties have significantly fewer physicians than urban counties, and rural patients see doctors less frequently (and later in the disease progression) than their urban counterparts (10). Furthermore, trends in health care professional workforce coverage are not reassuring, showing an increasing disparity between urban and rural health care resources (9). In the United States there are approximately 33% more dentists in metropolitan areas than in rural areas (11), and

state-specific studies have noted similar workforce disparities between urban and rural areas (11-17). Provider/patient ratios are relevant, and a significant positive relationship exists between the rate of utilization of Medicaid-enrolled children with participating dentist to population ratios (13).

A substantial portion of North Carolina's population is rural. In 2010 the state of North Carolina had the second highest number of rural residents of any state (only Texas had more) (18). And as a whole the state has been reported as having a much lower than average dental workforce in comparison to other states. Oral Health America gave North Carolina a "D" for dentist availability and pediatric dentist availability in 2003 (compared to the United States' overall "C' average) (19). In 2007, non-metropolitan counties in North Carolina had 3.0 dentists per 10,000 people, while metropolitan counties had 4.9 dentists per 10,000 people. Also, the ratio was as low as 1.6 dentists per 10,000 people in the counties designated as PHPSAs (Persistent Health Professional Shortage Areas) (20). Also, four counties in the northeast region of North Carolina did not have any active general dentists or dental specialists in 2009 (21).

The disparity in distribution of dentists in North Carolina has been explored by the Cecil G. Sheps Center for Health Services Research at the University of North Carolina (21). However, there is little information on the status of the dental workforce in the state with regards to specialists who typically treat children. While some generalists will treat very young patients, orthodontists and pediatric dentists have a distinct and unique role as part of the dental team, with a focus on the treatment of problems common in infancy through adolescence. For this reason, we chose to limit our data collection to these three dental practitioner groups (pediatric dentists, general dentists, and orthodontists) to better understand the state of the dental workforce with a focus on children's access to oral health.

Our goal was to determine the demographic and distribution patterns of oral health care providers for children (orthodontists, pediatric dentists, and general dentists) in North Carolina, calculate practitioner location/population ratios on a county level by metropolitan and PHPSA status, and graphically represent these changes using mapping technologies.

Methods and Materials

This cross-sectional study assessed the demographic and practitioner office characteristics of general dentists, orthodontists, and pediatric dentists in active practice in North Carolina in 2010. Data was obtained from the North Carolina Health Professions Data System (NCHPDS), maintained by the Cecil G. Sheps Center for Health Services Research at UNC-Chapel Hill. The North Carolina Health Professions Data System maintains annual licensure files obtained from the North Carolina State Board of Dental Examiners (NCSBDE) and has continuous data from 1979 for dental professionals (22). Permission was obtained from the executive director of the NCSBDE to use the data for this project and the project was approved by the Biomedical Institutional Review Board.

For each practitioner, demographic data including sex, race/ethnicity, state in which dental degree was awarded, and age were obtained. Additionally, county locations for the primary and any satellite offices were recorded for each practitioner.

County population data were obtained from publicly available data provided by the North Carolina State Data Center, a program designed to be a liaison to enhance North Carolina census data dissemination to interested users and assist in interpretation of the data. The NC Office of State Budget and Management serves as the lead agency for the State Data Center, and maintains an online system of most frequently requested data items called Log Into North Carolina (LINC)

(23). County census data for ages 0-17 (population of children) were obtained from personnel at the NC Office of State Budget and Management demographer office.

Practitioner location to population ratios were calculated by comparing the total practice locations (primary location + satellite locations) for practitioners with the population of each county, and represented as dental practitioner practice locations per 10,000 ages 0-17 population.

Counties were classified as metropolitan or non-metropolitan using the Metropolitan Statistical Area classification developed by the US Census Bureau Office of Management and Budget (24). Metropolitan Statistical Areas (MSA) "have at least one urbanized area of 50,000 or more population, plus adjacent territory that has a high degree of social and economic integration with the core as measured by commuting ties (24)".

Counties were also classified using a system which measures degree of health professional shortage. This classification relies on the Health Resources and Services Administration's (HRSA) definition of Health Professional Shortage Areas (HPSAs), which are "designated as having a shortage of primary medical care, dental or mental health providers. They may be urban or rural areas, population groups or medical or other public facilities (25)." A primary care HPSA exists when the physician to population ratio is 1:3500 or less, and a county can be classified as whole-county HPSA if the entire county is underserved or a partial-county HPSA if a specific geographic area or population group within the county is underserved (25).

Persistent Health Professional Shortage Area (PHPSA) is a classification created in part by the Sheps Center that indicates a county has met the HPSA shortage criteria in at least six of the previous seven years. Counties can be classified as Not PHPSAs counties, Part PHPSA

counties, or Whole PHPSAs counties (26). Information regarding dental HPSAs and dental PHPSA county designations for North Carolina are currently unavailable in usable form, so the 2010 primary care PHPSA county designations were used. Descriptive statistics for practitioner demographic and practice characteristics were calculated by year, practitioner type, and MSA/PHPSA status using SAS version 9.2. Practitioner location to ages 0-17 population ratios were also calculated. Maps were fabricated using MapInfo Professional 8.0 (Pitney Bowes) software.

Results

Practitioner Location Counts and Ratios

Table 3 displays the counts and total location ratios (practitioners per 10,000 ages 0-17 population) in 2010 by metropolitan classification. For general dentists, the metropolitan ratio (16.14) was greater than non-metropolitan ratios (11.87). Table 4 displays the counts and total location ratios (practitioners per 10,000 ages 0-17 population) in 2010 by PHPSA classification. There were few GPs (29) in Whole PHPSA counties, comprising 0.88% of the GP population. The GP Not PHPSA and Part PHPSA total location ratios were over double Whole PHPSA total location ratios. Map 7 displays the counties of North Carolina in 2010 with darker coloration in counties with a higher number of general dentists per 10,000 ages 0-17 population. 4 counties (Tyrell, Hyde, Camden, and Gates) did not have a GP location, and the ages 0-17 population of these counties was 7,331.

For orthodontists, the metropolitan total location ratio for orthodontists was nearly double the non-metropolitan total location ratio (Table 3). There was only 1 orthodontist location in any Whole PHPSA county (Table 4). Additionally, the Not PHPSA total location ratio was over 7

times the Whole PHPSA total location ratio, and Part PHPSA total location ratio over 8 times the Whole PHPSA total location ratio. There were 48 counties without an orthodontist location (Map 8), and the ages 0-17 population of these counties was 325,174.

For pediatric dentists the metropolitan total location ratio was over triple the non-metropolitan total location ratio (Table 3), and there were no pediatric dentist locations in any Whole PHPSA county (Table 4). The number of counties without a pediatric dentist location was at 66 (Map 9), and the 0-17 population of these counties was 670,312.

Practitioner Demographic Characteristics

For GPs, more males were present in all categories, and as a percentage of their own sex, there were more males (0.97%) than females (0.61%) in Whole PHPSA counties. There was a higher average age for GPs in Whole PHPSA counties than in Not or Part PHPSA counties (Figure 18). There were only White (24) and Black general dentists (5) in Whole PHPSA counties (Figure 19). As percentage of their ethnic group, there were more Black GPs in Whole PHPSA counties than White GPs (or any other group). Map 10, 11, and 12 display the counties of North Carolina in 2010 with darker coloration in counties with a higher average practitioner ages. Map 13, 14, and 15 display the counties of North Carolina with darker coloration in counties with a higher percentage of female practitioners. Map 16, 17, and 18 display the counties of North Carolina with darker coloration in counties with a higher percentage of non-white practitioners.

There was only 1 orthodontist (a white male) in any Whole PHPSA counties, and his age was higher than the orthodontist average age in Not and Part PHPSAs (Figure 18). There were no American Indian or Other orthodontists in 2010, and the only Hispanic orthodontist was in a

Not PHPSA county. There was only 1 White orthodontist in a Whole PHPSA county (Figure 20).

There were more female pediatric dentists in Not PHPSAs than males, which is the only PHPSA category where female count was greater than male count. The average age of pediatric dentists in Part PHPSAs was greater than Not PHPSAs (Figure 18). No American Indian pediatric dentists were present in 2010 (Figure 21).

Practitioner Location Clustering

In 2010 there were 4 counties without a GP, 24 counties with 5 or less GPs, and 46 counties with 10 or less GPs, while 7 counties had over 100 GPs. These 7 counties (Wake, Mecklenburg, Guilford, Forsyth, Durham, Buncombe, New Hanover) had over 100 locations each and together had exactly 50% (1700) of the 3400 GP offices in NC. The 4 counties without a GP did not have an orthodontist or pediatric dentist. 44 counties with a GP did not have an orthodontist, and Brunswick County had 33 GP locations but no orthodontists or pediatric dentists. 62 counties with a GP did not have a pediatric dentist (Rowan County had 46 GP locations but no pediatric dentist). For each specialty group in 2010, there were no counties with an alternate location without a primary location present in that county.

In 2010 there were 48 counties without an orthodontist, 86 counties with 5 or less orthodontists, and 94 counties with 10 or less orthodontists. 5 counties (Wake, Mecklenburg, Guilford, Durham, and Forsyth) had 18 or more locations each and together had over 50% (184) of the 362 orthodontic offices in NC. 22 counties that had an orthodontist did not have a pediatric dentist.

In 2010 there were 66 counties without a pediatric dentist, 91 counties with 5 or less pediatric dentists, and 97 counties with 10 or less pediatric dentists. 4 counties (Mecklenburg, Wake, Guilford, and Cumberland) had 14 or more locations each and together had over 50% (89) of the 165 pediatric dentistry offices in NC. 4 counties that had a pediatric dentist did not have an orthodontist.

Discussion and Conclusions

There were several limitations of this study. One limitation is that our specialty classifications for dentists were entirely self-reported at the time of their dental license renewal. Another is that data acquisition was limited to all practitioners reporting as "active", hours worked per week information was not analyzed, and there was no information available about the amount of time spent at each listed satellite location. This information could have differentiated practitioners based on the amount of patient care they provide in a certain area; other studies have further classified practitioners into "full-time equivalent dentists" (11).

The location/population ratios used in this study were calculated by taking into account both the practitioner's primary location and any satellite locations, resulting in what we termed "total locations". This calculation was used throughout the project, as we felt it more accurately represented the wider distribution of patients that each practitioner was treating at all locations. Numerous satellite locations within one county will overestimate the number of practitioners in that county. Also, for any reporting of practitioner demographic information (sex, age, race) by metropolitan county, only the practitioners primary location was taken into account. This may have skewed the practitioner demographics for a specific county that has numerous satellite locations but few primary locations.

This study utilized the Metropolitan Statistical Area classification developed by the US Census Bureau Office of Management and Budget, which lists 35 metropolitan counties (24). In 2003, the MSA classification was discontinued and replaced by the CBSA (Core Based Statistical Area) classification, listing 40 metropolitan counties in the state (27). We preferred the more exclusive definition of "metropolitan" which classified fewer counties as urban, so therefore we utilized MSA classifications in this study.

For each specialty, there were more practitioners and higher ratios in metropolitan counties in than non-metropolitan counties. This lack of dental workforce presence in rural counties agrees with studies completed in different states (11, 12, 14-17). Especially underserved are the 10 Whole PHPSA counties, which had less than half the GP location/population ratio of the Not PHPSA and Part PHPSA counties. There was only one orthodontist in Whole PHPSA counties and no pediatric dentists. There are four counties without any dentist (Tyrrell, Hyde, Camden, and Gates), nearly half North Carolina's counties (48) do not have an orthodontist location, and 66 counties do not have a pediatric dentist location. The home counties of 7 of the largest urban areas (Charlotte, Raleigh, Greensboro, Durham, Winston-Salem, Asheville, and Wilmington), had half of the GP locations in North Carolina, while 5 counties had over half of the orthodontic locations, and 4 counties had over half of pediatric dentistry offices in North Carolina. These findings of a widening gap in dental workforce between urban and rural areas are consistent with another North Carolina dentist workforce study published recently (28).

Additionally, the average age of general dentists in Whole PHPSAs is greater than the average age in Not PHPSA and Part PHPSA counties. This is discouraging because older practitioners are more likely to be closer to retirement, and if a replacement is not found it

detracts from the already deficient rural dental workforce (28). Whole PHPSA counties only had White and Black general dentists, and the only orthodontist in a Whole PHPSA county was white. This lack of racial/ethnic diversity in the Whole PHPSA counties is consistent with other health professional studies, finding that only 11% of non-white health professionals were located in non-metropolitan counties (29).

The geographic maldistribution of the dental workforce is evident with dentists clustering in the more urban counties of the state. While this is seen in the difference in ratios in metropolitan and non-metropolitan counties, it is far more pronounced in the Whole PHPSA classification, indicating an increased need in those counties. There does not seem to be an appreciable difference in the dental workforce distribution when comparing Not PHPSA and Part PHPSA counties.

Several authors have commented on the etiology of the disparity between rural and urban areas. Rural areas are not attractive to new dentists for a variety of reasons. Poverty is one issue, as Whole county PHPSAs have a higher percentage (15.2%) of residents living below the poverty line than non-PHPSAs (10.4%) (30), and therefore many rural residents cannot afford dental care. Also, areas with a high median housing value are among the likely predictors of a viable dental specialty practice according to a study by Solomon and Ceen (31), an attribute less likely to be found in impoverished rural areas. The lower population densities of rural areas is another factor in the lack of demand for dental services, further de-incentivizing a practice start-up (11). According to the authors of an Ohio dental workforce study, "it that it may seem that dentists have chosen to locate their practices in the most densely populated areas rather than where dental care is needed most (12)."

The outcome of the stagnant or declining demand for dental services (and therefore decreased economic attractiveness) in rural areas is an insufficient dental workforce which leads to an "accumulation of untreated oral disease in the population. As untreated disease persists, it frequently progresses in severity, leading to more complicated and expensive sequelae… Across generations, the outcomes are acute episodes, accompanied by pain, incomplete treatment, and, all too frequently, tooth loss without replacement (32)."

Implications for an underserved rural population of children are significant and go beyond the oral cavity. A study found that of the 26% of children who did not visit a general health care provider in 2008, over 34% did visit a dental practice that year, the author commenting that for those patients, "dental professionals are in a key position to assess and detect oral signs and symptoms of systemic health disorders that may otherwise go unnoticed (33)."

Numerous solutions to the maldistribution of the dental workforce have been discussed in the literature, including subsidies for rural practitioners (11), debt repayment or tuition reimbursement for rural service contracts (12), and expanded use of mid-level providers (11). Another solution is to foster interest in the profession within the young population of an underserved area, as new dentists are likely to practice in their place of rearing (34).

These results are consistent with the conclusions of other studies in that there is an increasing need for dentists who treat children in underserved populations and rural areas. This study is unique to analyze the ages 0-17 population with regards to specialists and the classification of counties by metropolitan and PHPSA status. Identification of areas of North Carolina that may be underserved will hopefully assist future general, orthodontic, or pediatric

dental practitioners in determining suitable practice locations, inform current dental practitioners of appropriate areas in which to perform outreach, or advise policymakers or dental school administrators in making public health initiatives or enhancing educational opportunities.

Tables

Table 3 – 2010 Location Counts and Ratios (practitioners per 10,000 ages 0-17 population) by MSA Classification

	MSA Non-Metropolitan Counties	MSA Metropolitan Counties
Population	0.66M	1.62M
GP Total Location Counts	786	2614
GP Total Location Ratio	11.87	16.14
Ortho Total Location Counts	65	297
Ortho Total Location Ratio	0.98	1.83
Pedo Total Location Counts	19	146
Pedo Total Location Ratio	0.29	0.90

Table 4 – 2010 Location Counts and Ratios (practitioners per 10,000 ages 0-17 population) by PHPSA Classification

	PHPSA Status		
	Not	Part	Whole
Population	1.38M	0.85M	0.048
GP Total Location Count	2078	1289	33
GP Total Location Ratio	15.01	15.18	6.91
Ortho Total Location Count	216	145	1
Ortho Total Location Ratio	1.56	1.71	0.21
Pedo Total Location Count	103	62	0
Pedo Total Location Ratio	0.74	0.73	0

Figures

Figure 18 – Practitioner Mean Age in PHPSA Counties

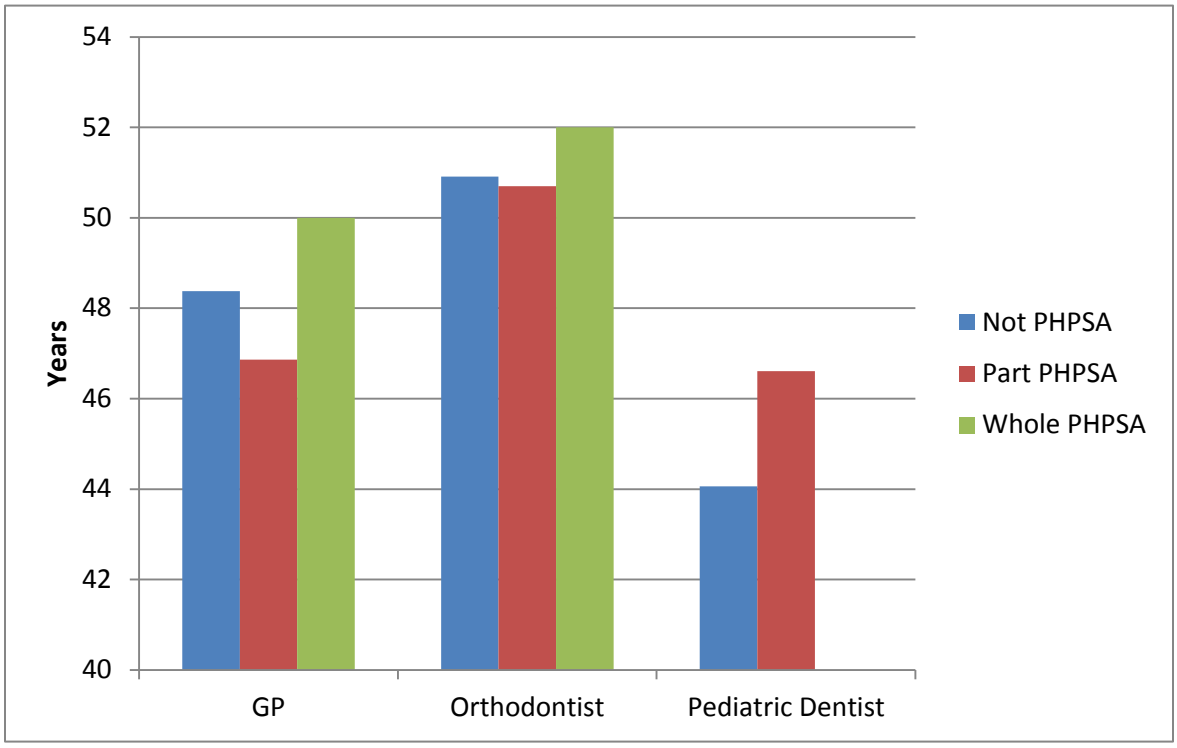


Figure 19 – General Dentist Race/Ethnicity by PHPSA County

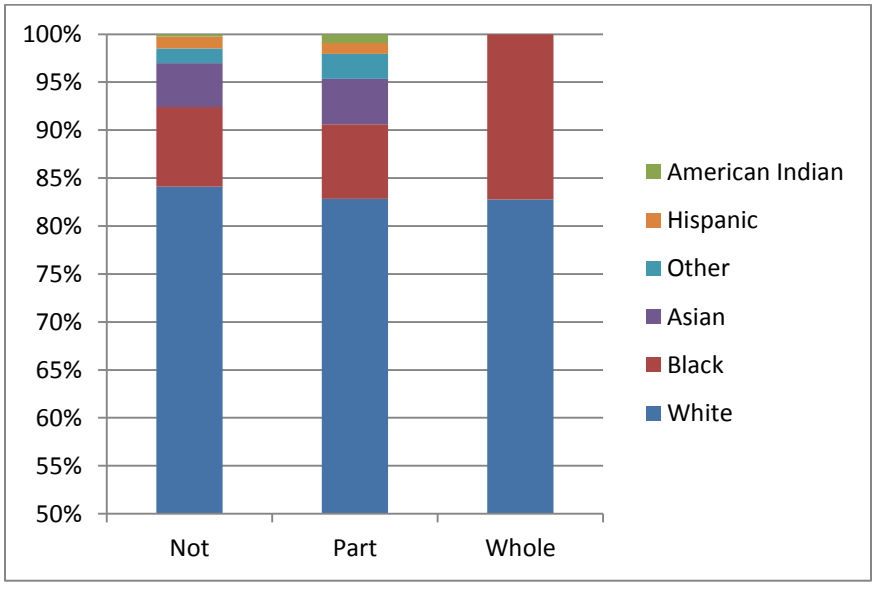


Figure 20 - Orthodontist Race/Ethnicity by PHPSA County

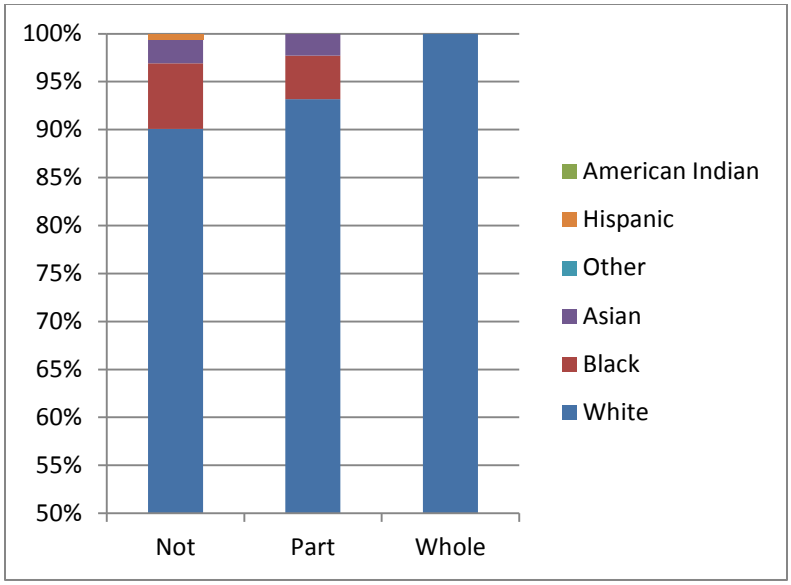
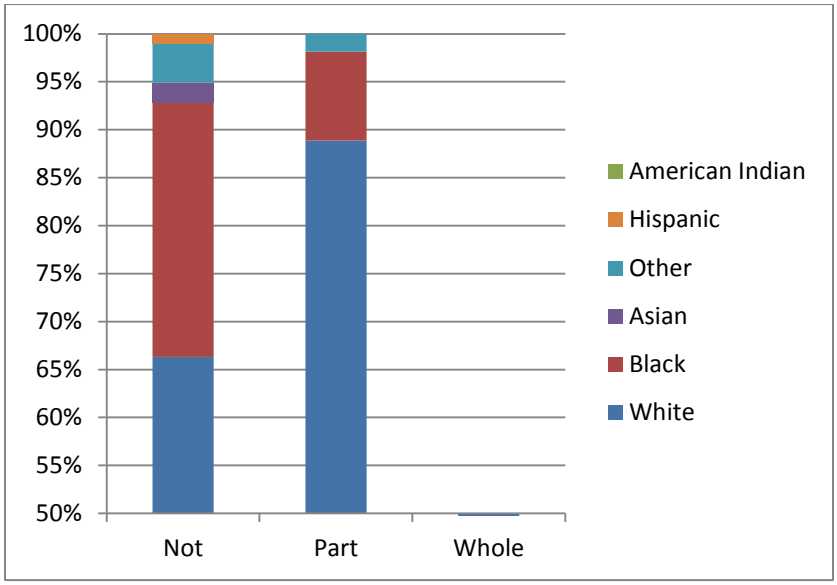
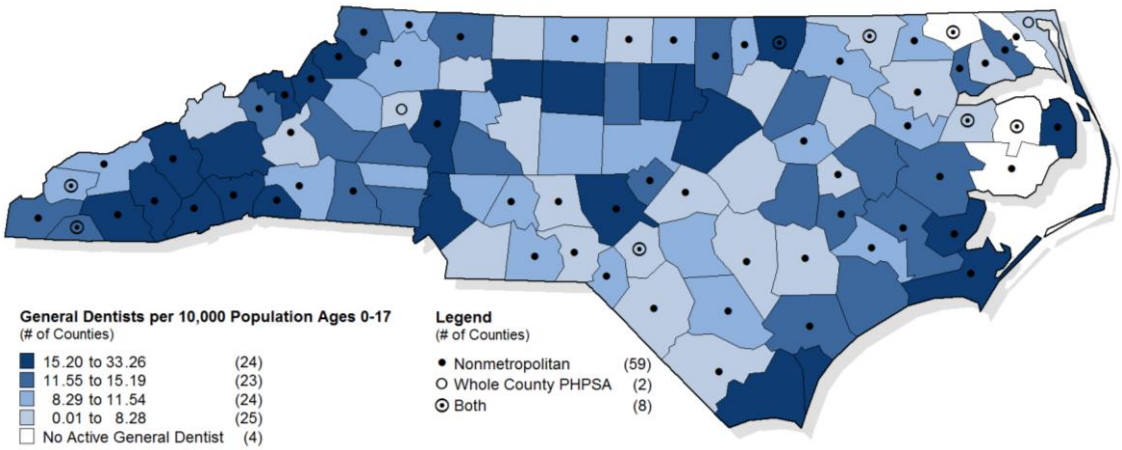


Figure 21 – Pediatric Dentist Race/Ethnicity by PHPSA County

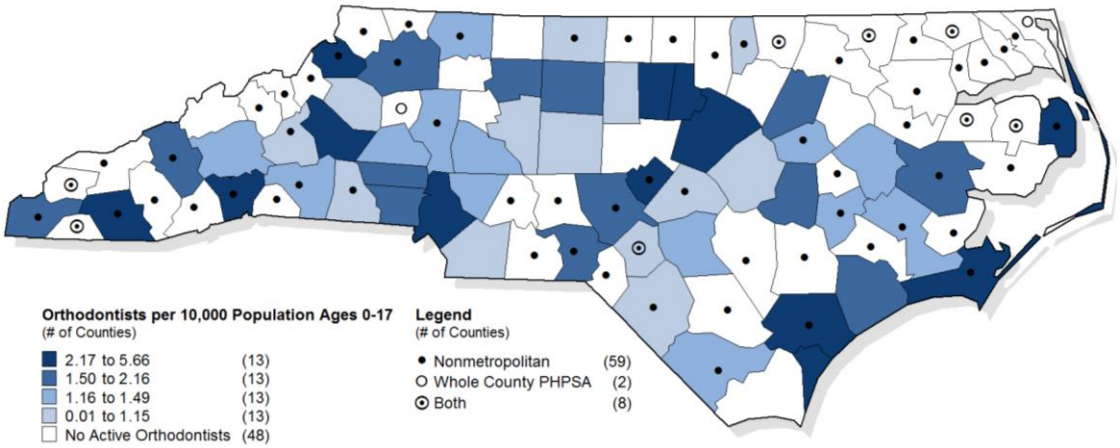


Maps

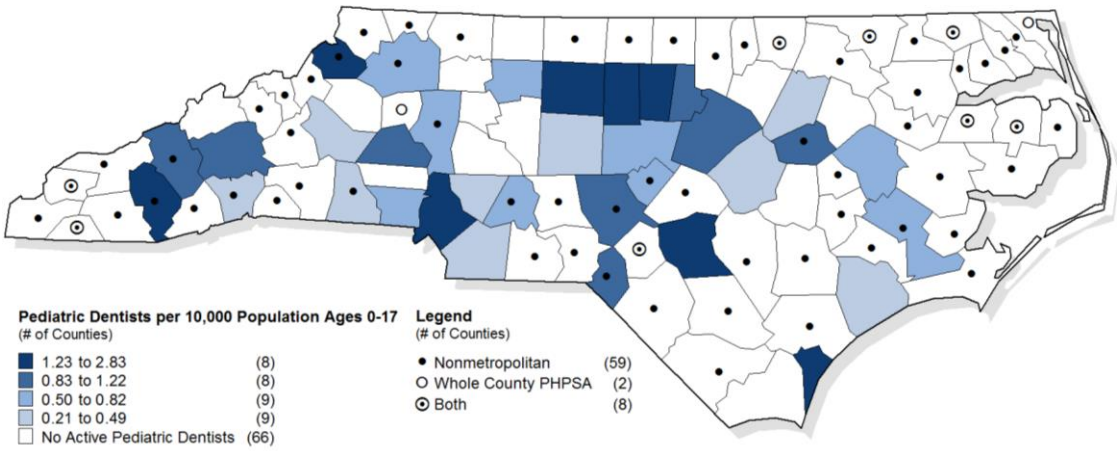
Map 7 – General Dentists per 10,000 Population Ages 0-17



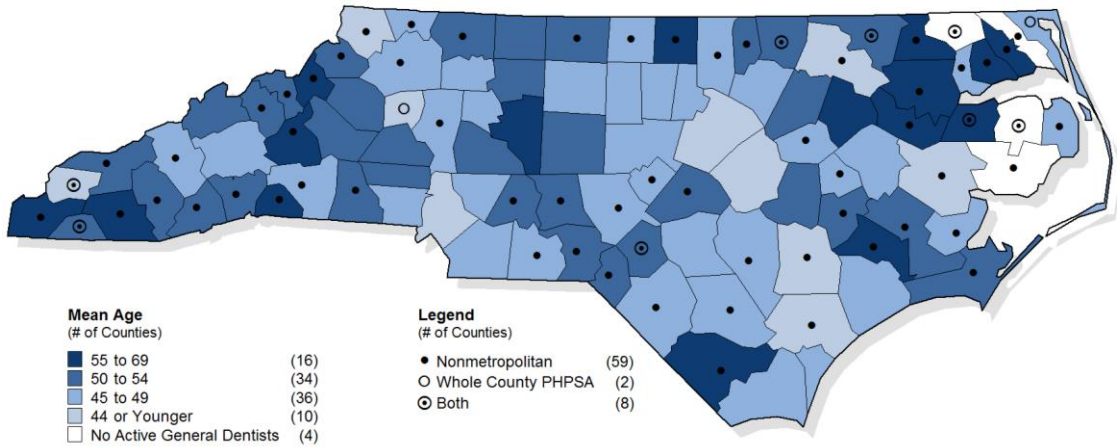
Map 8 - Orthodontists per 10,000 Population Ages 0-17



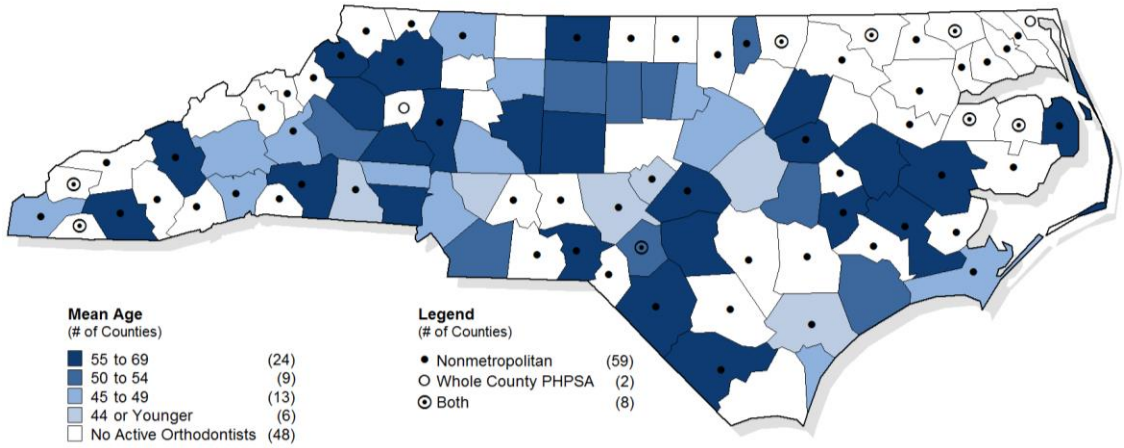
Map 9 – Pediatric Dentists per 10,000 Population Ages 0-17



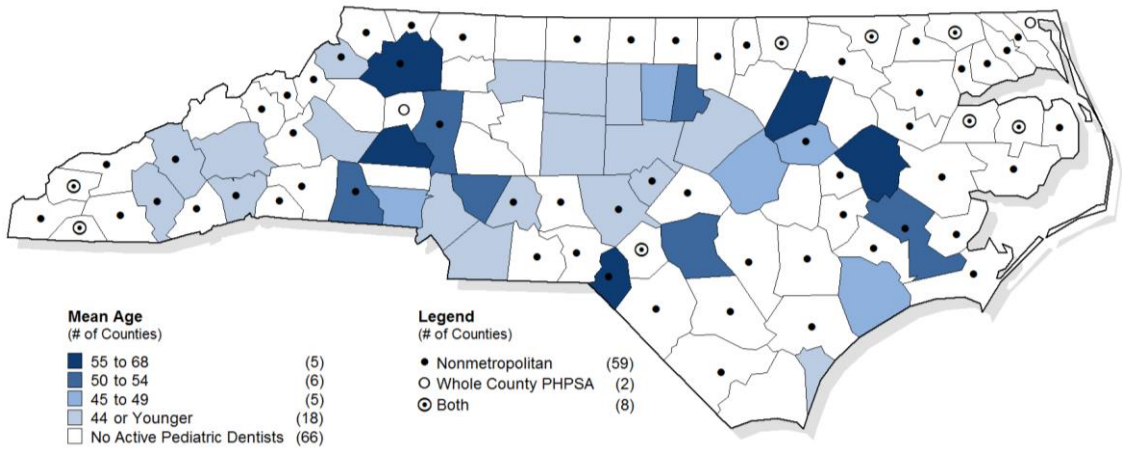
Map 10 – Mean Age of Active General Dentists



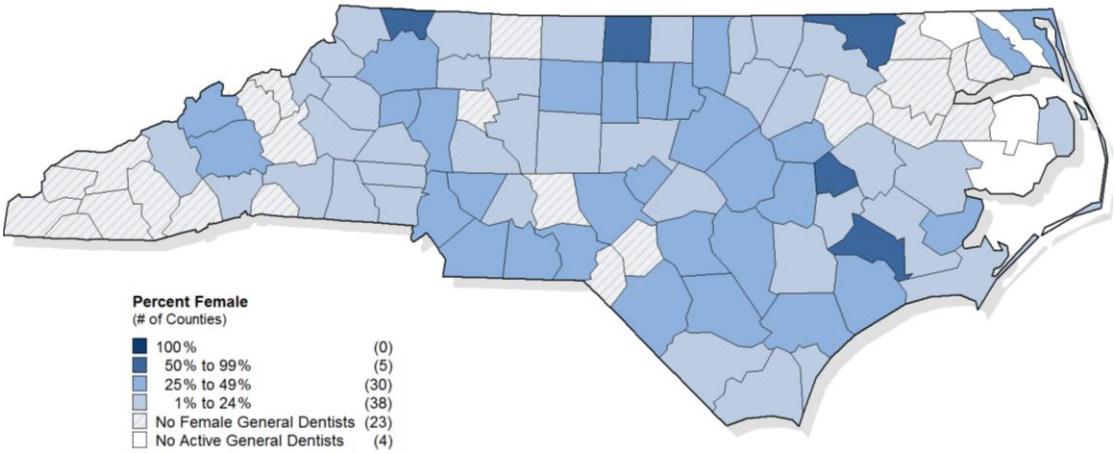
Map 11 - Mean Age of Active Orthodontists



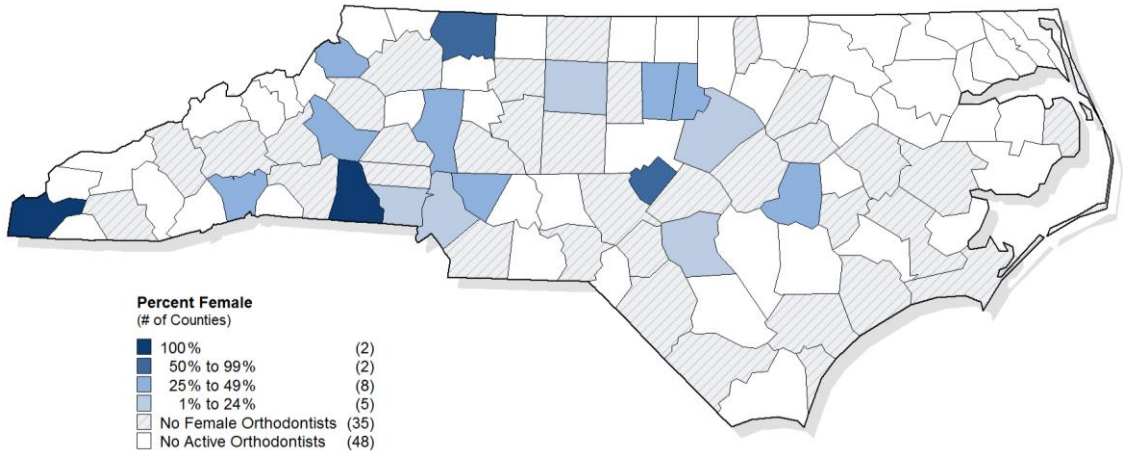
Map 12 - Mean Age of Active Pediatric Dentists



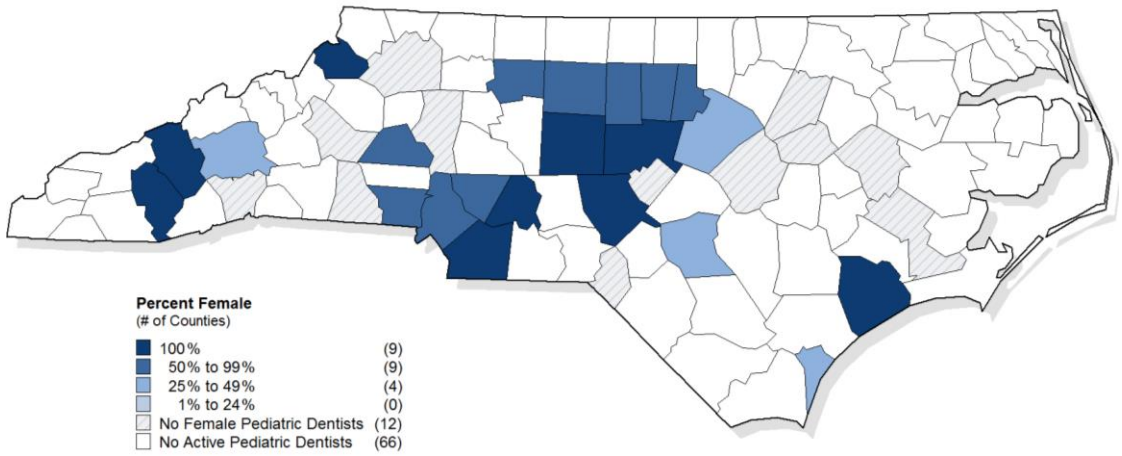
Map 13 – Percent of Active General Dentists Who Are Female



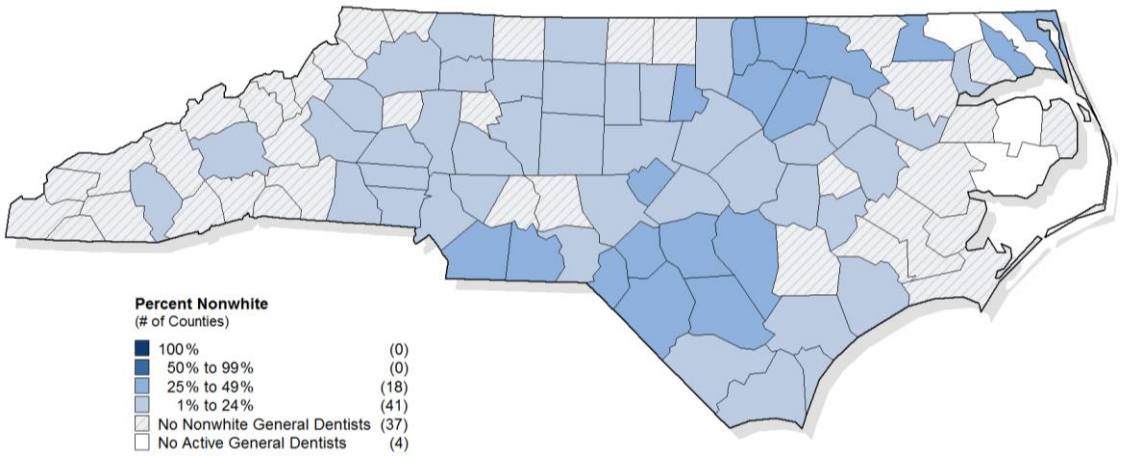
Map 14 - Percent of Active Orthodontists Who Are Female



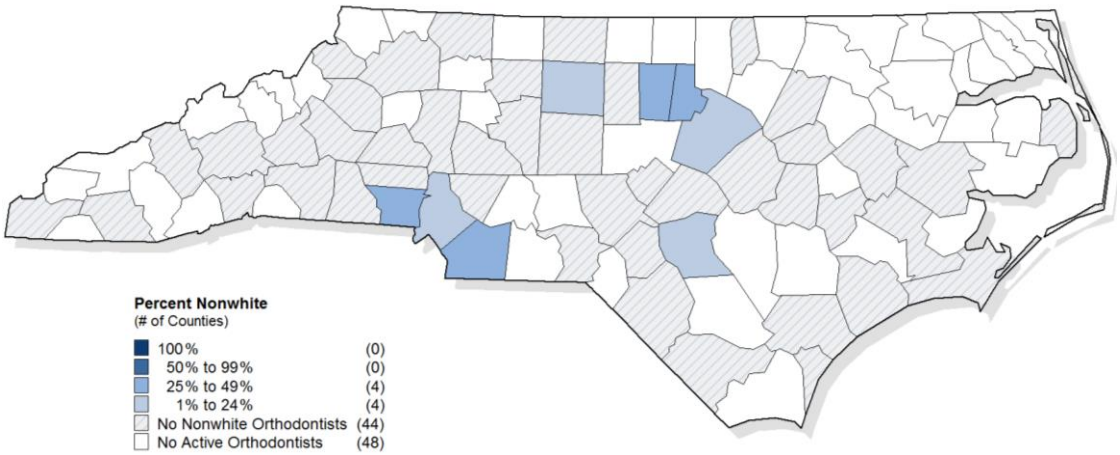
Map 15 - Percent of Active Pediatric Dentists Who Are Female



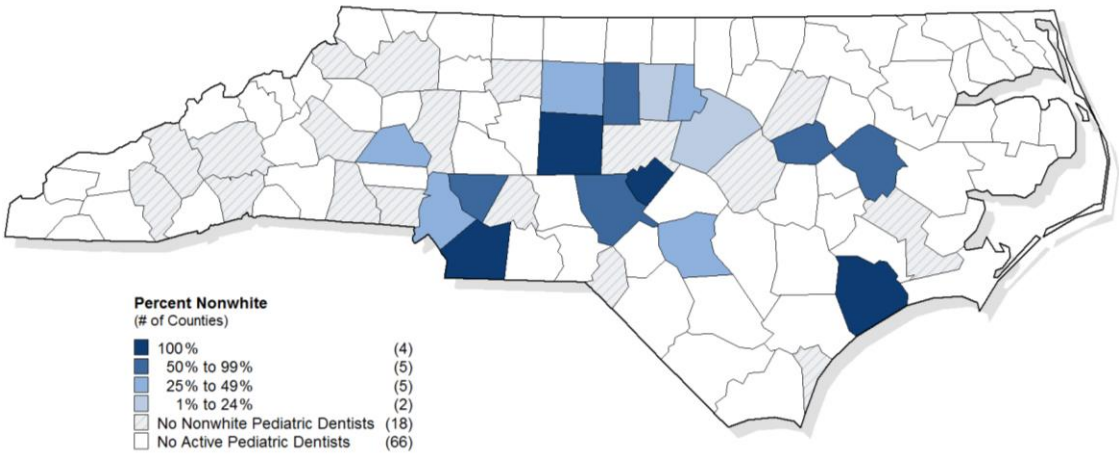
Map 16 – Percent of Active General Dentists Who Are Nonwhite



Map 17 - Percent of Active Orthodontists Who Are Nonwhite



Map 18 - Percent of Active Pediatric Dentists Who Are Nonwhite



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